Deconstructing Digital Video: The Ontological and Technical Complexities of a Medium

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27th EGOS Colloquium 'Reassembling Organizations'
Gothenburg, Sweden, July 7–9, 2011

Sub-theme 35: Deconstructing Institutions: Meaning, Technology and Materiality

Abstract

The present paper describes some historical and ontological aspects of video and its incarnation as a digital object. We first analyse the historical evolution of video, mostly centred on its screen-based constitution. Paying due attention to the crucial importance that Internet technologies associated with digital video are currently playing, we then move to analyse the case of digital video standard MPEG. Drawing on arguments by recourse to the literature on materiality and technology, we analyse video from its material evolution (analogue video) towards the non-material digital landscape and its main software-based functionalities. We will re-construct digital video within the definitions and properties of digital objects to analyse its constitution as a complex set of technological layers through which information supports it. Finally, we will make a brief account of how digital video characteristics impact in the media industry workplace.

1. Introduction

We usually understand video taking into consideration the consumption habits related to watching TV or, more lately, watching content on other multimedia devices (i.e., PC or a mobile phone). However, from a broader perspective, video should be seen as a technological construct that has been able to accommodate itself dynamically to a diversity of devices, not only the ones previously alluded, but also the new and vast set of emerging computational platforms (e.g., game consoles, tablets, home and professional media players) as well as to their operating systems and software applications, which are now part of our daily life and, consequently, to different forms of social practice.

Lay publics view characterizes video as a "medium", however, to understand video today it has to be envisaged with a higher order of complexity. Video is a construct, not just feats of engineering but projected layers of technologies, projected in that we ascribe to them a coherence they do not originally possess. Convergence is in general terms an outcome of that reasoning, since many elements that comprise digital video are shared or come from other media. Digital video is, therefore, a set of technologies arranged in a system and we have to look at the **elements from which it is composed** and the **commonalities it has with other media**. The elements from which video is composed describes its technical characteristics and how it has been influenced by the Internet and the current informational space. The commonalities that video has with other media requires a historical context in order to analyse the different technologies that come in place and what role do they take as well as the reasons why they were necessary. If technological innovation is a process of constant reassembling old parts into new forms, then technologies are also containers of history, and the past accumulated in them is what makes up their current state.

Digital video, in comparison to most other media that we consume regularly, has a distinctive trajectory and a vigorous evolution in which it is embedding into its projected layers new and sophisticated technologies that may have nothing to do with its initial characterization. This is quite evident today, where more than 50 percent of current internet data traffic is due to the use of video (Anderson and Wolff 2010) and recent studies suggest that the sum of all forms of digital video (TV, video on demand, Internet, and P2P) will continue to exceed 91 percent of global consumer data traffic by 2014. Internet video alone will account for 57 percent of all consumer Internet traffic in 2014 (Cisco 2009).

In the rest of this paper, I seek to analyse some historical and ontological aspects of video and its incarnation as a **technological construct**. I first analyse the historical evolution of video, mostly centred on its screen-based constitution, which dates from mid 19th Century. Paying due attention to the crucial importance that Internet technologies associated with digital video are currently playing, I move to analyse the case of a particular digital video playback standard, MPEG, which is the basis of digital video available on the Internet. MPEG has evolved, since its first public release date in 1993 (MPEG-1), to become the widest used method for playing digital video over the Internet. The discussion will be mostly focused on how the material perception of video has shifted in the digital landscape through software-based functionalities. We will support some of the arguments by recourse to the literature on materiality and technology (techno materiality) as means of re-constructing video within the definitions and properties of digital objects (Runde, Jones et al. 2009; Faulkner and Runde 2010; Kallinikos, Aaltonen et al. 2010; Kallinikos 2011). One of the central aspects that we allude in the following sections is that video originated from a material pre-condition and had been defined in this pre-condition for most of its recent history. However, it is not until the advancement of digital video, and particularly some of the technical standards created by the Internet, that digital video carried a more complex definition. The aim is **to analyse the technical constitution of video as a complex set of technological layers and a brief account of its current impact in the media industry workplace**. I will also support the fact that video in its current form should be analysed from its historical constitutive technological components in order to understand its evolution. Thus, the operations of the consumption of video today are intertwined with the technological layers through which information supports it, most important, the logics of Internet (Zittrain 2008; Kallinikos and Mariategui 2011).

It is not the idea of this paper to discuss how people interact today with video, but to contribute to the understanding of video in its current state based as a set of technical layers and to briefly give an account of its impact in the media industry working practices. More over our research intents to contribute to the understanding of video as a technological artefact in the same perspective of studies that analyse other types of media such as writing, image or sound (Kittler 1999; Flusser 2000; Flusser 2002; Liu 2004; Kallinikos 2009; Kallinikos, Aaltonen et al. 2010; Flusser 2011).

2. Material Origins: From the Printed Image to Video

Video is not easy to define. Etymologically it derives from the Latin verb "videre" meaning, "I see". This connotes the direct relation of video with the realm of images. The development of the technical image has been systematically studied (Mitchell 1980; Benjamin 1986; Debray 1992; Mitchell 1994; Carroll 1996; Brea 2010; Flusser 2011), but video stands distinctively on its own, due to several particularities: it was initially composed of a sequence of images (frames) at a determinate frame rate, but during the last century it also incorporated sound and become an audiovisual ensemble. Zienlisky, while studying the ‘archaeology’ of media, rightly defines this assemblage of video and sound as *audiovision* (Zielinski 1999). For this reason, the study of video as a technical artefact does not conform to a single media definition. It is rather made of a complex set of layers of technologies that put together define the technological object. As I will discuss latter, most of the history of video has been focused not only in terms of **visual quality considerations**, but also the ways in which it is **transmitted**. Several attempts to increase the portability of pre-video formats, such as the 16 mm film gauge, by using acetate film stock in an attempt to increase its portability outside of movie theatres (which at the same time generated the development of new social spaces, the home cinemas) or the introduction of 8 mm films are evidence of the importance of transportability (Wasson 2008). TV itself is the most evident analogy of the importance of transportability, since the TV set replaced most of home cinemas of the early 20th century in favour of instantaneous and diverse content and now, in the 21st century, the home TV has been by content in mobile apparatuses (i.e., phones, tablets). Hence transportability becomes transmissibility: video has been one of the few artefacts, along with text, image and sound, which could be transmitted, initially through airwaves and more recently electronically.

2.1 Historical considerations

Sean Cubitt mentions that hardware is a response to software studies (Cubitt 2009), therefore understanding the physical infrastructure (materiality) has an increasing importance in the study of the evolution of artefacts towards being digital objects. Stanley Cavell, calls “automatisms” (Cavell 1979) to the forms and conventions that arise creatively out of the existing materials conditions of given art practices, which constitute the bases for constructing the specific possibilities of a given medium.

The genesis of video can be traced back to the 19th Century, when William Henry Fox Talbot, a pioneer of photography, made the earliest known surviving photographic negative using a camera: a small photogenic drawing of the latticed window in the south gallery of Lacock Abbey. Continued experimentation by Talbot led to a breakthrough when he discovered that paper treated with a coating of silver iodide, exposed in camera, and developed in gallic acid mixed with silver nitrate and acetic acid would bring out a latent image. The latticed window was used as the basis for what today is called a raster, a procedure used to separate the screen into a set of small cells (or small screens). These set of small cells are the basis for the square pixels from which they share a set of design constraints that had been present since the first videographic image. This raster procedure also enabled the making of photography as an industrial process that revolutionized the printing press into rotary presses (1873). Therefore, to some extent, video has an early connection with printing as both were defined through the same technical principle.

Many decades after, in 1935, Bell Labs wirephoto applied the raster schema for the first commercial photo transmission system, which was able to send an image to 25 cities of the US within an hour, over the wires up to 3,000 miles away. It used selenium, but the image had to be scanned using a rotary scanner which rendered the image cell by cell, from left to right, and the image was then sent through fragments of electricity, an analogy with the binary code. After some decades TV's cathode ray tube also began to be based in a raster scan, where beams are directed in lines (scan lines) across a screen: the horizontal sweep controls the number of lines on the screen, while the vertical sweep controls how fast each screen is displayed; consequently, video not only incorporated information about the image quality, but also about how fast the images had to change, hence, the act of transmission. Computer monitors and TVs use this method whereby electrons are beamed (scanned) onto the phosphor coating on the screen a line at a time from left to right starting at the top-left corner. So the cathode ray tube does this in a similar principle as a print: illuminate or not illuminate (i.e., similar to the 0s and 1s of binary code). The concept of the pixel derives as a manifestation of the TV raster and in the recent years, it still maintains its physical constituency, even if digital video is no longer dependable of a definite type of monitor but it is transmissible through a variety of multimedia devices.

3. Non-material Renaissance: From Digital Video to a Data Object

For several decades video was associated to the TV set. The irruption of information technology generated a shift on this 'status quo' and increasingly video has been possible to play on PC screen or more recently to mobile devices and a diversity of other platforms. Initially playing video on computers was not an easy task as it demanded, in technical terms, specialized hardware (i.e., video cards, hardware accelerators) and the software to play a collection of hundreds or, even, thousands of still frames at a defined rate per second, as well as its synchronization with sound. Furthermore, moving image and sound, had different formats and had to be brought together in an embedded and unified format.

There were other technical considerations such as the difference of the sampling rate of the images in a TV monitor in contrast to a PC monitor. In video, the sampling rate is the repetition rate in which an image appears on the screen. Initially these samples were a series of complete frames (called *progressive* sampling) but in analogue TV this required a bigger bandwidth, which at the same time made more expensive and complex the entire production and broadcasting of video (i.e., cameras, tape recorders, broadcast systems). The solution to reduce the signal bandwidth was done by sampling of video in a sequence of *interlaced* fields, in which half of the information in a frame (one field) is sampled at each temporal sampling interval (Richardson 2003; Watkinson 2004). Interlacing has been an important factor which is still used today for most standard definition TVs.

Since digital video is free of many of the limitations of analogue TV transmission formats, this resulted in the reintroduction of *progressive* scan, which at the same time was used for new TV displays (i.e., LCD, plasma displays). As a result, digital video provided the means to capture, convey and present moving images in their original format, regardless of variations in video standards.

A similar change occurred with the equipment used to display and record images. This comprised the video players and recorders that were used in the media industry for decades. An emblematic case is from one of the main manufacturers, SONY, which developed several formats that became standards in the broadcasting world, such as U-Matic (3/4 inches tape) and Betacam. These two standards were used for more than four decades and millions of hours of material are recorded and archived in these formats. Physical standards had their drawbacks, for example, in the case of both U-Matic and Betacam, the physical tapes were of two sizes (the smaller size was a demand in order to introduce portable record players for field productions), which meant that the player deck required a level of mechanical complexity in order to accept both different sizes. This issue, among many others, and the commercial property of the standard by a sole manufacturer enabled these standards to remain closed and proprietary.

Added to these, critical aspects such as the perishability of tapes and the introduction of new consumer and “prosumer” (professional consumer) formats that were more efficient and had the same quality as these legacy ones, made evident the great limitations of proprietary technologies. Finally, the expansion of information technology made digital equipment start and replace analogue ones. Digital video was first initially introduced in 1986 with the Sony D-1 format, which recorded an uncompressed standard definition component video signal in digital form. However, as with many proprietary standards, D-1 was expensive and was used by large television networks.

As we can see, most standards in the media industry operated for decades in silos, manufacturers specialized in specific functions of the media production process with no communication among the different systems (even, sometimes among equipments from the same manufacturer), which prevented the industry to develop more efficient, standardized and collaborative practices. Many of these specialized systems were eventually replaced by tapeless solutions, which by not depending on specialized hardware were cheaper, open and eventually standardized and interoperable.

During the decade of the 90s, as computer-based digital video editing become available, the first tapeless formats started to be used commercially. This meant that the content (video) was separated for the first time from a particular container type (tape). Digital video was then mostly stored in specialized hard disks or tape backups[1]. The two most relevant aspects of tapeless video at this first stage was its **quality** and the **data space** it occupied. These two aspects came in hand, as the highest the quality the more data space a digital video file required. As time passed better compression schemas were developed, which enabled more efficient data

[1] We will not go into details, but in comparison to consumer grade data storage, broadcasting industry data storage requires a high degree of redundancy in order to be reliable in a large working

storage. Initially, those compression schemas required specialized hardware in order to work properly. This brought not only more specialized equipment to the media industry, but also very specific algorithms that worked with certain specialized hardware. This generated a variety of diverse and incompatible video formats.

To be efficient, digital video required compressing images into what it is know as standard digital video formats. I will not deal with any detail with the history of standards. It is crucial however to recognize that the history of digital video as a standard was focused initially in obtaining a higher image quality. And yet, as shown in the next section, the development of the most successful video standard, MPEG, entails a shift from techno-aesthetical concerns to more functional and informational considerations.

3.1 The case of MPEG: the deconstruction of digital video into technical layers

As the technology and processing power evolved, so did the algorithms that enabled better quality and demanded more processing power for digital video. As mentioned earlier, during the end of the 80’s and most of the 90’s high quality digital video was only possible in sophisticated workstations prepared with special video cards. In 1988, the 'Moving Picture Experts Group' (MPEG), a working group of experts, was formed to set standards for digital audio and video compression and transmission.

The standards developed by the MPEG were based on the compression technologies developed by the Joint Photographic Experts Group (creators of the JPEG still image compression, still widely used today) and the CCITT's Experts Group on Telephony (creators of H.261, a standard for video conferencing); this means that the knowledge brought to create the first digital video standards came from experts in **image compression** (i.e., compression stands as the study of the image quality) and **data transmission** (i.e., videoconferencing).

Being a working group of ISO (International Organization of Standardization), the MPEG is currently divided into ten subgroups: Systems, Video, Audio, MDS, Test, ISG, Requirements, Liaison, SHNC and Integration. Actually from those subgroups, the Video subgroup, which is the largest, is the only one that deals specifically with the video signal processing. Figure 1 shows the activities of each subgroup.

Subgroup	**Activity**
Requirements	Collect the technical requirement that the new standard shall satisfy, including new application domains that may require to be incorporated in the standard.
Video	Combines all technical experts that are concerned with video signal processing, in other words, the visual quality of the MPEG standard.
Audio	Gathers all aspects of audio coding and audio-signal processing. This group also specified sub-standards such as MP3, the most popular audio format on the Internet.
MDS - Multimedia Description Schemes	Responsible of the Description Tools (also known as Descriptors or Description Schemes), which include: content management, content organization, content description, navigation and access, user interaction, data types, structures and schema tools.
Test	Responsible for test and compliance of the specification in video, audio and systems.
Systems	This group is in charge of the combination and packeting of audio and visual data and other ancillary data.
ISG – Implementation Study Group	Is a technical subgroup whose task is to advise on the algorithms used for the MPEG standard and analyses the overall performance of each alternative available.
Liaison	Maintains communications between MPEG and other standards bodies on topics of common interest (i.e., ITU-T, ITU-R, EBU, ATSC, SMPTE, ISO, CEN, DAVIC, JPEG, VRML, W3C, DVB, FIAPF, INTELSAT, AES)
SHNC – Synthetic Natural Hybrid Coding	This group deals with the visual data generated from the computer (synthetic visual data).
Integration	This group deals with other standards that exist in the world in order to avoid duplication or work on common

	specifications with others as well as with video coders experts that work on separate groups.

Fig. 1 MPEG subgroups, adapted from Diepold and Moeritz (2005)

After 20 meetings and 4½ years of development and testing, the first MPEG-1 (H.261) standard was approved in 1993. The rationality for MPEG compression methodology is considered asymmetric, as the encoder is more complex than the decoder. The encoder needs to be algorithmic or adaptive whereas the decoder is 'dumb' and carries out fixed actions. This was one clear advantage in applications such as broadcasting where the number of expensive complex encoders is small (mostly available inside the media industry) but the number of simple inexpensive decoders is large (e.g., most PC's and mobile devices). In this sense the standardization approach is novel, because it is not the encoder that is standardized, but the way a decoder interprets the bitstream. The advantage of standardizing the decoder is that over time encoding algorithms can improve, yet compliant decoders continue to function with most of them. The lack of encoder specification means that MPEG-1 coding efficiency can drastically vary depending on the encoder used, and generally means that newer encoders perform significantly better than their predecessors and allows competition around who develops the best encoder (best image quality per bit). Similar concepts on open encoding process are employed for other types of media standards such as JPEG. MPEG fundamental capability is to pack digital media data more tightly fuelling a range of applications. A high level of compression provides significant cost savings and enables the development of new applications. The effect of its efficient compression has strongly influenced the development of Internet applications (Diepold and Moeritz 2005).

One of the first additions to MPEG-1 video was the audio layer, which was necessary in order that video performed sound during playback. In 1991, the Musicam technique, as proposed by Philips (The Netherlands), CCETT (France) and Institut für Rundfunktechnik (Germany) was chosen due to its simplicity and error robustness, as well as its low computational power associated with the decoding of high quality compressed audio. However, this layer was made flexible and open enough in order that several other vendors created their own formats of audio[2] (i.e., mp3PRO, AAC, and MP2). During the last years, MPEG has also combined or 'multiplex' audio data with video data to produce a one ensemble or data stream, instead of two separated ones.

MPEG-2 was developed two years later to support, mainly, the migration to digital video services and digital video broadcasting (Diepold and Moeritz 2005). DVDs and most of the digital set-top boxes are based also in MPEG-2.

In 2003, the H.264/MPEG-4 one of the most recent incarnations of the MPEG standards was completed. The H.264 was conceived to be usable in many different devices, which enabled also the diffusion of multiplatform devices (e.g., smartphones, tablets). H.264 is the first truly multiplatform format, used in such applications as players for Blu-ray Discs, videos from YouTube and iTunes, Adobe Flash Player and Microsoft Silverlight. Therefore, MPEG-4 enables the use of it in several operating systems, platforms and devices, bridging up the contents provided by telecommunication, broadcasting and computer industries. For the media industry it is commercially valuable to produce a content that can be used (or recycled) several times. However, each of these contents will have to be available in more than one quality to make it available for consumer's equipment. As there are number of portable devices is exploding, the MPEG format needs to be adapted specifically for each of these distribution channels and display devices. For example, media produced for a traditional TV cannot be displayed on smartphone without the appropriate modification and reformat (transcoding) to the specifications of that particular smartphone (Diepold and Moeritz 2005).

In the same way, previous MPEGs versions were mostly focused in video and audio components, but more recently the audiovisual technology trends urges

[2] Particular format for both video and audio, called "codec", which is based on computer program capable of encoding and/or decoding a digital data stream or signal.

the convergence of seemingly separate worlds: TV/film/entertainment, computing and telecommunications. Taking this into consideration, the H.264 standard was conceived with functionalities clustered in three key matters: Content-based interactivity, compression, universal access (Diepold and Moeritz 2005). **Content-based interactivity** and **universal access** were functionalities that required the development of new standards to supplement the current H.264, namely MPEG-21 (2001) and MPEG-7 (2002), both focused in incorporating layers of data.

MPEG-7 is formally called Multimedia Content Description Interface; it is mostly defined as a description standard which means it is associated with the content itself, to allow fast and efficient searching. Thus, this layer of data is not a standard that deals with the actual encoding of moving images or audio (i.e., like MPEG-1, MPEG-2 and MPEG-4). MPEG-7 uses XML[3] to store metadata that can be attached to a defined video time code in order to tag particular events (e.g., tag a person in a video, synchronise lyrics to a song). One of the driving visions of MPEG-7 was to make multimedia content searchable, just as we search for a video in YouTube or Google, but even more, instead of only searching by keywords, the user would be able to search by images, colours, sounds and melodies (query by humming). In this regard, the Internet in the form of metadata and electronic text has permeated the recent history MPEG (Diepold and Moeritz 2005; Kallinikos and Mariategui 2011).

In the case of MPEG-21, its aim is to define a normative open framework that support multimedia delivery and consumption for use by all players, in other words, the objective of MPEG-21 is to prove access to an almost unlimited supply of media in a seamless, secure and interoperable way, by identifying the mechanisms and elements to support the multimedia delivery chain (Diepold and Moeritz 2005). It is based on two essential concepts, the definition of a “Digital Item” (a fundamental unit of distribution and transaction) and how do the users interact with “Digital Items”. “Digital Items” can be

[3] XML (Extensible Markup Language) is a set of rules based on open standards for encoding and interchanging data, documents and web services over the Internet.

considered the universal token or exchange unit for operations in a multimedia framework. Therefore, the main objective of the MPEG-21 is to define the technologies needed to support users to exchange, access, consume, trade or manipulate Digital Items in an efficient way.

As it is evidenced, MPEG is no longer dealing only with audiovisual content (quality considerations), but its most recent incarnations (i.e., H.264/MPEG-4, MPEG-7, MPEG-21) describe the composition of these objects to create compound media objects that form audiovisual scenes and synchronize the data associated with media objects, so that they can be transported over network channels providing the appropriate interoperability and interact with other audiovisual scenes.

4. Discussion: Towards an Ontology of Video

After discussing briefly the characteristics, both historical and technical of video, I will now to introduce the study of its ontology, hence, a theory of its modes of being, particularly focused in the digital domain. However, to do this, we have first to clearly separate the material aspects of video from its non-material ones in order to elucidate and differentiate the characteristics we would like to centre our ontological distinctions upon.

4.1 The Material/Non-Material Ensemble

For most part of the 19th and 20th centuries moving images were connected to material relations. The physical film or videotape generated a sense of physical property around the moving image (Wasson 2008) and both shared similar outcomes in terms of what we see. However, as Yvonne Spielmann mentions, both media types depend on differently constituted premises in both their technology and apparatus (Spielmann 2008).

Some authors assert that it is not possible to define an ontology of video as there are basic distinctions between the analogue and digital, in which the former reaffirms the materiality of photography as a “receptive substance etched or sculpted by light forming a mold of the object's reflected image" whereas the later has "loosed its anchors from substance and indexicality" (Rodowick 2007). We may disagree with this last sentence, as digital objects had incorporated layers of information in order to gain indexicality through metadata. Moreover, video's indexicality in the digital world, which is also related to the concept of identification, is key to make it findable. In the analogue world substance and indexicality are always bound together. In digital objects, it can be separated into several layers of information, which can be reconfigured. Therefore the substance in the case of digital video is defined by its description, and in this way it confers the digital object a space and attribution (Kallinikos, Aaltonen et al. 2010).

Though we can assure the historical origins of video's technical constituency, we have also to assert that content-wise most of the history of video comes from the history of film. This is why many definitions of video are based in the study of the materiality of the screen of video (Tutt and Hindmarsh 2009) or had tried to analyse digital objects based only on their material properties (Schiffer and Miller 1999). Other studies, had even taken this stance relating it with elaborated reconstructions from Science and Technology Studies as a means to explain the social construction of technology in an intent to reason video's materiality (Oudshoorn and Pinch 2003). However, I want to argue critically that today a key aspect to analyse of video is not its material support but its technical constituency, which is based on software operations and is changing systematically permeated by the logics of Internet.

Faulkner and Runde in a recent working paper made clear distinctions between the characteristics of material and non-material objects in order to develop an ontology of the later. The authors mentioned that one of the defining attributes of material objects is that they endure (also referred as "continuants"), which means that its lifespan is based on the nature of the object. The second attribute mentioned is that material objects are "structured", which means that they are composed of a number of distinct parts that are organized or arranged in some way (Faulkner and Runde 2010).

By analysing video through the light of these material considerations, we can do the some historical analysis. Video "endures" while being part of a physical support, initially based on film, subsequently on tape, and now on hard drives. However, its level of "endurance" has always been directly related to the capacity of its physical support, therefore, any physical manipulation generated a nuance. For example, videotapes usually wear out after 10 to 15 years, and this event can only be prevented if the material object goes through a process of conservation (today, paradoxically, most of the preservation strategies for moving images are oriented to convert them to digital formats).

The second aspect mentioned by Faulkner and Runde is the "structural" attribute or the composition out of a distinct number of parts. Once more, in analogue video, an analysis could be done at the light of both its media but also the machines that are part of the media production process of shooting, recording, editing and broadcasting. All these are artefacts are mainly mechanical, constituted from objects which were relatively stable and that "endured" for decades. At the same time, both the tape as well as the tape player/recorder, being attained to physical properties, required the one of the other: there was a symbiotic relationship. This symbiotic relationship was used by several manufacturers to generate technological silos in which a manufacturer provided both the "format" (the tape) and the "machine" to run a particular format. The case of U-Matic and Betacam, explained in section 3, is emblematic for defining the material attributes of proprietary video technologies.

One central aspect mentioned in the historical account of video was that it comes technically from printing, and in that order, it is taking a similar path to print media, facilitating its transmissibility through the Internet. However, there is a limit in any material artefact in regards to its transmissibility; the solution has been to erode some physical attributes transforming them into software operations.

Considering the aspects mentioned in the first three sections of this paper, the analysis of video based only from material considerations would be very limiting. Video has to be understood not only as a digital moving image (in which aspects such as image quality and compression are key, as we have mentioned) nor as a transmission technology; it has to be understood in the sense that new characteristics emerge, more diverse and ever grounding. It is, as Yvonne Spielman calls, a medium that links to other mediums (Spielmann 2008) making evident that we are living a moment where there are many components in any medium (McLuhan 1964; Cubitt 2010). The formation of digital video must be understood based on its electronic constituency and in confrontation with its analogue form (Spielmann 2008). Video moved from being medium-specific to being “non-medium-specific” in which the technical development and distinction of digital video contributes to this “non-medium-specific” potential.

The real impact of video in contemporary society, from the account I have presented in section 3, belongs to its digital format and the attributes that were not available in its previous incarnation as a material construct (i.e., film, tape).

The correct way for studying video is analysing it as a complex media object, which is connected to the Internet. Some studies that focus on non-material objects had tended to give answers according to the technical constituencies of the artefact, but in the way human interact with them (Miller 2010). We do not criticize the later approach, however the problem emerges when we discuss of how different people use an object, and we know from previous cases that the diversity and context in which people use the apparatus defer quite substantially (Turkle 1996; Suchman 2007).

It is worth pointing out, however, that video has been used outside these formal material devices since the 50’s and 60’s, most notable in video installations and expanded cinema (Youngblood 1970; Hanhardt 1986; Cubitt 1993; Kacunko 2004). Interestingly, many of those seminal experimental projects questioned video both as a media related to TV **content** (i.e., soap operas, series, news), as well as the **support** (i.e., the TV set), but also its **context** (i.e., most TVs were the centre of the American home and portrayed its way life).

The main distinction of digital video is the description of its digital constituencies. Video as a digital artefact detaches in three main parts: **media, function** and **description**. Even more, if we analyse the basic constituents of video mentioned earlier, beyond the **image quality**, there was also a **function**, which was defined as **transmission** (how fast the images had to change in a video screen to denote a moving image). Since the basic concepts had prevailed, incorporating **functions** such as operations, algorithms and interfaces to databases are enabled only by understanding video as a digital object. At the same time, **descriptions**, made out of metadata, enable digital objects to be findable in the digital universe.

Faulkner and Runde made an important contribution by defining not only the attribute of material objects, but also some characteristics that constitute a non-material object, born from a variety of different bitstrings, yet with particular instructions, structures and properties. It is pertinent to take look at them in contrast to the case of digital video, taking as a stance its use in the media industry (Faulkner and Runde 2010).

Non-rivalry in use: the authors mean here when the use of a digital object from one person does not affect the use by others. This is pertinent in terms of digital video and particularly in the media industry environment, in which a central aspect of large-scale implementations are based in the use of a single digital video file by several people at the same time.

Infinite expansibility: once a digital object is downloaded to the system (once created) it can be downloaded several times. It is usually taken for granted that the digital space is unlimited due to the current low-cost of media (it is seen as a cheap commodity). However, as we get to enterprise environments, such as the media industry, the standards for data transfer speeds and the network sustainability makes the unlimited possibilities sound as that they are this still quite limited.

Recombinability: the object can generate new kinds of objects. In the case of video, due to its manipulation and crafting (post-production), this could be done at multiple levels. Material objects exhibit a smaller degree of recombinability than non-material objects. As we have seen, the digital process of video displaced the original analogue photographic one, that was based on the transformation of substance; digital video representation is based on data manipulation. Where analogue media record traces of events, digital video produce tokens of computational information (Binkley 1993).

Re-Use: in a similar fashion of code reuse, this practice has become one of the fundamentals epitomes of efficient programming. In the case of video, we could analyse the re-use of **media, function** and **description** as an economic imperative in order to optimize costs.

Some scholars had questioned the validity of digital formats, raising critical considerations about their quality limitations in terms of size, colour, audio, and many other comparative details that derive from cinematic aesthetics (Manovich 2001; Cubitt 2008; Wasson 2008). Though these arguments may be valid, it is also true that as more functions are added to digital video, many of the prior concerns (most of them regarded as quality issues) will be solved by enriching its technical layers. The interesting aspect, however, is that the questioning arrives from comparing digital video with the cinematic aesthetics, therefore, comparing it with a more institutionally embedded form of representation.

Future digital video may not only incorporate additional characteristics from its cinematic legacy, but will incorporate, mostly, layers that are filled with data which are increasingly becoming crucial in order to confront the current information explosion. As some authors mention, digital video is becoming data (Manovich 2001; Lovink 2008), and as such many of the conceptual arguments centred around the digital image may not be valid any longer, or might be loosing meaning in terms of the conditions that digital video will embed in the future, more over, due to the impact of the Internet. W. J. T. Mitchell describes the Internet as “a metamedium, that incorporates all the possible mediums […] images continue to arise and circulate in these new media in a way, so rapidly that no conceivable archive could ever contain them all” (Mitchell 2010).

5. Conclusion: Re-Materiality? the constitution of video as part of new working practices in the media industry

To conclude, we will briefly explain the impact that the technical characteristics of digital video are bringing to the media industry from the specific domain of their workings practices. The examples mentioned had been extracted from an extensive observation and conversation of practitioners at a major broadcasting organization in the UK from 2007 to 2011. In this organization during the last 3 years there has been a significant shift in the use of video, basically, from a tape-based environment towards a tapeless one (digital video). The intention of this section is not to give a detailed account of a case study, but to briefly illustrate some aspects of how the utilization of non-material objects is changing certain practices of the media industry environment.

First, it is important to consider that the broadcasting industry is primarily composed of content creators; people inserted within the creative industries. The general assumption of analysing video exclusively from a broadcasting and/or cinematic perspective focused on the image (aesthetical considerations to the most extent) will not help us elucidate the fundamental transformations that this industry is going through in which the rationality of the technology intermingles with the rationality of the non-material object. As we defined earlier, the main distinctions of digital video are based in three characteristics: **media, function** and **description**. We will briefly present these characteristics through its use in the media industry by looking at three working positions that have changed with regards of their relation with the objects (which for most of the time where material and they are non-material) and in which each of them utilizes these characteristics in a particular way. We have illustrated this in Fig. 2

Position	**Tape-based environment**	**Digital Video**
Producers	Participating with cameramen in the shooting, revising material, coordinating the final product.	Shooting, selecting, editing and searching for content.
Craft Editors	Selecting material, sometimes participating in the shooting, and editing rough cuts as well the final piece.	Since the producers are shooting or making rough cuts, its function is more specialized into tasks oriented to the quality and postproduction of the final product (image).
Media Managers	Were available in the Archive in order to help in find content as well as cataloguing content.	Participates as part of production team since the kick-off of the project, defines which content will be stored in the digital archive for future use. Defines the fields for the metadata for every content created.

Fig. 2 Comparison of working practices: Tape-based vs. Digital Video

What we can see from this account is the practices vary substantially from tape-based towards digital video. In some cases, as it is with the producers, their work has expanded to cover more practices than the ones that he or she were originally doing. The main idea behind this particular change is that they would be able to have more interdisciplinary expertise and incorporate some technical knowledge. One aspect in which we can realize the fundamental importance that digital video is bringing to this position is the shooting ratio (the number of hours that a person shoots for 1 hour of content), which has been duplicated or triplicated since the producers are also given the functions of cameramen. In contrast, a professional cameraman, due to his expertise may shoot the least, as he knows exactly what he is looking for.

On the other side, we have the craft editors, who elected material, sometimes participated in the shooting, and edited both rough cuts as well the final piece are now being given selected roughs in which they have not participated selecting. The problem here arises, in some cases, that the shots may not have the length necessary to create a good sequence for the final content and on the other side, not being in touch with the content since its inception, does not help the editors in understanding the material that they have in hand. However, their function has been set towards a more specialized and focused one: tasks oriented to the quality and postproduction of the final product (image).

Finally, we could say that the most interesting position, which is new in the production environment, is the one of the media manager. He is in charge of something that before was done at the end of the process, which was the archival of the material. Now that the material is permanently available, it has to have the right metadata in order to make it visible to the other member of the production team. The is even another fundamental function that the media manager has to take since the beginning of each project, which is to analyse what type of shots will go to the permanent archive and which will be the ones that may be deleted. In the case of some programs it may not be necessary to save any of the rough cuts and only the final product. The role of the media manager has turned to become strategic for the future of the content that will potentially be reused. Today, as video has become digital and is no longer based in a material construct, its physical management and conservation, has become the conservation of the database, its metadata, and of the format that will be able to be accessed in a foreseeable future. In the analogue era, the cataloguing of book, films, videos and any media type was separated from the technology; therefore, depending on the type of media you had a particular set of information about that entity group.

Finally, another important aspect that happen with production people is that now they have to manage video in a database instead than in a videotape, with all the advantages and disadvantages that this may carry. The tape generated a sense of property and of immediateness that sometimes looking up on a database does not help to solve. It is however, a process much more similar to searching to video in YouTube, therefore, as we have mentioned earlier, some of the quotidian practices that we follow on the Internet are being translated to the work place.

As we can see, the layers of **description** and **functions** available in digital video produce a dramatic change in the processes it is supporting within the organizational context in which it is embedded upon. As the media industry starts to deploy PCs able to manipulate video in the office desktops, it gets confined in a similar fashion to the bureaucratic order instituted by the word processor or the spread sheet programmes in work places (Zuboff 1988; Kallinikos 2004). The emphasis put by many broadcasting organizations in installing video editing software on the desktops PCs assigned people functions that previously were done by specialized personnel (i.e., during the age of specialized hardware, particularly through the use of analogue video).

As digital video is incorporated in the work place the use of it and other digital objects makes evident how more people from different disciplines and with different approaches have to work more closely together and have to understand each other technologies (Cox, Tadic et al. 2006). However, the expected outcome of this process in the work practice implies that by actively participating in the creation, production, manipulation (editing) and management (searching and indexing) of digital video people might find it as part of their daily routine, as usual as writing a text in a word processor.

Technological objects have increasingly detached from the constraints imposed by matter (Kallinikos 2011), but at the same time they epitomize the rise of design in the development of new technological constructs (Flusser 1999; Flusser 2002). Moreover, as Manovich recently clearly wrote, “digital media” does not have any unique properties by itself, the properties of a medium are now the operations and affordances defined by software (Manovich 2011). In considering video as a digital object, we have also to take into consideration that it depends upon the functionalities of software that enables some of the properties that we ascribe to video as a technological artefact.

We tried to explain with certain detail the evolution of video as an artefact, from its initial material support (e.g., film, tape) and through the recent years towards its non-material characteristics as a digital object. Digital video prompts the construction of new technological layers that are critical in order to manipulated a digital object, such as metadata, procedures, data rules and programs that are part of these new digital construct.

Video as a new digital construct, has other functionalities that are important for its management in a contemporary working environment, it needs to shared, categorized, findable, all these characteristics define the new routines of contemporary work environment that the former tape-based video workflow was unable to provide. Consequently many traditional practices that were available on the offline world of tape are now available on digital video, with particularities that makes the content defined for the Internet age.

Most of all, the Internet is in itself a system based on software-based techniques for organizing and ordering data and information, particularly the ones based on the Web 2.0 (i.e., Blogs, YouTube, Facebook). These tools bring a rationalization of practices that permeate not only the workplace, but, more profoundly, life in general. As Clay Shirky clearly estimated the old view of online separated the online from the offline space: cyberspace was one thing and the real world another (Shirky 2010). Now that computers and Internet devices are everywhere we can foresee the notion of global village, as was predicted by McLuhan (McLuhan 1992). Digital objects are therefore turning critical instances for coordinating and organizing human activities.

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