

Use of virtual sets in the broadcasting of major events

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Abstract: In 2000, the BBC virtual studios expert, Danny Popkin, criticised the television industry for making a poor use of virtual technology. Ten years later the situation has not improved significantly. So far, virtual studios are seen just as good technological tools to save money and time in the production of news, children's programming, commercials and elections coverage. However, the virtual studio must also enhance realism, improve the presentation of information, and increase entertainment. In order to help broadcasters achieving these goals, this article describes six examples of special television programmes, from 1996 to 2009, which presented some ideas to improve the quality and richness of the audiovisual language.

Keywords: Virtual scenography; virtual studio; virtual set; special television programme.

Summary: 1. Introduction 2. Hypothesis. 3. Methodology. 4. Preliminary considerations. 5. Use of virtual sets in special television programmes (1996-2009). 6. Conclusions. 7. Bibliography. 8. Notes.

Translation by **Cruz Alberto Martínez-Arcos** (Ph.D. Student at the University of London)

1. Introduction

Although the first experiments with chroma key were performed in film production in the 1950s, it was not until the mid-1990s when the virtual set started to be used in television. In 1994, in collaboration with IMP (a commercial audiovisual technology company), *Ultimatte* presented in the NAB show (an annual trade show produced in Vegas by the National Association of Broadcasters) the first real-time virtual studio in the history of television. Simultaneously in Spain, in collaboration with Antena 3, the Valencian company Brainstorm Multimedia carried out the first experiments with virtual technology in the production of television programmes. These steps were followed by TVE, Canal 9, TV3, and eventually by all the large and small Spanish

broadcasters, which integrated green or blue cycloramas in their studios to allow the production of virtual sets.

With the use of virtual sets, the bit becomes the essential component of the television production equipment. The process of digitalisation of television production and broadcasting consolidates a fully digital audiovisual environment. In this new scenario the virtual studio was developed as a technology that essentially involves embedding or integrating the foreground, which is the camera signal, and the background, which is a virtual computer-generated environment. The virtual environment must be updated in real time to reflect the changes in the camera signal. The result for the viewers is a uniform image.

2. Hypothesis

During more than six years of research on the use of virtual sets on television, the author of this article has studied and verified the technological and economic benefits provided by the use of these systems. However, the creative part, which is fundamental, in television production has been always rather ignored. TV producers who used the technology have done so with the idea of implementing an efficient production method for the digital environment. The use of virtual studios has allowed optimising the human and technical resources, which enables the production of several live shows on the same day and the same studio. Based on this reality, this article discusses the use of virtual sets in special television programmes from 1996 to 2009. These types of programmes found uses and applications for this technology that provide innovative visual solutions to the television language and present a technology with its own representative specificity, with an excellent future and great possibilities to give television its own representation space, which would set television free from the theatrical and cinematic obstacles that have constrained its discourse for more than six decades.

3. Methodology

The article presents the results of a process of observation, undertaken by the author, of the use of virtual sets in television from 2004 until today. Six examples of special television programmes using virtual sets were analysed for this article. All these programmes were broadcast live, at prime time, and were focused on important events that tested the image and prestige of the television networks. For all these programmes, the selection of a virtual set was not arbitrary, but was the product of a clear bet on a technology that allowed them to provide a televisual treatment that matched the relevance of the event. The Eurovision Song Contest, the Royal Wedding in Madrid, the Presidential elections in the United States, and the elections for the European Parliament are some of the major events in which the use virtual sets has been analysed.

4. Preliminary considerations

The observation of national and regional Spanish television channels (2004-2009) has revealed a correlation between the existence of a stable human team and the live broadcast of a daily programme. Having a stable team benefits other types of productions, like the special programmes discussed in this article. The production of these programmes requires the studio to have enough technological capacity to produce complex programmes live. This circumstance is reflected in the following table.

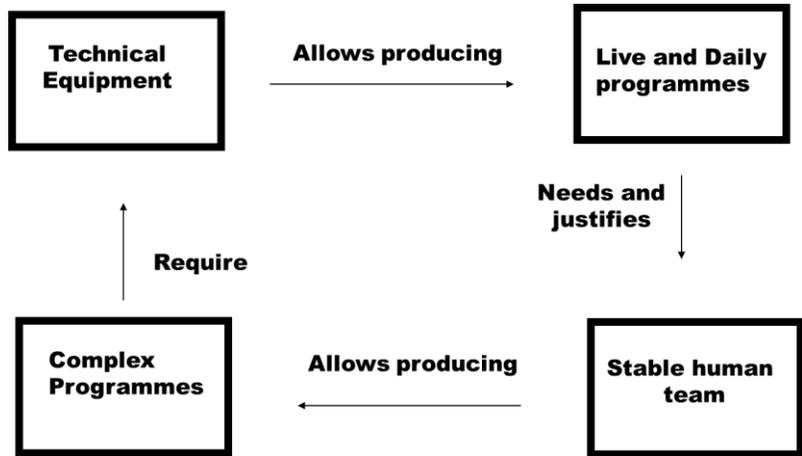


Table 1. Source: Author’s creation

The efficient operation of a virtual studio is represented in the diagram through four vertices that complement each other. In order to take good advantage of the virtual studio and have an efficient production the four vertices should be consolidated. Each of the four vertices in the diagram can be a tool to achieve excellence in production. For example, the production of a large-scale programme requires certain appropriate technical means, which in turn will allow live broadcasting. Live programmes will require a stable team that will make possible the production of a large-scale programme, which closes in this way the cycle.

A television studio with optimum operation needs to have, to a greater or lesser extent, these elements. Of these four elements one can differentiate between those purely technological and those serving as dynamizers of the technological aspects.

TECHNOLOGICAL ELEMENTS	DYNAMIZING ELEMENTS
Stable human team	Produce a daily live show
Studio equipped with virtual technology and staff well prepared to use it.	Produce a big-budget special programme.

Table 2. Source: Author’s creation

The success of the relationship between quality and production cost will depend to a large extent on the degree of fulfilment of these three requirements. It has been proved that having a stable team reduces failures and delays in production. Moreover, having a studio with the technical potential for large-scale productions also allows producing programmes in a cost-effective manner.

Of the four vertices shown in table 1, the one that has been developed the most is the one related to the possibility offered by the virtual studio to produce live or near live programmes at a much lower cost than the one involved when working in a real scenario. So far, television companies have not been interested in exploring the creative potential provided by the virtual studio system (Galán, 2008). However, virtual studio technology has been used in isolation in special programmes where the creative aspect has a greater weight. These special programmes serve to other programmes as incentive and visual reference. The production of such programmes often requires the acquisition of additional equipment -cameras, sensors, editing equipment- whose cost can then be amortised in small format programmes. The following sections examine some examples of the use of virtual sets in special programmes, which at the time sought to obtain some kind of visual solution that would offer advantages over the existing representation systems [1].

5. Use of virtual sets in special television programmes (1996-2009).

1996. Coverage of the Eurovision Song Contest by the Norwegian Broadcasting Corporation (NRK). The credibility of the integration of elements. The study of this example has a special qualitative value because it was the first serious bet on this technology for the coverage of a major live event.



Figure 1. Screenshots of the ESC (Hughes, 1996)

When the possibility of broadcasting the Eurovision Song Contest (ESC) using virtual technology was raised in 1995, the initial idea was to produce the entire event using a virtual stage. However, this possibility was soon discarded because of the difficulty that all the artists would face when acting and interacting on an empty blue studio floor. For this reason it was decided that this technology would be used only for the

voting section, which only involved the presenter of the programme, who could previously rehearse the navigability in the studio (Galán, 2009). Image 1 shows the use of real elements such as the lectern and the glass of water. The results of the video embedding are outstanding. There is a seamless integration of the glass of water; the shadow and reflection of the lectern and the presenter's dress appear perfectly projected on the studio.

The inclusion of the glass of water was not planned and it was actually a last-minute request from the presenter. However, this unexpected request was resolved successfully thanks to the power of the Ultimatte-8 software, which was used for the integration and whose potential had not been completely explored in previous programmes. The embedding of the presenter's hair and clothes offers a great sense of naturalness. This result was achieved thanks to the choice of the red colour for the clothing, which does not present any problems of brightness or contamination with the blue colour selected for the chroma key background. On the other hand, the choice of violet on the decoration avoids any kind of blue contamination in the set. The tidying-up of the presenter's hair also simplified the embedding. The use of video inputs in the decoration of the studio does not hide their virtual character at any time. The live audience is integrated in the virtual studio through a virtual window.

In conclusion, the designer achieved a welcoming, attractive and useful space to present the event, connect with the different countries and report the results of the votes. These images have been chosen because they belong to the 1996 Eurovision Song Contest (Hughes, 1996) and allow verifying that with creativity and intelligence all technical limitations can be overcome and high quality programmes with virtual sets can be produced. In 1996, the capacity of graphics cards to move high-quality scenarios in real time was still very limited and the sensor systems did not allow many possibilities. However, despite these limitations the result of the programme was entirely satisfactory. Then the existing difficulty to present in real-time the realistic scenarios, was minimised by creating a space dominated by an aesthetic inspired by the surrealist movement. The oneiric and minimalist elements that shaped the set did not require a high resolution or realistic detail. This choice simplified the work of the graphic engines. The only aspect that did not seem fully articulated was the direction of the presenter's eyes in relation to the plasma screens.

2003. Regional Elections on Canal 9. Real-time presentation of data in the virtual set [2]



Figure 2. Screenshot courtesy of Brainstorm Multimedia.

The image shows how the data was displayed in a floating and translucent plasma screen. Although the viewer could easily detect that the decoration was not real, the way in which the information was presented was effective and elegant. The data panel did not have a physical support to try to suggest to the viewer that it was real. However, the design of the set did not completely refuse the use of real elements. To confer greater credibility to the set, the architectural configuration of a real building was reproduced. Moreover, hazy images are used to simulate depth of field, which gives greater sense of credibility.

The decoration was composed of two panels which presented the results of the elections. Given the lack of camera motion tracking software and equipment, in order to change the panel the designer used a rotating platform that simulated the travelling movement of the camera. The rotating platform is used in some studies as a solution to the problems produced by space limitations. An alternative to overcome the limitations of a studio with small dimensions and little space to move the camera is to move the presenter, since this produces an identical visual sensation. The objective of the platform is to simulate the travelling movement of the camera. The platform has a remote control to execute the movement. In auto rotation mode the rotation is controlled with the software of the virtual studio, which can program the degrees of rotation -start and end- as well as the duration -which determines the speed of rotation.

2004. TVE's special coverage of the Royal Wedding. The virtual studio shows its creative potential at the service of a great event.

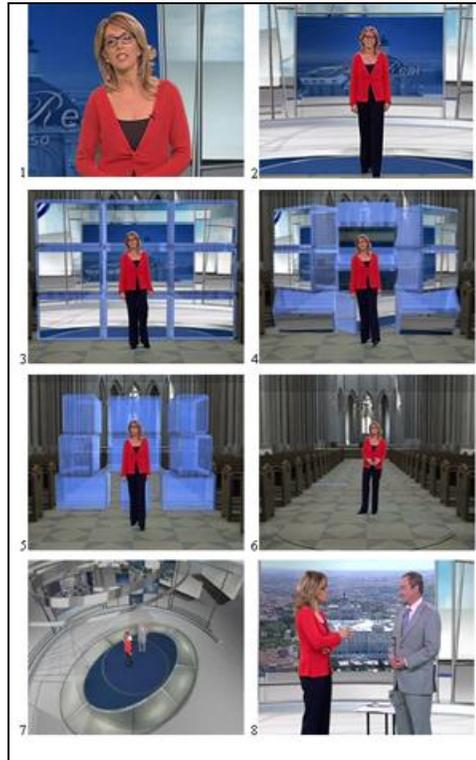


Figure 3. Screenshots courtesy of TVE

The screenshots in figure 3 are from TVE's special coverage of the Royal Wedding of the Prince of Asturias in 2004. This programme was chosen for this analysis because it is an excellent example of the use of virtual sets for creative purposes.

The embedding is perfect. For example, the screenshots 3, 4 and 5 show a full shot of the presenter, and we can see how her shoes cast a shadow and a reflection on the virtual set's floor. This detail, which may seem insignificant, gives credibility to the final composition. The blending of the presenter's hair and clothes with the background was achieved with a natural appearance. This result was achieved thanks to the choice of the colours red and black in the clothes of the presenter. These colours do not cause any problems of brightness or contamination with the green or blue chroma key backgrounds. In addition, these colours contrasted perfectly with the blue and grey tones that predominate in the virtual environment. It was also helpful that the presenter's glasses have black frames which are much easier to integrate than the frameless glasses.

One aspect that may have caused certain problems of integration is the hair of the presenter. As seen in the screenshot 1, the hairstyle had fine locks of hair pointing out, which are difficult to integrate. However, this aspect was resolved with great effectiveness. The producers probably used Ultimatte software to add certain shadow

noise to blur the edges of the hair with the background in order to provide a natural composition.

The screenshot 8 shows the use of real elements on the set. However, in this case, the real table looks like a fake accessory in the set. The inclusion of the table did not respond to an aesthetic choice but to the need of having an accessible place to put the script or a glass of water. The use of video sources in the decoration (screenshot 8) did not hide their virtual character at any time. It is worth noting that the screen is oval-shaped and is perfectly integrated in the set, and also that there was an absence of any physical element justifying the floating position of the plasma screen. The production team opted for a bold use of the creative potential of the virtual studio and obtained a credible result. In the bird's eye shot, in the screenshot 7, the combination of circles and ovals in the design of the set's floor is striking.

This design is also useful to integrate in the set the rotating platform that simulates the travelling movement. The disadvantage of using rotating platforms is that there is always a separation or small edge between the platform and the set's floor, which is difficult to integrate. This separation can be hidden with adhesive tape of the same colour as the cyclorama. The disadvantage of choosing this solution for a live programme is that adhesive tape can fall off when the platform rotates. Another solution is to design a set where the platform is concealed by the virtual set's floor.

The screenshots 2 and 7 show how the virtual set has a ring that serves to cover the physical intersection of the platform. However, the bottom of the screenshot 6 shows the embedding problems caused by the platform. The television studio was transformed into the Almudena Cathedral and therefore the change of texture in the floor revealed the intersection of the platform. In the screenshot 6 there is a complete transformation of the conventional set of the programme into the interior of the Almudena Cathedral, and this is presented to the viewers in real time. This visual effect is only achievable in a virtual studio. Moreover, the change of set goes far beyond a mere visual trick. The days before the Royal Wedding, the Cathedral was closed to the public in order to complete the preparations for the event. The virtual reconstruction of the Cathedral in 3D allowed the presenter to take a virtual tour within the space where the Royal Wedding took place.

2005. BBC's special coverage of the elections. The virtual set as the central element of the programme's narrative.



Figure 4. Screenshot of presenter Peter Snow walking over a virtual map representing the seats. Source: Brainstorm Multimedia.



Figure 5. Sequence of screenshots showing the real time transformation of the studio floor into the residence of the British Prime Minister at Downing Street, where a race between the different candidates is represented. Source: Brainstorm Multimedia, 2005 Elections.

This special programme covering the elections presented a series of recreations of real spaces through virtual sets that allowed the presenter to present graphically the latest data [3]. The biggest difficulty of the programme was the navigability of the

presenter. However, the involvement and complicity of presenter Peter Snow with the technology and the numerous rehearsals facilitated his interaction with the environment.

2008. BBC News' special coverage of the elections. The virtual stage of a date with history [4].



Figure 6. Screenshots courtesy of Brainstorm Multimedia

This example is an excellent demonstration of the representative potential a virtual set, which in this case aimed to create a hyper-realist environment with saturated colours and metallic textures. The presenter descends the stairs and stands in a position where he interacts with the graphics and the data. The production clearly exploited the graphic engines to present spectacular architectures in real-time. This great set highlights and emphasises the historical and media significance of Obama's victory in the presidential elections of the USA.

The main technological bet is the ability given to the presenter to interact in real-time with the 3D objects integrated in the stage. The presenter can finger point, move and interact with the objects in real time [5].

BBC. 2009 EUROPEAN ELECTIONS. Is simplicity a symptom of maturity?



Figure 7. Screenshots courtesy of Brainstorm Multimedia.

The screenshots, in Figure 7, show a virtual set that has forgotten the realistic aesthetic. The presenter is over a map of the European Union and the set is decorated with white elements and some significant icons of the EU member states. The graphics with the electoral information were drawn in 3D in real time on the studio floor. The presenter interacted with the information, and emphasised the most relevant parts of the graphs. In comparison to previous uses of digital sets, there is an improvement in the resolution of the graphics. Here the introduction of a video screen was no longer necessary to display the details of the information. Instead, the cameras simply zoomed in to the graphic that needed to be emphasised.

This set did not aim to imitate reality or to look real, and instead adopted its own iconic specificity. However, as it happened with the Eurovision Song Contest thirteen years earlier, the presenter's eyes were not directed to the virtual information embedded in the set, but towards the monitor used as reference outside the studio floor. Another issue was the navigation of the presenter. In other words, while it was technologically possible for the presenter to interact with virtual objects, there were not enough technological solutions to help him move easily and comfortably in the virtual environment.

6. Conclusions

In the six programmes analysed in this article the virtual set constituted a key element of the production. The virtual environment is a place where the story of the programme is developed, transformed and enriched. The Eurovision Song Contest special programme, which was produced by the Norwegian Broadcasting Corporation (NRK), offered viewers the outcome of the votes and the same time the reaction of the live audience and participants through the floating screen on the set.

In Canal 9's especial coverage of the 2003 elections, the presenter is helped by the movement of the rotating platform to navigate between the panels showing the participation data and the results of the votes in the regional elections. The panel does not have any physical support, and therefore did not try to hide the virtual nature of the set.

In 2004 TVE made a great effort to cover the wedding of the Princes of Asturias and reconstructed Madrid's Almudena Cathedral in 3D. In this way viewers received the news of the wedding from the site where the event took place. The transformation of the television studio into the Cathedral was produced in real time with a very remarkable visual result.

The work done by the BBC in the 2005 elections exemplifies the capacity of the virtual studio to determine the narrative of a television programme. The virtual set allowed the presenter to be simultaneously in the House of Commons, or Downing Street, or to walk over the map of Great Britain, showing the result of voting in 3D.

BBC News recreated a hyper-realistic stage in which the presenter interacted with the 3D graphics by pointing, directing and showing the information in real time.

Finally, the BBC's special coverage of the 2009 election exemplifies an exercise of restraint and moderation in the use of audiovisual equipment. The set only outlines some representative icons of the EU member states. The absolute protagonism is placed on the graphics with which the presenter interacts to display the information that is coming from the different countries. 3D animation television series like Pocoyo, which is produced by the Spanish company Zinkia, and commercially successful feature films, like Disney's Up, are already betting on using 3D technology based on simplicity.

In the early 1990s, the virtual studios made a constrained use of the 3D technology due to the limited capacity of the graphics cards to reproduce details. Today the 3D representation techniques are able to reproduce real spaces and objects with all their details. However, some cutting-edge audiovisual creators such as Disney, Zinkia or the BBC have started to realise that it is not necessary to always construct their stories on the basis of hyperrealism as a representation technique. Computer graphics and 3D tools are more than a vehicle to reproduce reality; they have the ability to get closer to the essence of what is represented. Simplifying the representation of a face, a landscape, or an object, allows identifying their essential features and to extract their essence. In this new concept, the aim is not realism. What is important is that the final composition is credible, represents a tangible reality and, in short, is alive.

7. Bibliography

BRINKMANN, R. (1999). The art and science of digital compositing. Morgan Kaufmann Publishers.

CRUZ-NEIRA, C.; SANDIN, D. J.; DEFANTI, T. A. (1993). "Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE". In: Siggraph. Los Angeles.

FERNÁNDEZ, C. (2009). "Estratificaciones significantes de la imagen en la realización de programas informativos de televisión: potencialidades de la tecnología más allá de la espectacularización" (Significant stratifications of the image in the production of television news programmes: potentialities of technology beyond spectacularisation). Castellón, UJI.

FUKUI, K; HAYASHI, M; YAMANOUCHI, Y. (1996). "Virtual studio system for tv program production" In: IEEE Multimedia.

GALÁN, E. (2008). "Escenografía virtual en TV. Análisis del uso de escenografía virtual en la realización de un programa de televisión" (Virtual scenography in TV. Analysis of the use of virtual scenography in the making of a TV programme"), In

Revista Latina de Comunicación Social, 63, pp. 31-42. La Laguna (Tenerife): University of la Laguna. Retrieved on 15 December 2008 from: http://www.ull.es/publicaciones/latina/2008/04/Galan_Cubillo.html

GALÁN, E. (2009). "El trabajo del presentador de televisión en un escenario virtual" (The work of the TV presenter in a virtual set). Revista Latina de Comunicación Social, 64, páginas 143 a 150. La Laguna (Tenerife): University of la Laguna. Retrieved on 6 April 2009 from: http://www.revistalatinacs.org/09/art/13_812_12_escenario/Esteban_Galan_Cubillo.html DOI: 10.4185/RLCS-64-2009-812-143-150.

GARCÍA, A. (2007). "Principios de interactividad: televisión interactiva y realidad virtual" (Principles of interactivity: interactive television and virtual reality) in Enlaces: journal published by the CES Felipe II, nº 7.

EDSALL, S. (2008). "The future of television graphics" in ACMSIGGRAPH

GIBBS, S. (et al.) (1998). "Virtual Studios: An Overview" In: IEEE Multimedia.

GRAU, O.; PULLEN, T.; TOMAS, G. A.; (2004). "A combined studio production system for 3-D capturing of live action and immersive actor feedback". In: IEEE Multimedia.

GUBERN, R. (2000). El eros electrónico (The electronic eros). Madrid: Taurus.

HUGHES, D. (1996). "Virtual studio technology. The 1996 Eurovision Song Contest". In EBU Technical Review. Summer of 1996.

LÓPEZ SILVESTRE, F. (2004). El paisaje virtual. El cine de Hollywood y el neobarroco digital (The virtual landscape. Hollywood cinema and the digital neo-Baroque). Madrid: Biblioteca Nueva.

MOSHKOVITZ, M. (2000). The Virtual Studio. Boston: Focal Press.

PAREJA E. (1998). Escenografía virtual (Virtual scenography). UD. 157. Madrid: IORTV.

PAREJA, E. (2005). Tecnología actual de televisión (Current technology used in television). Madrid: IORTV

PÉREZ MARTÍNEZ, V. (2009). "Multimedialidad e interactividad en la cobertura informativa de las elecciones presidenciales de los Estados Unidos de 2008 en los cibermedios españoles (Multimediality and interactivity in the coverage of the USA 2008 presidential elections by the Spanish cyber-media). Revista Latina de Comunicación Social, 64, pp. 161-175. La Laguna (Tenerife): University of La Laguna, retrieved on 10 January 2010, from:

http://www.revistalatinacs.org/09/art/15_814_09_Obama/Victor_Perez_Martinez.html
DOI: 10.4185/RLCS-64-2009-814-161-175

POPKIN, D. (1997). "Virtual studios - the BBC's experience". In: EBU Technical Review: Summer of 1997.

SOENGAS, X. (2005). "Los contenidos informativos en las televisiones generalistas" (Informative content on mainstream television channels), in Ámbitos (nº 13-14) pp. 59-77.

VÁZQUEZ, T. (2009). "Evaluación de la calidad de la programación infantil de las televisiones generalistas españolas" (Evaluation of the quality of children's programming in Spanish mainstream television channels), In Revista Latina de Comunicación Social, 64, Pp. 844-861. La Laguna (Tenerife): University of La Laguna, retrieved on 12 January 2010 from:
http://www.revistalatinacs.org/09/art/866_CEU/67_83_Tamara_Vazquez.html
DOI: 10.4185/RLCS-64-2009-866-844-861

VALERO, J. L. (2008). "La infografía digital en el ciberperiodismo" (Use of digital infographics in cyber-journalism), in Revista Latina de Comunicación Social, 63, pp. 492-504. La Laguna (Tenerife): University of La Laguna, retrieved on 12 January 2010 from:
http://www.ull.es/publicaciones/latina/08/42_799_65_Bellaterra/Jose_Luis_Valero.htm
|

VIDAL ZANÓN, E. (2001). Visiocascos y tarjetas estereoscópicas (*Visiocascos and stereoscopic cards*). Valencia: UPV.

WOJDALA, A.; GRUSZEWSKI, M.; RYSZAND, C.; (2000). "Real-time shadow casting in virtual studio", *MGV (Machine Graphics and Vision)* 9 (2000), n. ½ p. 315-329.

8. Notes

[1] There are attempts to make objective analysis of audiovisual products like the Index of Televisual Quality (ICT, according to its initials in Spanish) produced by the Austral University's Observatory of television. This index has been used by Vázquez (2009) to analyse children's programming in the Spanish mainstream television channels. According to this classification, the technical quality of the program accounts for 30% of the final assessment of the programme. The technical section includes the set, lighting and actual production. However, the analysis in this article is primarily descriptive and therefore will not use any quantifiable scale.

[2] Valero Sancho (2008) addresses the informative value provided by digital infographics in all newspaper genres.

[3] Although the character of the electoral programme is primarily informative, the network sees it as an opportunity to prove its prestige and for this reason deploys most of its human and technical resources to offer a coverage as good as possible (Galán, 2008). In Spain, for example, all the networks are connected to the database of the Ministry of Interior and therefore all have the information available at the same time. Thus, the added value that a network can offer is the way of presenting the data and here is where the virtual set comes into play.

[4] Pérez Martínez (2009) analyses the unprecedented impacts of Obama's victory on the media.

[5] The real-time interaction with 3D objects is an extraordinarily ambitious bet within the dynamics of the traditional work in television. In his analysis of the information content of the mainstream television channels in Spain, Soengas (2005) confirms that there is an under-utilization of the technological resources and a lack of innovative proposals in the audiovisual narratives. The technological resources are used to optimise the operational work routines, but their advantages are hardly seen in the final products.

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