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SUMMARY

Current Issue **EDITORIAL**

Communication is essential for the development of societies, and perhaps what distinguishes humanity from the other inhabitants of this planet is indeed its efficiency and plura-lity. We communicate primarily in an audiovisual way, even though we have been given five senses, all with the capacity of permitting the exchange of information and perceptions of the world.

Math developed as “Information Theory” shows the limits of this ability of communicating parties to exchange content and identifies the importance of the message. It is the end, while the channels and interfaces that adapt the messages to the system are the means for communication to happen.

Therefore, the development of long-range communication, for now electronic, involves producing content in a format easily comprehensible to the human senses, and, while observing the economic issues and natural limits, with the greatest possible similarity to local and direct perception. The pursuit of quality that fits in a channel (which is always physical, therefore, limited) and the scope or range of this message is the focus of resear-chers for whom the IJBE provides an opportunity to disclose their studies and experiments in the areas of production and distribution of information-rich content.

Best wishes,

SET IJBE Editors

Optimization of the propagation model choice by measuring field and artificial intelligence

Alberto Leonardo Penteado Botelho
Cristiano Akamine

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Optimization of the propagation model choice by measuring field and artificial intelligence

Alberto Leonardo Penteado Botelho, Cristiano Akamine

Abstract— **The propagation model to be chosen in the design of a digital terrestrial broadcast station is a tipping point for predicting the coverage area. There are several models, with specific characteristics that may be better than others in certain situations. This paper presents a study of the choice of propagation model, through the use of artificial intelligence (AI). A brief review of the most widely used propagation models in the literature, field measurements and simulations by the Progira coverage prediction software, which operates on the ArcGIS geoprocessing platform are presented. Using the propagation model criterion that presents the smallest error between the field measurement and the software simulation, an AI method of classification learning was developed. The objective of this method can choose, with the smallest error, the best propagation model in the entire study area, not restricted to the Sites measured in the field.**

Index Terms— **Classification Learner, Artificial Intelligence, Field Measurement, Propagation Model, Single Frequency Network.**

I. Introduction

The Technical project is essential for the deployment of terrestrial television broadcasting stations, whether analog or digital, as it allows a broadcaster to predict the coverage area. Coverage area is the region where the signal level transmitted by the television station allows decoding on TV sets.

As ISDB-TB (Integrated Services Digital Broadcasting Terrestrial version B) digital television technology allows operation with SFN (Single Frequency Network) stations, it is possible that coverage failures can be corrected by deploying auxiliary transmitters at the same frequency to improve the coverage area. In this way, the prediction of the coverage area and the field measurement become even more critical and dependent.

Most complex coverage area prediction softwares use the point-by-point method, which requires sophisticated algorithms.

Regardless of the software used, the tipping point is the choice of the propagation model that best suits the characteristics of the study region.

There are several propagation prediction models found in the technical literature, such as Okumura Hata, Longley Rice, Ordinance 53 of Ministério das Comunicações, Recommendation ITU-R 1546-1, but they are not always sufficient to characterize reception conditions in isolation [1].

The difficulty in finding the best propagation model evidences that there is no an ideal propagation model for each case and deviations are common from what was simulated and measured in the field. Field measurement becomes a way of adjusting the coverage area of the transmitter.

In order to improve the relationship between coverage area prediction and field measurement, this study is not intended to create a new propagation model, but to establish a method of choosing the best propagation model for a specific area and, if necessary, to establish a model of hybrid propagation for a given region.

Thus, a comparison was made between field measurements and software simulations, in order to establish criteria to predict the best model of propagation of non-field-measured sites.

The Progira coverage area prediction software was used and provided by LM Telecom [2] and the field measurement in the metropolitan area of Rio de Janeiro has been made available by Record Rio (Televisão Record do Rio de Janeiro Ltda.).

On the research, the most important criteria that determine which model of propagation was appropriate for each measured site have been approached and, therefore, present more reliable criteria for choosing the propagation model in the regions not measured in the field.

Point-by-point simulation software presents its predictions on a large number of points located in the study region, so a suitable computational tool must be created to process this information.

Each predicted site has a field strength value calculated by the propagation model chosen. It is possible to set a specific color for field strength with values equal to or above the stipulated and to form a limited noise coverage.

The limited noise coverage shows the regions with field strength above the stipulated, which represents good coverage and also demonstrates regions with field strength below the stipulated, which represents poor coverage and that should be addressed to improve the coverage area.

A program has been developed using AI to make the most appropriate propagation model decision making for each chosen measurement site.

The programming language chosen to implement the AI program was Matlab, which has Neural Network (NN) applications developed to support propagation model choice decisions. Matlab has been chosen because it has a set of NN and AI toolboxes. Matlab uses Jit Accelerator technology,

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which substantially increases the execution performance of applications, compared to other programming languages such as C / C ++, Foltran or Visual Basic [3].

This study is aimed at optimizing the coverage area prediction method so that broadcasters can install their systems with a high guarantee that the coverage area is consistent with the plan, minimizing new measures for correction of cover not provided in the software simulations.

This article is divided into seven sections in addition to this introductory section. In Section II, a brief description of the SFN operation, the importance of the coverage simulations and the complexity of choosing the best propagation model will be presented. In Section III, the methodology of the prediction simulations of the coverage area, the propagation models used and the equations for the database to be used by the IA will be presented. In Section IV the methodology of field measurements will be demonstrated. In Section V, AI techniques that can aid in decision making and formulate aspects of human intelligence that can be reproduced by machines will also be presented. In Section VI, the results of the application of AI in the choice of propagation model will be demonstrated. Finally, Section VII will present the main conclusions and final considerations of the work done.

II. SFN Operation

The set of essential functionalities required in digital television reception devices is regulated by the ABNT (Brazilian Association of Technical Standards). For Digital Terrestrial Television receivers, the ABNT standards [4] recommends that the minimum level of input to the receiver must be greater than or equal to -77 dBm for operation in mode 3, 1/8 guard interval, no time interleaving, 64 QAM modulation and 3/4 code rate.

Brazilian legislation defines SFN as a set formed by the generating station and auxiliary or retransmitters that operate on the same channel and transmit precisely the same content simultaneously. The viable channel for the retransmitter stations must be identified in the PBTVD (Basic Digital Television Plan) as reusable and its technical characteristics in it. Channel reuse is the reuse of the same channel used to provide the service granted [5].

In order to allow operation according to the distance between the stations of a SFN and ensure proper reception channel variations as a result of the Doppler effect of the mobile reception signal, one can select among three spacing options of OFDM carriers offered by the Brazilian system. These three must be identified as system modes.

In the case of Brazil, the frequency spacing shall be approximately 4 kHz, 2 kHz or 1 kHz, respectively for modes 1, 2 and 3. The number of carriers varies depending on the mode, but the useful bit rate of each mode must be precisely the same in all modes [6]. The different mode settings, modulation method, guard interval and convolutional code significantly change the coverage area, data rate and minimum distance between the carriers that allows synchronization in SFN.

The SFN operation can significantly improve spectrum efficiency, service quality and reduce power emission compared to single-transmitter networks. SFN uses several transmitters that operate on the same RF channel, transmitting the same programming, which can adequately cover a large geographic area [7].

The SFN operation is very advantageous, but it entails the need for a much more rigorous planning. SFN offers many potential advantages, the greatest of which is the reduction of interference between different TV stations and greater flexibility of coverage, but this system should be planned with great care, especially in marginal performance [8].

If a single electromagnetic wave of only one transmitter arrives at a receiver without any channel distortion, then it is easy for the receiver circuit to estimate the phase and quadrature components of the symbols carried by each OFDM frequency carrier. When comparing performance in the SFN scenario, the C/N (Carrier to Noise Ratio) required for acceptable reception is greater than in the single arrival signal scenario where there is a loss of reception margin [9].

Simulations, based on a case study, show that gap filler stations used in metropolitan urban regions are useful and necessary tools for improving digital TV coverage, covering some regions that may be obstructed by buildings, vegetation, relief or any other kind of obstacle [10]. This statement evidences the trend of installing SFN systems.

The simulations are aimed at predicting the coverage area. The coverage area is determined by the field strength value of the received signal, which must be adequate for the conditions of reception of the studied locality considering the environmental, urban and topographical characteristics [1].

When making reliable predictions of coverage, the number of measurements to be performed in the scenario of interest is considerably reduced, also implying a decrease in time and cost of the project [11].

Uncertainties in predicting coverage can also make engineers opt for more conservative transmission systems to ensure the lowest coverage, with higher radiated power. The higher the power, more areas of intersection of the network, increasing the loss of reception margin.

III. Software Simulation

With the values of field strength measured in each of the 44 Sites, a calculation has been made to predict the coverage area. In the calculations, Record Rio's SFN transmissions have been considered under the same installation conditions at the time of measurements and under the same field measurement reception conditions.

Figure 1 shows a map with an example of an area with the transmitting station, located in Rio de Janeiro, at Morro do Sumaré, and 4 of the 44 sites where field measurements have been taken.

The software used to predict the coverage area was Progira, [12] which operates on the ArcGIS platform, which creates and shares maps, scenes, applications, layers, analytics and data [13].

Coverage prediction software operates with propagation model, which is a method based on interpolation / extrapolation of empirically derived field strength curves such as distance functions, antenna height, terrain clearance, and link obstructions [14].

There is no single criterion for deciding the best model based on the comparison of experimental data. The most frequently used statistical measures are the mean and standard deviation of errors. There are other issues related to

the behavior and general nature of a model that can be decisive [15].

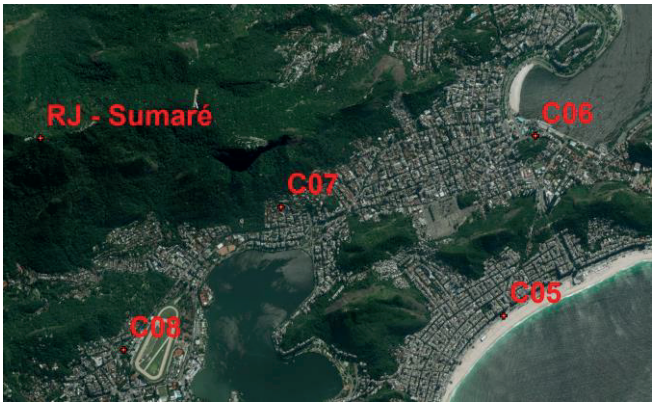

Figure 1: Map area with some transmitter and field measurement sites

Progira software currently offers ten propagation models, which are CRC-Predict, ITUR P.1546-5, ITUR P.1546-4, ITUR GE06, ITUR P.370-7, ITUR P.526-13, ITUR P. 526-11, ITUR P.1812-3, ITUR P.11812-2, Deygout-Assis, Longley-Rice, Okumura-Hata and Free Space. Each propagation model has some kind of option, such as climate, types of obstacles or types of population density, that increased the number of models of propagation to 37.

1. CRC-Predict has the options of Continental climate, Great Lakes, Maritime on Earth and Maritime on the Ocean.
2. Deygout-Assis has the options of Rounded Terrain, Main Round and Knife Edge.
3. Free Space has no options;
4. ITUR P.370-7 has options for Rural, Suburban and Urban geographic regions.
5. ITUR P.526-11 has options for Round Terrain and General Method.
6. ITUR P.1546-5 has options for rural / open, suburban, urban and dense urban geographic regions.
7. ITUR P.1812-3 has geographic options with software database, Forest, Suburban, Urban and Denso Urban.
8. ITUR GE06 has geographic options of region Rural / Open, Suburban, Urban and Urban Denso.
9. Longley-Rice has geographic options for Subtropical Continental Climate Options, Equatorial Continental, Desert, Equatorial, Tropical Seas, Temperate Seas on Earth and Temperate Seas on the Ocean.
10. Okumura-Hata has geographical option for Open, Quasi-Open, Suburban and Urban.

Thus, the software calculated the field strength of 11 stations, repeated for each of the 37 propagation models, totaling 407 limited noise coverages.

Anatel has a recommendation for survey accuracy for the average terrain level. The average terrain level for each radial shall be raised in at least 12 directions from the antenna site, taking into account the stretches between 3 km and 15 km. The radial ones must be traced with an angular spacing of 30º each other, including the direction of the True North [16].

Considering the current high computational capacity, the accuracy of each point was increased to 50 m spacing in steps of 1 °.

The propagation models calculate the field strength by the effective distance and height between the transmission and the average terrain level.

As the simulation software presents values in dBµV/m, and the field measurement presents values in dBm, it was necessary to convert the field measurement values to dBµV/m, since it presents smaller values for conversion. The equation of the conversion is demonstrated in Equations (1, 2, and 3).

$$E(dB\mu V) = 20 \times log\,10[E(V)] \quad (1)$$
$$K(dB) = -29{,}77 - 14 + 2 + (log\,10 \times 623) \quad (2)$$
$$E(dB\mu V/m) = E(dB\mu V) + K(dB) \quad (3)$$

Where:

$P(mW) = 10^{P(dBm) \div 10}$

$P(W) = P(mW)^{-3}$

$Z(\Omega) = 75$

$U(V) = P(W) \times Z(\Omega)$

$E(V) = \sqrt{U(V)}$

$E(\mu V) = E(V) \div 10^{-6}$

With the field strength values measured at each of the 44 sites, a prediction calculation of the coverage area was performed. In the calculations, Record Rio's SFN transmissions have been considered under the same installation conditions at the time of measurements and under the same field measurement reception conditions.

Progira has the option to analyze the characteristics of the link path, which can be either visual or data. Figure 2 shows an example of the visual link transmitted from Rio de Janeiro at Morro do Sumaré to Site 06.

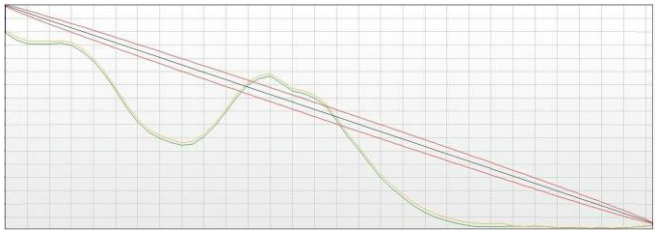
Figure 2: Link between transmission and reception on Site 06

The red line indicates the Fresnel curve, between the transmission at the highest point and the reception at the lowest point. The green line indicates the height of the terrain relative to sea level. The yellow line indicates the clutter, with information of the natural or artificial obstacles.

It is observed that the link transmitted from Rio de Janeiro at Morro do Sumaré to Site 06 is obstructed and has no direct vision.

Table 1 shows an example of the data link of the first kilometer transmitted from Rio de Janeiro at Morro do Sumaré to Site 06.

Table I shows for every 100 meters, the elevation of the land about sea level, the clutter code, the height of the clutter and the description of the clutter.

The accuracy of steps of 100 meters was defined to maintain the methodological criterion already adopted.

The relief database generated for each link displays different amounts of values. A 5 km link will have 50 values, while a 10 km link will have 100 values, but for AI to be efficient, all links must have the same amount of values.

Progira can not calculate the link by number of sites, so FFT (Fast Fourier Transform) approximation interpolation was performed so that all links have the same amount of

values.

Table I
Data in the first kilometer of the link between the transmission and the reception in the Site 06.

Dist (km)	Elev (m)	Clutter code	Clutter h(m)	Clutter description
0.1	720.2	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.2	706.1	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.3	703.6	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.4	703.8	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.5	706.6	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.6	699.9	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.7	674.6	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.8	638.3	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
0.9	589.0	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)
1.0	527.6	40	10	Closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m)

The information in the link database is not sufficient for correct manipulation, but it is possible to develop algorithm with the data.

It has been proposed that each step has the information of the type of terrain, the height between the center of the link to the base of the terrain and the distance of the link.

The information of the type of terrain and the height between the center of the link to the ground base was calculated according to Equations (4, 5, 6 and 7).

$$Ht = CBT + Hci \quad (4)$$
$$A = arctan(Ht + Hr - CBR) \div (DE) \quad (5)$$
$$He = (CBR + Hr + (passo \times (tan(A)) \quad (6)$$
$$Her = He - CBP \quad (7)$$

Where:
DE = distance from the link
CBT = tower base height
CBR = Height of the base of reception
Hci = transmission antenna height
Hr = height of the receiving antenna
He = Link height

IV. Field Measurement

Based on the quality assumptions, a field test was carried out for Record Rio, with a primary transmission coming from the City of Rio de Janeiro. Rio de Janeiro has been chosen because it is the city that has the most significant inconsistency between measured and simulated values in software. One possible cause of this inconsistency is related to the effective relief in the State, very varied, with high escarpments, seas of hills, hills and valleys, several rocks, besides an extensive area of plateau that occurs in all the west of the territory.

Record Rio operates in the City of Rio de Janeiro at Morro do Sumaré in SFN with two retransmitters, located in the City of Rio de Janeiro, Morro do Mendanha and Pena, duly registered in the Mosaic System of the National Telecommunications Agency - Anatel [17].

Record Rio's SFN network comprises 11 auxiliary retransmitters, located in the City of Rio de Janeiro and the Cities belonging to its metropolitan ring. The information of the technical characteristics of operation of the SFN network was made available by the broadcaster.

Thus, 44 sites have been strategically distributed in the metropolitan area of Rio de Janeiro, in order to obtain different propagation situations. The measurement was elaborated by the company hired for this service rendering. Record Rio authorized the use of the data for this research.

The 44 Sites have been chosen with the intention of regular distribution in the metropolitan region of Rio de Janeiro, based on the current noise limited coverage and the station facilities information.

The measuring system used an antenna with 14 dBi gain in the central frequency of 623.143 MHz, corresponding to the TV Channel 39, with height of 10 meters and cable attenuation of 2 dB.

As Record Rio has auxiliary retransmitters, the receiving antenna was directed to the signal with greater intensity of field.

Figure 3 shows the technical characteristics measured in Site 06, in layer B with Full Seg programming.

Figure 3 - Technical characteristics of Site 06.

In Figure 3, it is most possible to identify the transmitter station multiplex configuration, such as the 16-QAM modulation, FEC 3/4 and the guard interval of 1/8. It is also possible to identify the quality of the received signal power (*Potência*), C/N, Code Error Rate (CBER), Code Error Rate post Viterbi (VBER) and Modulation error rate (MER).

Figure 4 shows a constellation at Site 06, which is the C/N parameter and enables viewing if the transmitted symbol is a correct region and can be easily detected by the receiver.

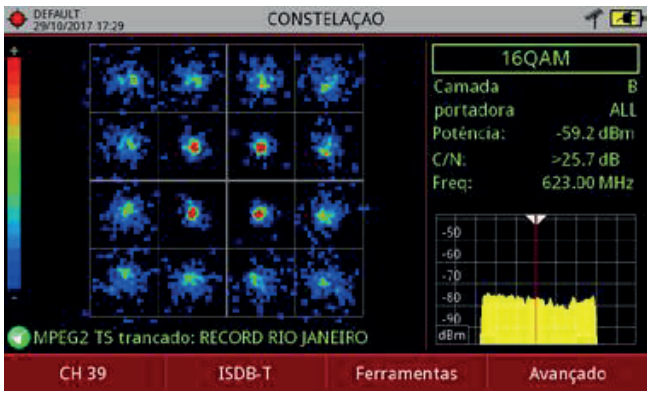

Figure 4 – Constellation of Site 06.

Figure 5 shows the delay profile at Site 06, where it is possible to verify the existence of the primary path with -59.2 dBm, a second path with -23.6 dBc at 20 µs and third path with -25.1 dBc at 48 µs.

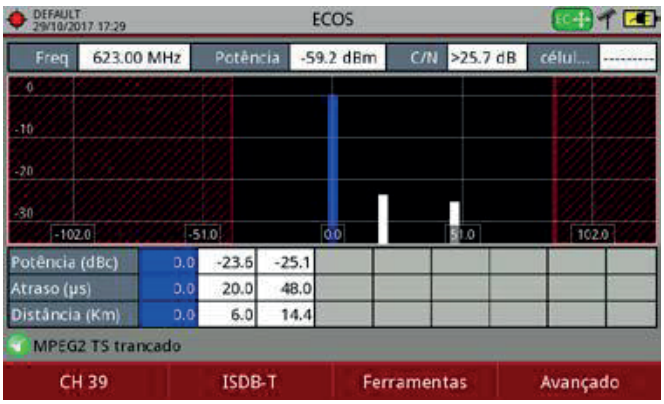

Figure 5 - Echoes in Site 06.

V. Artificial Intelligence

Research in AI and, consequently, involving AI-based systems, aims to discover and formulate aspects of human intelligence that can be reproduced by machines. These currently enable building models to perform tasks such as participating in Strategy Games, Recognizing Patterns in Audio and Images, finding proofs of mathematical theorems, and other computational tasks. Currently there are several initiatives involving software and hardware projects with the objective of using AI models to perform complex tasks, such as decision making in electronic negotiations, real-time decisions in dynamic environments [18].

Intelligence is mainly related to the rational action. In the ideal case, an intelligent agent adopts the best possible action in a situation [19].

With AI, you can delegate to the software the decision of choice for each site. An algorithm will be created to predict the best propagation model of each site in the study region.

The system is efficient when we omit information from field measurement and the AI can predict the best propagation model correctly and therefore able to predict all points in the study area.

The literature addresses several AI techniques. Intelligent Systems (IS) can be developed using some fundamental techniques, which can be applied alone or together to aid decision making. The main techniques and methodologies used by IS are: Knowledge Acquisition; Machine Learning; Neural networks; Fuzzy Logic; Evolutionary Computation; Agents and Multi agents; Data Mining and Texts. Each of these techniques offers a variety of degrees of ability to represent human knowledge. [20]. This statement shows that an in-depth study should be developed to define the appropriate technique to be used in the Study.

This study used the Machine Learning application, since they can model the behavior of the system through the learning process, based on observing performance data over a period. Once properly trained, they can automatically estimate and predict future system behavior and subsequently make admission decisions with high accuracy and speed [21].

The Machine Learning application presents a group neural network tool that allows you to create a digital television signal propagation curve. The network is trained to create a new propagation curve, based on field measurements [22].

Creating a curve with the propagation models may not yield the best result. In order to enable people with muscular disabilities to communicate only with eye movement, the classification learning tool has been applied in the research. The research demonstrates that this training application allows to explore data, select resources, specify validation schemes, train models and evaluate the results [23], so a Machine Learning technique with classification learning application may be more appropriate.

VI. Results

The field measurement report presented 44 measurements, however, when analyzing the echoes of the field meter, it is observed that in some measurements, it was possible to receive more than one relevant signal. These echoes may be reflected signals or signals from a second transmitter.

It is possible to compare the delay of the echo presented in the field measurement to the delay of the signals of all the transmissions presented in the software simulation. Data considered consistent were also included in the tests.

For these cases, the conversion equations of dBµV/m to dBm needed to be changed in cases, in which the receiving antenna azimuth does not point to the transmitting antenna of the second transmitter. The azimuth loss of the receiving antenna was subtracted from the antenna factor calculation. Thus, the tests considered 52 Sites of measures.

When comparing the values measured in the field to the simulated values by software, it was possible to calculate mean error of each model of propagation, according to Table II.

Table II concludes that the ITUR1812-3 propagation model with clutter for densely urbanized presents the best average error and is the most reliable to be used in the Rio de Janeiro study.

Despite the ITUR1812-3 propagation model, with clutter for densely urbanized presenting the best average error, does not mean that it is the most suitable model in all Sites.

An array was created with the profile data of each link and applied to the classification tool.

The FFT interpolation approximation algorithm can use any number of values. However, it was possible to observe that high values imply a considerable loss of accuracy. It was considered 20 values, to maintain high accuracy without mischaracterizing the terrain information.

Table II
Average error of each propagation model in the comparison between measured and predicted sites.

Average (dB)	
ITUR1812-3 - Dense Urban	**9.2**
ITUR526-13 - General Method	**10.0**
ITUR1812-3 – Forest / Urban	**10.2**
CRC - Continental / Great Lakes / Maritime overland / Maritime oversea	**10.8**
ITUR1812-3 - Suburban	**11.0**
ITUR1812-3 - Database	**11.0**
ITURG06 – Rural / Open / Suburban	**11.2**
Deygout Assis - Knife edge	**11.7**
Okumura Hata - Quasi Open	**11.9**
ITUR370-7 – Rural / Suburban / Urban	**12.1**
Deygout Assis - Main Rounded	**12.4**
ITUR1546-5 – Rural / Open	**12.5**
ITUR1546_5 - Suburban	**12.5**
Okumura Hata - Open	**12.8**
Longley Rice - Equatorial	**13.1**
Longley Rice - Desert	**13.1**
Longley Rice - Maritime Temperate oversea	**13.1**
Longley Rice - Continental Subtropical	**13.1**
Longley Rice - Maritime Temperate overland	**13.1**
Longley Rice - Maritime Tropical	**13.1**
Longley Rice - Continental Temperate	**13.7**
Deygout Assis - Rounded	**13.8**
ITUR526-13 - Rounded	**15.8**
Okumura Hata - Suburban	**16.1**
ITURG06 - Urban	**16.2**
Free Space	**16.8**
ITUR1546-5 - Urban	**18.1**
ITURG06 - Dense Urban	**20.6**
Okumura Hata - Urban	**22.1**
ITUR1546-5 - Dense Urban	**21.2**

Therefore, the matrix has 42 values. The 1st corresponds to the classification of the propagation model, the 2nd corresponds to the distance of the link, the 3rd to the 22nd corresponds to the height between the center of the link to the base of the ground and the 23rd to the 42nd correspond to the type information of ground.

The classification learning tool has the overfitting and partial protection options. The non-overfitting protection option, indicated for large amounts of data, was the one that presented the best accuracy.

Each type of learning returns a different value of accuracy according to Table III.

Table III shows that several types of learning present 100% accuracy, so, they were able to learn the behavior of each link, thus, 21 trained models were created. To test the capacity of the AI, tests were performed on all measured Sites. It was elaborated 52 trained models, each of them with discard of a link.

Each of the models trained with one Site discard and tried to predict the propagation models of the discarded Site. Some trained models correctly and others made mistakes, but a comparison has been made between sites measured and predicted by AI. Table IV shows the average error of the application of AI.

Table IV shows that the Coarse Tree application features an average error of 8.1 dB, with 1.1 dB better than simply choosing the propagation model for the mean error, but the mean error of 8.1 dB is still very high.

Table III
Accuracy of each type of learning.

Accuracy for each type of Classification Learner	
Fine Tree	**38.5%**
Medium Tree	**38.5%**
Coarse Tree	**17.3%**
Linear Discriminant	**100.0%**
Quadratic Discriminant	**Falha**
Linear SVM	**63.5%**
Quadratic SVM	**100.0%**
Cubic SVM	**100.0%**
Fine Gaussian SVM	**100.0%**
Medium Gaussian SVM	**98.1%**
Coarse Gaussian SVM	**15.4%**
Fine KNN	**100.0%**
Medium KNN	**15.4%**
Coarse KNN	**7.7%**
Cosine KNN	**15.4%**
Cubic KNN	**15.4%**
Weighted KNN	**100.0%**
Boosted Trees	**100.0%**
Bagged Trees	**100.0%**
Subspace Discriminant	**98.1%**
Subspace KNN	**100.0%**
RUS Boosted Trees	**65.4%**

Table IV
Average error of each Classification Learner.

AI Average (dB)	
Coarse Tree	**8.1**
Weighted KNN	**8.3**
Fine Gaussian SVM	**8.4**
Cubic KNN	**8.7**
Linear SVM	**8.8**
Quadratic SVM	**9.0**
Fine KNN	**9.2**
Coarse KNN	**9.4**
Bagged Trees	**9.6**
Coarse Gaussian SVM	**9.6**
Fine Tree	**9.8**
Medium Tree	**9.8**
Cosine KNN	**10.1**
Cubic SVM	**10.3**
Medium KNN	**10.4**
Medium Gaussian SVM	**10.6**
Boosted Trees	**11.1**
Subspace KNN	**11.6**
RUS Boosted Trees	**13.0**
Subspace Discriminant	**13.3**
Linear Discriminant	**14.8**

Some sites have very high errors. analyzing only the high errors of the best general average does not allow to conclude that this is a field problem or problem of the propagation model not suitable for the given situation.

When analyzing each case individually in the AI application, it was possible to observe that some Sites force errors of other Sites, without it being possible that the AI finds a relation that approximates the hit. It is concluded that these

Sites have some problems, either of field or prediction of the model of propagation.

The tests were remade, with disposal of these Sites with problems. The Sites discarded were 03, 04, 05, 07, 10, 18 and 20, coming from Rio de Janeiro at Morro do Sumaré, 20 and 21 coming from São Gonçalo, 36 coming from Queimados, 37 coming from Nova Iguaçu, 40 coming from Pedra de Guaratiba and 22 e 23 coming from Rio Bonito. The number of Sites has been reduced to 38.

With this new database, 38 trained models were created, discarding each of the links. The Accuracy for each type of learning can be seen in Table V.

Table V
Average error of each type of Classification Learner after correction of errors.

AI Average (dB)	
Weighted KNN	**4.6**
Bagged Trees	**5.0**
Fine KNN	**5.5**
Linear SVM	**6.2**
Boosted Trees	**6.4**
Fine Gaussian SVM	**6.5**
Coarse KNN	**7.0**
Medium Gaussian SVM	**7.0**
Coarse Tree	**7.1**
Cubic KNN	**7.2**
Medium KNN	**7.3**
Subspace KNN	**7.7**
Fine Tree	**7.8**
Medium Tree	**7.8**
RUS Boosted Trees	**8.1**
Coarse Gaussian SVM	**8.1**
Linear Discriminant	**8.1**
Cosine KNN	**8.3**
Quadratic SVM	**8.4**
Cubic SVM	**8.9**
Subspace Discriminant	**9.3**

In Table V, it is verified that the Weighted KNN application presented a mean error of 4.6 dB, with 4.6 dB better than simply choosing the propagation model by the mean error.

VII. Conclusion

When comparing the field measurements of the Rio de Janeiro coverage area to the field prediction of the Progira software, it was possible to identify that the ITUR propagation model P.1812-3 in the geographic region option Dense Urban presents the smallest average error and is the one that best suits the characteristics of the relief.

When applying the IA tool, Classification Learner, it was possible to find a small improvement of the average error, of 1.1 dB, however, when analyzing the Sites measured in isolation, some Sites force errors of other Sites, without it is possible that the AI finds a relation that approximates the hit. These sites have some problem, whether in the field measurement, transmission equipment or propagation model prediction.

By identifying these sites, treating them as problematic and suppressing them in the AI application, the accuracy shows a significant improvement with 4.6 dB rather than simply choosing the propagation model for the average error.

Weighted KNN is one of the Classification Learner approximation types that presented 100% accuracy in the network training and had the best performance in the comparison between the signal measured in the field and simulated in software, with a mean error of 4.6 dB.

The low error indicates that the AI presents a good correlation, very close to the correct understanding of the characteristic of each point. This average error considerably increases the predictive capacity of the coverage area.

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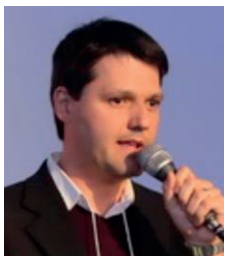

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A Technical Study on Cooperative Structure of a Hybrid Network for Video Content Delivery

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A Technical Study on Cooperative Structure of a Hybrid Network for Video Content Delivery

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***Abstract*—Cooperative structure of hybrid network is a topic of current interest in academia and industry since can serve to enhance content delivery technologies in order to face the "mobile data tsunami". This paper considers the latest technologies either in the broadcast and broadband environment to encourage the use of flexible bootstrap in the physical layer.**

***Index Terms*—Broadcasting, Broadband, Television System.**

I. Introduction

NOWADAYS, broadband networks have experimented many changes because exponential growth of media consumption. For instance, Internet traffic in Latin America will expect to reach 12.9 exabytes, comparable to 3 billion of DVD, per month in 2019 [1]. On-demand and streaming services have become predominant for users by offering rich interaction and a vast offer of audiovisual content.

Video delivery in mobile devices is a challenging task due to unexpected increment of users along the last years in broadband networks, both in local and cellular networks. For this reason, a robust and efficient video content delivery towards mobile users have attracted so much interest by academic and enterprise community. Mobile and broadcast industry have reacted by proposing new Information and Communication Technology (ICT) in order to improve the television viewing experience in small devices and to offer better multimedia services. Delivering high-quality video mobile services to indoor, portable and hand-held receivers is challenging because of high-noise levels in wireless communication channels, fading and doppler effect.

Historically, broadcasting and broadband technologies have walked on separate railroads, building its own infrastructure and business model. It was thought that these technologies were incompatibles regarding the type of services they delivered. Nevertheless, the growing demand for audiovisual content by users from all over the world paves the way for a cooperation in terms of infrastructure and a converged transport architecture.

The Fifth Generation Mobile Networks, 5G, open countless opportunities for convergence of mobile broadband and broadcast services. For instance, it is expected that transmission of mass multimedia services to mobile and stationary receivers through different network infrastructures might be allowed and the radio functions can be configured on demand depending on the specific needs of the service and the status of the network [2]. Besides that, 5G requirements point out that can handle enormous numbers of connected devices; because of the advent of new technologies such as Internet of Things (IoT), vehicle to vehicle (V2V), machine to machine (M2M) and device to device (D2V) communication, and a latency of 1 ms, almost ten times reduction from 4G's [3]. For that reason, optimized and efficient video mobile traffic offloading is of high relevance for future communication platforms.

Additionally, the advent of new technologies, such as the 4K ultra-high definition television (UHDTV), the high dynamic range (HDR), the higher frame rate and the wider color gamut, allows to user experiencing wider range of services; Virtual reality (VR), augmented reality (AR), Free ViewPoint Television (FVT) and Multi/Companion Screen Viewing are becoming increasingly popular and will be offered to smart devices in the coming years.

This paper aims at investigating how beneficial could be a converged broadband/broadcast network regarding to current technologies have been deployed. Also, is detailed each layer of the network where can work jointly and in complementary way in order to get a more efficient content delivery over the core and radio access network.

The remaining of this paper is organized as follows: Section II presents a technical overview of the system model. Section III proposes the cooperative structure of the video content delivery network. Finally, Section IV concludes this paper.

II. System Model

People search for new audiovisual services anywhere and at any time. They are rarely aware of the radio access technology they are using when connecting to broadband or broadcast network. Personalized media experiences are demanded because of providing better quality of experience (QoE) to the users [4]. Hence, future network solutions must absorb as much as possible of field experience from latest content delivery standards that have been deployed in different countries in the last years in order to meet the peoples's demand and consumer behaviour about how the appearing of new technologies can impact in their everyday activities. For instance, pure broadcast solutions in the mobile ecosystem did not attract the attention of users when were launched because that technology only worked in specific devices. The lesson learned was that a mobile broadcast standard must be supported by a worldwide ecosystem to promote continuous development, that is of crucial importance to market success [5].

The new challenges for future networks is to provide higher data capacity, more robust performance, better spectrum efficiency with lower power consumption and CAPEX/OPEX cost. New technologies must enable deep indoor TV services,

http://www.set.org.br/ijbe/ doi: 10.18580/setijbe.2018.2 Web Link: http://dx.doi.org/10.18580/setijbe.2018.2

mobile services and traditional TV services, using a fixed reception outdoor over-roof antenna. Furthermore, it is important to take into account the different scenarios, either urban, suburban or rural in order to envisage the technical details of infrastructure and physical layer of the network.

Advantages and disadvantages of main technologies of video delivery over wireless channels will be considered, since the system model is based on a thorough review of the state-of-the-art of these technologies that give solution to different technical problems that this work tries to solve. From this point of view, is important to point out that there exist no elements to suggest that technologies involved in mobile networks are better than technologies from broadcasting. This work tries to explore and highlight the importance of seeking synergy between the two networks in benefit of future media transmission.

To cope with the unlimited levels of demand at peak times in densely populated areas, broadcasting is the ideal solution for urban scenarios, however, broadcast efficiency decreases when broadcasting less popular TV channels [6], a smart dynamic TV scheduling framework is required to maximize radio resource usage [7]. On the other hand, mobile networks have been evolving along the years from first transmitting voice services to delivering high quality video content in mobility environment. Despite of this, people prefer to reserve higher bandwidth activities for the home or workplaces by connecting to local wireless connections, engaging lower bandwidth services while is stayed outside [8], because of high data plan cost. Unlimited internet access over mobile networks are offered by operators in United States, pursuing the growing demand of mobile video. This is one the key factors driving the wireless industry to develop the fifth generation of network technology [9].

The system model should comply fundamental requirements to make feasible an efficient content delivery over hybrid network aiming at creating a revolutionary and disruptive audiovisual medium that enables the best user experience and can be the starting point for a global integration in terms of development and cooperation, thinking out beyond 2020. Therefore, then main requirements are: to form a common physical [5] and transport layer, to develop a return channel among users and service providers, to make flexible and efficient use of the available spectrum; and to provide system forward compatibility. To comply with these requirements, this work will emphasize on how cutting-edge technologies that have been deployed in recent years contribute in the sketching of the final network infrastructure.

The latest video content delivery standards over broadcast and broadband network have improved channel robustness, get better spectral efficiency and higher data capacity (throughput) thanks to developing new physical interface technologies. As a unified physical interface for wireless communications, OFDM modulating waveform is used to cope with time and frequency selective channels. Also, physical layer framing carries signal basic information about the technology in a way that the type of service can be described. Concerning the transport layer, the use of Internet Protocol (IP) instead of Transport Stream (TS) opens new opportunities for development of routing protocols [10] aiming at creating a single communication network, involving external networks, either a local network such as WiFi or a mobile network. Carrier Aggregation (CA) approach allows to combine different carries to a virtual channel and thereby to increase both bandwidth and data rate. One carrier may be configured as a broadcasting service and in the same way be connected to a cellular network simultaneously [11].

III. Video Content Delivery Over a Cooperative Structure Network

In this section, the main technologies that support and make viable the proposal of this work will be addressed and will be explained the reasons they were chosen. Our approach involves the exhaustive revision of theoretical framework from baseline technologies of physical layer, transport layer and application layer to software-based technologies, whose main ideas may beneficial with the mission of sketching, building and deploying a future cooperative structure network.

A. Physical Layer Baseline Technology

The emergence of a new multiplexing technology that takes advantage of time, frequency and signal strength in a interval time dramatically improves spectral efficiency. Layered Division Multiplexing (LDM) [12] is a constellation superposition technology, controlled by power level differences of two data streams, known as Upper Layer (UL) and Lower Layer (LL). Figure 1 shows the LDM 2-Layer Transmitter and Figure 2 shows the LDM 2-Layer Transmitter, these figures were extracted from [13].

LDM was adopted by ATSC 3.0 [14] as one of the physical layer baseline technologies and is investigated as an enabling technology for future broadband (LTE or 5G) systems to deliver multicast/broadcast services with high spectrum efficiency [13].

The LDM receiver, depicted in Figure 2, can only decode the strongest signal layer to allow certain backward compatibility with existing technologies, whereas cutting-edge devices can decode signal with lower power levels. For instance, coexistence of ISDB-Tb and new technologies could be deployed by performing a two-layer LDM transmission. This ensures a soft transition towards hybrid network solutions. Moreover, experimental results demonstrated that this arrangement can transmit more data and be more robust against noise and multipath interference using reception diversity [15]. LDM can coexist with emerging technologies, such as Bit Interleaved and Coded Modulation (BICM) to configure a more robust signal to delivery high data rate services such as UHDTV, tailored to fixed reception, and robust indoor/hand-held/mobile services over a large coverage area, strong channel coding and modulated is mandatory to provide good detection at very low SNR in the same spectrum resource [12]

Figure 3 depicts the block diagram of the BICM module. Its main importance is the wide range of baseband resource tools, such as Non-Uniform constellations (NU-QAM) and 24 original low-density parity check (LDPC) codes with coding rates from 2/15 (0.13) up to 13/15 (0.87) for two code sizes: 16 200 bits and 64 800 bits. It is though to achieve high efficiency

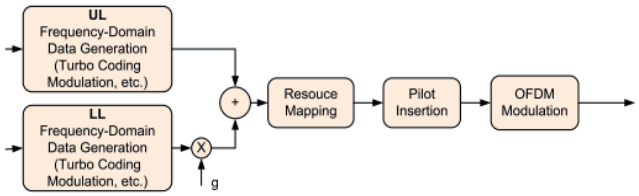

Fig. 1. LDM 2-Layer Transmitter

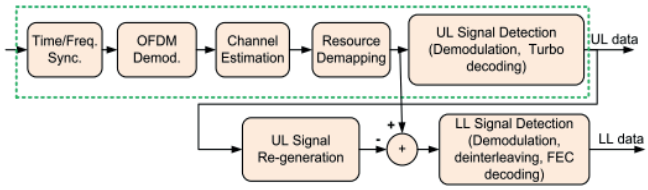

Fig. 2. LDM 2-Layer Receiver

over a wide range of reception conditions. Concerning to performance, the spectral efficiency is closer to the theoretical Shannon limit [16]. Channel bonding is a good alternative to increase spectrum flexibility for broadcasting with the possibility to provide scalable video coding services across two Radio Frequency (RF) channels [17]. Free ViewPoint Television (FVT) and Multi/Companion Screen Viewing could be offered by using this type of technology.

Tower overlay over LTE-Advanced+ (TOoL+) provides an interesting tool for converged network approaches, taking advantage of traditional broadcasting services that works over a High Tower High Power (HTHP) infrastructure in order to cover large areas at low cost, reducing power consumption. Besides this, this approach can cope with reduced Inter-Site Distance (ISD) of towers in cell network due to short OFDM cyclic prefix mode allowing larger Single Frequency Networks (SFN) and overcome the main drawback of evolved Multimedia Broadcast Multicast Services (eMBMS), the shared spectrum with unicast services in Time Division Multiplexing (TDM) which almost occupies 60% of bandwidth resources [18]. Figure 4 presents the basic diagram of the technology, the figure was extracted from [11].

With the development and deployment of the technologies described above, cognitive radio access networks, involving cooperative broadband and broadcast solutions can handle consumption of video content from a large audience. For example, transmission of sporting events, which are mostly consumed live and have little interest for time-shifted viewing, can switch radio transmission between broadband and broadcast access, optimizing the total data rate used by the network, that would be transparent for end user.

B. Transport Layer Baseline Technology

For many years, TS was the anchor transport layer protocol since the advent of digital television. Principally, because of constant delay across the delivery link between users and station; and that the streams could be encrypted by packet. Conversely, growth of content delivery services are based on

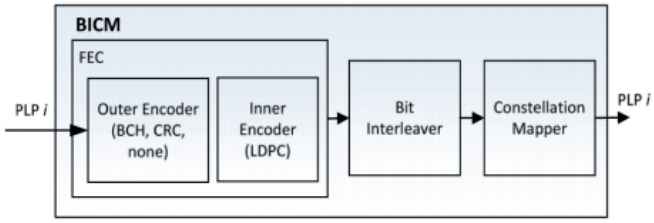

Fig. 3. Block diagram of the BICM module

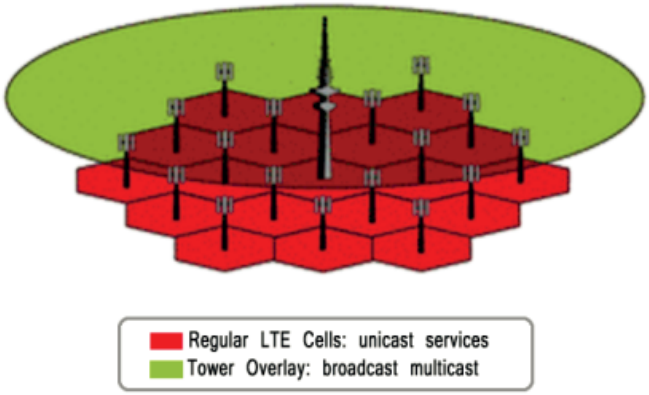

Fig. 4. The Tower Overlay Overlay over LTE-A+

HTTP Streaming, where the deployment of servers and caches became easy, economic, and scalable. For this reason, IP stack is fundamental for user interactivity and to get better user experience [10]. Figure 5 shows the unified broadcast/broadband IP Stack. This allows to developers using stable version of software frameworks such as HTML5 and JavaScript (JS).

C. Cooperative Structure Network

This work encourages the use of a Unified Broadcast Layer (UBL) for delivery of multimedia services. Technologies such as LDM, BICM and channel bonding should be part of the physical framing, however is important the creating of a new bootstrap,that provides synchronization and signals basic information about the technology used in the physical layer itself, this is important because new advances with respect to multiplexing, modulation or LDPC codes in the future can be added with no restriction.

The development and deployment of this cooperative structure should be on software-based technologies such as Cloud Radio Access Network (C-RAN), Software-defined networking (SDN)-based framework and Network Function Virtualization (NFV) approaches. these technologies are promising and envision more democratic platforms, making the telecommunications sector more free.

IV. Conclusion

The main contribution of this work is to highlight the importance of hybrid transmission structure on video-content

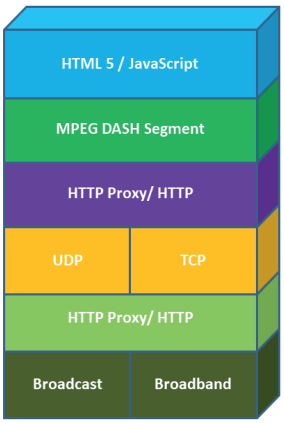

Fig. 5. IP Stack

delivery solution. Latest Broadband and Broadcast technologies can be crucial to enhance in terms of efficiency the future wireless communications and will provide a better user experience.

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Improvement of the Content Transmission in Broadcasting Systems: Potential Proposal to Rayleigh and Rician Multichannel MIMO Systems

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Improvement of the Content Transmission in Broadcasting Systems: Potential Proposal to Rayleigh and Rician Multichannel MIMO Systems

Reinaldo Padilha, Yuzo Iano, Ana Carolina B. Monteiro and Hermes José Loschi

***Abstract* — In the last years, the transmission of signals has been a widely approached theme, aiming the creation of methodologies that make channels increasingly efficient. Based on that, the present study implements a model based on discrete events applied to a broadcasting system entitled hybrid method, using the Simulink simulation environment of the MATLAB software. This study has the objective of improve the transmission of content, through a pre-coding process of bits applying discrete events in the signal before of the modulation process. This proposal brings a different approach, in which the signal transmission on the channel is realized in the discrete domain with the implementation of discrete entities in the process of bit generation. The results show better computational performance related to time and memory utilization related to the compression of the information, showing improvement 9.61 to 26,5%, respectively.**

Index Terms* — *discrete events, memory, simulation, bits.

I. INTRODUCTION

Computer simulations are excellent tool that supports the best knowledge of the behavior of a broadcasting system without building it, your results are accurate in general, compared to the analytic model. In the simulation environment, can be studied complex systems that would otherwise be difficult to investigate [1] [2] [9] [14] [15] [16]. As also can be used in engineering broadcasting to develop um proposal investigating the effect these changes without producing a physical prototype, providing the flexibility to implement different types of system architecture analyzing different layers, such as physical, transport, transmission and higher layers, improving and validating the system for different applications [1 - 9] [14 - 18].

The modeling Discrete Event is mainly used to represent the system being analyzed as a sequence of operations being performed on entities (transactions of state) of certain types such as data packets, bits, etc. The entities are discrete items of interest in a discrete event simulation. The meaning of an entity depends on what is being modeled and the type of system, and can have attributes that affect the way they are handled or may change as the entity flows through the process [1] [3] [5] [9 - 12].

Discrete events are the results of actions that occur in the system, an event that changes its state, being these actions intentional, spontaneously controlled or with the verification of a condition [3] [37 - 42].

This technique has been used to model concepts with a high-level of abstraction, as patients in a hospital in the healthcare system, clients in a queue in bank system, emails on a server and/or transmission of data packets in telecommunication's systems, etc. [2] [9 - 16].

Through of academic records, can be verified modeling of high-level of abstraction concepts such as people in business process systems, computers in computer networking systems, nodes in networks of data or telephone communication, vehicles in transport systems, service providers such as banks, transaction systems for databases, communication protocols in telecommunication's systems, people in call centers, vehicles in

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intelligent transport systems, process control in control engineering, military equipment in defense systems, as many others [19 - 36]. In this way, are clear that the technique of modeling of discrete events is generally used to model concepts with a high-level of abstraction [42].

In this study, the authors developed a hybrid model for broadcasting and for radio broadcasting using an AWGN (Additive White Gaussian Noise) channel with advanced modulation format DQPSK (Differential Quadrature Phase Shift Keying) in simulation environment [42]. This study has the objective of to increase the transmission capacity of information content through of the channel.

Which a bit treatment with discrete events methodology was modeled in the step of bit generation, being the differential of this paper the use of discrete events applied in the physical layer of a transmission channel, being this a low-level of abstraction [42], reaching the second objective this paper.

The present paper is organized as follows: Section 2 discusses traditional simulation models, showing the modeling of transmission channel AWGN. Section 3 presents and describes the proposed framework of this paper, based on the hybrid model with discrete event methodology. Section 4 presents the results and, finally, in Section 5, the conclusions are presented as also the potential of the research.

II. TRADITIONAL MODEL

The communication channel is the medium that provides the physical connection between transmitters and receivers in a communication system, be it as a wire, or to a logical connection over a multiplexed medium such as a radio channel in telecommunications and computer networking. Carrying data typically uses two types of media: cable (twisted-pair wire, cable, and fiber-optic cable) and broadcast (microwave, satellite, radio, and infrared). For the analysis and development of proposals for improvement of communication systems, it is important to construct mathematical models that describe the main characteristics of these means and of the changes it makes to the signals transmitted [6] [7] [8] [17] [18].

An AWGN channel is a model practical of a communication system widely used due to its simplicity and mathematical treatment. It applies to a large set of physical channels, which introduces in the transmitted signals a noise modeled statistically as a white Gaussian additive process.

In the context of wireless communications, the main source of thermal noise is the addition of random signals arising from the vibration of atoms in the receiver electronics.

So, use the AWGN in these communication channels having a statistically random radio noise characterized by a wide frequency range with regard to a signal in the communications channel.

Systems operating largely in the AWGN conditions can be exemplified as space communications with highly directional antennas and some point-to-point microwave links.

The modulation formats QPSK (Quadrature Phase Shift Keying) and DPSK are widely used in satellite broadcasting, in various cellular wireless standards such as GSM, CDMA, LTE, 802.11 WLAN, 802.16 fixed and mobile WiMAX, Satellite as also CABLE TV applications. Being that the first is used in the streaming of SD satellite channels and some HD channels, however, the second has higher bit rates of HD video and a high satellite bandwidth, as also DQPSK can be significantly simpler to implement than QPSK [6] [7] [8] [17] [18].

Both DQPSK and QPSK are modulation formats for Digital Video and Radio Broadcasting, the DQPSK modulation is a particular form of QPSK modulation, in which instead of being sent a symbol corresponding to a pure phase parameter, this symbol represents a phase change [1] [4] [8] [17] [18].

In QPSK, the information is transmitted by the absolute phase of each symbol. Already on DQPSK, each set of bits represented by a symbol cause a determined phase variation in the carrier signal, in it, the bits for the data symbols are determined based on the phase change of the previous symbol [4] [8].

In this way, there are four possible states 0, π, $+\pi/4$, $-\pi/4$. Thus, each symbol represents two bits of information. The division of the binary pattern is equal to QPSK, except that a bit string is shifted in phase about of $\pi/4$ or $\pi/2$ depending on the system [4] [8].

This means there is a total of 8 ideal state positions (compared to the 4 states for QPSK). The ideal state positions for symbols alternate between the four states of 45 degrees normally used by QPSK and four states on the axis. Due to this alternation, the ideal trajectory between symbols never crosses zero [1] [4] [8].

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This session is presented a broadcasting system modeled with an AWGN channel with DQPSK modulation. For this, the authors used the Simulink simulation environment of the MATLAB® software in its version 8.3 of 64 bits (2014a).

In the model, Figure 01, the signals corresponding to the bits 0 and 1 are generated, and then modulated in DQPSK, following for an AWGN channel according to the parameters specified as sample time of 1 second, power input signal of 1 watt, initial seed in the generator of 37 and in the channel of 67, Eb/No of 0 to 14dB. Then the signal is demodulated in order to perform the bit error rate (BER) of the channel. The values obtained referring to the BER are sent to the MATLAB workspace, for further processing and generating of the signal BER graph [42].

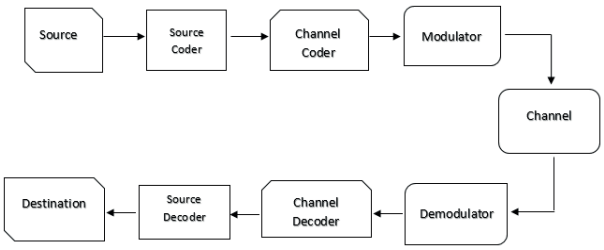

Figure 01 – Traditional Model

III. PROPOSAL

A. Proposal

The modeling of the pre-coding process according to proposal implemented with discrete events is similar with that shown in the previous section. Differentiating that in this model, was added the discrete events process of pre-coding, consisting of the treatment performed on the signal corresponding bit 0. The bit 0 was converted into discrete entities, and forwarded for an FIFO queue with infinite capacity, without limit of capacity and retention in the block. The storing entities in the First-In-First-Out sequence, orders the bits following really your order of arrival, and thus, driving to a server. This server has the configuration of service time equal to the simulation time [42].

The differential of this paper is in the use of discrete events applied in such low-level of abstraction, being the bit generation. After the signal passes through the server, is converted back to its original format respecting the original format and data type specified and maintaining the sampling period respectively. Thus, the signal is modulated in DQPSK and inserted into the AWGN channel, and then demodulated for the purposes of calculating the BER of the signal. The relative values of this BER are also sent to the MATLAB workspace, for further processing and generating of the signal BER graph [42].

The model presented in Figure 02, incorporates the traditional modeling with a proposal presented, as well as highlights the part modeled according to the approach of discrete events, in blue, as previously described [42].

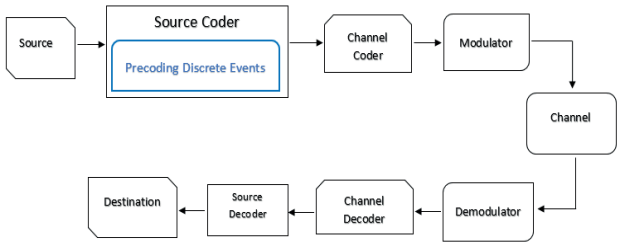

Figure 02 – Hybrid Model

In Figure 03, was used 10000 seconds of simulation time, being placed the flows of transmission of the DQPSK signal in relation to the hybrid model (below) and traditional model (top) for better viewing and comparison, noting that both methodologies generated the same result.

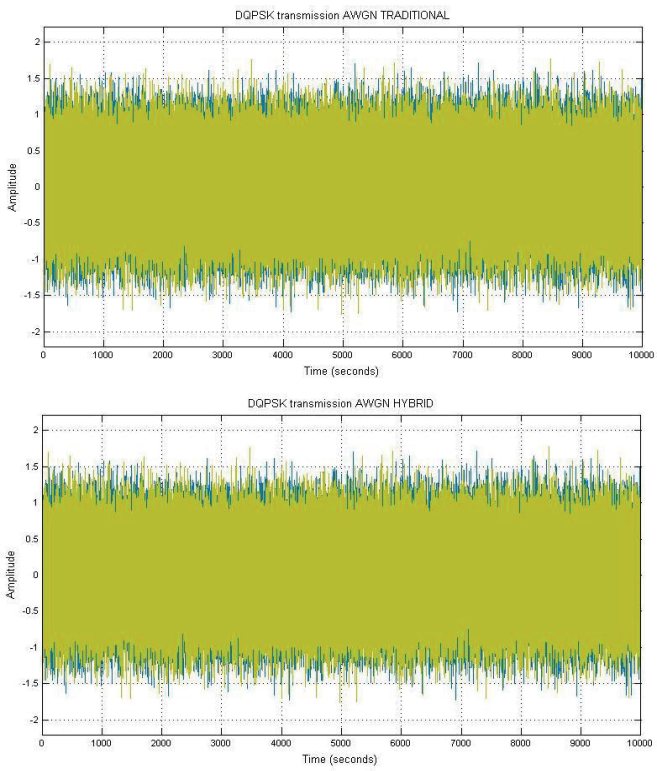

Figure 03 –Transmission Flow DQPSK

The Constellation Diagram was used to view the constellation of the modulated digital signal also being useful for comparing the performance of one system with another [42].

In Figure 04 is shown the results for visualization of the constellations in 5, 10 and 15 dB, according to the hybrid model (below) and traditional model (top).

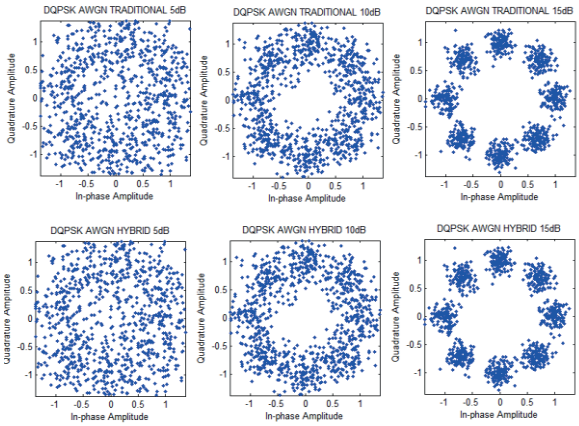

Figure 04 – Simulated DQPSK Constellations

B. Proposal with Rayleigh and Rician

The authors also applied to the proposal presented in a radio broadcasting system, where the mobile wireless channel is susceptible to several impediments including multipath, fading, shadowing, noise among other interferences. In such a way that these deficiencies can cause an enormous degradation in the performance of the system [6] [7] [8].

Rayleigh fading is a useful model of real-world phenomena in wireless communications. Characterized as a statistical model for the propagation effect in an environment with radio signal, is considered a reasonable and ideal model for heavily built urban environments with the propagation of signals in a means where there is no dominant propagation along a line of sight between the transmitter and the receiver [7] [8].

Rician fading is also a useful model of real-world phenomena in wireless communications. Characterized as a stochastic model for the propagation anomaly of the radio signal, caused by the partial cancellation of a radio signal by itself. When the signal reaches the receiver displaying multipath interference, at least one of the paths is changing (lengthening or shortening), and occurs when one of the paths, typically a line-of-sight signal, is much stronger than the others [6] [7] [8].

Generally, wireless networks differ mainly in their physical layer, wherein the transmission of data electromagnetic waves are used that propagate through space. Thus, for this type of transmission an efficient carrier frequency data modulation is required [6] [7] [8].

Within this context was modeled following the pattern of Figure 01, the signals corresponding to bits 0 and 1 are generated and then modulated in DQPSK. Posteriorly it is passed through a multipath Rayleigh fading channel and other with multipath Rayleigh fading, both containing Jakes model with Doppler shift defined at 0.01 Hz, as also inserted a block incorporated which has a math function 1/u [42].

Such a function is required to track the time-variability channel where the receiver implementation ordinarily incorporates an automatic gain control (AGC). After is followed to an AWGN channel, according to the parameters specified as sample time of 1 second, power input signal of 1 watt, initial seed in the generator of 37 and in the channel of 67, Eb/No of 0 to 14dB. Then the signal is demodulated in order to perform the bit error rate (BER) of the channel. The values obtained referring the BER are sent to the MATLAB workspace, for further processing and generating of the signal BER graph [42].

So, applied the same approach in relation to the pre-coding of the bits, noting the same result regarding the transmission flow and the constellations of the systems, validating the proposal [42], as shown in the Figures 05 to 08.

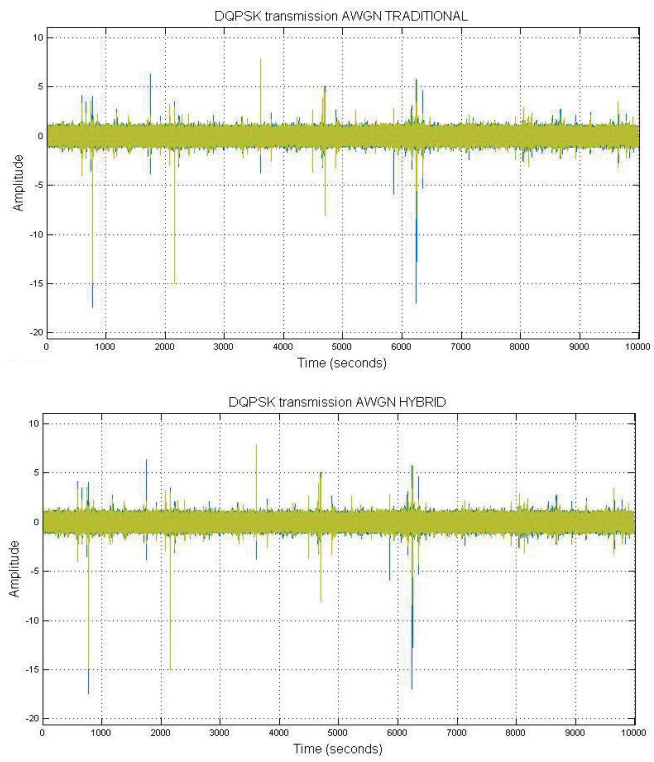

Figure 05 –Transmission Flow Rayleigh DQPSK

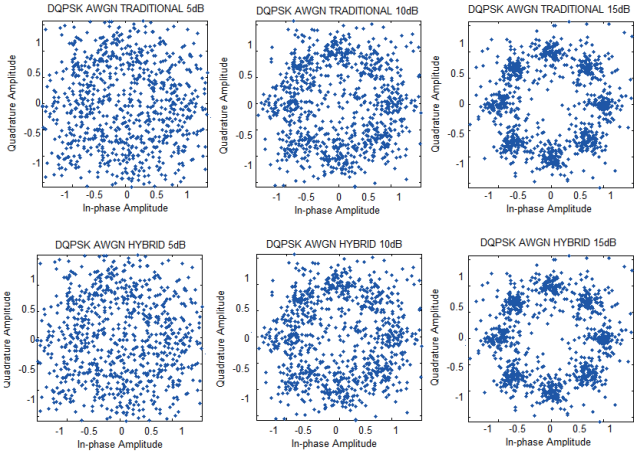

Figure 06 – Simulated DQPSK Constellations Rayleigh

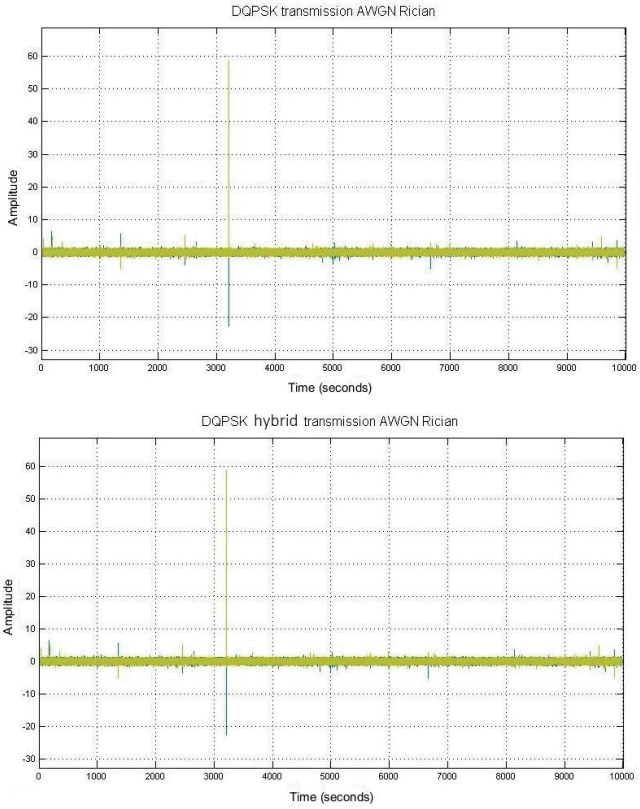

Figure 07 –Transmission Flow Rician DQPSK

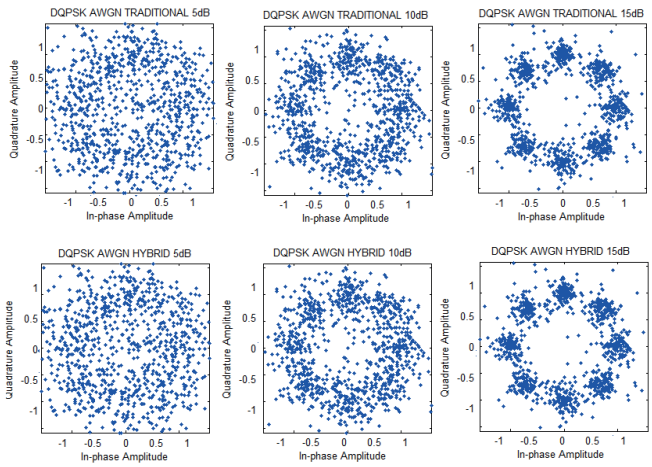

Figure 08 – Simulated DQPSK Constellations Rician

IV. RESULTS

In this section, the results will be presented in relation to the evaluations of the time and memory consumption of the models according to the techniques studied and presented in the previous session. Also, will be presented a comparison among them, simulated on physical machines with different hardware configuration, consisting of an Intel Core i5 processor and 8GB RAM, and another with an Intel Core i3 processor and 4GB RAM [42].

The authors used the commands “tic”, “toc”, and “sim”, via command line at the MATLAB’s prompt, this measuring how much time the model takes to do the simulation (in seconds), that is, the simulation runtime [42].

The “sldiagnostics” function displays information about the modeling system in Simulink. This function is responsible to calculate the time spent on the simulated model, being this, the responsible to the accounting of the time spent in each phase of the simulation of the model (in seconds), that is, the simulation runtime [42].

This function also calculates the sum of all the memory consumption processes used in the model in simulation, by the ProcessMemUsage parameter. This parameter counts the amount of memory utilized in each phase of the model, during the entire simulation, displaying the total amount in MB [42].

In the same way, the authors analyzed the first simulation of both models in each command, and more the “cputime” command, which returns the total CPU time (in seconds). This command refers to the computation time, used by the application in use in MATLAB from the moment it was started. It's important because it is the first simulation that the variables are allocated and the memory reserved for the execution of the model [42], according presented in the Figures 09 to 11.

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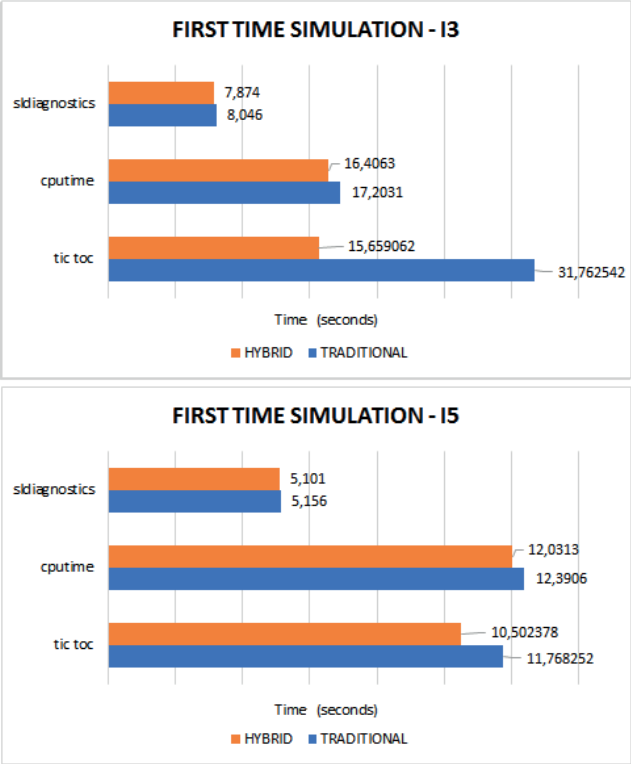

Figure 09 – First-Time Simulation

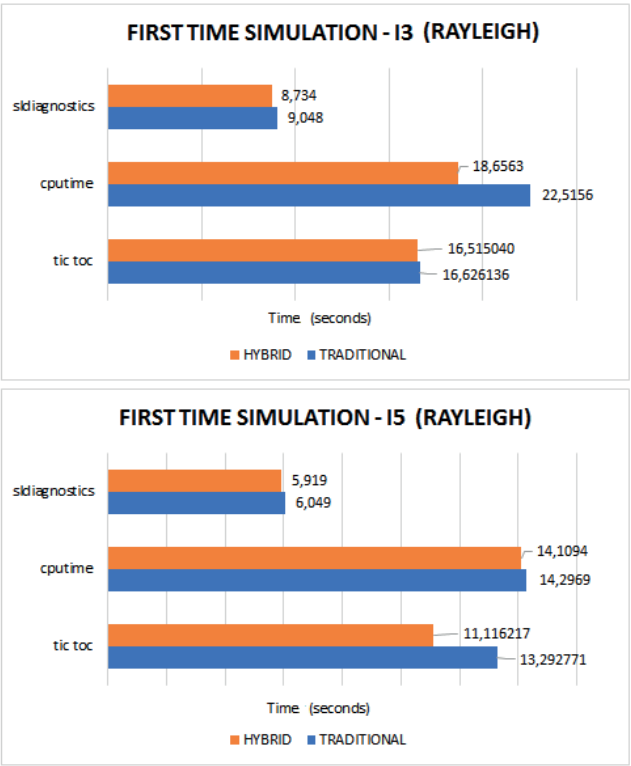

Figure 10 – Rayleigh First-Time Simulation

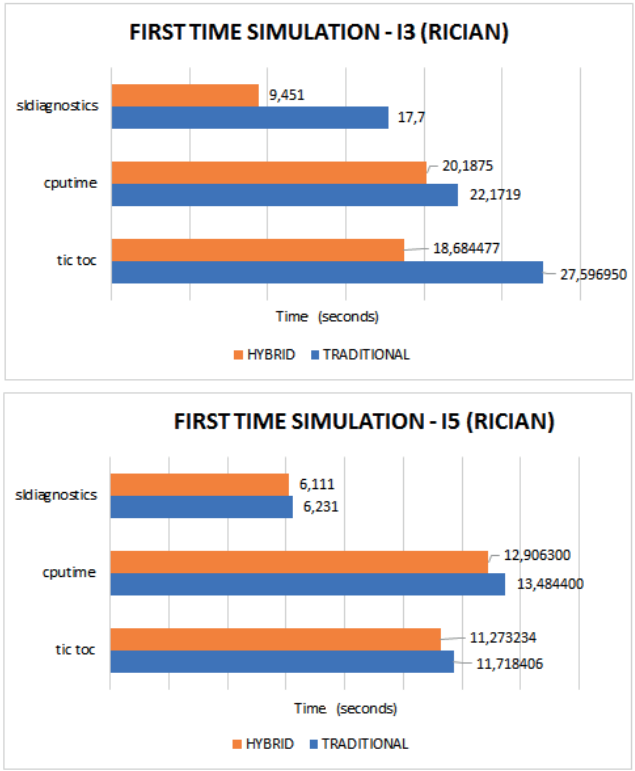

Figure 11 – Rician First-Time Simulation

Similarly, also was observed the first simulation of the models regarding their memory consumption [42], having a better performance as shown in TABLE I and related with the Figures 12 to 14.

TABLE I. COMPUTATIONAL IMPROVEMENT

Memory Consumption / Rate Compression		
Machines	***i3***	***i5***
Broadcasting DQPSK	24,20%	9.61%
Broadcasting DQPSK Rayleigh	26,59%	9.51%
Broadcasting DQPSK Rician	22,85%	11,65%

Can be understood that if in a transmission channel containing the proposal and in another the traditional methodology, they passed the same information content (quantity of bits), without any loss (signal and constellation) and with the same quality (BER). The result related to the memory consumption of the proposal is relative to the compression of the information [42], as shown in TABLE I and related with the Figures 12 to 14.

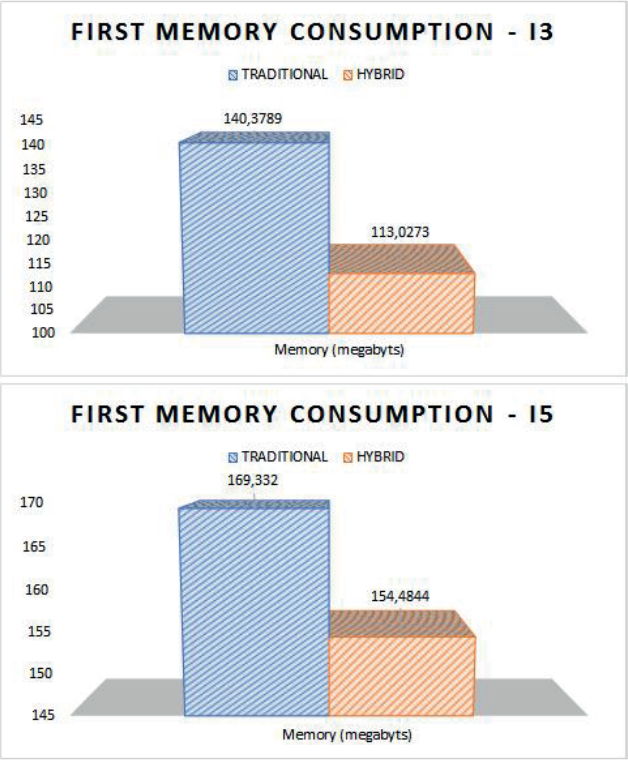

Figure 12 – First Memory Consumption Simulation

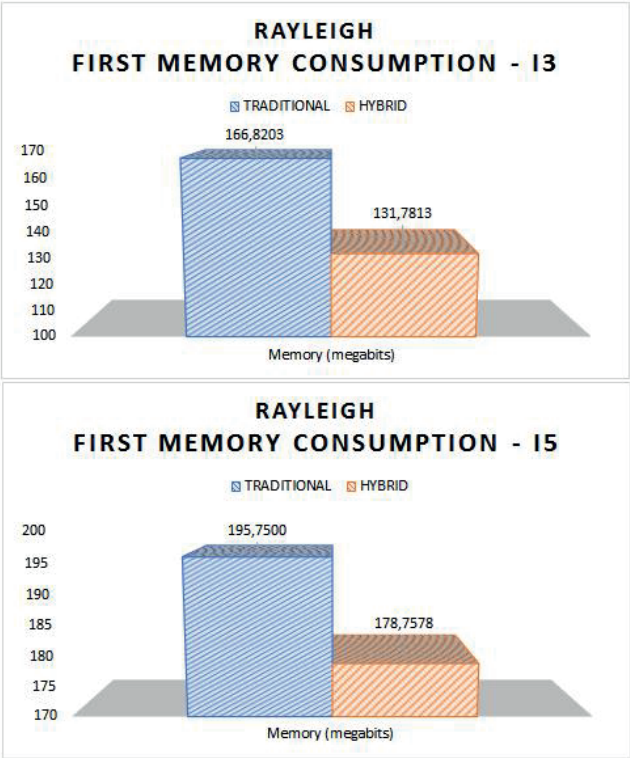

Figure 13 – Rayleigh First Memory Consumption Simulation

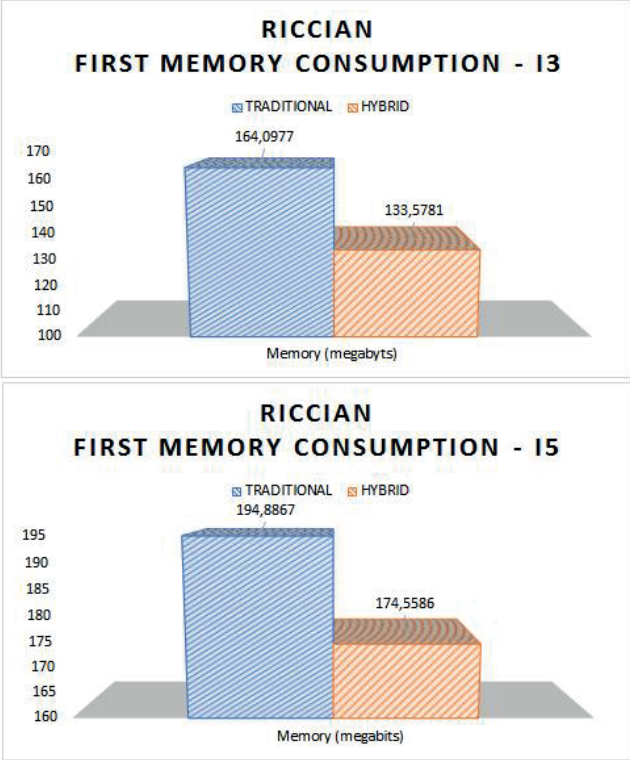

Figure 14 – Rician First Memory Consumption Simulation

Also, is noted that the proposal reduced practically all the memory consumption resulting from Rayleigh and Rician multipath fading in models simulated with such distributions and in both machines. Equalizing its resource consumption to a channel without the Rayleigh and Rician techniques, preserving all the benefits and characteristics of propagation across multipaths [42], as shown in the Figures 15 and 16.

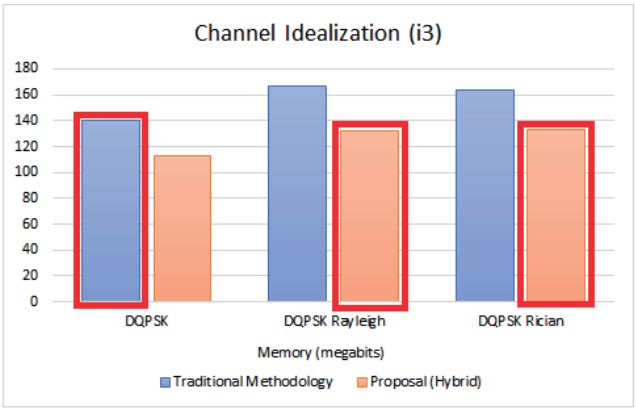

Figure 15 – Channel Idealization i3

http://www.set.org.br/ijbe/ doi: 10.18580/setijbe.2018.3 Web Link: http://dx.doi.org/10.18580/setijbe.2018.3

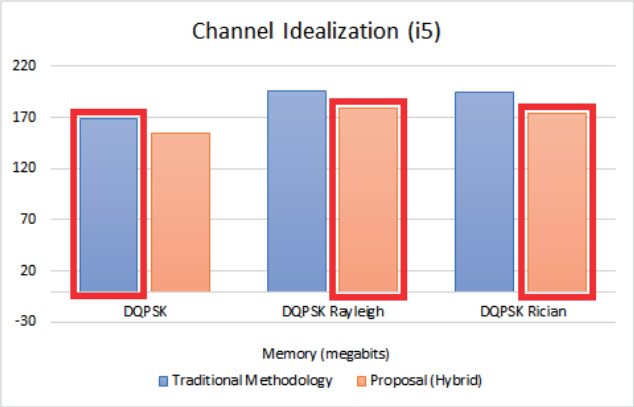

Figure 16 – Channel Idealization i5

To analyze the relationship between the simulation methodology and the impact on the physical layer of the channel, scripts were made in the MATLAB workspace for processing of the graph relative to BER. This allows analyzing the performance of bit error rate (BER) in communication's systems [42].

In the Figures 17 to 19, is displayed the performance of the models according to simulation methodologies under study, along with a transmission with noise ranging from 0 to 60 dB.

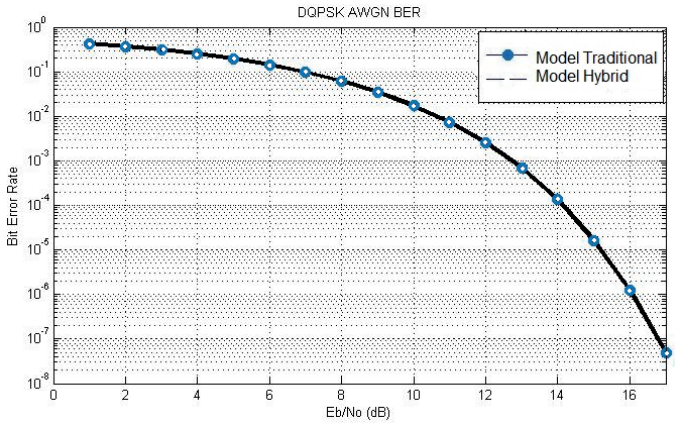

Figure 17 – Performance BER

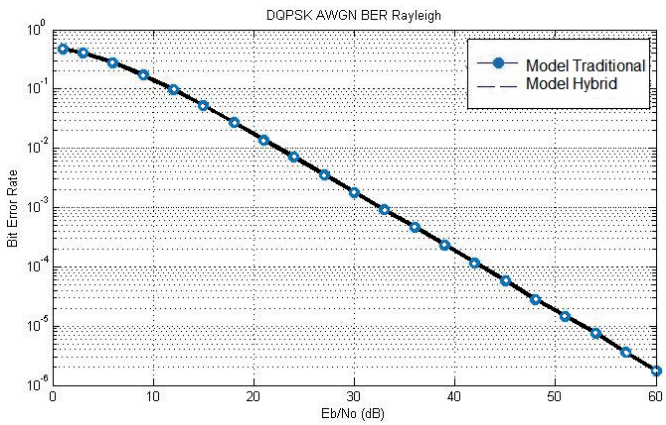

Figure 18 – Performance Rayleigh BER

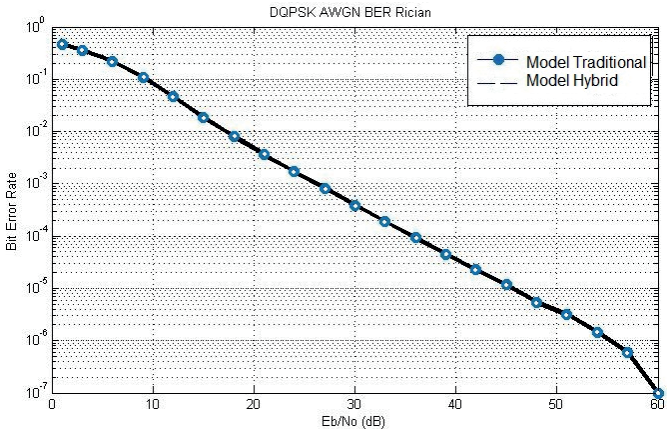

Figure 19 – Performance Rician BER

V. CONCLUSIONS

The use of discrete events applied in a low-level of abstraction such as the bit, in generation phase in a broadcasting system, was the differential of this research since it generally does not apply discrete events in this way.

Evaluating the results, show that the simulation models of broadcasting systems taken a different approach from what is normally done. This proposal applied a concept of a methodology, naturally applied at higher levels, in a lower abstraction level, in bits in the transmission of a channel, through discrete entities

In all scenarios and prospects analyzed the model of the broadcasting system, where was applied the proposal with discrete events show consistent results in the simulated virtual environment. The results obtained on different hardware configurations, evaluated memory consumption and simulation time, and show better performance compared with the model that had only with the traditional methodology.

One extension of the results of this research, being her the compression of the information, strongly affects similar methods performed in higher layers, like MPEG-4 for example, as well as others, can improve them even more since this proposal acts on the bits.

The results related to channel idealization showed the potential of the proposal on Rayleigh and Rician multi-channel MIMO systems, where it is considered within the context of NOMA (Non-Orthogonal Multiple Access), future cellular radio access, 5G.

The purpose of this research together with the proposal presented in this paper is to contribute to the study area and in growing development, the broadcasting.

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Technical review in digital image/video processing algorithms

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Technical review on digital image/video processing algorithms

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***Abstract*—This article presents three techniques for applying digital image processing. Unlike conventional techniques, it will be possible to gain in terms of processing time, pixel manipulation, and image quality for database storage. Both techniques have been tested and proven through real images, and can also be applied in video. The algorithms created use JavaScript, Java and Lisp programming languages, combined with mathematical models in the time domain and frequency domain. As an expected result, improvement in digital image processing and performance is sought for future work.**

***Index Terms*—Digital Image/Video Processing; Discrete Cosine Transform; Filters; High-Dynamic Range; Histogram; Java; JavaScript; Lisp; Partial Differential Equation.**

I. Introduction

THE digital image/video processing (PDI/V) is understood as a process of manipulating an image (in video, called a frame) by computer so that the input and output of the process are images [1]; hence, generating an image is something trivial for computers, but high-resolution digital image/frame processing is very complex. There is several types of visual artifacts and distortions; some of them are inherent to the acquisition process, transmission and image visualization, which impacts negatively the image quality [2].

This paper pretend to analyze the quality and time processing from three different digital image/video processing algorithms. For this purpose, two applications (web and local) were developed, using the languages JavaScript [3], Java [4] and Lisp [5]. First, the image/frame is captured by a camera/sensor or chosen from the system itself, then, the stage of processing is performed using as many threads as available. This process initializes with a neighborhood analysis; that is composed by the scan process of the images, and the generation of the pixel sheet saved into a MxN matrix.

In this case, all pixels were filled in the generated worksheet and standardized to avoid discrepancies between current pixel and the others; increasing the quality of images by 2% (value found through matrix-level tests of pixel quality), a relatively small value but really relevant in the digital image/video processing area.

This neighborhood standardization is based on the MSAA (MultiSample Anti-Aliasing) technique, which creates an intelligent process of rendering multiple copies of each pixel and interpolates them. For instance, if there are four identical pixels inside a polygon, they are processed as if were just one, attributed to one color. Hence, time processing can be reduced. To safe this data, a text document is created that is not influenced by the information of the pixel when is storaged.

The last step is to generate a graph of all the pixels and to draw a linear of evaluation for study of that image/frame, that is, a recognition is made if those pixels are linearly plotted on the graph or if they still need to be reworked in the standardization, increasing the rate from 2% to 2.3% of image/frame quality.

Once this is done, the image/frame is prepared to go through the histogram analysis stage, generating a new assessment. This technique is applied into all images for manipulation purposes and is ready to be evaluated by three different algorithms: partial differential equation (PDE), high-dynamic range (HDR) e discrete cosine transform (DCT).

II. Methodology

A. *Partial Differential Equation*

The use of partial differential equations [6] in digital image processing improves the restoring process of the image by doing a mathematical modeling. This is an alternative against to conventional filtering techniques. The results obtained improving the quality of the filtered images with minimum loss of resolution [7][8].

The mathematical model is then presented: The image is represented by a function $\vartheta(x_i, y_j)$, where, 'i' and 'j' are the rows and columns of the matrix. To obtain the differences relatives to the partial derivatives, the finite difference approximation method is used to make an approximation in the expressions ϑ_x (1), ϑ_y (2), ϑ_{xx} (3), ϑ_{yy} (4) e ϑ_{xy} (5).

$$\vartheta_x = \frac{\vartheta_{i+j} - \vartheta_{i-j}}{2} \tag{1}$$

$$\vartheta_y = \frac{\vartheta_{ij+1} - \vartheta_{ij-1}}{2} \tag{2}$$

$$\vartheta_{xx} = \frac{\vartheta_{i+2j} - 2\vartheta_{ij} + \vartheta_{i-2j}}{4} \tag{3}$$

$$\vartheta_{yy} = \frac{\vartheta_{ij+2} - 2\vartheta_{ij} + \vartheta_{ij-2}}{4} \tag{4}$$

$$\vartheta_{xy} = \frac{\vartheta_{i+j+1} - \vartheta_{i+j-1} - \vartheta_{i-j+1} + \vartheta_{i-j-1}}{4} \tag{5}$$

The solution of the partial differential equation is obtained using the time scale, $t_n = n\Delta t$, where 'n' represents the *course of time in the application. The new function is (6):*

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$$\vartheta(x_i, y_j, t_n) \tag{6}$$

Finally, to obtain the resulting image (I_{result}), it is necessary to apply (7), thus generating in the application an image filtered by the method of partial differential equations.

$$I_{result} = \delta|\nabla\vartheta| \operatorname{div}\left(\frac{\nabla\vartheta}{|\nabla\vartheta|}\right) + \sigma(1-\delta)(\vartheta - I_{original}) \tag{7}$$

B. High-Dynamic Range

HDR is a feature developed to electronic devices in order to generate and reproduce image with better contrast levels and brighter/darker black tones (light source/shadows) [9]. The first step of the algorithm is to obtain the images with their respective information. In (8), each image is represented by x, but all contain in their information the exposure time data (Δt_j) and radiance (E_i), represented in (9).

$$Z_{ij} = f(x) \tag{8}$$
$$Z_{ij} = f(E_i \Delta t_j) \tag{9}$$

After this analysis, a Z_{ij} for each value of intensity of the representative pixel, which is a non-linear function with respect to the exposure values x, represented in (10) and (11).

$$f^{-1}(Z_{ij}) = E_i \Delta t_j \tag{10}$$
$$\ln f^{-1}(Z_{ij}) = \ln E_i + \ln \Delta t_j \tag{11}$$

In the equations presented, the known values are Z_{ij} and Δt_j of each image. The values to be obtained are E_i, as well as a new function $g(Z_{ij})$. This new function, represented in (12), has a finite and well-defined range of values (0-255), which is the value of the RGB pixels, since the brightness domain associated with each of these pixels is finite [9].

$$g(Z_{ij}) = \ln E_i + \ln \Delta t_j \tag{12}$$

In this case, we need to use a mathematical analysis to find the points of $g(Z_{ij})$ and E_i which minimize the quadratic error of the function, represented in (13).

$$\varrho = \sum_{I=1}^{N} \sum_{J=1}^{P} [g(Z_{ij}) - \ln E_i - \ln \Delta t_j]^2 + \lambda \sum_{z=Z_{min}+1}^{Z_{max}-1} g''(z)^2 \tag{13}$$

Where:
P = number of photos available;
N = number of pixels evaluated;
Z_{max} = maximum pixel intensity values;
Z_{min} = minimum pixel intensity values;

Using (13), the image is not suitable for the application, then a triangular weight function is created, smoothing the image, represented in (14).

$$w(z) = \left\{ \begin{matrix} z - Z_{min} \rightarrow z \leq \frac{1}{2}(Z_{min} + Z_{max}) \\ Z_{max} - z \rightarrow z > \frac{1}{2}(Z_{min} + Z_{max}) \end{matrix} \right\} \tag{14}$$

By inserting the smoothing in equation (13), the new function is obtained, represented by (15).

$$\varrho = \sum_{I=1}^{N} \sum_{J=1}^{P} \{w(Z_{ij})[g(Z_{ij}) - \ln E_i - \ln \Delta t_j]\}^2 + \lambda \sum_{z=Z_{min}+1}^{Z_{max}-1} [w(z)g''(z)]^2 \tag{15}$$

Getting the values of $g(Z_{ij})$, are converted to relative radiance values, assuming that Δt_j of each photo is known, represented in (16).

$$\ln E_i = g(Z_{ij}) - \ln \Delta t_j \tag{16}$$

To generate the map of radiance/histogram, the information of the images is used, performing a weighted average of these values, represented in (17).

$$\ln E_i = \frac{\sum_{j=1}^{P} w(Z_{ij})(g(Z_{ij}) - \ln \Delta t_j)}{\sum_{j=1}^{P} w(Z_{ij})} \tag{17}$$

C. Discrete Cosine Transform

Discrete Cosine Transform (DCT) [10] makes use of real numbers and is widely used in digital image processing and data compression. It expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies, where the high frequency components may be discarded with no visual impact.

Before applying the DCT transform to an image, is important to split a frame into blocks of sizes, 4x4, 8x8 or 16x16. In some case, sizes of 32x32 or 64x64 blocks are used in order to optimize the computational complexity and improve the coding efficiency. The block size has an impact on the compression ratio, and the larger the blocks, the lower the compression ratio [10].

This algorithm divides the luma component and the two-chrominance components matrices into several matrices, each with a size of 8x8 pixels. The DCT transform is applied to these matrices, whose values are close to zero. This process transforms the time domain to the frequency domain [10].

The NxM DCT, is presented in (18):

$$F(\mu,\vartheta) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Delta(i) \times \Delta(j) \times \cos\left[\frac{\pi \times \mu}{2 \times N}(2i+1)\right] \cos\left[\frac{\pi \times \vartheta}{2 \times M}(2j+1)\right] \times f(i,j) \tag{18}$$

Where:
$F(\mu,\vartheta)$ = coefficient in the field of processing;
μ = horizontal axis in the transform domain;

ϑ = vertical axis in the transform domain;
$\Delta(x) = \frac{1}{\sqrt{2}}$ for $x = 0$;
$\Delta(x) = 1$ for $x \neq 0$;
$x = \mu \mid \vartheta$;
$f(i,j)$ = amplitude in the time domain;
i = horizontal axis in the time domain;
j = vertical axis in the time domain;

The inverse (IDCT), is calculated as (19):

$$F^{-1}(u,v) \tag{19}$$

Because of the DCT coefficients are real numbers instead of integer numbers, a quantization process is applied to reduce the number of bits required to store a value by reducing the precision of an integer. This process removes the spatial redundancy and is known as lossy compression.

Applying the (19), it is seen that when the pixels of the image were recovered, the values were very close to the originals, proving that the losses are negligible, only the high frequencies were discarded.

III. Results

For this comparative analysis, three NVIDIA GeForce GTX 1070 Ti video cards and two Intel Core i9-8950HK processors were used.

A. Partial Differential Equation

The first test of the Partial Differential Equation was to measure the image/frame processing time in the noise filtering stage. The Signal to Noise Ratio (SNR) is a useful and universal way of comparing the relative amounts of signal and noise to any electronic system in which high ratios will have little visible noise while the opposite is true for reasons. Thus, an intermediate-level SNR was used, that is, random noise, which is characterized by fluctuations in intensity and tone of color in relation to the original image/frame, leaving less clear. As a result, "Algorithm 1" (represented as the standard filtering technique using mask and pixel analysis by neighborhood [6]) processed the image in 32.1 seconds, while in "Algorithm 2" (represented as the search technique) was 25.13 seconds, thus generating a time savings of 6.97 seconds.

The second test generated, is to analyze the profile in terms of the quality of the pixels in the image/frame, for this, the image/frame was matricially compared at the pixel level. Processing time of this technique took 7 hours, 13 minutes and 07 seconds to complete. As a result, "Algorithm 2" achieved on average 92% of quality and precision in the generated pixels, while "Algorithm 1" reached 84%. To calculate the mean value of the PSNR (Peak Signal to Noise Ratio), which is used to define the relation between the maximum energy of a signal and the noise that affects its reliable representation, the MSE (Mean Squared Error) is formulated and then applies the signal-to-noise ratio.

For "Algorithm 1" the value of the PSNR reached was 32.70dB, but in "Algorithm 2" the value was 44.09dB, with that, it generated a gain of 11.39dB. And the last test was at the histogram level, comparing the image/frame, classifying "Algorithm 2" as best at the level of histogram quality, presenting in each RGB layer a larger number of pixels located in the zone of medium tones. The "Algorithm 1", in turn, had a higher concentration of pixels in the zones of shadows and high lights. All tests are shown in Fig. 1.

B. High-Dynamic Range

The first test of High Dynamic Range was to measure the processing time in the resulting image generation. As a result, "Algorithm 1" (represented as Debevec and Malik [9]) processed the image in 17.8 seconds while "Algorithm 2" (represented as the search technique) in 11.7 seconds, obtaining a gain of 6.1 seconds from the previous one.

The second test generated, is to analyze the profile in terms of pixel quality in the resulting HDR image, for this, a new resulting image was generated matricially and compared at the pixel level. Processing time of this technique took 6 hours, 11 minutes and 25 seconds to complete. As a result, "Algorithm 2" achieved 93% of quality and accuracy in the generated pixels, while "Algorithm 1" reached 81%.

And the last test was at the histogram level, since "Algorithm 2" standardizes the pixels of the resulting HDR image, that is, it performs a matrix and graphical analysis in advance, obtaining the best combinations of the neighborhood pixels, the image is compared, classifying "Algorithm 2" as best at the level of histogram quality, presenting in each RGB layer a larger number of pixels located in the zone of medium tones. The "Algorithm 1", in turn, had a higher concentration of pixels in the zones of shadows and high lights. All tests are shown in Fig. 2.

C. Discrete Cosine Transform

The first test of the Discrete Cosine Transform was to measure the processing time of two images/frames. As a result, "Algorithm 1" (represented as the standard technique of the DCT/IDCT application [10]) processed the image/frame in 32.3 seconds while "Algorithm 2" (represented as the search technique) in 27.7 seconds, with that, generated a saving in time of 4.6 seconds.

The second test generated is to analyze the profile in terms of pixel quality in the image/frame, for this, the two images/frames were matricially compared at the pixel level. Processing time of this technique took 5 hours, 12 minutes and 17 seconds to complete. As a result, "Algorithm 2" achieved 97% of quality and accuracy in the generated pixels, while "Algorithm 1" reached 90%.

And the last test was at the histogram level, comparing the image/frame, classifying "Algorithm 2" as best at the level of histogram quality, presenting in each RGB layer a larger number of pixels located in the zone of medium tones. The "Algorithm 1", in turn, had a higher concentration of pixels in the zones of shadows and high lights. All tests are shown in Fig. 3.

IV. Conclusion

This paper assess the impact on quality and processing time of three different state-of-the art algorithms. In summary, the three algorithms developed in the research were better, since the technique used allows the search of the best pixels in a matrix form, allowing the neighborhood pixels to be standardized, besides the use of the histogram to evaluate the average area of their position. All content and algorithms will be used for future work in the digital image/video processing area.

Fig. 1. (A) Original Image; (B) Test 1; (C) Test 2; and (D) Test 3.

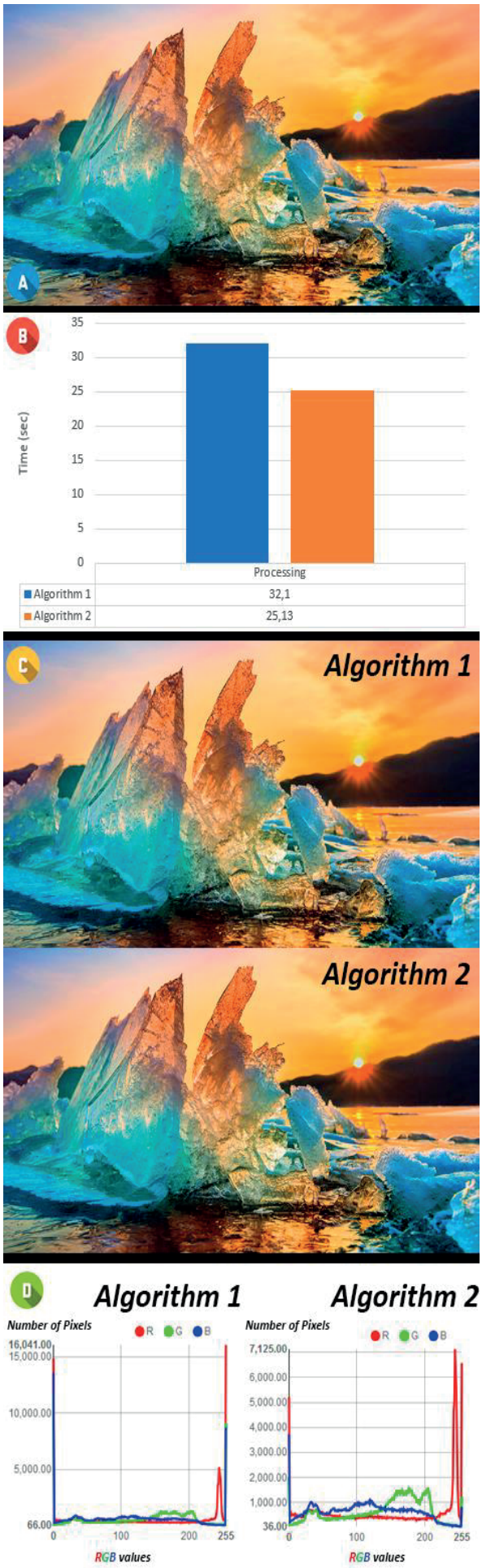

Fig. 2. (A) Original Image; (B) Test 1; (C) Test 2; and (D) Test 3.

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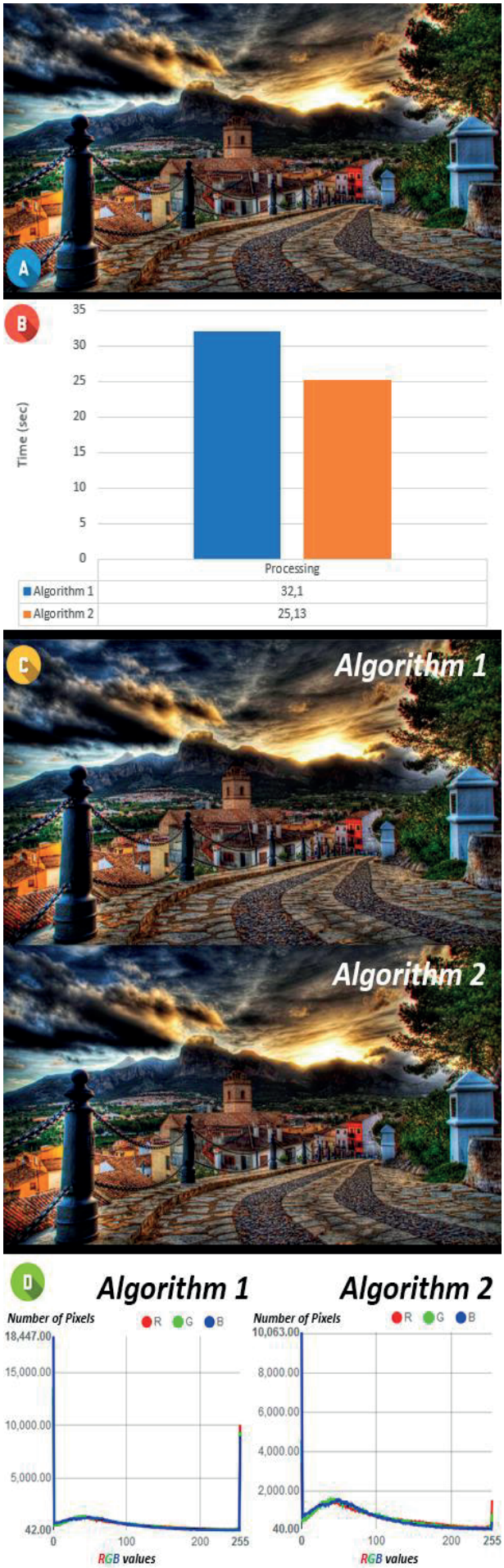

Fig. 3. (A) Original Image; (B) Test 1; (C) Test 2; and (D) Test 3.

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Field Tests for Immersive and Interactive Broadcast Audio Production using MPEG-H 3D Audio

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Field Tests for Immersive and Interactive Broadcast Audio Production using MPEG-H 3D Audio

Christian Simon, Yannik Grewe, Nicolas Faecks and Ulli Scuda

Abstract— Next Generation Audio offers new features for the consumer such as advanced user interactivity, immersive sound and optimized reproduction across different classes of playback devices. All of these strongly depend on additional information that is affixed to the audio in the shape of metadata. Thus, some processes of the final sound reproduction assembly shift from the mix process during production to the rendering stage in the consumers' device. Using the MPEG-H TV Audio System as an example, this paper outlines the workflow for Next Generation Audio content creation with a focus on broadcast production for live and offline applications. Initially, the MPEG-H TV Audio Systems fundamentals will be detailed. It is shown, how new tools can be integrated into well-established production workflows and how they ensure full control of produced mixes in anticipation of the end users' experience. Use cases for immersive and interactive audio broadcasts are presented by example of an international music competition and a major tennis event. Finally, an outlook to future requirements and improvements is given.

Index Terms —3D Audio production, Broadcast Audio, Immersive Audio, Interactive Audio, MPEG-H 3D Audio, Next Generation Audio, Production Tools.

I. Introduction

NEXT Generation Audio (NGA) systems, such as the MPEG-H TV Audio System [1] based on the ISO/IEC 23008-3:2015 MPEG-H 3D Audio Standard [2], provide revolutionary features, such as immersive and interactive audio, supporting channel-based, object-based as well as scene-based audio [3]. MPEG-H meets requirements of increasing types of delivery platforms and infrastructures for broadcast, streaming services, TV on demand or mobile applications by using the same bit stream across different device classes. This feature is called 'universal delivery'. Bit rates of 192 kbit/s to 384 kbit/s, which are commonly known for six-channel transmissions, can be used to broadcast various content such as twelve-channel audio or twelve audio objects, depending on the production scenario.

Since 2017, the MPEG-H TV Audio System is in use for 24/7 broadcasts in South Korea, making it the first region worldwide to use NGA for regular services. In 2018, MPEG-H was selected as transmission codec for the upcoming UHD TV services in China.

The production, distribution and rendering of immersive and interactive audio poses a number of challenges for content creators and providers:

- How can they use advanced features in an efficient way?
- How is it possible to produce immersive and interactive audio without completely changing well-established production or contribution workflows?
- How can scene related metadata be created, handled, securely transmitted and accessed at any critical point in the chain?

Based on these considerations, specific production tools were developed to offer an efficient workflow for live and post-production using the MPEG-H TV Audio System.

This paper outlines challenges, requirements and solutions for an efficient production workflow for immersive and interactive broadcasting, based on two field tests.

Section II continues by describing fundamental features of the MPEG-H TV Audio System, detailing the need for new production tools. To demonstrate how these tools and concepts can be used in practice, field tests and trial transmissions of MPEG-H Audio content were conducted during the Eurovision Song Contest and the French Tennis Open in 2018 [4] which are described in section III and section IV. The outlined workflow is focused on Serial Digital Interface (SDI) based studio infrastructure, which is most common in today's broadcasting facilities.

Unless explicitly mentioned, MPEG-H refers to the MPEG-H TV Audio System, based on the ISO/IEC MPEG-H 3D Audio standard.

II. Fundamentals of the MPEG-H TV Audio System

The MPEG-H TV Audio System enables all NGA features. In the following, most important ones are briefly described.

A. Immersive Audio

By adding elevated sound sources above and below the listeners' position, more detailed spatial reproduction can be achieved [5]. The system supports, but is not limited to, over twenty different loudspeaker configurations including setups such as stereo, 5.1, 7.1 [6] as well as 3D audio setups, namely 5.1+4H, 7.1+4H or 22.2 [7]. Immersive audio can be carried

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http://www.set.org.br/ijbe/ doi: 10.18580/setijbe.2018.5 Web Link: http://dx.doi.org/10.18580/setijbe.2018.5

as channels, objects or ambisonics coefficient signals or any combination of the above [2].

The ISO/IEC MPEG-H 3D Audio standard supports up to 128 channels, objects or ambisonics coefficient signals, rendered simultaneously to a maximum of 64 loudspeakers. To constrain implementation complexity, limits were defined and described in an MPEG-H Low Complexity Profile (LC-Profile). This paper refers to Low Complexity Profile Level 3, which is adopted by ATSC 3.0, DVB and SCTE standards for the definition of Next Generation Audio and video coding systems for broadcast and cable applications. Up to 32 audio elements can be transmitted within one bit stream, while 16 of them can be decoded simultaneously. Other broadcasting scenarios going beyond the limitations of the LC-Profile Level 3, for example using a 22.2 channel format, can be covered using the LC-Profile at Level 4 [2].

B. *Interactive and Personalized Audio*

Using audio objects and combining them with channel- or scene-based audio enables the listener to interact with the content by using the standard TV remote control. Simple adjustments, such as increasing or decreasing the prominence of dialogue in relation to other audio elements, to more advanced scenarios are possible. Listeners may choose from different languages or commentators or even change position of audio objects.

To achieve grouping of exclusive components, the concept of ′switch groups′ was designed. This can be used for switching between different languages or other audio signals, whose semantic content is not meant to be played back simultaneously.

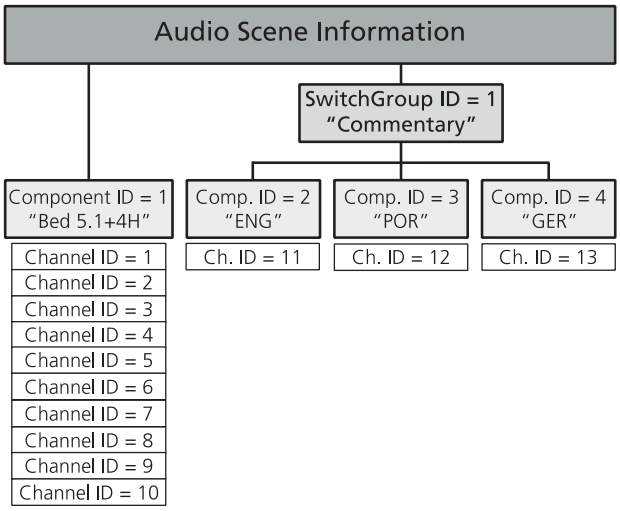

Figure 1: Overview on a MPEG-H scene description. Channel 1-10: ambience bed, channel 11-13: audio objects with different commentators within a switch group.

The MPEG-H TV Audio System describes the sound of a TV program as a set of audio components and its related metadata, combined in an audio scene. Metadata can configure different mix presets offered by the broadcaster, such as a default mix as a first preset and secondly a hearing impaired mix in which the dialogue is boosted. Metadata contain the range limits on the viewers′ control of the audio scene, such as dialogue level and object position. Furthermore, metadata include text labels, information about content kind, downmix coefficients and loudness values to adjust the playback to different device platforms and environments such as a home cinema or a noisy train station. An exemplary illustration of an MPEG-H scene description including a 5.1+4H immersive bed and three commentator tracks compiled within a switch group is presented in Fig. 1.

The creation of MPEG-H related metadata and respective parameters is always under full control of the content provider.

C. *Universal Delivery*

The MPEG-H TV Audio System offers flexibility by delivering the same bit stream through different distribution platforms (e.g. satellite, broadband or mobile network) to different devices (e.g. TV set, AVR, soundbar, tablet, virtual reality devices) in different environments (e.g. living room, home theater, noisy public).

Therefore, multiple technologies have been implemented to ensure that the consumer experience always is complying with the content producers' intention. The core element for the object-based audio is a high quality renderer, while a format converter handles channel based audio. In this way, the main intention of a mix can still be transmitted even though it is played back on different reproduction platforms. Furthermore, the MPEG-H 3D Audio standard features binaural rendering technology to directly output signal for stereo headphones, creating immersive audio experiences.

Loudness-, dynamic range- and peak control, as well as ducking for voice over applications are conducted by advanced Dynamic Range Control (DRC) mechanisms [8].

D. *MPEG-H Metadata for SDI-based Infrastructure*

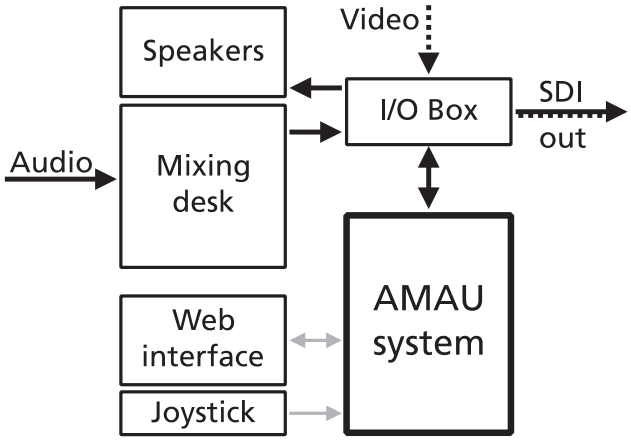

Figure 2: Signal flow of an Audio Monitoring and Authoring Unit system (AMAU). Solid lines represent audio, dotted lines represent video. A solid and dotted line represent audio and video. Grey lines indicate control data.

As mentioned, metadata are essential to control audio objects and interactivity within NGA. The most fundamental information being channel count and layout, types and labels of audio objects, interactivity control limits, loudness information and position data for dynamic objects. In general, metadata need to be synchronized and attached to the corresponding audio, in order to be processed together while encoding. During decoding, metadata control the rendering process.

For live productions using MPEG-H, metadata are usually created as a so-called control track (CT) [9] with the help of an Audio Monitoring and Authoring Unit (AMAU) [10]. The

AMAU modulates metadata into the CT and feeds this additional channel on a MADI or SDI link back to the OB van′s or studio′s audio equipment, as shown in Fig. 2. Later the encoder uses this CT to encode audio accordingly to metadata created in the AMAU.

The CT is a timecode like audio signal and can be handled as a regular audio channel. Typically, the CT is carried on channel 16 within an SDI framework (see Fig. 3). This tightly coupled transport of the CT together with the audio channels carrying the audio essence ensures integrity of the transmitted audio scene. In a future IP based production workflow, video, audio and metadata parts will be transmitted as separate IP streams according to SMPTE ST2110, where all streams are synchronized by global time stamps and recipients are able to extract only data portions relevant for a certain application [11].

Handling the CT as an audio channel ensures that it is always synchronized with its corresponding audio. It is robust enough to survive A/D and D/A conversions, level changes, sample rate conversions or frame-wise editing. The CT does not force audio equipment to be put into data mode or non-audio mode in order to pass through.

For post-production scenarios, the CT can be created using standalone applications, such as the Fraunhofer MPEG-H Monitoring and Authoring Tool (MHAT) as well as plugin solutions for digital audio workstations (DAW) [12].

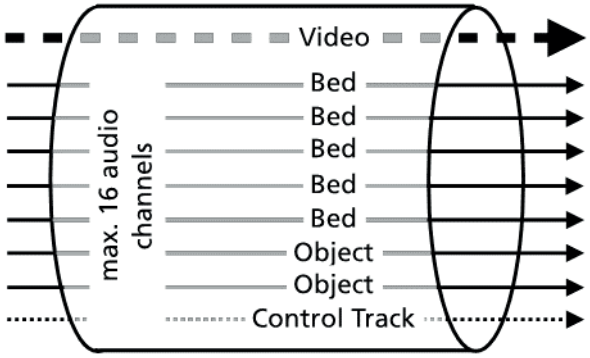

Figure 3: SDI signal for MPEG-H distribution. It contains max. 15 channels of audio (Bed and/or audio object tracks) and a control track. The control track includes all scene related metadata on channel number 16.

III. Immersive and Interactive Audio Production For The Eurovision Song Contest

A. Scope of the Event

The Eurovision Song Contest (ESC) is an international song competition produced by the European Broadcasting Union (EBU) and one of the most viewed non-sporting-events worldwide. In 2018, it took place in the Altice Arena Lisbon, Portugal and was watched live by 186 million viewers [13]. It was supported by the national Portuguese broadcaster Rádio e Televisão de Portugal (RTP). The EBU and Fraunhofer Institute for Integrated Circuits IIS collaborated to conduct a field test for immersive and interactive live audio production, based on the MPEG-H TV Audio System. The field test was done to evaluate future production and reproduction scenarios. The authoring and monitoring of the immersive mixes was done live for demonstration purposes as well as executed in post-production after the event. The immersive mix was not broadcasted but played back during the event in Lisbon.

Producing immersive audio raises several general questions to content creators, such as:

- Which audio production and reproduction formats need to be used?
- How can the immersive part of the content be captured in an efficient way?
- What are changes regarding the editing and mixing workflow?

Firstly, production and reproduction scenarios need to be clarified. Both scenarios comprise of different requirements for live broadcast and offline recording, sound quality and transmission. In the case of the ESC field test, an offline audio production was targeted towards reproduction over loudspeakers, soundbars and headphones. The focus of the following considerations lies on the immersive aspect with a production format of 5.1+4H, by adding four height channels to an ITU-R BS.775 surround configuration as defined in [2].

B. Production Scenario

The legacy audio production format for the international feed at ESC was a 5.1 surround sound mix and an additional 2.0 stereo mix. Both were created by the host broadcaster′s OB van on location. The signals used were a mix of microphone feeds and pre-produced material, such as special sound effects (SFX) and trailers for the participating competitors.

In total, 232 microphones were employed by the broadcaster to capture sound from the main stage, hosts, interview partners and arena audience. Based on these signals, international feeds were mixed. 26 ambience microphones were put into different zones throughout the audience, both in front of the stage and on the rear floor area, aiming to the upper tiers and downwards from the PA rigs. Positioned this way, a versatile mix of audience reactions can be created, surrounding the listener by blending more diffuse and more direct ambience signals and giving the mixer the possibility to select the most appropriate sounds. Microphone signals representing the diffuse upper part of the arena, preferably with minimum direct PA sound, were missing in the conventional production workflow to create an immersive experience. For that, a Hamasaki Square [14] was additionally placed underneath the roof in the center of the arena about 25 meters above the floor. Minimizing direct sound from PA and audience by its polar patterns and direction, it provided the upper layer ambience signal by adding just four additional microphones.

A 3D audio mixing room was set up, receiving all OB van′s signals including sub-mixes and additional commentator feeds from a second service provider, as shown in Fig. 4. All signal transmissions were realized by Multichannel Audio Digital Interface (MADI) connections.

For creating an immersive, three-dimensional sound impression, the Hamasaki square signals were panned 100% to the loudspeakers' upper layer, which created the intended 'dome' effect. Microphone signals from the upper part of the arena that are panned to the middle layer for regular 5.1 audio production, have been used differently for the immersive mix. Here, they were panned slightly upwards to bring them to their natural position in the sound field, about 15 degrees

upwards from the arena floor. It is also possible to use the existing 5.1 ambient mix from the OB van, adding only the additional height layer microphone setup. The latter case has a significant drawback. Microphone signals that carry spatial information of the upper part of the sound field cannot be elevated by panning, which leads to a loss of spatial information. Therefore, in case of the ESC field test, a new ambience mix was done.

Once the immersive ambience was created, remaining stems like music and hosts were mixed in a legacy way, panning them in the mid-front line of the immersive loudspeaker configuration. The stereo SFX stem was panned slightly upwards to produce an immersive effect. For future events, sound effects and interstitials should already be pre-produced in an immersive channel layout to be more impressive. Additionally, a selection of the 20 available commentary feeds were added to the audio scene, whereupon interactivity was configured and monitored.

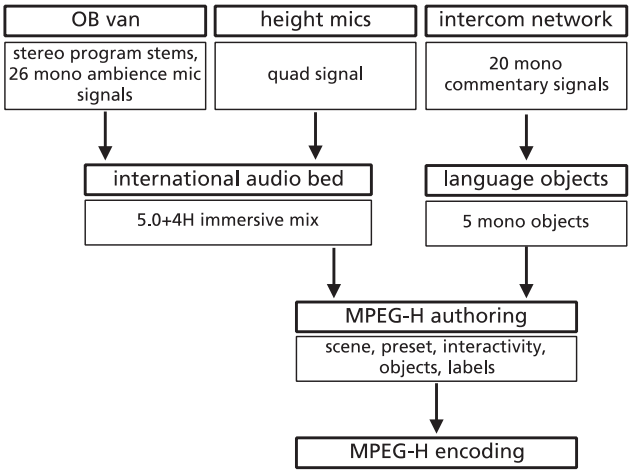

Figure 4: Schematic audio production and authoring workflow of the ESC MPEG-H field test.

The resulting 5.1+4H mix can be monitored using an AMAU or DAW with MPEG-H enabled plugins [12] to monitor downmixes from 5.1+4H to 5.1 and stereo as well as the binauralized playback. In a live scenario, the 5.1 and stereo mixes from the OB van should also be monitored frequently to prevent major differences in the level balance of the stems.

After finishing the mix, a CT including all metadata was generated by the MPEG-H production tools and used for controlling the MPEG-H Audio encoder. An exemplary GUI on the receiver side, based on the authored audio scene and preset creation, is shown in Fig. 5.

The field test showed that the already existing infrastructure for sound capturing and processing only needs few additional changes to be able to produce immersive and interactive sound. In the described case, four additional microphones and loudspeakers plus an MPEG-H enabled authoring tool were required. The resulting immersive and interactive audio mix received positive feedback compared to the legacy stereo or 5.1 production, as stated by involved producers and audio engineers during on-site demonstrations.

IV. Immersive And Interactive Audio For The French Tennis Open

A. Scope of the Event

During the major tennis tournament held in Paris in May/June 2018, the host broadcaster, France Télévisions, provided a test channel for UHD broadcast including MPEG-H Audio supported by the Fraunhofer Institute for Integrated Circuits IIS. The aim was to broadcast appropriate NGA for UHD video including immersive and interactive features as well as High Dynamic Range with Hybrid Log Gamma (HLG-HDR) [15] to preserve more details in the darkest and brightest areas of the picture. Along with the video, immersive sound and interactive audio objects were transmitted over satellite and terrestrial broadcast. The tournament was the first event for an immersive and object-based production using the MPEG-H TV Audio System to go on air in Europe. The test channel covered all games taking place on the center court. The transmission was receivable via DVB-T2 [16] in the area of Paris and via DVB-S2 [17] all over France and was on air until the end of the tournament.

B. Production Scenario

Immersive audio is well suited for live sports events broadcast because the ambience of the event location including audience reactions can be reproduced much more detailed, resulting in a stronger emotional experience for the viewers. Using audio objects allows for level interaction on commentary to support better understanding, especially if ambient and audience noise is high. Furthermore, a 'Venue preset' with stadium sound only can deliver a more realistic live experience on the consumer device. In addition to French commentary, an English commentary was provided for several matches. Both commentaries were delivered as separate audio tracks and configured as static dialogue objects.

For the 2018 event, the host broadcaster added an ORTF 3D microphone array to their legacy microphone setup on the center court. This microphone array captures 3D audio with a compact setup and provides a 4+4H audio signal [18]. The array was placed behind the umpire, above the lower terrace about one meter in front of the gallery. The legacy field microphone signals as well as the lower layer of the 3D array were used to create the international stereo and international 5.1 mixes. Broadcasters all over the world used these mixes and the UHD or a down-scaled HD picture to serve their customers with a legacy broadcast. The upper layer output of the 3D microphone array created the upper layer in the 5.1+4H immersive bed. Since 3D audio monitoring was not enabled in the used OB van, it took some iteration to tweak the immersive bed mix before broadcasting. Recordings from the encoded signal were checked in an ITU-R BS.1116 listening room [19] off-site and the observations and suggestions were provided to the responsible audio engineer in the OB van. Both mixes, international stereo and 5.1, as well as the signal of the upper layer and commentaries, went through a MADI link into an AMAU.

To generate metadata, the channel layout was first defined in the AMAU by selecting related channels from the MADI link and grouping them. In this case, the ambience bed was defined in the production layout configuration of 5.1+4H.

Two additional commentary tracks were added for French and English, respectively. Furthermore, the AMAU measured loudness for every audio component. Loudness measurement is an important step in the production to ensure adequate loudness metadata, which control the renderer during the decoding process.

To allow more interaction with commentary beyond selecting the language, corresponding metadata were created in the AMAU. Gain and position interaction for both commentary audio objects were configured. On the users' TV on screen display, interactivity options are shown and can be selected via the remote. An example which shows user interactivity for commentary language and its prominence level is shown in Fig. 5. The prominence of an audio object describes the level relation of this object to all other audio components in the scene. If for example the commentary level is increased in reproduction to improve intelligibility, the level of the bed channels is attenuated. This way the overall loudness remains consistent.

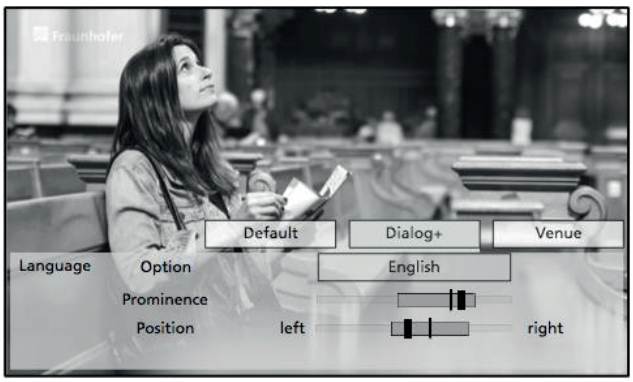

Figure 5: Schematic on screen display on the user´s TV set to show available interactivity options. The top line (Default, Dialog+, Venue) represents pre-configured mix presets to choose from. The bottom grey part shows options for the language audio object.

In addition, the user may manipulate the position of the commentary audio object to left and right and—on an immersive reproduction setup—to the upper layer. During production, the host broadcaster emphasized this as an important feature, due to its benefit for users who use audio description services. Users are able to separate the audio description service from the regular dialog (e.g. by positioning the audio description service to a rear speaker in a 5.1 system).

To ease the use of MPEG-H features, user presets were created in the AMAU. In addition to a default one, which represents an immersive broadcast mix, a preset with increased dialogue prominence and a preset without commentary were configured.

As the last processing step, the AMAU modulated the metadata into the CT and fed this together with all audio tracks back to the OB van. The metadata creation in the AMAU is the only additional processing in the workflow for an MPEG-H based production. The basic signal flow for this production is shown in Fig. 6.

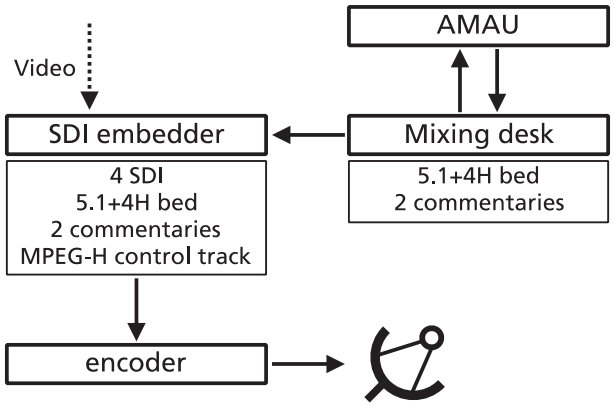

Figure 6: Signal flow used in the sports event production. The AMAU is the only device added especially for the NGA production.

The OB van provided an SDI feed including the UHD video signal and all needed audio channels including the CT (see Fig. 3). The live match or a rerun of a recorded SDI stream was fed into two redundant encoders for a 24/7 live encoding broadcast. The encoders processed HLG HDR video and MPEG-H audio simultaneously in one service. A satellite carrier and a terrestrial carrier received the encoder output on a fiber-based IP connection. They mixed the signal into their regular DVB-S2 and DVB-T2 multiplex, respectively. An Over-The-Air receiver allowed playback of these signals (DVB-S2 and T2) on different playback devices such as TV sets, soundbars and binauralized on headphones.

V. Conclusion

This paper outlines the workflow for Next Generation Audio content creation with a focus on broadcast production for live and offline applications. Initially, MPEG-H TV Audio Systems fundamentals have been detailed. On the basis of two major events, an international music contest and a tennis tournament, production workflows have been described. It has been shown, that capturing, mixing and authoring interactive and immersive content can easily be conducted without major changes in the existing legacy live and offline production chain. All needed tools and devices are available on the market. Practical advice and experience has been described to optimize the consumer experience regarding immersion and interactivity.

To simplify future NGA productions, next needed steps are to upgrade production facilities and to educate broadcast engineers and producers about the required workflow and about the additional features and experiences offered by NGA.

Acknowledgment

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First Experiences with the MPEG-H TV Audio System in Broadcast

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***Abstract*— In May 2017, the worldwide first UHDTV broadcasting service using with the MPEG-H TV Audio System, a Next Generation Audio codec, was launched in South Korea. Now the system is in regular operation for more than one year and in the meantime the leading terrestrial broadcasters have tested the different formats available. It is the perfect time to do an intermediate summary and report about the experience made during the first year. Starting from the necessary modifications to integrate the MPEG-H TV Audio System into the existing infrastructure and operating it with legacy formats (stereo and 5.1 surround), this paper will describe the different phases of the transition to the full usage of the feature set of the MPEG-H TV Audio system.**

***Index Terms*—3D-Audio production, Broadcast Audio, Immersive Audio, Interactive Audio, MPEG-H 3D Audio, Next Generation Audio**

I. Introduction

MPEG-H 3D Audio [1] is the latest audio standard developed by MPEG and besides improving the coding efficiency it brings a set of advanced new features. Therefore MPEG-H is more than just an audio codec, it allows to transmit different audio formats, enables user interaction with the audio mix and provides best audio experience for each playback device. Also, often referred to as "Next Generation Audio Codec (NGA)", the MPEG H TV Audio System [2] has been adopted by ATSC [3], DVB [4] and SCTE [5], [6] specifications for usage of audio and video codecs.

II. The MPEG-H TV Audio System

The MPEG-H TV Audio System allows the transport of audio as traditional audio channels, representing a loudspeaker signal in a predefined target setup, as well as audio objects and scene-based audio. While any one of these three formats can be used individually for the delivery of complete audio scenes, the MPEG-H TV Audio System also supports any combination of them. Scene-based audio or Ambisonics, is basically a mathematical representation of the sound-field, where the spatial accuracy of the reproduction increases with the order of the representation. Therefore, a Higher Order Ambisonics (HOA) signal offers a higher spatial accuracy compared to a First Order Ambisonics (FOA) signal. An audio representation using Ambisonics is independent from the final reproduction setup and will be rendered at the receiver side to the available loudspeaker setup. This independency from a loudspeaker configuration makes it also easy to rotate the sound field in all directions. For that reason, the Ambisonics representation of audio is commonly used in virtual and augmented reality applications.

The third option in MPEG-H 3D Audio is the use of audio objects. Here we can distinguish between dynamic and static objects. Dynamic objects are commonly used for describing any audio source which is moving in the sound field. A typical example is a sound effect like a helicopter moving in a scene from the front right to the rear left. Static objects are sound elements which keep their position in a scene, like a commentary in a sports event or the dialogue in a movie. These objects can be used to offer the viewer the opportunity to interact with the audio mix and personalize it according to its own preference. The viewer can change the volume of these objects, for example for enhancing the intelligibility of the dialog, or select between different language versions or commentaries. Audio description (AD) can also be transmitted as an object, which allows the user to position the audio description at a different location than the main dialog during the playback (e.g., position the AD to the right rear loudspeaker, exactly where the visually impaired person sits in the living room). Moreover, the advanced receivers with MPEG-H support can offer audio with audio description over the headphone output, while the speaker system reproduces the audio without the video descriptive service. Audio objects are introducing a lot of flexibility into the mix and create new opportunities for the creatives while offering the viewers an unprecedented flexibility to adjust the audio to their personal preferences.

To avoid that the viewer gets overwhelmed by the new options and flexibility, the MPEG-H TV Audio System includes a user interface with two levels. In the first basic level, the user has the choice to select between a number of presets, which provide different versions of the program. The number of presets and their properties are defined by the broadcaster and offer most commonly used settings, such as: an increased dialogue volume or stadium atmosphere. Viewers who want more control over the settings can access the advanced menu which provides all options for the available objects (e.g., level and position interactivity). The presets as well as the limitations of the user interactions are entirely controlled by the broadcaster, by means of comprehensive metadata carried in the audio stream and used for enabling/disabling specific features and controlling the audio decoding and playback. A reference design of the User Interaction Interface is provided in Figure 1.

Besides the above-mentioned features, the MPEG-H TV Audio System also offers immersive audio which in combination with a UHD picture leads to the full immersion of the viewer into the scene. The integrated energy preserving

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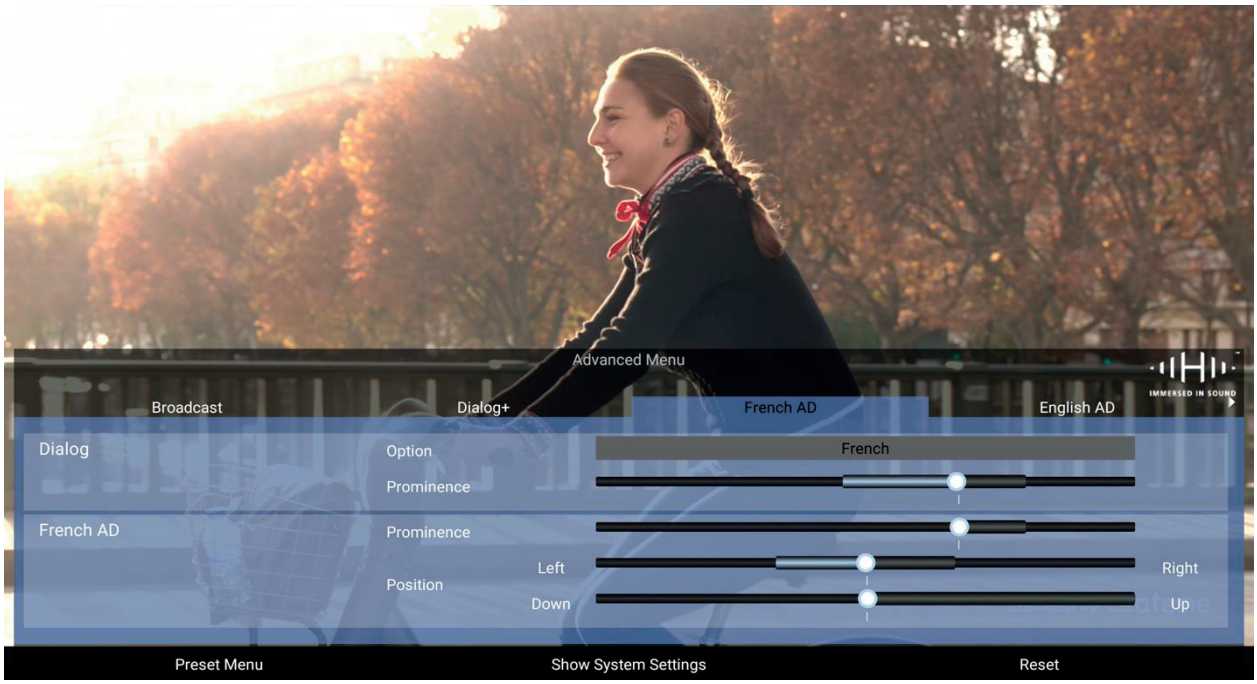

Figure 1. User Interaction Interface Example

format converter adapts the original channel layout to the final reproduction setup using phase alignment methods and avoiding the well-known problems of the passive downmix algorithms used in previous audio coding systems. Advanced loudness and dynamic range compression algorithms allow the use of a single bit stream to be send to different target devices ranging from mobile phone and tablets to TV set and AVRs, while always producing the best sound experience adapted for the target device. The core behind all these advanced functionalities is the carriage of additional information about the single elements of the mix and the overall mix, the so-called metadata.

The metadata describe the properties of each single element of a mix and the structure of the mix. It defines whether the element is an object or a channel or a part of an Ambisonics signal. For example, the metadata associated with an object includes amongst others the position of the object in the sound field, the level for playback, which type of audio and the language ID in case of a dialog. The structure of a mix, also called the audio scene description, defines the relation of the single elements of a mix to each other. It includes the definition of groups, presets and the limitations of user interactions. All these metadata need to be created during the production and then transported through the production facilities to the final emission encoder.

III. Phased Introduction of the MPEG-H TV Audio System

Looking at its advanced features it may sound complicated to use the MPEG-H TV Audio System in today's broadcast facilities and that this would require large investments in new equipment. But there is no requirement to use all features with the introduction of the MPEG-H TV Audio System. Broadcasters can gradually enable features of the MPEG-H TV Audio System in their production workflow based on their needs.

In a first stage a simple replacement for their current audio coding system will allow usage of the MPEG-H TV Audio System for producing only stereo or 5.1 surround sound with a fixed set of metadata. In this scenario the MPEG-H audio encoders are just a drop-in replacement of the legacy encoders and no metadata authoring and transport is required in the production and broadcast facilities. The immediate advantage is the increased bit rate efficiency of MPEG-H compared to the legacy codec and of course that a future proof audio coding system is now introduced which can be exploited at any time in the future.

In a second step the interactivity feature using audio objects in combination with a stereo or 5.1 channel bed for music and effects can be introduced. Even without immersive sound, the interactivity features greatly improve the attractiveness of the offering, efficiently enabling for example multiple languages or video description services. For this step, the generation and transport of metadata within the broadcast facilities is required. The necessary changes will be described in the following section.

The third phase would be the addition of the immersive sound experience. This makes the user experience complete and opens a new dimension in the entertainment. With the introduction of immersive soundbars, it is also possible to reproduce the experience into the viewers home environment without the need to install a large number of speakers.

IV. Required Changes To the Broadcast Infrastrucutre

While during the first step of the introduction of the MPEG-H TV Audio System no changes to the basic infrastructure and production workflow are necessary, the following phase requires additional equipment and editing work. The second step introduces metadata authoring and monitoring into the production process and requires a secure and reliable mechanism to transport the metadata within the broadcast plant. The metadata can be either authored live or during post production. In the file-based workflow of the post production these metadata elements are stored in an XML structure and later on inserted in the workflow by a playout server. For the generation of the metadata plugins for DAWs and standalone metadata generation tools are available (see Figure 2). These plugins and tools also allow the monitoring of already existing productions with metadata. In the live

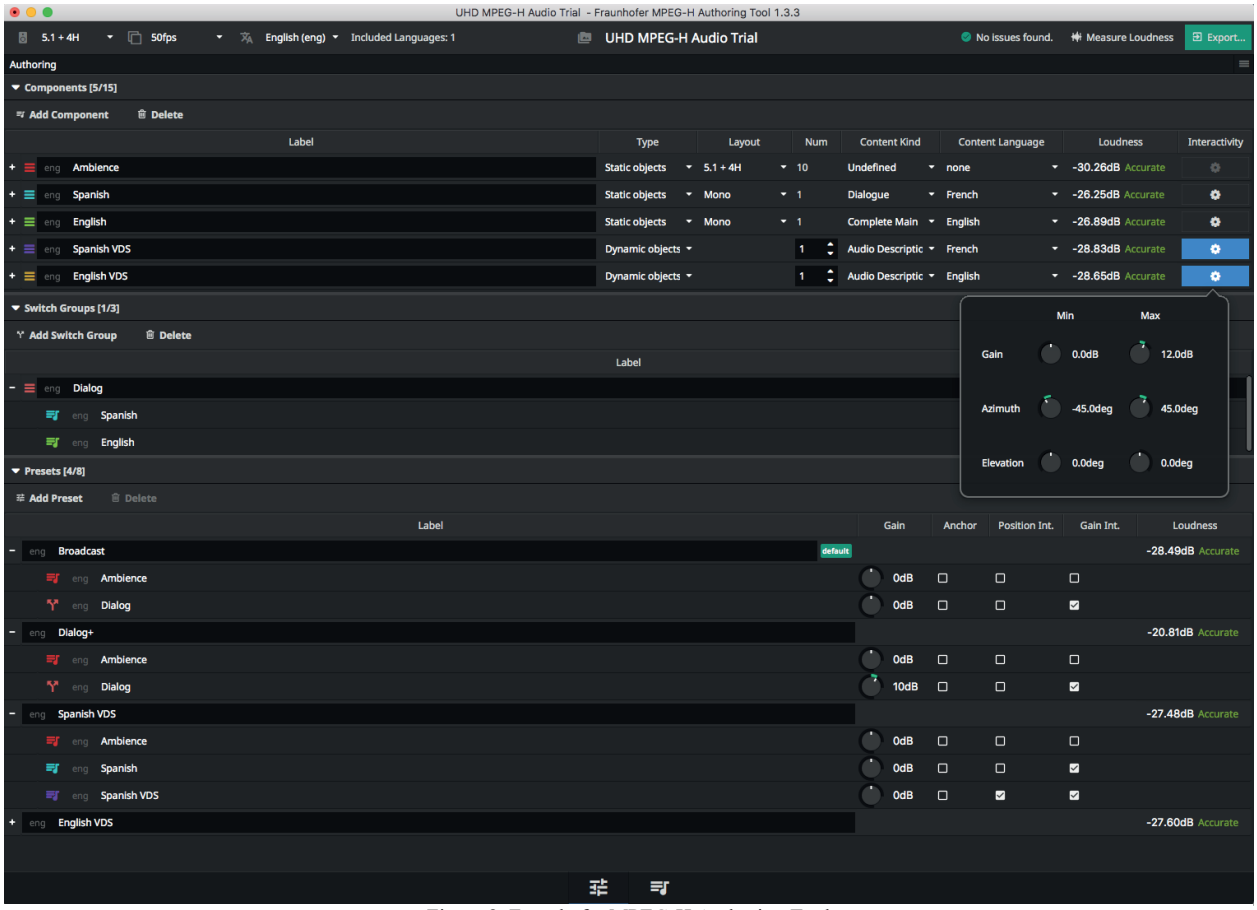

Figure 2. Fraunhofer MPEG-H Authoring Tool

scenario the so-called audio monitoring and authoring units generate the metadata. For the transport of the metadata within the broadcast facilities based on SDI infrastructure a so-called Control Track was developed. This Control Track is basically a PCM signal which carries the metadata as modulation. So, the 16th PCM channel of 16 channel SDI signal is used for the Control Track.

This solution ensures that the metadata is always carried together with the associated audio signals and no additional complexity is introduced since the audio signals are carried in PCM format. This format is designed to be robust against any processing usual in a production chain (e.g., re-sampling, attenuation, cutting to video frame boundaries) and is also used for the connection between the playout server and the emission encoder. In summary, the required changes are limited to adding authoring and monitoring units to the production chain and to install the necessary plugins in DAWs or use the standalone tools for the authoring and monitoring the metadata.

When adding the immersive sound component, it is necessary to upgrade the audio monitoring system in the control rooms to the immersive target format. In many cases the target loudspeaker layout is a 5.1 or 7.1 surround setup with four additional height speakers in the corners. In addition, the production environment needs to upgraded to handle immersive sound. There are several 3D audio production plugins available in the market, which will support the generation of immersive sound. The MPEG-H TV Audio System can be used with any available 3D audio production plugins.

V. First Real Deployment of the MPEG-H TV Audio System

In May 2017, Korea was the first country worldwide to launch a regular terrestrial UHD service. The Korean standard for this service mandates the MPEG-H TV Audio System as the only audio codec [7]. The Korean broadcasters adopted the phased approach described above. During the first year of operation they transmitted the content in the legacy stereo and 5.1 format. This allowed them focus on solving the usual problems which occur when you start a completely new system with new modulation, new transport format, new video resolution and new audio and video codecs.

Now, they start to move to the next phase, which will combine the above mentioned second and third stages. At the end of May 2018, the first immersive and interactive transmissions went on air. The selected target loudspeaker setup was 5.1+4H and included two additional objects and three presets [8].

The Korean government gave the broadcasters strict rules and timeline for the transition from the current HD service to the future UHD service. From the start in 2017 on the Korean broadcasters were required to produce 5% of the content for the UHD service in native UHD resolution. To fulfill this quote and to stay on the safe side, the Korean broadcasters decided to broadcast in UHD the news programs. This allowed them to make the first UHD productions in a very controlled environment with little risk.

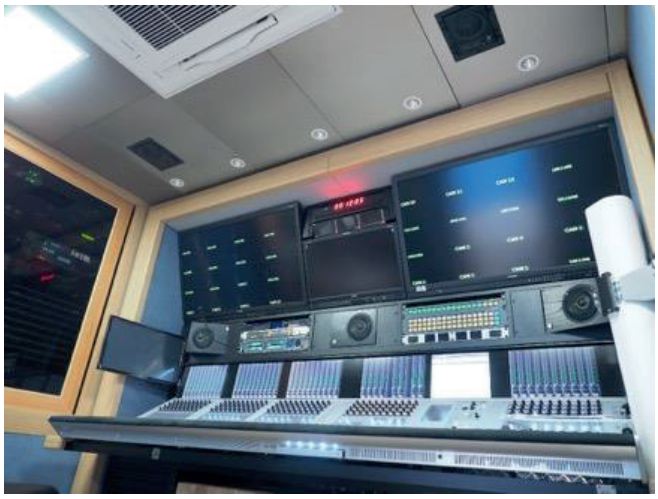

Figure 3. MBC's UHD OB van with immersive audio monitoring setup

The Koran government timeline requires the percentage of native UHD content to increase in three steps from 5% now to 25% in 2020, to 50% in 2025 and finally to 100% in 2027. In 2027 the HD service, currently operated in a simulcast, will be switched off. Although, the three major broadcasters in Korea might have different strategies how to fulfill the necessary quote of native UHD content, it is safe to assume that they will do a more linear increase of the native UHD content then the government requirement. And using the advanced audio features is part of their strategy. In the meantime, they have already started to implement immersive monitoring setups in control rooms and OB vans. Professional equipment from encoders, metadata authoring and monitoring units as well as test receivers are currently available. On the consumer side TV sets from Samsung and LG are on the market supporting the full feature set of the MPEG-H TV Audio System. Immersive soundbars supporting MPEG-H Audio from Samsung and Sennheiser were announced during the Consumer Electronics Show in January 2018 in Las Vegas. Thus, the complete end-to-end chain is available to allow broadcasters to make full use of the advanced features offered by the MPEG-H TV Audio System.

Currently the Korean broadcasters, CE manufacturers and government agencies are discussing the next system, a mobile TV service based on the ATSC 3.0 standard to replace the existing mobile TV service based on T-DMB. The audio side of this service will also be using the MPEG-H TV Audio System.

VI. Further Trials in Europe

Besides Korea, the MPEG-H TV Audio System was also successfully tested during the French Tennis Open in Paris, France, end of May 2018 [9]. During the tournament, France Télévisions provided a live UHD signal from the center court, which was transmitted using DVB-T2 for the terrestrial distribution and DVB-S2 for a satellite signal. The live signal consisted of UHD video and a 5.1+4H immersive sound bed for the court atmosphere and two objects for commentaries in French and English with three presets. The signal was on air 24h per day during the tournament with a live coverage during the matches and a replay loop with the matches from the previous day in between. The trial demonstrated how easy it was to enable MPEG H into a common remote production

Besides Korea, the MPEG-H TV Audio System was also successfully tested during the French Tennis Open in Paris, France, end of May 2018 [9]. During the tournament, France Télévisions provided a live UHD signal from the center court, which was transmitted using DVB-T2 for the terrestrial distribution and DVB-S2 for a satellite signal. The live signal consisted of UHD video and a 5.1+4H immersive sound bed for the court atmosphere and two objects for commentaries in French and English with three presets. The signal was on air 24h per day during the tournament with a live coverage during the matches and a replay loop with the matches from the previous day in between. The trial demonstrated how easy it was to enable MPEG H into a common remote production

VII. Conclusion

The MPEG-H TV Audio System offers revolutionary new features for the broadcasters and the viewers. It can be introduced in several phases into the broadcasting process and should therefore be considered for the first changing opportunity in the broadcast infrastructure, such as the upgrade from HD to UHD.

The MPEG-H TV Audio System has demonstrated its strength and maturity in regular operation in Korea for more than a year now. Successful DVB-T2/S2 transmission trial in France and streaming trial Norway demonstrated that the MPEG-H TV Audio System can also be used with other transmission standard then ATSC3.0. The necessary equipment on the professional side as well as on the consumer side is already available and the system can be used immediately.

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Stefan Meltzer studied electrical engineering at the Friedrich-Alexander University in Erlangen, Germany. In 1990 he joined the Fraunhofer Institute for Integrated Circuits (IIS) in Erlangen, Germany. After working in the field of IC design for several years, Stefan became the project leader for the development of the WorldSpace Satellite Broadcasting system in 1995 and in 1998 of the XM Satellite Radio broadcasting system. His team was responsible for the system design, chip set design, field trials and development of a reference signal generator.
In 2000 he joined Coding Technologies in Nuremberg as Vice President for business development, Germany. His responsibilities included broadcasting and consumer electronics. During his time at Coding Technologies HE AAC was accepted in numerous broadcasting standards and applications.
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Design of Stepped Impedance Microstrip Low-Pass Filter for Coexistence of TV Broadcasting and LTE Mobile System Close to 700 MHz

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Design of Stepped Impedance Microstrip Low-Pass Filter for Coexistence of TV Broadcasting and LTE Mobile System Close to 700 MHz

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Paulo Eduardo dos Reis Cardoso, Hermes José Loschi, Diego Pajuelo

***Abstract*— The evolution of mobile networks has demanded more frequency spectrum and in many countries part of UHF band previously allocated to TV broadcasting now is used to broadband mobile networks and is important avoid any interference caused by signals transmitted in adjacent bands.**

In the Brazil and in others countries the new spectrum is being assigned to Long Term Evolution (LTE) mobile networks at 700 MHz band that is close to the frequency spectrum used by TV broadcasting. In this context the paper presents a microstrip low-pass filter to be used into television and avoid interferences produced by LTE signals.

The proposed low-pass filter was designed using microstrip step-impedance method, fifth-order Chebyshev with ripple of 0.01 dB and cut-off frequency at 700 MHz. The designed low-pass filter was simulated using full wave simulator Ansoft HFSS. After simulation the low-pass filter was fabricated by photolithographic process in a FR-4 pcb. Finally, it was tested using vector network analyzer and the measured results presented a good agreement with the simulations.

***Index Terms*— filter, interference, microstrip, TV, LTE**

I. Introduction

THE fourth generation technology of mobile telecommunications, whose base is the standard 3GPP Long Term Evolution (LTE), and improvements in speed and capacity have been made available from telecom operators to customers, boosting the market to propose services and applications and they need more and more bandwidth.

This paragraph of the first footnote will contain the date on which you submitted your paper for review. It will also contain support information, including sponsor and financial support acknowledgment. For example, "This work was supported in part by the U.S. Department of Commerce under Grant BS123456".

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This requirement of bandwidth to use in mobile broadband telecommunications is feeding the debate among regulators and the according to the spectrum reforming process, currently is in progress all around the world [1] [2] [3].

As a consequence of these reforms in spectrum, the LTE is operating alongside broadcast applications (UHF TV channels) and potential coexistence issues might arise [4] [5] [6] [7].

This article proposes a low-pass filter to use in TV receiver that allow all frequencies up to 700 MHz to pass without influence on the TV signals to be received, while blocking all frequencies above 700 MHz used by LTE. The low-pass filter was designed in microstrip FR-4 pcb using step-impedance method, fifth-order Chebyshev with ripple of 0.01 dB and cut-off frequency at 700 MHz.

II. Design of Microstrip Low-Pass Filter

The microstrip filters are highly researched [8] [9] [10] and popular in design of filter at frequencies beyond of 500 MHz because of the difficult to realize filters with lumped elements that have predetermined commercial values and physical dimensions comparable with the wavelength of frequency operation of filter resulting in degrading of performance.

There are several ways to implement low-pass filters in microstrip and an easy way is use alternating sections of high and low characteristic impedance lines like inductors and capacitors and this filters are usually referred to as stepped-impedance, or hi-Z, low-Z filters [11] [12]. The Fig. 1 shows a general structure of the stepped-impedance low-pass filter in microstrip.

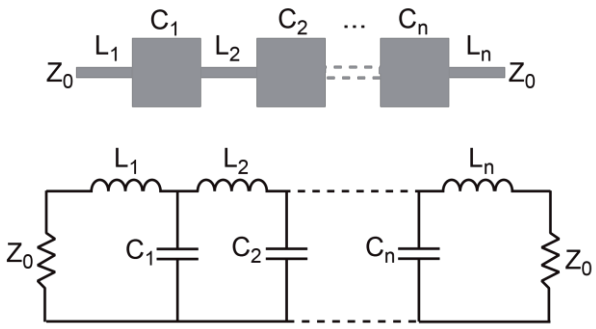

Fig. 1. Structure of the stepped-impedance low-pass filter in microstrip.

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The design of the stepped impedance low-pass microstrip filter is a well-known method [11] and basically consists to find the order of the filter, determine the filter element coefficients from the table, calculate the inductors and capacitors, and determine the values of lengths and widths of transmission lines are calculated using the effective dielectric constant.

To design the low-pass filter was chosen a low cost dielectric substrate FR-4 ($_r$ = 4.2 and *tan* = 0.02) with a thickness of 1.6 mm was used.

Thus, the low-pass filter was designed in microstrip configuration with the following specification:

Order: 5ª
Cut off frequency, f_c = 700 MHz
Dielectric constant, $_r$ = 4.2
Loss tangent, tan δ = 0.02
Pass-band ripple = 0.01 dB
Substrate thickness, h =1.6 mm
Approximation = Chebyshev
Input/Output impedance, Z_0 = 50

The initial dimensions were calculated and a model was made using the full wave electromagnetic (EM) simulator Ansys HFSS. In the software simulator the dimensions were parametrized and adjusted to better filter operation. The final dimensions of the low-pass filter simulated and manufactured are shown in Fig. 2.

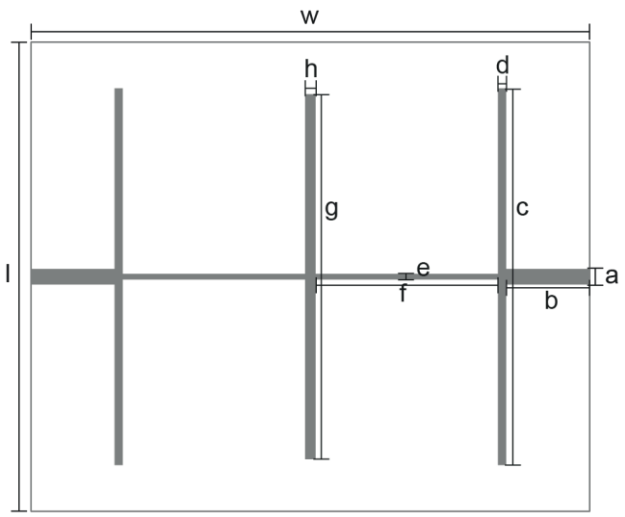

Fig. 2. Dimensions of low-pass filter: *a = 3 mm, b = 16 mm, c = 72.325 mm, d = 1.575 mm, e = 1.1 mm, f = 35 mm, g = 70.086 mm, h = 2.018 mm, l =90 mm , w = 107.168 mm.*

In order, the stepped-impedance low-pass filters have the advantage take up less space than a similar low-pass filter using stubs [11], therefore is a good choice to use in devices with limited dimensions.

The Fig. 3 shows the model built in simulator software with the magnitude of electric field.

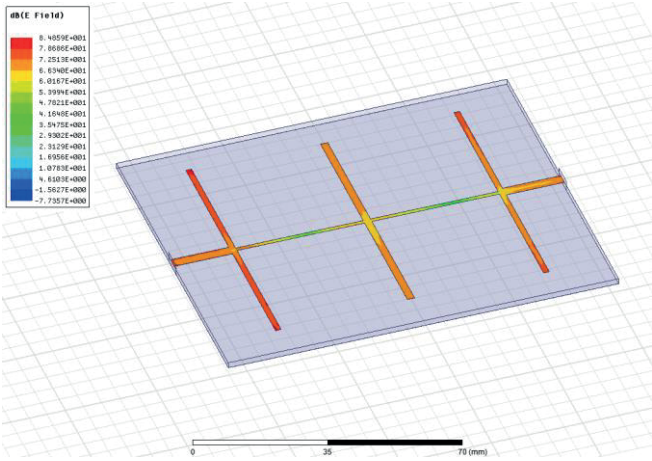

Fig. 3. 3D model of low-pass filter with magnitude of electric field.

III. Measurements and Results

Once we carried out all the simulations was manufactured a prototype using photolitography process that is standard in manufacturing printed circuit board. Fig. 4 shows the photograph of fabricated low-pass filter.

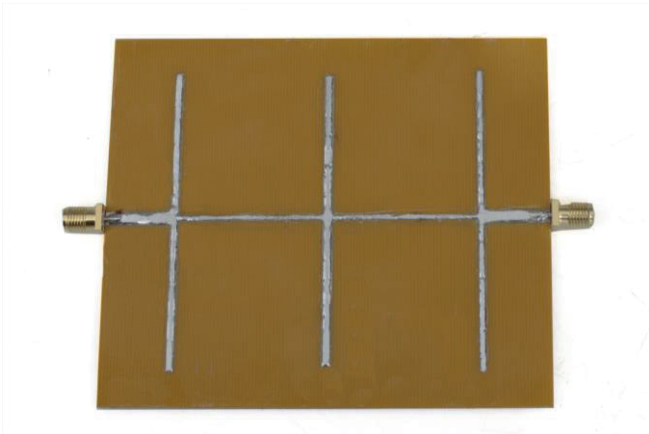

Fig. 4. Fabricated prototype of the low-pass filter.

The performance of the low-pass filter prototype was measured using vector network analyzer (VNA) to get the S-parameters as shows the Fig. 5.

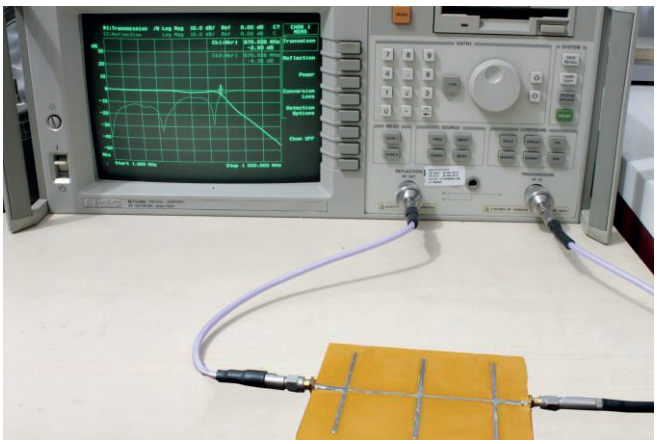

Fig. 5. Low-pass filter measurement with VNA.

Fig. 6 show low-pass filter scattering parameters (S_{11} and S_{21}) to the VNA measurements results and the EM simulation results.

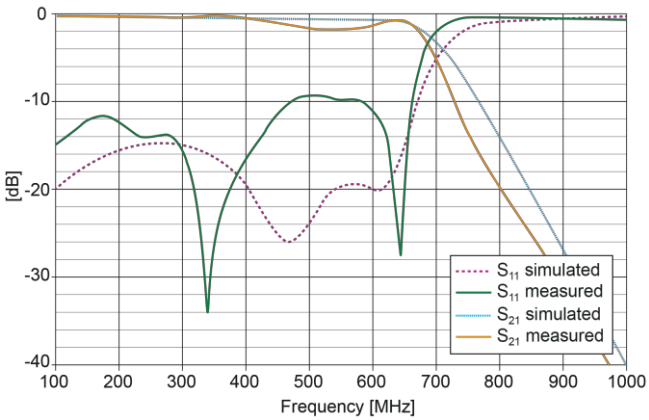

Fig. 6. Comparison of measured and simulated scattering parameters (S_{11} and S_{21}) of low-pass filter.

Measurements results show a cut-off frequency at 680 MHz, maximum insertion loss (S_{21}) of 1.7 dB at 540 MHz and stop band attenuation is better than 10 dB at 730 MHz. The offset of cut-off frequency of 700 MHz to 680 MHz can causes signal degradation of TV channels close to 700 MHz.

IV. Conclusions

A low-pass filter using microstrip on FR-4 PCB was designed using step-impedance method with fifth-order Chebyshev with ripple of 0.01 dB and cut-off frequency at 700 MHz. The proposed low-pass filter was fabricated and tested with vector network analyzer and shows good agreement with the simulations.

The low-pass filters presented a maximum insertion loss of -1.7 dB at 540 MHz that is admissible, but has impact on increasing the receiving system noise figure. The filter not has a sharp cut-off frequency and the measured results shows an offset of cut-off frequency to 680 MHz, therefore the TV channels close to 700 MHz will have an additional loss. But this offset of the cut-off frequency is due to FR-4 class material not have a specific value of $_r$ but it can be corrected by a preliminary characterization of the FR-4 used in the manufacture of the filter. Effects caused by parasitic capacitances and inductances and/or by adapters and connectors which were not considered in the simulations and may also affect the results.

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Proposal of a Medical Algorithm Based on the Application of Digital Image Processing and Visual Communication Techniques

Ana Carolina Borges Monteiro, Yuzo Iano and Reinaldo Padilha França

Abstract— Blood tests help detect various types of diseases, where the erythrocytes count (RBC) and leukocytes (WBC) can use automatic and/or manual methodologies. The evaluation of RBC and WBC has a direct impact on the diagnosis of anemia, leukemia, viral, parasitic and viral infections. Given the importance and wide applicability of the Watershed Transform (WT) and Morphological Operations (MO), they can segment medical images to increase the efficiency and reliability of medical diagnostics. This study uses a WT-MO algorithm for segmentation, detection, and counting of blood cells that attend the criteria of efficiency and reliability. This methodology may be the first step in making blood tests more accessible to people from developing and underdeveloped countries. The WT-MO algorithm has been benchmarked using 30 microscopy images of a blood smear. The WT-MO algorithm results presented high accuracy (93%). The simulations of the algorithm executed in different hardware platforms presented average simulation and processing time with less than 3 seconds per sample. Therefore, the WT-MO based algorithm is accurate, reliable and a low-cost technique, which can be applied as a third methodology to perform the laboratory tests and to speed up further medical diagnostic.

Keywords — Image segmentation, Watershed Transform , Blood cells, Image processing, Biomedical engineering, Soft computing.

I. INTRODUCTION

A. Image Segmentation

Often, image segmentation is the first step in general object recognition in many applications for identifying regions of interest (ROIs) in a scene or annotating the data [1] [2].

Image segmentation is an essential process for the image analysis task. The segmentation process consists in the act of fractionating an image into groups of spatially connected pixels homogeneously [3] [4].

There are many techniques for describing and recognizing correct image viewing, with image comprehension being a highly process dependent on the outcome of segmentation processing [3] [4]. There are many methodologies of image segmentation. However, the focus of this study is the Watershed Transform (WT).

The intuitive idea of the Watershed Transform comes from the geography: landscape of topography reliefs responsible for the formation of watersheds, these being divided into lines of domain aiming the attraction of rainwater over the region. An alternative approach is to imagine a landscape being immersed in a lake, with holes drilled in local minimums [5] [6].

In this way, the river basins fill with water starting at the minimum place, where the water meets barriers. When the water level is at the highest peak in the landscape the process is stopped. As a result, the landscape is fractioned into regions or basins separated by dams called basin hydrography lines. The image segmentation process presents wide applicability, being used to solve problems in several areas [5] [6].

There are many researchers about still image and video segmentation. These studies are wide and includes many techniques as motion-based segmentation [7][8][9][10], spatial segmentation and motion tracking [11][12][43][44], moving objects extraction [13][14][43][44], and region growing using spatio-temporal similarity [15][16]. Many of the existing segmentation techniques, such as direct clustering methods in color space [17][18], work well on homogeneous color regions but natural scenes are rich in color

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and texture. The existence of texture and motion can also be used to characterize pathologies.

The algorithms for image segmentation based on the WT [19] need a way of measuring the similarity or difference between pixels that form an image. So, the WT needs to be combined with some gradient of an image complex in scenes. One example of this is the MPEG-4 standard that needs segmentation to object-based video coding.

It is possible to associate different segmentation techniques to solve these image segmentation problems. The combination of morphological segmentation (MO) and the WT technique has been applied to improve sports scenes. This process consisted of coarse segmentation by binary reconstruction based on the areas detected by thresholding the color histogram and segmentation by WT. This process results in segmentation image sequences in sports scenes containing brisk movement. That is an important feature in automatic morphological segmentation during broadcast [20].

Other studies showed that the WT works quite well for image segmentation. The WT technique computes the dissimilarity of pixels using RGB-D cues and gradient maps, where an RGB-D image is a combination of an RGB image and the corresponding image depth map. The process captures an image gradient map to enhance and explain directional variations in image intensities. A distance function or metric measures the similarity between adjacent pixels according to RGB-D values [21].

Due to the importance and wide applicability of the WT in image segmentation regardless of the dimensionality of the image space, and applying the essence of the multidisciplinarity of scientific research. So, the application of the WT in biomedical engineering can help the development of better blood diagnosis algorithms.

B. Blood Cells

The human blood consists of approximately 55% plasma and 45% blood cells. The blood cells that compose the blood are erythrocytes, leukocytes, and platelets [22] [23]. The cells are responsible for the homeostasis of the organism (through the transport of gases), organism defense against distinct etiological agents, tissue repair, and blood coagulation. However, such observations could only occur through the invention of the optical microscope [23].

Through observations in optical microscopy, biconvex disc-shaped structures with no cell nucleus were visualized. These cells were called erythrocytes. Its main function is the transport of gases by the organism [24] [25].

Leukocytes are the defense cells of the organism, being morphologically characterized by the presence of segmented nuclei in lobes and the presence of granules [26]. The leukocytes are divided into 5 cell subtypes: neutrophils, basophils, eosinophils, monocytes and lymphocytes. These cells present morphological differences according to the function performed such as the defense of the organism against external agents such as bacteria, parasites, and viruses [27] [28].

Over time, the study of blood cells was restricted to just the observation of cell morphology began to use specific methods. However, new technologies do not negate the need for conventional microscopy. This new methodology responsible for the analysis of blood cells was called hemogram [28] [29].

The hemogram is a laboratory exam for the quantification and qualification of blood cells [8]. In this exam the erythrocytes should be expressed between 4.0 to 6.0 x 106 /mm³ of blood. Values lower or higher than this parameter is indicative of genetic anemias or deficit of food, leukemias or polycythemias [30].

Commonly, the total leukocyte count should be between 3.500 and 10.000 leukocytes/mm³ of blood. Changes in this value may be indicative of leukemias, sedentary lifestyle, skin infections, stress, bacterial infections, HIV, among others [27] [28] [30].

Today's importance of hemograms demands new technology from the field of biomedical engineering [31]. The MATLAB© software contains several toolboxes with algorithms that have broad applicability such as the Watershed Transform, and the Morphological Operations (MOs). Initially, this work segments images by labeling pixels, and detecting objects corresponding to specific stain patterns [32] with the objective of identifying blood cells based on their morphological characteristics. Hence, this algorithm may automate the count of blood cells.

This work is organized as follows. Section II discusses the traditional methodology. Section III describes the proposed method. Experimental results appear in Section IV. This manuscript concludes with Section V.

II. TRADITIONAL METHODOLOGY

The quantification and qualification of the blood cells are performed by an examination called hemogram. This exam is currently performed through two methodologies: manual and automatic [29].

The manual hemogram depends entirely on human performance, and it uses non-automated equipment relying on either a blood smear sample or a hemocytometer using a standard optical microscope. This work handles the manual blood count from a blood smear to determine the number of blood cells, where the blood smear was obtained by depositing a few microliters of blood on a glass slide. The monolayer regions are mechanically scanned for counting the total number of cells.

The specimen can either be seen directly over the microscope or from image files. Even though the manual technique is more laborious and time-consuming, it allows the use of several objective lenses for the standard microscope for high-quality, inexpensive, and careful visual examination of the samples.

This methodology presents a lower cost but requires more time for the release of reports. Besides, it gives less reliability because it depends on manual counts and calculations performed by health professionals. It is considered a good alternative for small laboratories, where the demand for exams is low, and the cost with the acquisition with hematological equipment and reagents does not match the cost-benefit of the process [29]. A common shortcoming of the manual counting method is its error due to the way the specimen is observed. A standard microscope performance is influenced by its space-bandwidth product, leading to a trade-off between the image resolution and the microscope Field-of-View (FOV). Generally, to view and count blood cells under a conventional microscope, an objective with an adequate magnification. However, in manual methods, the FOV is very small, which necessitates mechanical scanning of the specimen during the counting process. This setting is unfavorable because the scanning movement has to be correctly aligned and regulated to bypass any overlap of the regions undergoing scanning. Another disadvantage is the physical strain on the professionals performing the manual scans by direct observation of the microscope, which may be detrimental to the physician diagnostic.

The automation of the hemogram implies greater agility in performing the exams and in the release of reports. However, it is a more expensive methodology when compared to the manual methodology. Automation is based on impedance and flow cytometry methods for the differentiation and counting of blood cells [6][28] [33].

However, before acquiring a hematological equipment's it is necessary to take into consideration the following parameters: automation equipment's versus the type of patient attended; demand for daily exams, cost of each exam, interfacing and training of employees [6][29].

It is important to emphasize that even with the acquisition of hematological equipment, the manual hemogram is not a dispensed practice. Manual hematology is a recommended technique for confirmation of hematological findings, such as pediatric patients, patients over 75 years of age, cancer patients, patients with suspected leukemia or polycythemia, patients with leukocytosis and patients with severe state of hospitalization in Intensive Care Unit (ICU) [29].

III. WATERSHED TRANSFORM WITH MORFOLOGICAL OPERATIONS (WT-MOs)

The experiments were conducted through digital images acquired by the camera coupled to the optical microscope to obtain images of blood smears. The fields of the blood smear contained erythrocytes and leukocytes in different sizes, colors, and quantities.

The system modeling, as well as the program, were implemented using an IDE the MATLAB® version 2014a. In this environment, image segmentation algorithms were developed for counting and detection of erythrocytes and leukocytes.

The algorithm developed has as an emphasis the image segmentation process through of the union of WT techniques and morphological operations. The detection and counting of erythrocytes were performed through the WT, while the counted leukocytes were the result of the morphological operations process.

The counting and differentiation processes of these cells are performed based on the morphological characteristics of the blood cells. The logic of the algorithm is shown in Figure 1.

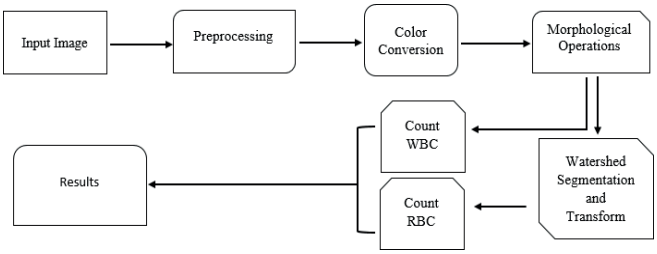

Figure 1 Block diagram for the WT-MO algorithm

A. Erythrocytes Counts

The segmentation process consists in the act of fractionating an image into groups of spatially connected pixels homogeneously [34][35]. Image segmentation can be used alternatively as a pixel labeling process, where all pixels belonging to the same homogeneous region are marked with the same label, as shown in Figure 2 [35] [36].

The definition of homogeneity of a region of the image presents a particular concept of the segmentation process because each image presents its pattern of pixels [32] [37].

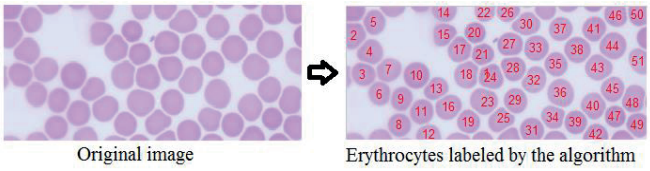

Figure 2 Erithrocytes labeled by the Watershed Transform

For the labeling of erythrocytes, the pixel is assumed as a variable directly related to the morphological characteristics of the cells under analysis. In that case, the labeling would consider the size and staining of erythrocytes [32].

C. Leukocytes Counts

Morphological Operations (MOs) constitute a broad set of image processing operations based on the shape of binary images. The morphological operations are applied to the structural element at the input of an image creating an output of the same size, as shown in Figure 3 [36] [37].

In this way, the value of the pixels in the image output is based on the comparison of pixels corresponding to the pixels of the image input and neighboring pixels. The number of pixels added or removed from objects in an image depends on the size and format of the structural element used to process the image. Morphological operations consist of the following steps: dilatation; erosion; opening; closure and reconstruction [36][37]. The dilation consists of adding pixels to the edges of objects in an image to the purpose of repairing breaks or possible intruding elements in the image. Erosion, in turn, consists of the removal of pixels from the edges of the image, being used to divide bound objects or remove extrusions. The aperture is applied for the elimination of protrusions and/or smooth contours [19]. In turn, the closure is used to merge fine and long gaps and gaps, eliminate small holes, and fill spaces in the contour and smooth out the contours. The reconstruction is responsible for extracting relevant information referring to the shapes present in the image [19].

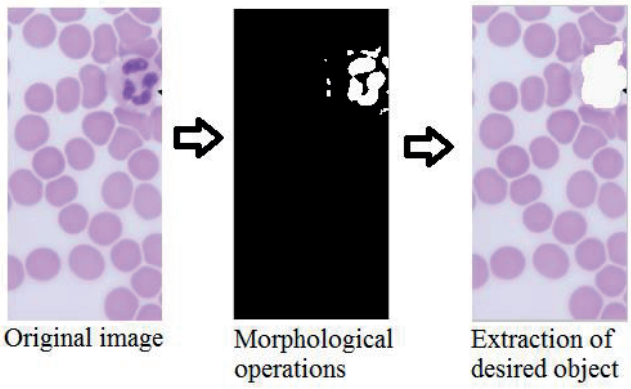

Figure 3 Leukocyte count by the WT-MO algorithm

IV. RESULTS

Thirty microscopy images containing a total of 6453 erythrocytes and 187 leukocytes served as benchmarks. Both cell types were automatically and manually counted, with subsequent counting by the algorithms of detection and counting of blood cells. Subsequently, the results were compared to determine the accuracy of the WT-MO approach, according to Figures 4 and 5.

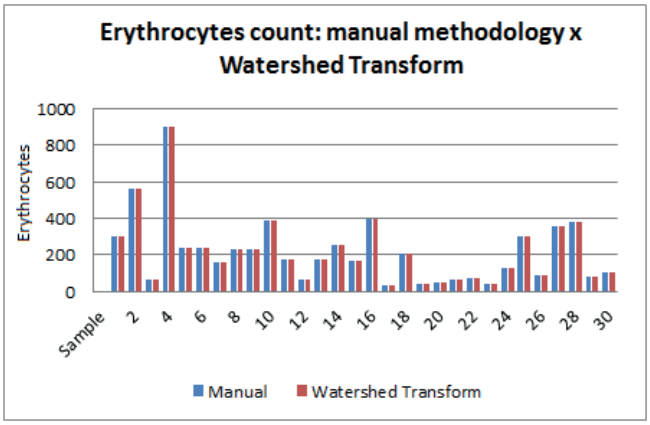

Figure 4 Comparison of the erythrocyte counts by the manual method with the automated counting using the

Watershed Transform

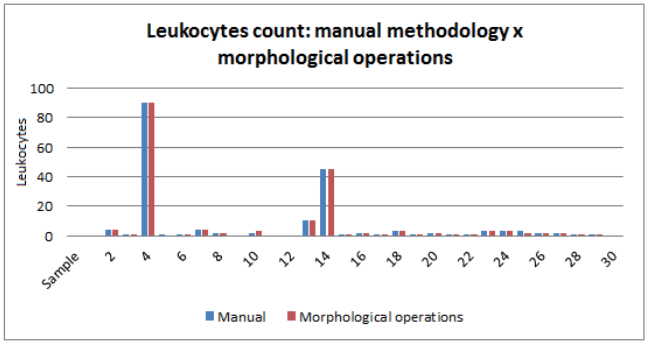

Figure 5 Comparison of the leukocyte counts by the manual method with the automated counting using morphological operations process

The comparison of the manual methodology of cell counting with the developed algorithm demonstrated an accuracy of 93% in the detection of erythrocytes and 90% in the detection of leukocytes.

The developed procedure was also submitted to evaluations of runtime and execution time. For this, executions of each command were realized in machines with different hardware configurations, consisting of a Dual Core processor, with 2GB of RAM, an Intel Core i3 processor, with 4GB of RAM and an Intel Core i5 processor with 8GB RAM.

The `tictoc` MATLAB© command measured the time spent by each of the algorithms during their execution (in seconds). The algorithm also used the `cputime` command, whose function is to return the total CPU time (in seconds) since the moment it started [38] [39] [40].

The `tictoc` function measures the algorithm execution time. The `cputime` function calculates its computational time [39] [40]. Figures 6, 7, 8, 9, 10 and 11 present the performance and efficiency of the algorithm.

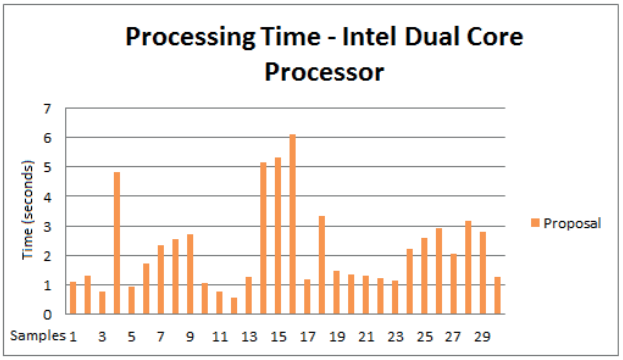

Figure 6 Processing times in a Dual Core processor

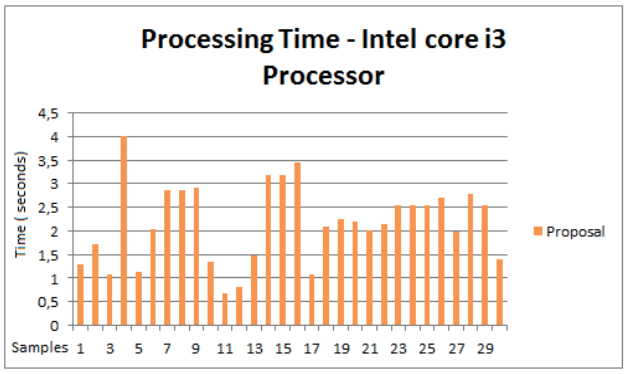

Figure 7 Processing time in Intel Core i3 processor

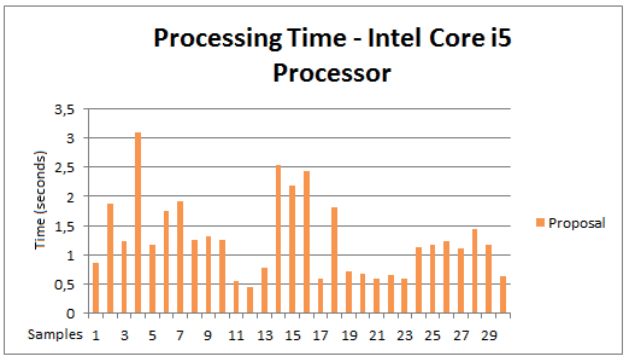

Figure 8 Processing times in Intel Core i5 processor

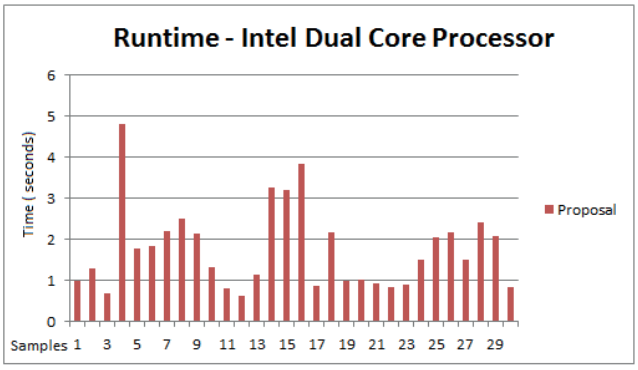

Figure 9 Execution times for the Dual Core processor

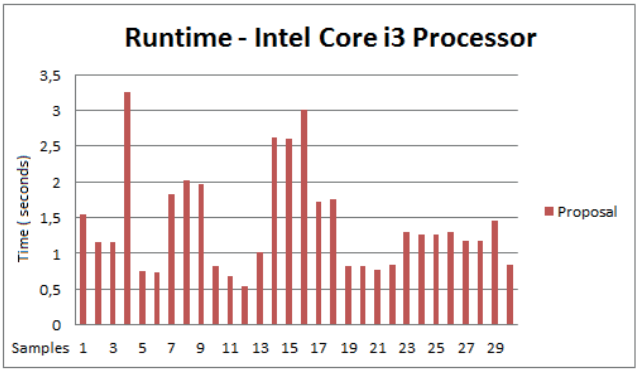

Figure 10 Execution times for the Intel Core i3 processor

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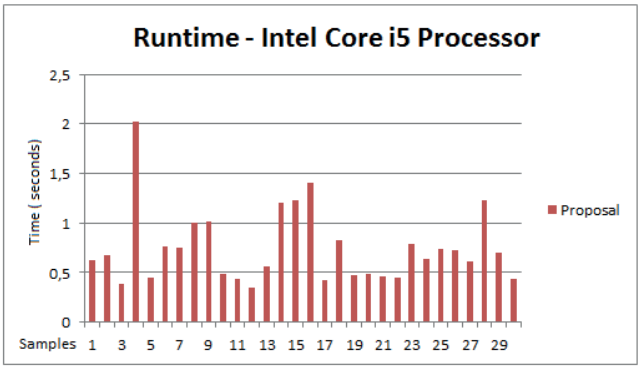

Figure 11 Execution times for the Intel Core i5 processor

An execution time of 3 seconds per sample makes this approach better than the one in [39]. Figure 12 shows the average times to run the proposed algorithm in the Dual Core processor, Intel Core i3 processor, and the Intel Core i5 processor.

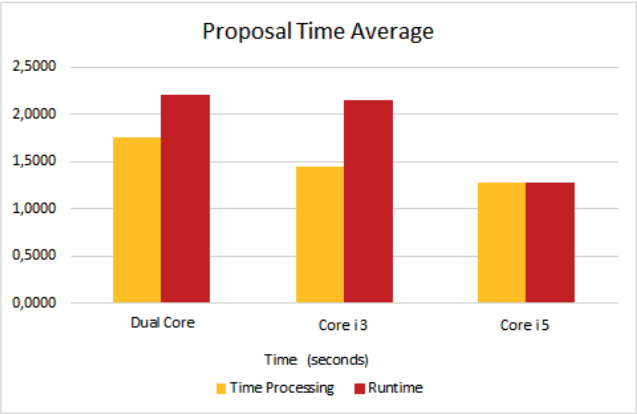

Figure 12 WT-MO algorithm average time

V. CONCLUSIONS

Performing clinical laboratory tests is a distant reality to some healthcare facilities in underdeveloped and developing countries, especially in remote areas. Furthermore, even in developed regions, automated clinical tests can bring more safety to patients and healthcare professionals.

This work introduced the Watershed Transform and Morphological Operations (WT-MOs) algorithm, which delivered results, in all analyzed scenarios and with all samples, with better execution and processing times when compared to other papers. The good performance of the proposed method in different hardware platforms indicates that it is feasible for the different laboratory realities.

The automated confirmation of the diagnosis and the accomplishment of laboratory tests provide higher reliability of the results to both health professionals and patients because the computers reduce the chances of human failures.

The creation of new methodologies, such as the one presented in this paper, results in a considerable reduction in equipment costs without loss in quality and accuracy of hematological diagnoses.

This study is a first step towards the realization of a fully automatic blood cells segmentation and classification subsystem of a computer-aided clinical platform that can deliver telemedical care for remote and hard to reach places [45][46].

In the future, Content-Based Image Retrieval (CBIR) systems can integrate and handle information about blood cells count and fuse it with other image modalities [45][46]. It is worth considering that the development of low-cost mobile microscopic devices can significantly improve the successful deployment of computer vision-based medical diagnosis solutions. Smartphones are now very likely health diagnosis and treatment platforms in poverty-stricken areas.

The image acquisition capabilities and processing power of mobile devices can reduce the effort for exhaustive and time-consuming microscopic examinations. Additionally, less specialized professionals with knowledge about the telemedicine system and preparation of blood smears can supplement the lack of highly trained microscopists in rural areas. The use of mobile devices can also bring important improvements in healthcare portability and biomedical data transmission.

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Contemporary Audiovisual Experiences

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Abstract - Reflecting on real-time imagery and sounds experiences is thinking about a wide range of possibilities and experiences for humanity, from the earliest times. Because the real-time audiovisual experiences are numerous in time and space, and already widely quoted in different studies, this presentation aims to make a more restricted cut off to real-time audiovisual experiences in the contemporary cinematographic field: an art, medium and an expanding process that culminates in the existence of a semiotic phenomenon, performed mainly through experimental modes, not necessarily with the presence of performers in front of the screen, but mainly with the presence of the author(s) directing the audiovisual experience in real-time, together with the technological apparatus, the cast, and the viewers, all participants in the editing and exhibition of the audiovisual work at the same time as it occurs, in direct transmission to the cinema screen, monitors, digital screens or architectural spaces. Based on audiovisual works carried out between 2007 and 2017 we will develop a reflection and analysis of the poetic and techniques of audiovisual experiences in real-time. In order to understand with a closer look the possibilities of creation in live cinema and contribute with reflection on these forms of the contemporary audiovisual, whose means and processes are in continuous expansion of its borders. In aesthetics of the cinema, this research follows in continuity to the studies and practices of the experimental cinema, and in its vertex to the expanded cinema.

***Keywords* -** Experimental Cinema, Expanded Cinema, Live Cinema, Audiovisual Experience, Real-Time.

Introduction

The real-time audiovisual is as stimulating as it is unpredictable. The possibility of invention and communication in the present time in which information occurs, the incorporation of available technical media, the exploration of times, spaces, combinations, repetitions, colors, sounds, movements and technologies point to the emergence of new perceptions and sensations through images and sounds. All this is permeated by improvisation, where an error can become an instrument for creation and the new appears in an unpretentious way, favoring other perspectives on language.

Reflecting on real-time experiences with images and sounds is to think of a wide range of possibilities and experiences for humanity, from the earliest times. Such experiences arise in the distant age of fire with the theater of shadows. In the Middle Ages, rudimentary projectors, popularly called the magic lantern, projected images etched into glass in sequence through the light of the fire inside an iron box. In more recent times, we can consider the emergence of cinema in the late nineteenth century as real-time audiovisual experiences, when movie films were manipulated by projectionists creating different narratives in each session, as well as the sounds and music of films were created by live musicians in the projection rooms during this period. This process can be traced with projections in the theater from 1910 to 1920, and live television from the mid-1930s, as well as the videogames that remain at the forefront of real-time experimentation and the internet that processes these arts and enables images and sounds to be manipulated and transmitted without the need for heavy load television industry, as well as other experiences such as videomapping: projecting on architectural surfaces, audiovisual performances and vjing on the music and theater scenes.

Because those real-time audiovisual experiences are numerous in time and space and have already been widely quoted in different studies, I intend in this article to cite the audiovisual experiences in the field of contemporary expanded cinema.

One reason for this is the difficulty in describing exactly what real-time audiovisual experiences are in the cinema and what constitutes this recent area of study and experimentation, also called live cinema.

In the artistic field, live cinema is unstable and associated mainly with the presence of a performer handling, mounting or remixing images and sounds near the screen in the space of the projection, but this art can also utilize the internet and the direct transmission of images and sounds via link or streaming for its realization.

In this article, the term live cinema will be understood as an art and a process in expansion that culminates in the existence of a semiotic phenomenon, realized mainly through experimental modes, not necessarily with the presence of performers in front of the screen, but mainly with the presence of the author(s) directing the experience in real-time. Together the technological apparatus, the cast and the audience, all participants in the montage and exhibition of the work at the same time in which it occurs, in direct transmission to the cinema screen, monitors, digital screens and architectural spaces.

Thus, live cinema takes place under the aesthetics of cinema and the subjective experience of the audiovisual work is realized through the confluence of the technical and poetic devices of the images and sounds created live.

Development

The interest in this area of research is due to practical experience in this area.

In the last ten years I have participated in several scenic and audiovisual works that uses video projection on real-time. Between 2007 to 2011, I participated in the renowned group Teatro Oficina, projecting videomapped audiovisual during the theatrical plays.

Between 2011 to 2016, I was invited to join the real-time video teams for different theatrical companies, among them *Cia Falbalá, Cia Livre*, *Doutores da Alegria* and *Teatro de Narradores*, in all of them performing VJ and audiovisual creation and production for live stage plays.

In common with the work for these five theater companies were the various audiovisual experiences during the creative

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process, presenting film proposals and complementing the audiovisual work previously performed by the artists in real-time.

In addition to my audiovisual experience in the theatrical scene, I am a screenwriter and experimental film director, with short films shown at festivals and televisions around the world, among them: *The Shortest Love in the World* (2008), *Fishing up Shit* (2009), *The Okra Planter* (2010), *Infra-Region* (2013) and *Underground Odete* (2017).

Since 2012, I've directed *Cine-Cicletada* [Cine-Cycling]: an annual film festival that takes place in São Paulo and mixes open air cinema, cycling and audiovisual experiences in real-time.

My experience with the cited crossing areas of audiovisual have led me to reflect on the linkages of images projected in live cinema, exploring modes of association of the most varied possible.

The reason for presenting this research on live cinema and contemporary audiovisual experiences in real-time in this artistic area is also due to the fact that theories of knowledge recognize that there are at least two basic modes of knowledge of reality, one obtained from its singularity and another from a practical nature.

For the formulation of a concept of experience that is related to the audiovisual in real-time and helps us to understand the present research object as a semiotic phenomenon, we will relate to the word experience always associated with poetic and semiotic issues that occur through of the senses, especially those of vision and hearing, necessary experience for the identification of the object *live cinema* as an experience in arts.

As the relationship between art and experience is well exemplified by Maurice Blanchot in his book *The Literary Space*:

> In common is the idea that art is experience, because it is a research, not indeterminate but determined by its indeterminacy, and which passes through the whole of life, even if it seems to ignore life (BLANCHOT, 2011).

Amongst a color, an image, a video, a photograph, an animation and a real-time montage, there would be an existential communication that would constitute a moment that is not representative of sensation. Therefore, it would be up to the audiovisual artist to identify a kind of unity of the senses and to make a multiple figure appear. This operation is only possible if the sensation of this or that domain (here, the visual and sonorous sensation) is directly captured by a vital power that overflows all the domains and traverses them. The power found in the spectator is the rhythm, deeper than the vision, the hearing, etc.

Deleuze continues that: "the last hypothesis, therefore, is the relation of rhythm to sensation, which places in each sensation the levels or domains through which it passes" (Deleuze, 1992).

Traditionally, in cinema, history is the central element of films, and mainly produced by the technique of montage. It was the russians, led by Lev Kuleshov, who first theorized the assembly and regarded it as essential for cinematic language. Russian filmmaker Sergei Eisenstein, a former student of Meyerhold, followed in Kuleshov's footsteps by exploring the expressive qualities of the montage, and experimented with different types of editing techniques, which he separated by mounts: intellectual, metric, rhythmic, tonal, overtonal.

Umberto Eco, in the book *The Open Work*, mentions that

> to capture and to put on the air an event at the same instant that it occurs puts the audience in an montage - an improvised editing and simultaneous to the fact captured and edited. Filming, Editing and Projection, three phases that in the cinematographic production are very distinct, each one of them endowed with their own physiognomies, are identified here. This derives the identification of real-time and television time without any narrative expedient reducing the time duration, which is that of the transmitted event. (ECO, 2008)

Live cinema can be defined as trying to make visible images that are not visible. The live image here has a close relation to the sensation: it is necessary that an image is exerted on a body, on a receiver, so that there is sensation, in direct transmission to the event narrated.

The definition of "live", for example, reflects the realization of a performance, heard or seen, in the time in which it occurs, and differentiated from that recorded on film or tape. This definition reflects the need to define the concept of the term by its opposition. And the need to separate what is recorded and what is live comes after the advent of sound recording techniques in the late of 1890s. As recording technologies brought the "live" into existence, this also reinforced the primacy of existing performance modes. Live and recorded performances coexist clearly as distinct, complementary experiences, requiring particular effort to distinguish them.

According to Gene Youngblood, author exponent in the expanded cinema:

> In real-time multiple-projection, cinema becomes a performance art: the phenomenon of image-projection itself becomes the "subject" of the performance and in a very real sense the medium is the message. But multiple projection lumia art is more significant as a paradigm for an entirely different kind of audiovisual experience, a tribal language that expresses not ideas but a collective group consciousness. (YOUNGBLOOD, 2001)

In audiovisual, the person in charge of the editing of a real-time experience can be considered by the functions: director of cut, director of image, editor, video operator, or VJ. As for the projected sounds, the real-time sound editor can be the sound director, audio director, sound editor, sound operator, or DJ.

These audiovisual professionals project situations in the present tense and bring a direct contact with the public in time and space through the visual, sound and rhythmic narratives that only the subtle presence of temporality and the mastery of technique reach.

The term VJ goes beyond the simple act of presenting video clips on television, a term that was popularized by MTV from the 80's. VJ's culture had already been present in the the experiences with expanded cinema and video in the 60's, and invades the nightclubs, dancefloors and raves parties in the late 1970s. Vjing is currently used as technique and poetic by visual artists worldwide who design real-time video in music concerts, electronic parties, digital interventions, virtual environments, live cinema, theatrical plays, videomapping, audiovisual performances, live

cinema, among other means and processes in real-time. Reinventing expanded cinema, but unlike the artists of the 1960s, the concern is more about providing a visual identity to the places where they present themselves, often creating narratives from the effect catalogs presented by the software.
It is within the context of expanded cinema, live television and vjing that live cinema arises and can even use the same equipment such as cutting table, midi keyboards, cameras, real-time editing software and laptops.
Among the various possibilities offered in expanded cinema in the last 10 years, we will focus on the works performed as an audiovisual experience, where we find constituent elements of this expanding art, in order to understand how the poetic and techniques of the audiovisual systems enable the existence of live cinema.

Okra Filmes: Cine-Cicletada

The Cine-Cicletada Film Festival, has taken place in Sao Paulo city annually since 2012, mixing open air film projections, cycling and real-time audiovisual experiences in different places at the city, and it is produced by Okra Filmes – a film company focused on videomapping and filmmaking.

The audiovisual projection at this festival always looks for national and international short films and the curation is guided by social themes, such as: urban mobility, environmentalism, human rights, homage to tortured and persecuted politicians, occupation of space, indigenous land, etc...

During the editions of Cine-Cicletada in 2016, we realized beyond the national and international short film sessions, some real-time audiovisual experiences, live cinema sessions, direct broadcasts to Brazilian Cinematheque in April, and to Sesc Santana in October, which we will see in more detail below.

Figure 1: Bikers arriving at the Brazilian Cinematheque during the 1st Cine-Cicletada. Photo: Ramiro Fernandes Garcia

6th Cine-Cicletada, April 2016

At the invitation of the São Paulo City Human Rights Office, we held the sixth Cine-Cicletada festival on April 8, 2016, with projections in the Ibirapuera Park and Brazilian Cinematheque, we were able to explore live cinema art. That began with a projection, through a camera connected to a cell phone via internet recording the images of the cyclists and participants starting from Paulista avenue, until the end of the route, with a stop at Ibirapuera Park for short movies screening, and also Doi-Codi, a civil police station that served as the military's torture against activists and political enemies during a military dictatorship.

This real-time audiovisual experience was projected on the external screen of the Brazilian Cinematheque, with spectators watching the on-screen experience, while the other audience of about 200 cyclists participated actively in the experience as an integral part of the dramaturgy. This was also exhibited on the internet through the IPTV website of USP, coordinated by educator Prof. PhD Almir Almas.

During this experience, I directed in partnership with Andrei Moyssiadis while filming and pedalling with the riders participating in the streets of Sao Paulo.

In the editing of the film's exhibition in real-time, Andrei Moyssiadis also made a cutting direction in the technical cabin installed in the Brazilian Cinematheque. The main editing in this case, happens during the cinematography of the cycling tour in continuous plane. The live sound was being operated by the musician Luiz Romero, and a soundtrack performed with brazilian songs remixed between different artists.

Figure 2: Live Cinema at the Brazilian Cinematheque during the 3rd Cine-Cicletada. Photo: Marcos Finotti

7th Cine-Cicletada, October 2016

On October 12, 2016, ocurred the seventh edition of the Cine-Cicletada film festival, following the invitation of Sesc in Sao Paulo, with a theme on the occupation of public space.

On this occasion, we projected a live broadcast from the cycling to a led screen installed at Sesc Santana unity, with a duration of approximately 60 minutes. In this experience I conducted the direction with Andrei Moyssiadis. The images were being recorded live by three videographers via Iphones and streamed to an image-cutting table edited by Nando McPhild simultaneously.

With the audio we made other experiences and the musician Tatá Aeroplano made a remix of songs interpreted by brazilian and international musicians, as well as remix of jazz, blues and sounds recorded before 1940, constituting multiple sounds in references and sonorities.

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During this live movie, a detail to be noted: the presence of the clown character Pilequinho, played by the actor Venicio Toledo, during an activity with the participants, transformed a direct transmission in a comic play. Every moment the clown appeared on the scene, with a performance based on mimicry, he stood out in the crowd of cyclists who accompanied the festival. And the gags, costumes, grimaces, performances and improvisations created new situations to add in the dramaturgy of the live cinema.

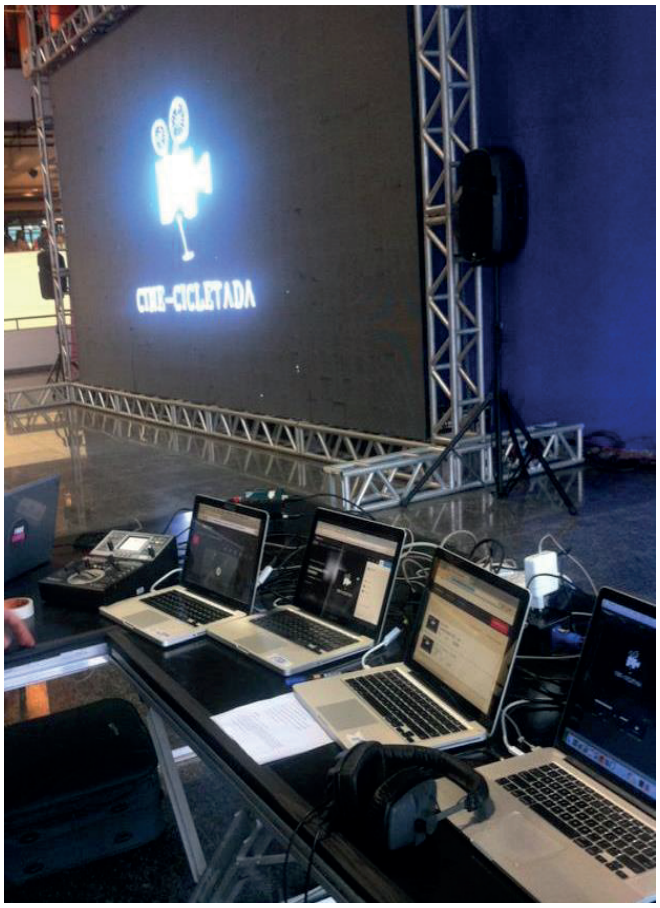

Figure 3: Broadcast at Sesc Santana during the 7th Cine-Cicletada (2016). Photo: Nando Mcphilld

The transmission began with the cyclists already near the Pacaembu Stadium, towards Sesc Santana.
This experience in October 2016 can also be considered an innovation by joining the practice of cycling, with three cyclists-cameramen, that allowed the direct transmission of the three cameras to the technical center by internet, the same to a television station, in addition to the projection with cinematographic aesthetics for cinema screen.

Figure 4: Live Cinema at Sesc Santana during the 7th Cine-Cicletada (2016). Photo: Marcelo Siqueira

Conclusion

From the examples mentioned, we observed audiovisual experiences in real-time, which reflect a possibility of the expanded cinema, making the existence of live cinema possible, mainly by the editing in real-time, either through images in sequence planes, or with the live editing between two or more cameras simultaneously to the narrated dramaturgy.
Thus, the poetic of live cinema is applied in continuity to the theory of the montage, but in this case the three items necessary for cinematographic realization: Filming, Editing and Exhibition occur simultaneously through the direct transmission to the projection media in the physical space, through screens, monitors, led screens, computers, cameras or cell phones, or even videomapping for architectural surfaces.
The thinking capacity of live cinema is partly allocated in their equipment, since without them (and in the absence of some other equivalent technical resource) it would not be possible to design digital audiovisual content at the same time as the image and sound material was realized.
For a live film to be performed, a main path is needed: the subjective identification of the viewer with the images and sounds projected on the movie screen.
In the technical part, for the phenomenon of the live cinema to occur, most of the previous combinations are necessary between the videographers, the cast, the editor and the exhibitor. The entrances and exits of the plans can be punctuated by very specific markings, either through radio monitoring, or combinations simulating a virtual control over the images in an instant, to make the technical device (cameras, videographers, cutting table, projectors) invisible to the audience, or even showed. The relative fluency in the equipment is part of the strategy of the visual artists to master the execution of the cinematographic work.
Since it is the dramaturgy that seizes the scientific media of contemporary communication, the full development of live cinema takes place through the creative potential of the performing team, the cast, the cinematographers, the technician, the editor, the director, the vj, the writer, the producers, every one is creative in this process, with a special conduction by the autor of the play, or a collective, that can be on direction in different parts of the play in the same time.
The need for experimentation by the audiovisual artists allied with technological evolution makes the *live cinema* becomes an art in construction, and has been practiced by different artistic groups, even if not yet cataloged by specific genre, since it exists in historical continuity to the expanded cinema and the practices in audiovisual contemporary field. This research in live cinema has the main objective to promote and value this kind of audiovisual practice by different artists and researchers of experimental cinema and expanded cinema in real-time all over the world.

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Automating and Simplifying Multiparty Workflows

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Automating and Simplifying Multiparty Workflows

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Abstract - Any broadcast organization that remains static runs the risk of being overtaken by newer, more agile alternatives. To remain competitive, broadcasters must constantly work to increase process velocity, accuracy, and flexibility. These goals cannot be reached without reducing time to market, manual touch-points, and associated labor costs. A major hurdle on this road to efficiency is the absence of a universal method to identify content, resulting in unnecessary manual workflows and time- and resource-consuming communications with third parties for the production, processing, and exchange of content. Root causes for these impracticalities include problems with work identification during acquisition, reconciliation, and de-duplication of assets obtained from multiple sources; placing high demands on limited resources; and causing delays or reducing content capacity. A necessary element to solve this problem is the use of globally unique and persistent works identification. As such, it will open the door to quasi-instantaneous, metadata based, machine-to-machine processes. A well-designed ID will include content and video service identifiers. Its architecture will also allow the embedding of other IDs such as pre-existing, in-house, local, application-specific, third-party, or content-rich commercial identifiers. Whether for feature films, episodic series, or even sports, significant benefits can be found by leveraging a unique ID recognized throughout the workflow and by all partners from content origination to processing, enrichment, storage, distribution, measurement, and attribution. In this paper, we explain the desired structure of identifiers plus their positive impact on workflows and speed. Finally, use case examples will demonstrate real-world applications.

CONTENT MANAGEMENT CHALLENGES IN BROADCASTING

Broadcasting is an unforgiving, real-time environment where the show must always go on, and the VOD or EST catalogs must always remain well stocked – dead air is simply not an acceptable option. Operational considerations abound: asset management for both acquired and locally-produced content, collating and presenting guide data, audience measurement, language versioning, VOD and ancillary digital distribution channels beyond initial broadcast, content archiving and retrieval, contract compliance, etc.

Live event broadcasting raises the ante by eliminating the delay between content creation and public presentation. Sports broadcasting is more challenging still, combining all the normal broadcasting attention points with the immediacy of live event programming (variability in start times and durations, weather and other delays, groups as participants, late changes to participants, etc.) and the special nature of sports programming (local blackouts, regional presentations, multiple productions of the same competition, frequent repetition of past matchups, frequent reuse of clips, sharing clips and content among broadcast competitors, etc.).

Why Identify?

None of the above is practical without a means to identify content as it moves along the production, storage, modification, and distribution chain.

This is just a modern example of the problem of naming things. If there is no name for something, you cannot talk about it. If you are working with someone else, the two parties must have either a shared name or a way of translating each other's names. If neither of those is present, no exchange of information is possible.

To remain financially competitive, all broadcasters must undertake continuous process improvement by increasing process velocity, accuracy, and flexibility while reducing time to market, manual touchpoints, and associated labor costs. One of the most effective ways to do this is by automating repeatable processes. Often, a necessary first step is standardizing manual processes so that they become amenable to automation. Along the way, organizations must also give up a certain amount of proprietary customization in the name of standardization, automation, and overall process efficiency.

Any asset identification scheme that is clearly defined and consistently applied can be used within a broadcast organization. In fact, organizations tend to have several different identification schemes in play at any given time, including separate IDs for accounting, production, scheduling, etc.

The Need for a Universal Identifier

However, the limitations of these proprietary constructs, developed within broadcast organizations over time, are often not apparent until one attempts to improve workflows that include an external input or output.

For workflows related to content management, these external interfaces almost always include manual touchpoints for title matching. Traditionally, when two parties in the broadcast ecosystem have communicated about a work of common interest, they have identified the work by exchanging descriptive metadata along with any contract, query, asset, or transaction and then relied on manual labor to match everything together. Unfortunately, communicating parties do not always agree on what these descriptive data are or how they are structured – even titles may differ, especially when abbreviated to fit within arbitrary space limitations or when dealing with international releases or foreign works. Thus, record matching has been a long-standing challenge and remains an ongoing expense.

In this light, internal identifiers are of limited use when communicating with third parties. Organizations can agree on an identification scheme with each of their supply chain

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partners, but this leads to an explosion of point-to-point identifiers. In theory, there could be 10 different identifiers per title in a 5-party ecosystem, though the actual number is lower thanks to the use of commonly exchanged IDs, usually those of a dominant partner. Regardless of the number, the receiving parties must still manually match each received ID. This could lead to five matching efforts per title in this example.

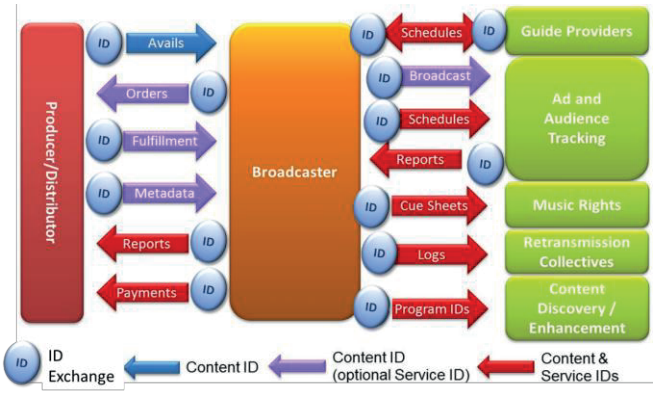


FIG 1: ID Uses in Workflows with External Touchpoints

These manual touch points must be removed if the benefits of automation are to be realized.

Using a common, global identifier for these third-party interactions reduces the number of IDs in play to one, regardless of how many partners are involved in the Exchange[1], and in turn facilitates a greater automation of processes while accelerating time to market.

An independent industry services company reviewed one such use case, where several major broadcasters (ITV in the UK, ABC Television Group and NBC in the US plus Sony Entertainment Networks) and studios (Universal and Warner Bros.) reviewed the opportunities and challenges of using a universal ID in broadcast workflows. With full implementation, they anticipated an annual savings of US$26M (i.e. 79%) in content identification and management costs[2].

Desirable Attributes for IDs

Useful identifiers for multi-party media workflows possess several key characteristics:

- **They are globally unique** – a particular identifier resolves to a particular object. That object could be a single asset or a collection of assets, but whatever it is, it the association between the identifier and the identified never changes.
- **They are permanent** – once assigned, the identifier never goes away. It is always available for use in reference to the identified asset.
- **They are not proprietary** – they may be issued by a controlling organization, but once issued, there is no restriction on their use. Anyone can use them at any time in any workflow.
- **They are large** – the ID space must have sufficient capacity to identify all the different assets that might conceivably appear over time.
- **They are resolvable** – there is a mechanism where the ID can be converted into a description of what it identifies (and ideally the reverse, where you can find the ID via its descriptive metadata). You cannot have a shared identification system without an open and accessible means of sharing the relationship between the identifier and the identified.

If an identifier fails in any one of these dimensions, then any workflow that depends upon it will eventually fail itself. Implementing a shared identification system is not without cost, so the parties in a supply chain should take great care in the selection of their identification scheme to make sure that it will continue to serve their needs far into the future.

Classes of ID

There is a wide variety of identification schemes at play in the media industry, each with its advantages and adherents. The most common options for shared identification include.[3,4]

- **Shelf Numbers** (for physical assets) **and Directory Paths** (for digital assets)
  These are most useful for locating an asset once it has been identified but are not useful as identifiers themselves. They are only meaningful within the context of a particular storage system and are not durably linked to the asset being described – if the asset is relocated, then its shelf number/path is changed.
- **Classification Systems**
  These are most commonly found in libraries[5] . The most widely used of these is the Dewey Decimal Classification system[6] . They were first applied to print works and have since been extended to include audiovisual assets. They are "intelligent" numbers in that meaning may be derived by parsing the classification identifier according to a predefined formula. By their very nature, they include subjectivity in their assignment, so the same work may receive different classifications in different collections even when using the same classification system.
- **Proprietary Inventory Indexing**
  These systems consist of a simple identifier assigned by whoever holds an asset. They are easy to create, are unique within their domain, and are permanently associated with an asset. These are popular with media archives, such as the British Film Institute[7] , and are the sort of identifier most commonly associated with a digital asset management system (DAM). Since they are only unique within their domain, the same ID could be assigned by different parties to reference different things and so are not globally unique. They can be used as point-to-point identifiers between specific parties, but this does not scale well.
- **Statistically Unique Identifiers**
  This includes things such as UUIDs (Universally Unique ID)[8] , UMIDs (Unique Material ID)[9] , and file hashes (C4. MD5, SHA-2, etc.).[10,11,12] They can be generated by anyone at any time in such a way that they are globally unique for all practical purposes[13]. The most common failing of such non-hash-based systems is that

the same asset will receive a different ID every time an ID is generated. File hashes will always be the same for a given asset no matter who creates them, but they can only be applied to digital files and a single bit's difference in a file results in an entirely different ID. Finally, there is no way to determine what is identified by a particular statistically unique identifier (they are not resolvable outside the organization that created them).

- **Shared, Curated, Globally-Unique Identifiers**
  This is the ultimate media asset identification and the only type of identifier that meets all the criteria for use in multi-party media workflows. Such identifiers are issued by a controlling organization that ensures uniqueness and provides ID resolution services. The preeminent identifier of this type is the Digital Object Identifier (ISO Standard 26324) [14,15,16]. The Entertainment Identifier Registry (EIDR) is a DOI registration authority providing identification services for audiovisual works[17].

Desirable ID Structure

For broadcast applications, a typical DOI-compliant content ID is organized in three fields.

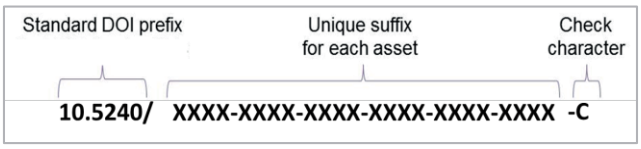


FIG 2a: DOI-Based Content ID

Such IDs are part of the Digital Object Identifier (DOI) namespace. Each DOI begins with a prefix that identifies the particular type of DOI and the organization that administers it. For audiovisual content identifiers, this is 10.5240, indicating a Content ID administered by EIDR. That is followed by a 20-character hexadecimal number, generally presented in 5 hyphen-separated groups of 4 digits for human convenience, and an alphanumeric check character. Such a number space has sufficient capacity to identify 1,208,925,819,614,630,000,000,000 unique audiovisual works, edits, and encodings, so it will remain viable for decades – if not centuries – to come:

With 1 Septillion, 208 Sextillion, 925 Quintillion, 819 Quadrillion, 614 Trillion, 630 Billion different values, that works out to roughly 160,000 IDs for every grain of sand in the world, if this were a sand identification system.

As with all DOIs, this is a "dumb," or opaque, number. Unlike a cataloging system, no intelligence can be derived from the ID itself other than the fact that it is an ID of a given family as determined by the prefix. The ID associated with a work in the abstract (a "title" ID) looks just like the ID for a specific encoding of a particular edit of that work. The only way to know for sure what the ID references is to resolve the ID. EIDR IDs are always "read-for-free," and public resolution services are offered by both DOI and EIDR[18]. In addition, users of such IDs, such as EIDR members, offer their own, internal resolution services integrated into their proprietary workflows [19].

ID Architecture in Registries

As pointed out earlier in this paper, the use of an ID administrator brings many benefits. A good administration authority will provide a publicly consultable registry of IDs as well as methods of resolving IDs and searching for IDs.

The right registry must contain a number of different record types, including Movies, TV programs, Radio programs, Shorts, Series, Seasons, Episodes, Web programs, Clips, Compilations, Composites, Supplemental programs, and Manifestations (i.e. technical variations such as resolution, encoding type etc.).

Most of these must be arranged in a hierarchical inheritance tree for each audiovisual work. At the root of the tree is the abstract Title record, which encompasses the referenced work in all its forms. Beneath that, one must include the Edit records that represent the different creative versions or cuts of the work. If one Edit is derived from another, the Edit relationship can be denoted by using child Edits (or Edits of Edits). Beneath the Edits are the Manifestation records that represent the different encodings or fixations of the Edits. Manifestations must have the flexibility of being quite detailed, so to enumerate each video or audio track with all their technical details.

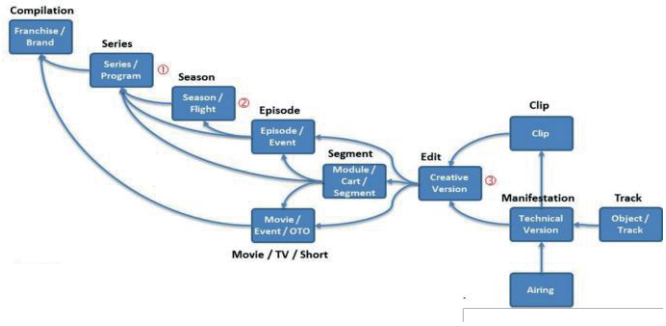


FIG 3: Broadcast Hierarchy Example for Works of Fiction

In addition to the standard hierarchical inheritance tree structure, the proper registry structure must also support a number of different non-hierarchical relationships, such as a Promotional relationship to link a trailer/teaser to the work it promotes and a Composite relationship to link a composite work (such as a "clip show") to the source materials from which it was assembled.

Live Programming Considerations

News and, even more so, sports present specific challenges as depicted in the "Content Management Challenges in Broadcasting" section above. The need for clips for reciprocal exchanges with competitors down to several generation of re-editing; variable and inconsistent schedules due to weather or stoppage time, etc.; the existence of sub-events (football leagues, regional vs national cups, disciplines in track-and-field, etc.); and the atypically high number of re-runs (or Replay TV) imply the

need of additional relationship structures. Additionally, last minute program changes due to last-minute cancellations, team elimination from a knock-out round, etc. must be carried out without confusing the consumer if program guides are not properly updated.

The proper registry must include fields that provide the means to unambiguously identify works and their associated derivatives.

For instance, in the case of program information for Digital Video Recorders (DVRs), additional identifying characteristics should be included as part of a standardized registration practice, including:

- The original broadcast date (or anticipated broadcast date for a program that has not aired yet)
- Anticipated running time (useful to distinguish a full game from game highlights)
- The primary language used in the presentation (for sports, this is generally the language spoken by the commentators and used for on-screen text)
- Any alternate titles by which the program may be known (quite useful for language disambiguation and later discovery)
- Any alternate identifiers that may be available (including house production IDs and event IDs)

The TV Network Challenge

Many Broadcast networks, Multichannel Video Programming Distributors (MVPDs) and streaming services are organized in different regions, each with their own schedules, time zones, or even languages.

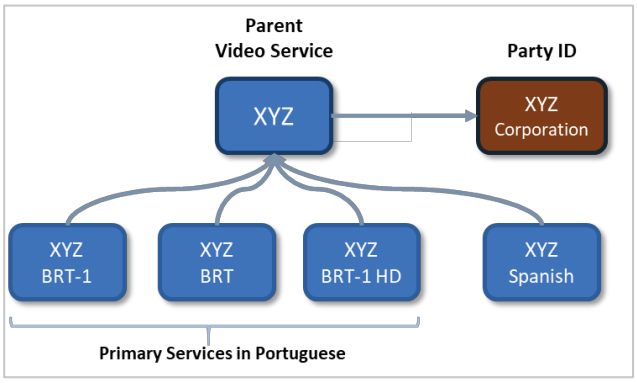
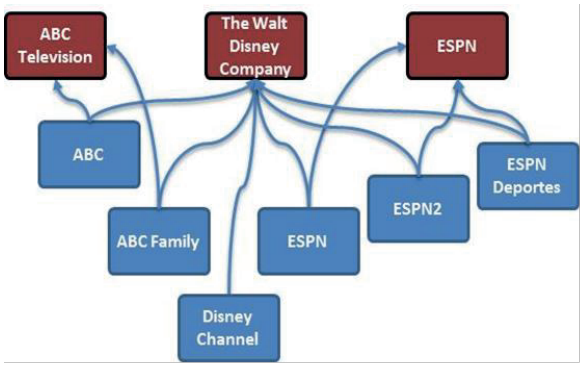


FIG 4: ID for Video Services in Networks

Complex sophisticated organization also own multiple brands or affiliates each with their own identity. The right ID and its registry will allow the inclusion of brands and station affiliations. The examples below show a structure for the Disney / ABC broadcast group.



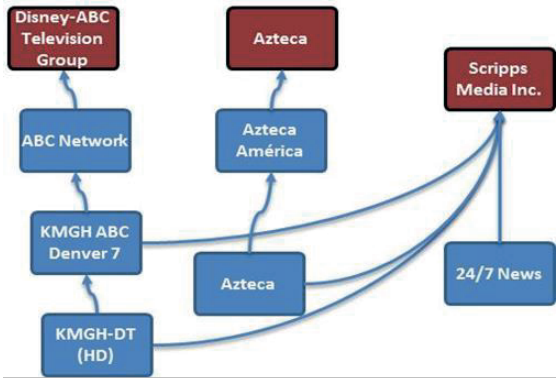


FIG 5: Example of ID for Video Services by Brand or Affiliation

All of this results in a broadcast industry need for universal video service – or channel – identification nearly as great as the need for content identification. EIDR also administers a DOI identifier for this purpose.

FIG 2b: DOI-Based Video Service ID

The EIDR Video Service ID begins with the DOI prefix 10.5239 and is followed by eight hexadecimal digits, presented as two groups of four. This has the capacity to identify 281,474,976,710,656 different content delivery services. As with EIDR Content IDs, the Video Service IDs are read-for-free including ID resolution, metadata search, and alternate ID cross-references. The individual Video Services can indicate network affiliation and content distribution relationships in addition to ownership interests tied to other Video Services or separate organizations (themselves identified by EIDR Party IDs in the form of 10.5237/XXXX-XXXX). As always, each Video Service record can contain an unlimited number of Alternate IDs (see "The Need for Nested IDs", below), allowing the Video Service registry to act as a cross-reference service that helps to bring proprietary identification systems and supporting workflows into the global identification framework.

The Need for Nested IDs

Broadcast organizations have often relied on legacy identifiers sometimes developed during the days of analog signals and tape recorder infrastructures.

Routinely, different stations of a broadcast network – and in some cases, different departments within an organization – have their own content identifiers. (See "Why Identify?" and "The TV Network Challenge").

Concurrently, there is a need for application-specific identifiers used internally or with partner companies for uses such as audience measurement, human consumption (e.g. EPG, VOD thumbnails, rating etc.), and many other applications.

Therefore, a universal ID must not exist in a vacuum. The universal Registry must maintain a cross-reference service for other third-party identifiers and house identifiers from a variety of motion picture and television organizations and industry service organizations. Not only should you be able to resolve to an ID (and its associated metadata record) from one of these alternative identifiers, but you should also be given the ability to come in with one ID and go out with another.

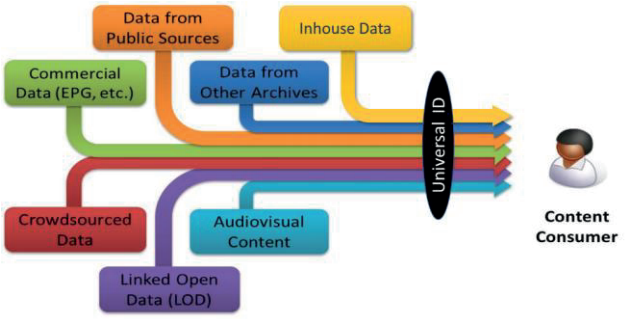


FIG 6: Universal ID as a translator to all other IDs

For example, one of EIDR's studio members uses the EIDR Registry to translate IMDb IDs (which they already have) into Flixster IDs so they can access the Rotten Tomatoes scores for critical and consumer review ratings.

Taken as a whole, a good Registry can deliver IDs for any form of any type of audiovisual work. Once a particular object has been identified, all parties in the media ecosystem leverage that same ID for unambiguous identification and automation without further manual intervention.

By using universal IDs, a world leader in digital distribution measured a reduction of on-boarding time from 50 hours per title to 12 minutes translating into faster time to market, cost savings, and expansion of content capacity.

Conclusion: The Positive Spiral

A few moments spent with a blank whiteboard will lead to the identification of many use cases where a universal identifier (globally unique, permanent, and universally accessible) can help reduce costs, increase accuracy, facilitate new services, and make content even more accessible and profitable. The value of universal identification grows significantly with each additional party participating in the ID ecosystem. To achieve these goals, a content identification system must have a global reach and accurately and unambiguously identify the various types of audiovisual works, from the parent level through their derived edits down to their specific representations with clips, composites, and compilations alongside. In addition, such content IDs must be accompanied by a compatible system of content delivery channel IDs to capture a complete picture of the broadcasting ecosystem. Following the rules of standardization, workflow-agnosticism, commercial neutrality, and translation to existing IDs ensures broad adoption and invaluable economies of scale.

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[16]. It is important to note that the Digital Object Identifier is a digital identifier of objects, not an identifier of digital objects. This is akin to the Flying Purple People Eater being an eater of purple people rather than a purple creature who eats people. (See: Song Facts. "The Purple People Eater by Sheb Wooley." Accessed June 1, 2018. http://www.songfacts.com/detail.php?id=25985). The importance of this is that DOIs in general, and EIDR IDs in particular, can be used to identify media assets in the abstract or when fixed in physical or digital media.

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François Modarresse has over 30 years of experience in broadcast and media technologies, playing key roles in the launch of HDTV and H264. He currently runs international business development for EIDR, a consortium of the major Hollywood Studios, many of TV Networks and streaming companies. Before EIDR, François served many clients spearheading innovation in the broadcast production and metadata worlds. Prior to that, he led product marketing at Dolby, productizing major technologies such as Dolby Mobile, Atmos and Vision.

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Algorithms, artificial intelligence and NLG in the production of Brazilian journalism

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Algorithms, artificial intelligence and NLG in the production of Brazilian journalism

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Abstract — **Technologies such as algorithms, artificial intelligence and Natural Language Generation (NLG) are present in several economic activities, essentially in the media field. However, the studies that discuss those facets are scarce in Brazil, notably the empirical studies that evaluate their applicability to the journalistic production. This work speaks about the scenario and possibilities of use for algorithms and NLG in the Brazilian media companies. An exploratory and descriptive research was performed, in which the administrators of the biggest communications companies in Brazil in national and local levels were interviewed. Amongst the achieved results, we can highlight the disbelief and skepticism regarding those technologies, with reduced prospects for their deployment in news production.**

Index Terms — **Algorithms, Artificial Intelligence, NLG, Journalism, Media companies**

I. Introduction

THE communications field was one of the most affected by the expansion of technology. The innovations generated by new media companies altered the way that people get informed, communicate and exchange information. Also, the technological changes put in check the business model used by traditional communications media because the production, distribution and consumption of news are not the same as in the 20th century [1]. In the wake of technologies like algorithms, they become more dominant on the Internet for the most varied appliances, from search engines, digital social networks to content production [2].

The media field is one of the main appliances of algorithms as the mass media were massively automated with the evolution of technology. The search for the economies of scale and more processing speed raised criticism regarding ideological aspects [3], journalistic ethics [4], and transparency [5]. Studies showed that computing systems used by many media vehicles present prejudgments and hostile feelings as a consequence of the operation based on standards.

Furthermore, there is a margin for error, manipulation, commercial and political interests that may interfere in the task performed by algorithms at all times [6]. Studies have already shown that the human collaboration is indispensable as a way of preventing failures as well as the need to broaden the debate and the studies on mechanisms that amplify the algorithmic transparency [7].

Despite the relevance of the subject and the many potential doubts, the discussions regarding algorithms are still very premature and secluded in Brazil. A keyword search was performed in August 2017 at Scielo, the main database for scientific publications in Latin America, for the terms "jornalismo" (journalism) and "algorítmos" (algorithm) and got none results. The result was the same for the keywords "algorítmo" (algorithm) and "transparência" (transparency).

Despite the noticeable absence in the debate, Brazil stands out in the international media market. It is the third country in the world rank of most people connected to the Internet using smartphones, and forth in the world rank of the number of inhabitants connected to the World Wide Web. Also, Brazil is one of the biggest advertising markets in the world and is the home of Grupo Globo, which is 14th in the rank of the biggest media companies of the world [8]. Furthermore, studies that bring a retrospect of the market about specific technologies, as performed by reference [9], are rare. Many types of research evaluate the perspectives, functionalities and human aspects in relation to algorithms [10] but there is not much work on the opinion of media companies about this new technology. Therefore, the following question guides this article:

What the biggest media companies in Brazil, both national and local scopes, think about algorithms that produce content and which are the perspectives for this technology in this country?

II. Methodology

In order to answer that, reference [11] performed an exploratory qualitative and descriptive research based on semi-structured interviews with administrators from the biggest media vehicles in Brazil. This research used a qualitative questionnaire with general questions about i) the opinion of the administrators about the use of algorithms to produce content, and ii) the probability of using algorithms in the production of content in those companies they operate. Besides, Berg asked specific questions in relation to i) the practice of algorithmic journalism; ii) the use of Natural Language Generation (NLG) technology in the newsrooms. With all the data gathered from the interviewers, this article analyses the answers using the content analysis method [12]. In this type of analysis, the answers were evaluated mainly in the light of specialized literature, as well as the Brazilian and international realities in relation to the question in the research. With that, information was gathered on the companies' sites and news

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on the media from the Internet, for a broader perspective of the current scenario in Brazil and abroad.

In order to perform the field research, the six biggest media groups in Brazil were selected: Grupo Globo, Grupo Folha, Grupo Estado, Grupo Abril, Sistema Brasileiro de Televisão (SBT) and Grupo Record (more information in Annex A). Also, in this group are the three biggest and oldest local communication groups in Brazil: Grupo RBS, Grupo RIC and Emissoras Pioneiras. The choice of using local groups results from two factors. Firstly, because Brazil is a country with continental dimensions and very accentuated regional diversity, including development, protection and amplitude of innovation [13]. Secondly, because the crisis in the media sector is even stronger in local companies, which have been being affected in a more accentuated manner by the effects of the decline in revenue: "people get their news online, but still gravitate most toward the websites of their local papers and television stations. Local press isn't dead, but it's fragmented and weakened" [14]. Therefore, it is imperative to analyze how the local media groups are dealing with technological innovations such as algorithms and NLG. We believe research that also comprises companies from the regional scope brings a more truthful picture of the Brazilian media corporations.

In the groups Grupo Folha, Abril, RBS and RIC, the CEOs were the respondents in the research. In the other companies, the respondents were directors associated with areas such as programming and digital media (more information in Annex B). The interviews were conducted in person, by telephone calls or email messages in the months of March and May 2017. The interviews in person lasted approximately 30 minutes each.

III. Algorithms, Artificial Intelligence and NLG

According to reference [15], algorithms are not necessarily a software; they are procedures coded to convert input data in the desired output, based on specified calculations. We can consider both the instructions to browse the web and the mathematical formulas necessary to predict the movement of a celestial body across the sky as algorithms. "Algorithms do things, and their syntax embodies a command structure to enable this to happen" [16]. Therefore, we can consider computers as algorithm machines, as they are designed to store and read data, apply mathematical procedures and offer new information as outputs.

Described as "a finite series of precisely described rules or processes to solve a problem" [17], algorithms operate using stages that transform the data inserted in the system. In most cases, all applications of algorithmic selection are described from a basic format of input-processing-output. After the detection and relevance assignment, there is an output under different forms, for example, rankings, music playlist, and texts. The output may further serve as an additional input in subsequent processes of algorithmic selection [17]. Neural network is the possibility of employing their own data to alter the decision-making process, labelled as an attempt to mimic the computing structure of neurons in the human brain [18].

Such networks are constituted by layers of algorithms randomly connected. A given set of inputs, which represents a problem to be solved, generates a reaction in this network, which output provides an answer. For the most part, the answers are not accurate but contribute to the learning process of the machine, which adjusts the forces of each interneuronal connection [19]. Reference [20] thinks the diversity and intensity of the connections are, at the same time, the biggest virtue and the biggest problem of neural networks: "The time taken to calculate the error derivatives for the weights on a given training example is proportional to the size of the network because the amount of computation is proportional to the number of weights". Another problem associated with neural networks is the obscurity embedded in the data processing in deeper layers. Unknown amongst the same scientists that built them, the information provided by those networks are extremely important to a series of commercial and human appliances, but we do not know for sure how they created them [21].

Aiming to improve the level of predictability, artificial intelligence interconnects many neural networks, a phenomenon classified by reference [22] as the ability of the machines to develop an intelligence similar to the human. Besides thinking and acting like humans, it demands other requirements from the machine with artificial intelligence: "i) Natural language processing to enable it to communicate successfully in English (or some other human language); ii) Machine learning to adapt to new circumstances and to detect and extrapolate patterns" [23].

Natural Language Processing (NLP) is the base to develop the Natural Language Generation (NLG), which raw material is gross data with meteorological numbers and cost sheets, which are used to produce texts [24]. Amongst the many appliances for NLG are the generation of textual meteorological forecasts using maps and graphs, in medicine and in communications. The mapping performed by reference [9] identified ten companies in the world that have NLG technology for journalistic appliances. NLG technology can do various roles, such as i) create short news videos (USA Today has been using the online service NLG Wibbitz to perform videos with journalistic narratives and adding machine voice); ii) prepare news for segmented local audiences (machines with NLG technology evaluate trending topics and write texts about them, which contributed to media companies producing more local content and diversifying the content); iii) keep the information up to date (NLG tools can track the progress of sporting events, elections, live shows, and thus automatically update published reports when new information arrives); iv) automatic generation of personal reports (machines with NLG technology have the possibility of generating copyrighted texts from data reports, a common use in the financial and capital markets) [7].

Amongst the ten companies that have conditions to use NLG in journalism, only Aexea from Germany elaborates texts using the Portuguese language. According to reference [9], this market division is a consequence of factors such as the complexity of NLG, limited availability of data, standardization of journalistic products, and the general view that journalistic products are not profitable by themselves. The data types and functions chosen determine the algorithms results. The quality of the data interferes directly with the product from algorithms because the inputs

decide the results possible to get. Google, for example, operates notably as a search engine. Thus, the algorithms employed are programmed to refine search engines, based mainly on keywords. In the other hand – although they also serve as a search engine for the user –, Facebook codes its algorithms mainly for programmatic mechanisms, which allow the crossing of users' information with other users that are not classified as companies. In both cases, the focus of the technology companies is that those algorithms serve both the marketing of products and services of the sponsors, as it shows reference [17].

> For algorithmic selection applications, not only the various undisclosed algorithms but also the supply and the quality of selection elements and data signals are crucial for competitive advantages and economic success. There are different types of suppliers of selection elements: suppliers based on contracts who are financially compensated (e.g., music labels that license music for streaming services); customers who provide the data to service suppliers (e.g., police for predictive policing applications); and suppliers whose content is mostly used, some would say appropriated without approval and compensation (e.g., websites of newspapers).

IV. Content Production and Journalism

NLG and algorithms are very versatile technologies, indispensable in digital communication as its appliance [17]. In regard to the content production, we can highlight the algorithmic journalism, defined as "the innovative processing that occurs at the intersection between journalism and data technology" [25]. Also named as computing or automated journalism, this type of journalism can be "the combination of algorithms, data and knowledge from the social sciences to supplement the accountability function of journalism" [26].

However, reference [27] believes that such definitions do not distinguish journalism from similar practices. A better classification in the opinion of the author is "a strand of technologically oriented journalism centered on the application of computing and computational thinking to the practices of information gathering, sense-making, and information presentation, rather than the journalistic use of data or social science methods more generally". Reference [7] classify computing journalism as "finding, telling, and disseminating news stories with, by, or about algorithms". Reference [28] highlights that computing journalism deploys algorithms with little human intervention to generate news for everything, from criminal reports to earthquake alerts and corporate profit reports.

Therefore, the automated journalism shall not be mistaken by data journalism and even less with Computer-assisted Reporting (CAR), which comes from the practice of using computers in the search for empirical data. Reference [27] reminds that the precision journalism created CAR, a technique developed by reference [29] in the 1960s. He gained notoriety after performing researches and statistical analysis based on data to obtain clearer answers to journalistic matters. Reference [30] highlight that data journalism represents the convergence of several fields and practices, being characterized as a hybrid form that encompasses the statistical analysis, computing, visualization and web design, and reports. Therefore, reference [27] concludes that the social sciences methods and in the orientation of public matters of the investigative journalism are the roots of CAR. Data journalism is characterized by its participative openness and crossed hybridity while computing journalism is focused on the appliance of abstraction and automation in journalism.

In this way, the automated journalism represents a new frontier in the journalistic activity and a radical innovation in terms of news production and distribution [25]. In journalism companies, algorithms can prioritize, classify and filter information, as well as engage in journalism in several stages, including the distribution – as per search and public metrics results –, establishing topics they will address or even writing the stories [31]. Despite all those possibilities deeply alter the way that the press operates, the most abrupt change is, without a doubt, the possibility of a machine elaborating a text using NLG with reduced human intervention.

Reference [9] stresses out that there are few studies that evaluate the impacts of NLG in journalism, which usually are divided in a) bring together algorithmic journalism and other techniques based in number, such as data journalism; b) evaluate the news production by machines from an institutional prism of journalism; c) verify how readers evaluate the news made by algorithms; or even d) discuss ethical matters. Notwithstanding the variety of options to approach the subject, "communication science has not been able to supply a coherent model of NLG in journalism so far, as well as identifying the possibilities and limitations of this technology" [9]. According to reference [17], a major part of an investigation in social sciences on algorithms have been focusing on search engines and recommendation systems.

Reference [32] evaluate computing journalism in the newsrooms of Norway and concluded that they are not far from the traditional way of making journalism. The rooted cultural orientation in the journalism traditions reduced the possibilities of improving the efficiency of newsrooms, or of taking from journalists the simpler technical work. To reference [25], "the critical issue is the facilitation and development of an innovation-oriented mindset among the people working professionally in the field". Therefore, the assignment of changes in the mindset does not apply solely to journalists but also to communication companies, which need to be open to changes.

The fear of changes, notably in relation to the appliance of technologies with the massive use of algorithms, was scientifically evaluated in an experiment performed by reference [33]. They studied an aspect of human behavior related to a feeling of rejection in relation to algorithms. The researchers affirm that despite several pieces of evidence of the superiority of algorithms in the ability to make judgements, "decision makers are often averse to using algorithms, opting instead for the less accurate judgements of humans". The researchers highlight that people acknowledge a higher accuracy in predictions made by algorithms as they are notably based on evidence. However, scholars state "that people will use imperfect algorithms to make incentivized forecasts so long as they can slightly modify them" [33]. In other words, people are willing to use algorithms as long as they have the freedom to alter the decisions made by it.

V. The View of Brazilian Communication Companies (Research Question)

Costs

The administrators from Brazilian communication companies that were interviewed for this work were skeptical and in disbelief concerning algorithms. They acknowledge that it is a promising technology with a great potential for growth, although they do not see a higher integration with the technology in a short-term. To the CEO of Grupo Abril, Walter Longo, "I believe the use of algorithms is spectacular not to find out what people want to consume but want to acquire. If I find out what people want to acquire using algorithms, it is a good way to sell more of a product or have more audience".

The interviewed people made a point of highlighting that the social networks algorithms, search engines and online stores play well the role of getting consumers and sellers together. However, this appliance is very limited when they get integrated to technologies to produce news, such as NLG. One of those limiting aspects is the cost. "Such technologies are usually from abroad, which generates elevated import costs. If this type of technology is developed in our country, probably will have lower costs, facilitating its appliance", said the superintendent of Grupo Record, André Dias. To the multi-platform director of SBT, Rodrigo Marti: "The binomial cost-benefits will determine if the NLG technology will or not be used. It will be necessary to find a value in this business that will not cost too much for the company".

To reduce costs and make technologies such as artificial intelligence (AI) and NLG more accessible, reference [34] suggests that: "For custom-built AI, which is too expensive for smaller operations to afford, newsrooms should consider investing time in partnerships with an academic institution". The academic institutions could perform a basic research that helps to expand the knowledge about advanced technologies like AI and machine learning. Besides that, empirical researches in newsrooms would bring relevant insights into the applicability of machines in the journalistic routine. Those are some of the most delicate and difficult factors to be solved, as they depend on a close collaboration between the machine designer and journalists, and deepened knowledge of technology by journalists: "there is both a knowledge gap and communication gap between technologists designing AI and journalists using it that may lead to journalistic malpractice" [34].

The approximation with the academic field could help to solve another issue: the initiatives of artificial intelligence in the media companies usually get interrupted at the prototype level. A research performed in the United States shows that online media represents only 1.33% of investments in artificial intelligence, while platforms such as Facebook, Google and Amazon are leading the ranks with 32% [35]. The elevated costs in hiring experts in machine learning that are highly qualified, with time and competence to understand the issues of the news sector and coach machine learning apprentices to solve them are the cause for the reduced investment. Besides that, is not that simple or cheap to create a set of reliable data that could train the machines. Often it will be necessary to interfere in the work-flow of journalists to make room for automation, enable editorial teams on technology and management and still await significant results amidst several structural changes.

Concerned with immediate results and the maintenance of a business model already worn-out, media companies try to adapt to the technological innovations, showing a reduced success. In Brazil, the 11 biggest daily journals gained 88 thousand new digital subscribers in 2016 but printed editions registered a decrease of 162 thousand copies in the average daily run. Most Brazilian journalists adopted the pay-wall as a strategy to increase revenue. However, the increment of digital subscriptions is not being able to compensate the loss of the sector regarding advertisements of printed copies and the revenue with the digital advertisement is still too low [36]. Even in Europe countries, where there are more capitalized media groups and the news-consuming public has a different profile, the innovative projects in digital news are usually focused on: a) reaching new audiences; b) better serving existing audiences, and c) boosting digital subscriptions [37]. In other words, the transition of media companies to the digital world is often conditioned to the short-term financial results, which generates to the firms an imbroglio difficult to solve: as they do not take effective measures to develop new technologies, they do not get good financial results, and, without those results, they do not feel confident to invest in the development of new technologies.

In specific fields of the media industry, such as broadcast, the distancing in relation to algorithms, artificial intelligence and NLG is even bigger. Brazilian administrators already identified trends in Over The Top (OTT) services but without perspectives to the broadcast field. According to the Director of Programming of Grupo Record, Marcelo Caetano:

> Whoever produces content will inevitably benefit from this technology. One example is the House of Cards series by Netflix, which was created from decisions made by algorithms using a database. Nevertheless, Brazil is taking the first steps in this field. As it is still in the beginning, we are not able to discuss financial or commercial viabilities. The evolution is gradual. We lack information on how it interferes in the broadcast business.

Algorithms and artificial intelligence are being used for now by cable TV and Internet for the recommendation, development of new products and sales from the patterns generated by user data. It is the same mechanism used by digital social networks, which distribute a great variety of videos created by third parties. This content hardly interferes in the journalistic production made by the broadcast, although reduces its audience. This is the reason traditional television watches the vertiginous growth of video on demand and social networks without performing substantial investments in technologies for journalism like NLG: "no one seems to have found the right recipe for online video news or IPTV News" [38].

Cultural and training aspects

Besides the elevated costs and the difficulties in applying NLG in the TV journalism, some interviewees showed concern with legal and cultural factors, as NLG substantially alters the news production system. In addition to the job extinction, the appliance of algorithms represents a change in the assignments for journalists and its own structure of roles in the newsrooms. Walter Longo believes that "the use

of technologies such as NLG is a point of no return. It will bring huge benefits in efficiency and gain of scale but also many problems like unemployment, which we do not know how to handle. Especially in a country like Brazil, with a very low educational level among its population".

The deficiencies in the educational training are also present in the journalistic environment. Only 11% of journalists are prepared for a data analysis in the United States [39]. In Brazil, the scenario is even more severe given the problems faced in the professional training and precariousness of the occupation. Such factors certainly interfere in the acceptance and integration of innovative technologies like NLG. Studies already demonstrated that the organizational culture of many media companies did not internalize integration mechanisms between humans and machines for the news production [32]. They can perceive the same scenario in interviews, such as with the Chief Executive Officer of EPTV, Antonio Coutinho Nogueira: "We use none computing system to journalistic information capture and edition. We believe in the human potential to investigate and find the best and more updated information". That explains, at least in part, why the interviewed administrators showed so much skepticism and disbelief regarding NLG.

The reluctance to machines, however, is harmful to the very same media companies, which evaluate algorithms, artificial intelligence and NLG as creators of fake news. They fail in realizing that the same press helped to create this issue when it tried to stop the advance of social networks. When the newsrooms focused on the use of machine learning by using algorithms, to present customized reading recommendations or segmented advertisements, they adopted a copy approach for the customization of editorial and commercial content. "Personalized communication may work for push notifications and special interest editorial content like weather, sports and entertainment, but personalizing general interest news can implode in filter bubbles" [40].

As much as the hidden bias of machines is something that needs to be constantly confronted to establish an ethical journalism and for the public service [34], human beings, especially the administrators of Brazilian media companies, must notice the benefits that NLG and algorithms can bring to journalism. There is no doubt about that machines also make mistakes; however, it is necessary to know how to handle it.

Amongst all administrators of Brazilian media companies, only the Executive Editor of Digital Content of Grupo Estado, Luis Fernando Bovo, showed optimism towards the idea of using machines in the editorial department:

> I do not think it is bad to have a technology like NLG producing news that is commodities. It makes little sense in using a journalist to perform this task for information, which is solely gathering data, producing a text and distribute. I will assign the journalist to what is really important: perform an analysis, synapse and contextualize factors. The journalism is increasingly going towards this direction: more analytical and less worried about simply relaying information.

Although Bovo has been the only one amongst the interviewees with ideas favorable to integrating NLG in the newsrooms, his opinions comply with the view of other administrators on the new directions of journalism. For most of the interviewees in this research, such as the CEO of Grupo RIC, Leonardo Petrelli: "it is necessary to separate information from journalism. It is possible to gather data and create a commodity information, such as the weather forecast and capital market. But when we build the news, we need to have the human sensitivity and perception to prevent mistakes as the lack of ethics".

Potential incompatibilities between journalism and NLG

Many administrators think journalism and NLG are incompatible. The CEO of Grupo RBS, Eduardo Melzer, believes that algorithmic technologies "are adequate for simple information and feedback. They are not adequate for the serious, professional journalist production that demands discernment, investigation, plural view, and social responsibility". The CEO of Grupo Folha, Maria Judith Brito, thinks similarly about NLG: "it has limited use. The journalism production with quality and of depth analysis require qualified reporters' teams, experts, and writers".

Besides cognitive and cultural factors, the difficulty in bringing it closer to newsrooms causes the negative view predominant in media companies about the integration between journalism and NLG. Although there are no empirical studies that tested the level of acceptance of NLG technology in Brazilian media companies, is fully possible to infer that the reasons pointed out as causes for the low efficacy and some rejection observed in international studies can apply to Brazil's reality.

In the algorithmic journalism, technology is not only a support but part of the news production process. Cognitive technologies like NLG impose new skills for journalists necessary for the integration between man and the new apparatus of machines with intelligence. One of the most important competencies in this new context is the computational thinking, characterized by a cognitive process instead of a practice necessarily performed by a computer [27]. Administrators and journalists create a mentality grounded in processes and practices in which the machines play a role of support in the news production. The new technologies like NLG have put this new history of the machine' subservience to human disposal in check. If we had all the news production under human control, now it is possible to produce types of news with very little human interference. Without a doubt, there are many obtuse points in his regard such as ethical aspects, but the future certainly has a place for it. As stated by the Chief Executive Office of EPTV: "We do not intend to use this [NLG] technology in the near future but it is obvious that we must follow the evolution of systems".

The perspective of Brazilian administrators complies with the results of the research performed by reference [37] with European media companies. As in Brazil, the European interviewees are proud of the past and present of their organizations but are aware that the media environment is changing faster than most news organizations. However, unlike in Brazil, European firms are investing in several new digital news projects in the attempt of promoting organizational and cultural changes that facilitate the

adaptation and innovation. While being aware that this is a slow process and demands an effort that originates from superior hierarchical layers, European media companies are searching for the short-term return "but equally often towards 'innovation for innovation's sake' – attempts to change the very organization and culture of a given newspaper or broadcaster" [37].

However, many startups around the world are already producing news from the integration between human work and machines, as in the generation of visualizations guided by data. One example is The Pudding, which uses algorithms to elaborate interactive graphs and allows the readers to choose which subjects they want to be informed about. An empirical research performed by reference [41] developed a software based on artificial intelligence that facilitates the data calculation and identifies opportunities for new reporting. The use of algorithms can be relevant especially to the reporting, notably with predictive models and descriptive statistics. An opinion shared by reference [40]: "there is a strong case for letting machines do the tedious research and get better at fact-checking, as well as automated news writing based on structured data sets".

Is content the most relevant factor?

Although the startups and academic projects do not face all peculiarities and challenges of the market, they usually indicate trends, many times based on empirical results. Reference [42], for example, concluded that the main reason for the abrupt fall in the revenue of newspapers in the United States was the loss of 74% of the values received from classifieds between 2000 and 2010. Although the classifieds were not the main source of revenues, they contributed substantially for the reduction in the number of website readers because "while the economics of news depends on attracting readers one by one, the economics of classifieds is about connections between buyers and sellers. A network effect". To reference [42], the Internet did not finish with the news. The Internet destroyed the subsidies from classifieds. Media companies from the printed field did not make a mistake in producing content but did in not protecting an important source of revenue.

This observation also derives from good results achieved by other media companies. One of them is the Scandinavian conglomerate Schibsted Group. The journal Svenska Dagbladet, one of the main journals in Sweden and part of this group, fully integrated the use of algorithms into the news production, distribution and featuring. The journal has a robot that projects the website homepage, using algorithms to distribute content and even manage online ads, without using the services from Google and Facebook. In addition, applied NLG in the news production.

Therefore, journalism does not lose validity or leave its principles aside when human beings work together with machines. In the same manner, journalistic content continues to be extremely relevant in innovative journalistic companies. From the statements made by Anand, what we can highlight is how much the deployment of algorithms and technologies like NLG can contribute in the news production, distribution and consumption. Such aspects meet the demands from communications sciences [9] and from media companies, which must find alternatives with the better monetization of the news due to the loss in revenue.

Researches indicate that the artificial intelligence applied in NLG form, for example, allow journalists to examine large quantities of data, texts, images and videos. Such possibility not only makes the work more efficient but also allow a better communication and collaboration between journalists and the public. The networks formed inside and outside the newsrooms bring more audience and reduce the incidence of fake news as they increase the reach of the journalistic news. Therefore, networks and journalism are complementary, not dissonant. As well as the algorithms and NLG technology that are tools that can aid journalism and not the responsible for the crisis of trust that harms the field.

VI. Conclusion

Despite the appliance of algorithms in journalism is still unknown amongst the Brazilian press, it might reach the segment soon, as it happened with other technologies in the past. As this is inevitable, it is more appropriate for Brazilian media companies to take a leading role in this process rather than simple adaptation. For that, it will be required to invest in innovative projects, as European and North-American firms are already doing. As much as the Brazilian and Latin American reality is different, there is no other way but experimentation, and the interviews of the European media administrators also made it clear [37]. The search for innovation from artificial intelligence by voice, essential in the broadcast sector, should begin with machine learning in newsrooms, brainstorms between journalists and the public, and also with research and development. Since NLG did not reach the Brazilian newsrooms, it is necessary to start as soon as possible.

For decades that established companies, such as those in this study, are reluctant to innovate and tend to inertia in the face of past good results. However, the adaptability to innovation may be a competitive advantage over long-term. Future studies could evaluate to what extent this adaptation is taking place in media companies and what would be the most promising projects. As reference [9] stated, the communication science needs to bring answers to the concerns of the area regarding algorithmic journalism, which has altered the way people do journalism. Thus, new exploratory or descriptive studies about the challenges and opportunities of this new technique in Brazilian newsrooms are recommended.

Appendix

Appendix A

National companies

Grupo Folha: It controls the newspapers with the widest circulation and influence (Folha de S. Paulo), the largest Brazilian company of internet content and services (UOL), the news website l with the most audience (Folha.com) and the largest commercial printing company in Brazil (Plural). It also publishes three newspapers: "Agora" the leader among the popular diaries in the State of São Paulo, "Valor Econômico", released in 2000 in association with the Globo

Organizations, and "Alô Negócios", the widest newspaper from the capital of the state of Paraná in number of ads.

Grupo Estado: It owns the newspaper O Estado de São Paulo, one of the oldest periodicals in activity in Brazil, founded in 1875, and among the largest in circulation in the country. The group also manages one of the largest and oldest news agencies in Brazil, the Agência Estado, Rádio Eldorado, and an advertisement company addressed to small and medium-sized enterprises, Serviços Planeta Digital.

SBT: the "Sistema Brasileiro de Televisão" (SBT) is the major groups of communication in Brazil, but it does not invest in other media segments as many organizations in the sector do. The company owns the open transmission TV channel SBT, which is present in a big part of Brazil.

Grupo Record: The company has the Rede Record, open transmission TV station vice-leader in audience in Brazil and the oldest country's TV in operation; Record News, an exclusive news channel with an open signal; R7, online content portal; four printed newspapers; three radio stations.

Grupo Abril: It is one of the largest and most influent groups of communication and distribution in Latin America. The company operates based on two business segments: Abril Media, which concentrates the business of Abril Publishing company, Gráfica Abril and CasaCor; and DGB, the holding company of distribution and logistics. Abril Mídia has on the Board of Directors representatives of the South African media group Naspers Group.

Grupo Globo: 14th-largest media company on the planet, the group is a collection of Brazilian media companies that reaches all national territory. The group is constituted by shares in a variety of media, including the Globo (a leader in open TV in Brazil), Globosat, Globo.com, Editora Globo, InfoGlobo, Rádio Globo, Som Livre, Globo Filmes and ZAP.

Local Companies

Grupo RBS: It is one of the largest multimedia company groups in the country. Within Brazil, they operate through e.Digital Bricks, Fund for investments of companies in the digital sector. In addition to an affiliate of Globo TV in the state of Rio Grande do Sul, it owns six radio stations, two content portals and three printed Newspapers. All of them are market leaders in the field they operate.

Grupo RIC: It is the largest communication group in the Southern region in Brazil and the second largest group of local communication in Brazil. The company operates in the states of Paraná and Santa Catarina, which reaches 16 million people. It is TV Record affiliated in 11 TV stations, and still controls 3 internet portals, 4 radio stations, 2 printed newspapers, 2 publishers of magazines and a multimedia platform.

Emissoras Pioneiras: They are part of the group of four Rede Globo affiliates; a newspaper; three radio stations and a news portal. The companies are installed inside the states of São Paulo and Minas Gerais. The area covered by the group is of 11 million inhabitants in 371 municipalities.

Appendix B

List of Interviewees

National Companies

a. André Dias, National Director of Affiliates, Grupo Record
b. Luis Fernando Bovo, Executive Editor Digital Content, Grupo Estado
c. Rodrigo Marti, Director of Multi-platforms, SBT
d. Antonio Guerreiro, Superintendent of Multi-platform Strategy, Grupo Record
e. Walter Longo, CEO, Grupo Abril
f. Marcelo Caetano, Director of Programming, Grupo Record
g. Washington Theotonio, Director of Innovation in Communications, Grupo Globo
h. Maria Judith Brito, CEO, Grupo Folha

Local Companies

a. Leonardo Petrelli Neto, CEO, Grupo RIC
b. Eduardo Melzer, Chaiman and CEO, Grupo RBS
c. Antonio Carlos Coutinho Nogueira, General Director, Emissoras Pioneiras (EPTV)

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