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Stratigraphy of Media: A Review of Media Analysis Using Spatiotemporal Visualization

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This paper proposes media stratigraphy as a methodology for analyzing the temporal structure of audiovisual media, distinct from the content-focused approach of traditional media analysis. Drawing on geological metaphors of sedimentation, media stratigraphy examines the internal organization of time—rhythms, repetitions, and cuts—rather than semantic meaning. The study reviews the evolution of spatiotemporal visualization techniques, structuring them into two primary domains: two-dimensional strip imaging (slit-scans, movie barcodes, etc.) and three-dimensional video volumes (video-cubes and their operations). Through an analysis of seminal works by artists and researchers, the paper identifies a lack of standardized terminology that hinders methodological consistency. In response, it proposes a taxonomy of spatiotemporal operations, classifying techniques into spacetime capturing, slit extraction, time displacement, and volumetric manipulation. Ultimately, the paper argues that these stratigraphical tools allow scholars to visualize and interpret the structural "sediment" of digital media, revealing patterns invisible to standard observation.

1 Introduction

In the introduction to *Media Archaeology*, Erkki Huhtamo and Jussi Parikka define the field as a discipline that "rummages textual, visual, and auditory archives as well as collections of artifacts, emphasizing both the discursive and the material manifestations of culture" (2011). Unlike traditional history, which often seeks linear narratives, media archeology operates similarly to physical archeology: it excavates ruins to understand culture through scattered parts, mundane objects, and the accidental survivors of time. This material focus is radicalized by Parikka in *A Geology of Media*, where he argues that media history conflates with earth history (2015). Media are deeply connected to the soil, constructed from a collection of minerals—copper, gold, and rare earths—extracted directly from the lithosphere. Digital media is thus not an ethereal "cloud", but a heavy inscription supported in stone. However, this materiality is often obscured by the abstract, binary nature of digital code. Parikka suggests we view media as sediment, as the obsolescence of devices composes a new geological stratum often termed the Anthropocene.

To study this "media sediment", we must distinguish between two geological approaches. The first is archaeological excavation, which digs through the surface to access the past, and the second is stratigraphy, which examines the succession of layers themselves (see Figure 1). While excavation looks at the artifacts, stratigraphy looks across the time-scale of their deposition. This approach limits our access to spe-

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cific "content"—we cannot see the artifact in full detail—but it opens up different understandings of time. It shifts the focus from simple historical change to the change of changes—the structural evolution of the sediment itself. By studying "time within time", we move beyond linear teleological progression to observe rhythms of repetition, accumulation, and sudden fracture. This paper seeks to establish a foundation for stratigraphical media analysis: analyzing audiovisual media not for its semantic content, but fot its time structure, studying the use of spatiotemporal visualizations in media analysis.

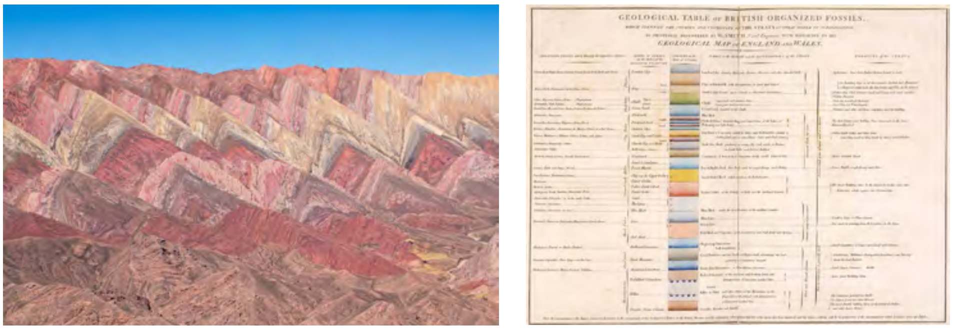


Fig. 1. On the left: Serranía de Hornocal near Huamahuaca, Jujuy Province in Argentina by Havardtl (2017). On the right: Stratigraphical Column of Britain made by W. Smith (1815).

A stratigraphical analysis requires a reframing of our ontological expectations. To treat video as sediment, we must detach ourselves from the regime of visibility for which it was constructed. We must ignore the intentionality of the author and the traditional content of the frame to analyze the deformed image of the video-sediment itself. Otherwise, we risk using the strata merely as a proxy for other things. Cinema, in this view, acts as an anomalous sedimentation sample of the immaterial soil of images. Geologists sample the soil in various points or analyze it directly through its fractures. Media stratigraphists might study films as rare sediments of light. Our understanding of the history of light is limited to a very few sedimented samples made by specific actors in restricted time and field of view, while the rest constitutes a gap in the sedimentary record.

In this paper, we explore the tradition of "strip imaging" in photography and graphical interfaces, examining how artists, engineers and film theorist have utilized these techniques since the 1990s, and particularly how this has been used for media analysis. We present a taxonomy of spatiotemporal strip imaging to clarify the terminology between slit-scans, video-cubes, and types of samplings; and propose a set of possible operations on video-cubes which contributes to media theory and art practice.

2 Strip Imaging

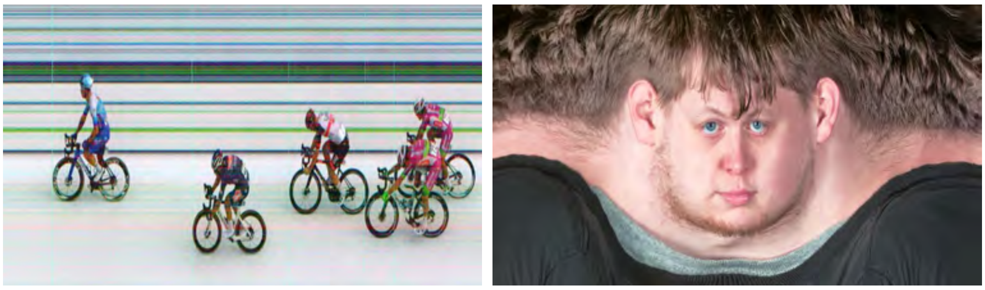


Fig. 2. On the left: Finish photo at a cycling race in Slovenia. On the right: Slit-scan Self Portrait by Waveluke / Pat Cunn.

2.1 A Brief Introduction to Slits and Scans

We adopt the more general term "strip imaging" to refer at any type of image that is composed in a set of chronologically arranged strips, despite the medium or technique. A full taxonomy is provided in part 4. One common type is scanning photography, or scanography, which describes imaging in which exposure occurs sequentially across the image rather than simultaneously. It is most often used to digitalize documents. Another type is slit photography, or strip photography, and line photography, which exposes the medium through a narrow slit, moving the film to render a temporal distortion of objects, a method common in racing sports for photo finishes (see Figure 2). Both techniques converge in slit-scan, where a narrow aperture slides over the medium or lens. This captures a single image across chronological moments or, with rotation, the entire surface of a 3D object (as in Figure 2, on the right). This technique is famous for creating otherworldly temporal displacement effects, such as the psychedelic sequence in *2001: A Space Odyssey* (Kubrick 1968) or recent filters on TikTok. Additionally, slit-scan can be achieved not by moving the slit, but by moving the camera across space, rendering a spatial scanning that has also been referred to as slit-scan, such as the works in the series *River Studies* in which Michael Aschauer photographed the banks along several rivers using a line camera onto a moving boat. This technology can also be referred to as line-scan.

Slit-scan is often used interchangeably with "slit", but "slit" should define the general category of narrow aperture photography. In the case that slit photography method is also used for scanning long panoramas by moving the camera in panning or translations, it can be referred as slit-scan. However, the effect of slit photography is to scan time in space, while scanography maps space in time. Thus, slit-scan can image space-in-time in time-in-space, thus deforming both temporal and spatial dimensions. In video editing software, this function is often called "Temporal Displacement".

Typically, electronic photography is constructed through a scanning of lines. Most Complementary Metal-Oxide-Semiconductor (CMOS) sensors intrinsically use a strip imaging process by sampling pixels sequentially line by line, which generates "rolling shutter" artifacts during rapid movement. On the other hand, analogue video signal is transmitted in horizontal lines from top to bottom, but Charge-coupled device (CCD) sensors use physical shutters which make the exposure simultaneous. However, because these artifacts are the result of intrinsic mechanisms of the scanning architecture of the sensor or the signal, they do not constitute strip images per se.

2.2 Two-dimensional Spacetime Visualizations in Media Analysis

A diverse number of applications have been given to spatiotemporal visualizations, such as slit-scan and video volumes (see section 3). They have been used for retinal imaging, object detection, aerial photography, motion estimation, and even measuring the displacement of protons, among many others. We have seen that they have been widely used as a visual effect in media, in the form of art, cinema, or internet objects. There are some documented cases of the use of spatiotemporal visualizations for moving image study. Although the examples presented here represent a comprehensive search of the literature, the lack of standardized definitions in this area makes it highly probable that further applications of these techniques in media analysis remain undocumented or difficult to retrieve. Although these kinds of visualizations are limited and fail to maintain the figuration and semantics of the original media, they allow for the analysis of some visual characteristics, and specially for an overall study of time within a single instance.

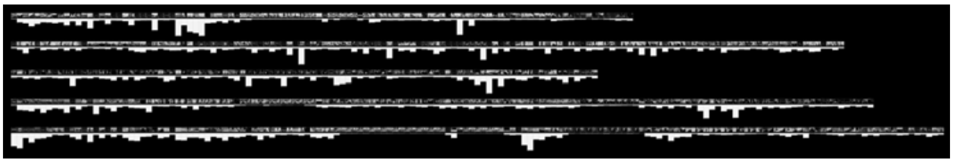


Fig. 3. *Eleven_RowReels_bar_shotlengths.24000*, softwarestudies.com, 2009. Bar graph of length of shots in the film *The Eleventh Year* (Dziga Vertov, 1928).

Lev Manovich conducted various experiments visualizing media and video for its study, most often by plotting a sample of frames in a two-dimensional grid (2012). The sample might be every *n*-th frame, or the first frame of every shot. The visualization allows him to observe the film or video at a single moment, recall it, and study it in many ways. It is a great way to study films like *The Eleventh Year* (1928), by one of the fathers of montage, Dziga Vertov. Although he analyzed the film in a grid, he did not use spacetime visualizations for the same effect, which would be a compelling way to reveal the editing of Vertov's montage. Instead, he measured the length of shots and represented each shot in a bar graph, favoring a more objective representation of time (see Figure 3). Manovich is interested in observation; he wants to see the frame content in his visualizations. Spacetime visualizations, despite containing the whole video, do not make the film observable, but rather inaccessible.

Fig. 4. Slice of 4.535 covers of Time magazine organized by publication date (from 1923 to 2009, left to right). Lev Manovich and Jeremy Douglass, 2009. In the original resolution, every one-pixel wide vertical column is sampled from a corresponding cover.

Manovich and Jeremy Douglass made at least one image using strip imaging, in which they plotted strips from 4.535 *Time* magazines (see Figure 4). They called the technique "slice visualization," since it would correspond to an internal slice over the height axis of a cube made by all the magazines, revealing the changes in the layout and design of the covers. According to Manovich, this experiment “demonstrates [that], sometimes dramatically limiting the part of the data is actually better for revealing certain patterns than using all the data” (2012). The dataset of *Time* magazine covers can also be represented as a cube due to its chronological structure. Once again, they favored describing the grid visualization of the covers (where all covers are visible) and reporting the characteristics whose change can be traced in that grid-image: Medium, Color vs. Black and White, Hue, Brightness, Contrast, Saturation, Content, and Meta-patterns. Many of these characteristics can also be attributed to the slice in Figure 4. In the “Media Species” poster, Manovich et al. (2009) present slice visualization for edited video of four different sources alongside other types of visualizations, but—as far as we are aware—not much attention is given to this in his literature. On another software research project, Tang et al. (2008) showed that sliced video could be used in stationary camera footage to analyze events and patterns, like the opening of a door or the intersection of vehicles and pedestrians.

Fig. 5. Visualization of *2001: A Space Odyssey*, Moviebarcode, 2011.

Movie barcodes are another type of strip imaging far more common for movie analysis, probably because of the colorful patterns which gathered much attention around a specific Tumblr blog (Moviebarcode 2011). In this technique, the colors of frames are sampled and organized in a determined number of stripes that usually do not correspond to the number of frames (see Figure 5). This technique can be implemented by averaging the color in frames (or sections of the frame) and plotting these values chronologically or extracting an array of all the pixels in each sampled frame. Some other smoothing and color transformations might be applied. Although there is a relative preservation of information on cuts, there is an absolute loss of figuration and movement. Despite its popularity on the internet, moviebarcodes are exclusively interesting for color analysis of films and videos, such as the one performed by Redfern (2021) regarding US movie trailers. Recently, Kreten and Kipke (2025) presented an interactive system called CineSearcher for film and video exploration through visualizations and metadata generation, using interactive moviebarcodes as a core navigation element to access individual frames, aligned with metadata generated from CLIP embeddings to enable some level of language interaction. They report-ed evaluating the system with 56 horror movies, but no analysis of the films has yet been provided.

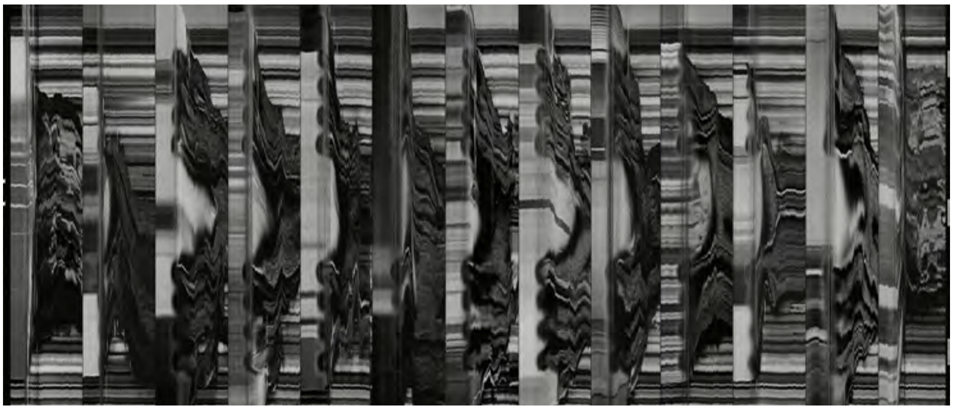


Fig. 6. The resulting image of Hollis Frampton's (nostalgia) (1971) when revisualized with Image Macroanalysis.

One of the most prominent examples in the use of the slicing techniques for whole film analysis, was performed by Patricia Ledesma Villon in the plotting of *Nostalgia* by Hollis Frampton (1971). The film is composed by 13 distinct shots, each of which depicts a still photography being burnt. In Ledesma Villon's result (see Figure 6) each of the shots can be easily identified, as well as the burning pattern. As she puts it: "we can visually depict sequences within a film and visualize their relation to the entirety of the given work during a single instance" (Ledesma Villon 2021). In this case, repetition and transformation become particularly evident due to the recurrent structure of the film. Most of theorist using these visualization techniques, are often focused on single sequence shots and scenes, most often a single shot. Ultimately, space-time visualizations allows one to see time, but specifically, it is good at showing the changes in time over time, similarly to stratigraphy. For this, the most recognizable characteristic is also the more drastic change in time: the cut. So, in visualizing edited video, we can decipher the editing itself, more than the visual elements that compose the actual semantics of the montage.

3 Video Volumes

3.1 Some History of Video Volumes

Video can be rendered in a three-dimensional space using its temporal dimension as an additional visual axis, plotting it frame by frame in chronological order. The result of this process has been called various things, most prominently a *video-cube* or *video stream*. A simple metaphor for this arrangement is the flip-book, a book made of sheets of paper where each sheet represents a sequential frame of animation. However, with digital video, it became possible to virtually arrange the frames in a three-dimensional space in the form of cubes and perform several transformations of spatiotemporal relations.

In 1992, Edward Lee Elliot published work on video-streams as part of his master's thesis at MIT in chapter 3, "The Video Streamer". He used this visualization method in software to review video in a 3D space but also to “appreciate the rhythm of colors and motions embedded within video” (1993). He says of his experience that one starts identifying clear characteristics of video in the cube: “After a while, one learns to read even more subtle streaks” (1993). Elliot coined the term “video stream” since he was using mostly live video, and was repeating the most recent frames in what could resemble a water stream itself. However, this term is obsolete nowadays due to the popularity of online video streaming services. Aside from the Video Streamer, the first academic publication exclusively addressing this idea was presented by Fels and Mase in a workshop (1999). They named this object a “video cube” or *video cubism*, different to the Video Streamer, they perceive video as a finite contained volume.

According to Susanne Jaschko (2002), Camille Utterback and Romy Achituv were using the term “Video Cubism” to refer to the work *Liquid Time Series*, publicly exhibited for the first time in Tokyo in 2001 after being prototyped in New York in 1999. Although Jaschko does not state that the artists coined the term, it is likely that they became aware of the term used by Fels et al., of which Jaschko seems to have been unaware in 2002. Furthermore, Fels et al. (2000) described the idea that shifting the cutting plane of the cube resulted in an image that presented a temporal distortion like those in slit-scan photography. Moreover, this plane can be slid across the video-cube to obtain a video in which each frame has the same altered temporal visual structure. This visual effect is called temporal displacement and it is analogous to slit-scan in photography.

Fig. 7. On the left: Frame of *Structure of Slit-scan*, Kitasenju Design, 2022. On the right: Frame from *tx-transform*, Martin Reinhart and Virgil Widrich, 1998.

Notable visual explanations of these techniques were already used by artists in the late 1990s, such as Martin Reinhart with the technology and video developed in 1992, *tx-transform* (Reinhart and Widrich 1998) (see Figure 7). *An Informal Catalogue of Slit-Scan Video Artworks and Research* (Levin 2005), posted online by Golan Levin originally in 2005 and last updated in 2015, served as a broad recollection of visual works from 1986 to 2009. Referring to the informal catalogue, Reinhart states in a blog entry: “Looking back, it is interesting to see just how many approaches were running in parallel… It is amazing that I was only aware of a handful” (Reinhart and Widrich 1998). This reveals that awareness of similar work at the time might not have been general or global. Moreover, it suggests that the video-cube was more of a discovery rather than an invention, happening as a natural realization of the volumetric properties of video, just as Jaschko says regarding cinema: “[after chronophotography the] discovery of film seem[s] an unstoppable and logical cultural step forward" (2002).

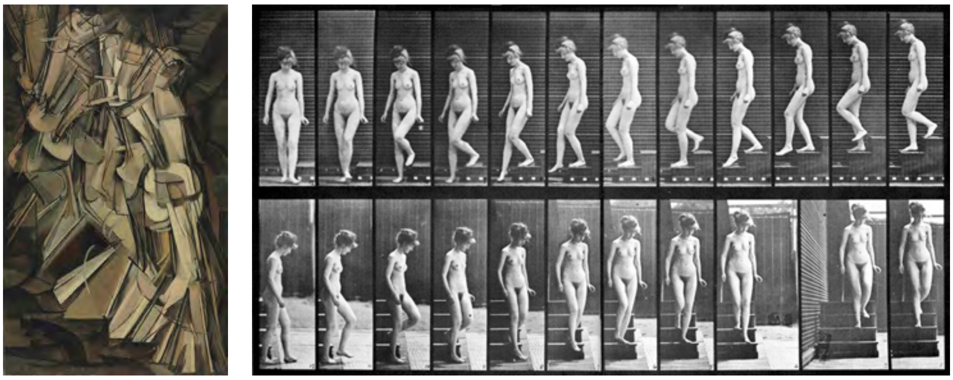


Fig. 8. On the left: *Nude Descending a Staircase, No. 2*, Marcel Duchamp, 1912. On the right: *Female nude motion study*, Edward Muybridge, 1887.

The term "video cubism" risks confusion with the Cubist art movement. Although, Fels et al. do not reference the pictorial movement but rather a literal cube made of video, correspondences could be drawn between the pictorial movement and video cubism. The 1912 painting by Marcel Duchamp, *Nude Descending a Staircase, No. 2* (see Figure 8), depicted not simply a body but the states of the body in time. He was in part inspired by the chronophotographic works of Eadweard Muybridge (see Figure 8), the famous precursor of cinema. Time displacement deformation might recall the deformed structures created by Cubist painters, but their intention was not to deform time except for a few cases. While artifacts in video-cubes recall Cubist deformations, the spirit of the movements is ultimately different except for a few cases. For this paper, we have chosen to use "video-cube" to describe the three-dimensional visualization, while "slit-scan video" refers to the bi-dimensional effect of altering the spatiotemporal mask. However, there is no unambiguous terminology to describe any of these spatiotemporal objects. We hope that our taxonomy helps clearing out distinct terms that are used interchangeably, and that opens a path towards a more strictly defined terminology.

Another very useful visual explanation of the effects achieved through plane cutting is a video modeled by Kitasenju Design (2022), in which the cutting plane is moved across a section of a video-cube of fixed dimensions, showing simultaneously the different types of temporal distortion effects achievable. Some of these manipulations of spatiotemporal cube processes are taxonomically explained and organized by Bach et al. (2014), although their focus is a wider set of spatiotemporal visualization mainly for scientific applications.

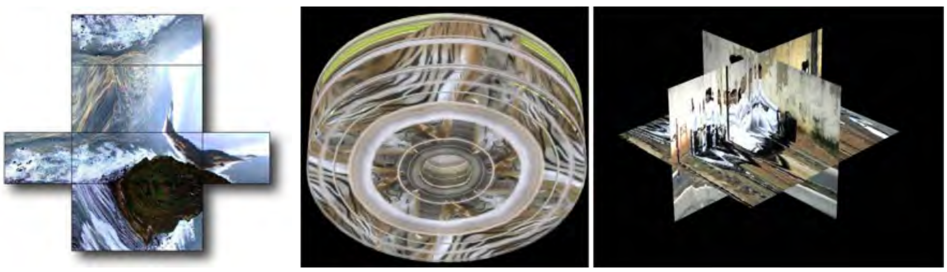


Fig. 9. On the left: *Streamer Box No. 8*, Eddie Elliot, n.d. The camera is tilted down towards the crashing waves. On the right: *Spatio-temporal Objects*, Tania Ruiz Gutiérrez, 2000-2003.

The most popular way to manage video-cubes is through digital interaction, but their simple geometrical form makes them easily transferable into print. We haven't found many examples of this, except for Elliot (1993). As he was extensively finding applications for the "video stream" technology, he described in a "future work" section the formatting for printing as a possible outcome of the arrangement (see Figure 9) since "things are more tangible when we can touch them or hold them" (1993). However, he probably made these cubes with short shots of less than a few minutes, very likely due to memory limitations. We believe these printed cubes were part of the installation, but there is a lack of evidence online. A similar video technique can be easily used for communication purposes, making video-cubes accessible, cheap, and tangible. It can also serve as sort of redemption to film, delivering it from its digitalized immateriality back to our tangible experience. "Film" is on itself an anachronism just like often "slit", since digital capturing, storing and exhibiting is mostly done digitally, involving no physical "film".

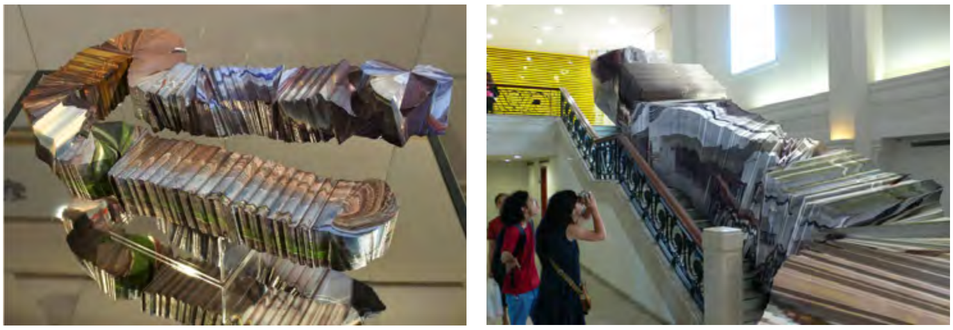
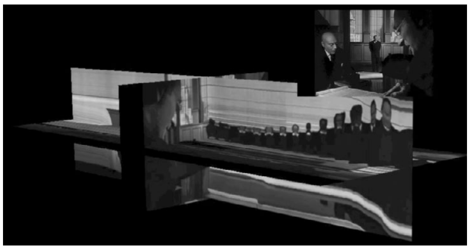


Fig. 10. *The Invisible Shape of Things Past*, Dirk Lüsebrink and Joachim Sauter, 1997. On the left: small sculpture. On the right: virtual sculpture.

In 1997, Dirk Lüsebrink and Joachim Sauter made 3D models of video sequences taken inside a building in an installation called *The Invisible Shape of Things Past*. The resulting form is not a cube at all, but a video-volume that was later transformed into a small sculpture as part of the installation (see Figure 10). In the archived text of the presentation at the Prix Ars Electronica, they show interest in "designing a real architectonic or sculptural object" (1997), for which they also made a virtual model (see Figure 10). These experiments make us able to think about the form of time and the relationship of images with space and the places where they are made. On the other hand, Tania Ruiz Gutiérrez showed it was possible to deform the volumetric properties of the cube and juxtapose various slices in orthogonal visualization to obtain contrasted information from the inside of the cube (2004) (see Figure 9). This further explores the possible forms of the cube which are both visually interesting and useful for shot analysis.

3.2 Media Analysis of Video-cubes

In the peer-reviewed video *Volumetric Cinema*, Kevin Ferguson (2015) shows how the technique multi-planar can be used as for analyzing changes in a long shot of *Citizen Kane* by Orson Wells (1941) as seen in Figure 11. He uses the technique orthoslice, plotting slices across the middle of the X, Y and Z axes. One of the slices show the middle frame which allows to understand the general composition of the shot; another slice shows the changes in the vertical axis, which makes evident the movement of one of the characters along back and forth across the space; the other slice is not interpreted. Ferguson showcases the use of different video-cube operations in the analysis of shots, especially long-shots such as the famous corridor scene in *Vertigo* by Alfred Hitchcock (1958) and the kiss scene in *Vertigo* by Alfred Hitchcock (1958), both seen in Figure 11. He also uses chroma transparency across black pixels to give form to the volume. However, his analysis is restricted to single shots, ignoring the potential of these techniques to reveal cuts, and taking advantage of its capacity to showcase internal changes within a shot.



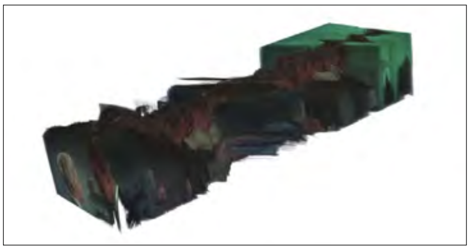


Fig. 11. On the left: Ferguson's orthogonal visualization of *Citizen Kane* sequence. On the right: Ferguson's volumetric visualization of sequence from *Vertigo* with transparency on dark pixels.

Following Ferguson's methods, Dave Rodríguez visualized sequences from several experimental films, mostly abstract films from the late twentieth century. According to Rodríguez: "Transformed [...] into 3D objects, we are able to study and experience these works in entirely new ways that are unconstrained by conventional theories and practices of cinematic spectatorship" (2020). Rodríguez manages to reveal interesting temporal patterns which create unique volumetric objects that show movement and change in the analyzed films, particularly the continuity in animated lines and text, but also the random discontinuity in other films. One good example is his visualization of *Lines Vertical* by Norman McLaren and Evelyn Lambart (1960) (see Figure 12), because it is a very simple frame by frame animation of vertical lines traversing the horizontal axis, by removing the background the movement of the lines forms a very clear structure, revealing linear movement patterns. The 3D structure is so defined, that it almost looks as it was a sculpture was hidden in the film itself. This is somehow reminiscent of Michelangelo's notion that the sculpture lies inside the marble block and the artist simply extracts it. The sculptor must work around the layers of sediment and the properties of the rock, limiting what they could extract from a specific block and utterly connecting their work to the geological history of the material. Similarly, in the video-cube, video itself becomes a sculpting material that can be transformed to achieve certain results only, which all depend on the internal composition of the video itself. Through the video-cube technique, video sediments into a block becoming a volumetric material, with unique properties. Although somehow malleable, the video-cube has a very specific composition that utterly depends in the original images.

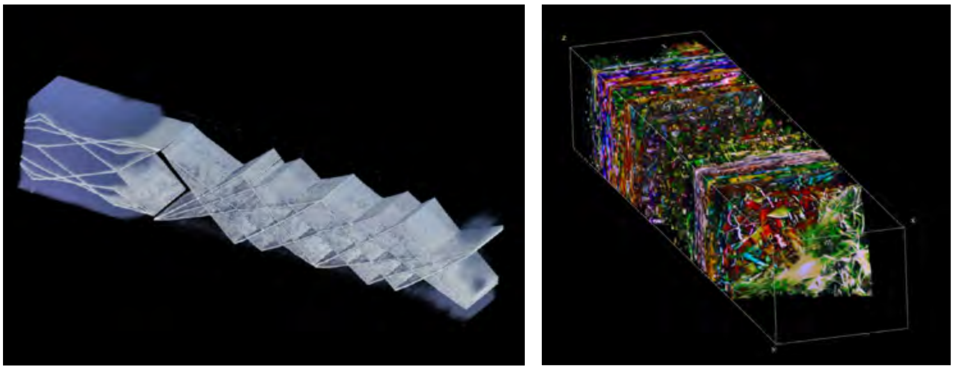


Fig. 12. On the left: Rodriguez's visualization of frames 2880-3600 from *Lines Vertical* (Norman McLaren and Evelyn Lambart, 1960). On the right: Rodríguez's visualization of *Rage Net* (Stan Brakhage, 1988). (Rodriguez 2020).

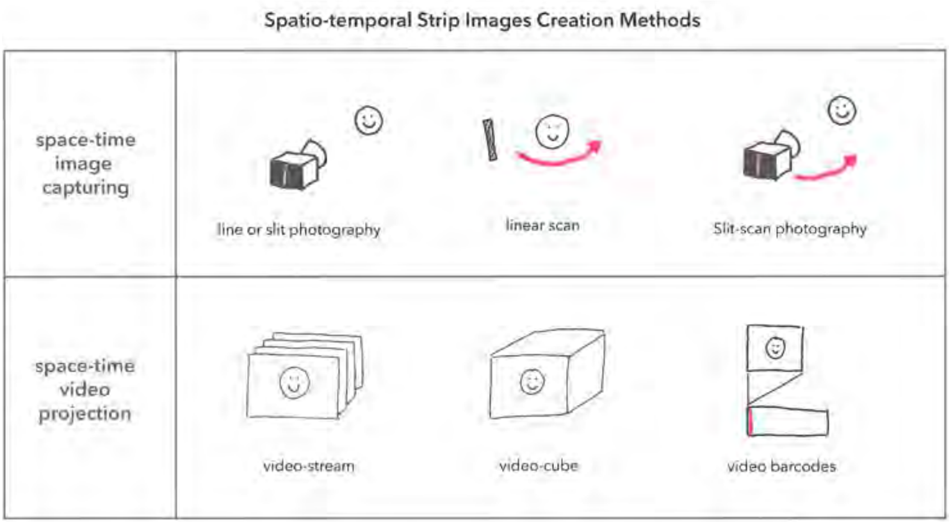
To our knowledge, these are the only authors that have used video-cubes for media analysis. We believe that the reason for Ferguson and Rodríguez to limit the length of the analyzed video was related to the software they were using (ImageJ) and potential constraints in the visualization capacities which was designed for scientific and medical uses, or due to hardware limitations. Furthermore, long videos end up creating very elongated structures that while revealing more information, are also harder to include in editorial publications or video-essays. The only known case of whole film analysis using this technique is Rodriguez's analysis of *Rage Net* by Stan Brakhage (1988), the whole film was analyzed since its duration is of only 37 seconds, which reveals the many color transitions throughout the film, while allowing a glimpse of the inside of some of the sequences.

The work of these authors is foundational to the analysis of spatiotemporal visualizations of media and opens the doors to a type of analysis which is more concerned with time transformations than pure semantics, which is ultimately analogous to the focus of stratigraphical analysis. We argue that the development of software tools for spatiotemporal visualization designed specifically for film analysis is needed, not only to provide a user-friendly interactive interface, but also to offer the proper tools to manage information extraction and visualization options that address the interest of digital humanities. As Ferguson himself puts it: "Work at the intersection between digital humanities and media studies must willingly explore more experimental methods, arresting our temporal experience of films as narrative things to be consumed." (Ferguson, 2019)

4 Taxonomy of Spatiotemporal Visualizations

Considering the previous discussion, we now introduce a brief taxonomy that might help researchers and media analyst to better describe and use spatiotemporal strip imaging. In Figure 13 presents the broader techniques for image generation, and in Figure 14 presents a set of relevant video-cube operations relevant to media studies and, to a certain extent, art practice.

Fig. 13. Spatiotemporal Strip Images Creation Methods.



We have divided the spacetime images into two categories. In one hand, there are spacetime image capturing, which are represented here by their classical photographical examples. However, it should be clear by now that images are not exclusively photographical, and these terms can be used for the outputs of video-cube transformations. Although "slit" refers to the capturing method, the word is often used to describe the style, whether it was created with a narrow aperture or by digital means. We present "slit photography" and "line photography" as a single category since they produce the same kind of results, despite the use of different mechanisms. The term "slit-scan" implies then a junction of narrow aperture and movement, whether the movement is of the slit or the camera itself. What we describe here as linear scan, relates to the specific technology of CCD strip with LED lights, which is most used in document digitalization. On the second category we grouped the terms coined by Elliot and Fels, despite the authors intending similar meanings. We took advantage of these synonyms for disambiguation: video-stream refers to the succession of frames, while video-cube refers to the volume made of video frames. While Fels's video-cubes tend to be finite and contained, Elliot's video-streams tend to be continuous and undefined. Additionally, we differentiate video barcodes, which are not operations performed on a video-cube, but rather an independent process where each frame is individually computed individually transformed into an array of pixels that most often preserve colour information only. However, some video barcodes can be generated from a slice of the video-cube.

Having proposed this general terminology, we can dive now into the video-cube operations which might be the most relevant for media studies and that are presented in Figure 14. We propose three categories to encapsulate some of the most relevant operations: *Slit Extraction*, which is like slit photography; *Time Displacement*, which is like slit-scanning but also considers other types of samplings; and *Volumetric Operations*, which corresponds to the 3D manipulation of the video-cube.

Horizontal slit and vertical slit are similar, they correspond to the plotting of time and only one of the physical dimensions, whether horizontal or vertical. These techniques can be used to do still images and video. Slice sampling refers to a single cut of the volume, commonly on the middle. Slit-tear is not a common operation, referred to only by Tang et al. (2008), it corresponds to a slit extraction from one section of the video, and is preferably used to identify patterns of movement in long static shots like surveillance video.

In the second row, we identify cuts of the video-cube where the three dimensions intersect, generating images where time shifts in the space of the frame producing all kinds of distortions. We have time displacement or slit-scan,[1] where time is deformed over one of the spatial dimensions. Other types of cuts are named oblique cutting; this type of plane is not necessarily rectangular like the previous cuts, slits and slices. It is also possible to do non-planar cuttings, where time is deformed over space in multiple ways. Although the results of oblique cutting and non-planar cuttings are very interesting visually, their direct application in media analysis appears limited. Finally, there is volumetric sampling, here shown as cylinder extraction due to parallelism with stratigraphy previously proposed, however, any kind of volume can be extracted from the cube by removing parts of the volume similarly to how a rock sculpturer would do. This latter technique might be useful to observe the inside of the cube, or specific parts of it.

Finally, we propose some broad volumetric operations. First there is object recognition, while most media analyst have achieved a similar effect by removing dark pixels from the volume, often revealing the forms of objects, for example in Rodríguez's work, a more refined approach is to do a frame-by-frame extraction of the object or character before the construction of the object. On the other hand, the orthogonal projection or multi-plane projections consist in an object constructed from slits or slices over the main axis of the video-cube, normally these slices correspond to the centre of the cube in its three dimensions. As we have seen before, this technique might show the changes in the frame during a shot, while also maintaining a reference to the original frame itself which might make easier to understand what is represented in the slices. We have also included volumetric transformations of the video-cube, the most common being bending, since it makes it possible to observe simultaneously the first and last frame of the video, however, any kind of 3D transformation can be applied to the video-cube. Lastly, and due to its cube form, we suggest that a relevant transformation of the video-cube is to plot its surfaces into a printable folding cube, which is an easy and cheap alternative to make video into tangible physical objects.

1. Here "slit-scan" is used to denote the visual effects as a metaphor to slit-scan photography.

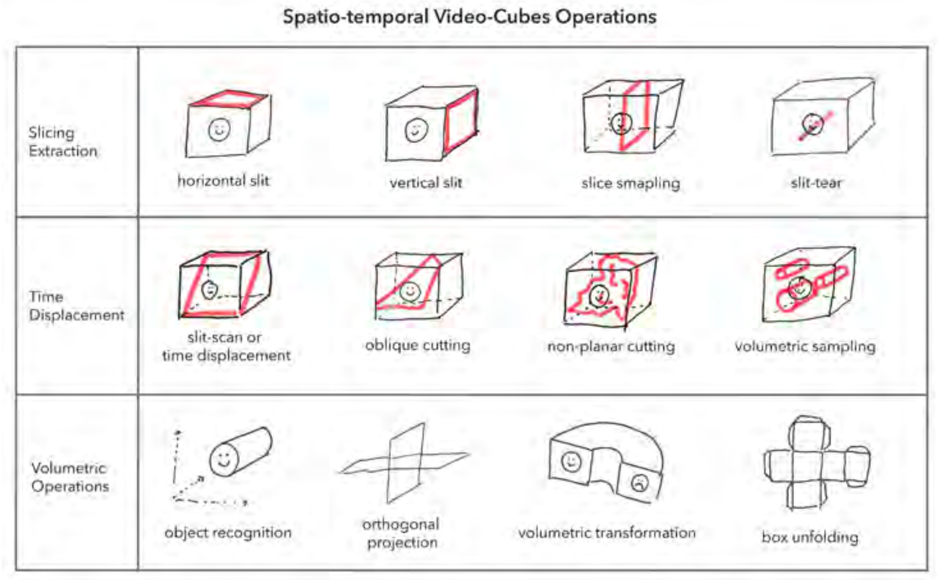


Fig. 14. Spatiotemporal Video-Cubes Operations.

5 Conclusion

This review is intentionally selective rather than exhaustive: it tracks a lineage of spatiotemporal strip imaging and video-volume practices through representative artworks, systems, and publications, but it cannot cover every parallel tradition where similar operations appear under different names. It is focused merely on media analysis, leaving behind many other practical uses for similar tools and techniques in other disciplines. The approach embraces a known trade-off discussed throughout the paper: strip and volumetric views can reveal global temporal structure (rhythm, repetition, cuts) while making frame-level semantic inspection less direct, so these techniques should be understood as complementary to—rather than replacements for—conventional viewing and shot/frame analysis; or tools to easily visualize large corpus of films.

A first next step is to operationalize the taxonomy as an annotation scheme and test its practical utility on diverse corpora, measuring agreement and documenting which operations best surface montage, cuts, and within-shot change. Another direction is to develop and evaluate interactive tools that let analysts fluidly move between cube, slices, and perform all kinds of samplings and transformations, alongside standard playback, so that pattern discovery and content verification can be performed within a single workflow. We also see opportunities to extend the taxonomy toward reproducible research infrastructure similar to how well-established tools in geology have made stratigraphy comparable and reproducible worldwide, which ultimately has pointed out to similarities in sedimentation and deposition. Likewise, reference implementations, operations and conventions might help media analyst to perform similar task with different data.

In this paper we proposed the idea of media stratigraphy, a conceptual framework for the use of spatiotemporal visualizations to treat moving images as sedimentary structures of light, shifting attention from semantic "content" towards time features—repetition, accumulation, movement, and discontinuity. We argued that unlike media archeology which focuses on the study of past objects, media stratigraphy allows for the direct study of time in those objects, and particularly to the changes of time over time. This is somehow similar to geology, which uses stratigraphy to perceive the changes on sediment formation which often follow cycles of sedimentation that change after long periods forming distinctive layers. One clear difference is that traditional stratigraphy studies billions of years of sediment, what is called deep time, while media stratigraphy is more focused in individual films. While this technique could be used for the study of big corpus of films and comparative analysis, that kind of work has not been found in the literature.

Through a review of strip imaging traditions across photography, interface practices, and computational media work, we showed that closely related techniques have circulated under overlapping terms (e.g., slit, slit-scan, temporal displacement, video-stream, video-cube), which has hindered precise description and comparison across studies. At the same time, the review highlighted a productive tension: these visualizations can reveal global temporal patterns at a glance, yet they often do so by restricting observability of frame-level detail—an effect that is not a flaw but requires a methodological reorientation of the analysis practice.

The main contribution is a taxonomy intended to stabilize terminology and connect analytic goals to specific operations. We first separate space–time image capturing families from volumetric video representations, clarifying "video-stream" as frame succession and "video-cube" as a bounded frame volume, and distinguishing video barcodes as a separate process rather than a cube operation. We then group media-relevant cube transformations into three operational families—Slit Extraction, Time Displacement, and Volumetric Operations—so researchers can report what was done to the cube, not only what the resulting image resembles. By making these distinctions explicit, the taxonomy supports more comparable analyses and opens a path toward method choices that foreground montage, rhythm, and temporal structure as primary evidence in media study.

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References

Aschauer, Michael.
2006–2013. *River Studies*. https://play.riverstudies.org/

Bach, Benjamin, Pierre Dragicevic, Daniel Archambault, Christophe Hurter, and Sheelagh Carpendale.
2014. "A Review of Temporal Data Visualizations Based on Space-Time Cube Operations." *Eurographics Conference on Visualization (EuroVis)*: 1–19. https://doi.org/10.2312/eurovisstar.20141171

Brakhage, Stan, dir.
1988. *Rage Net*. Short film.

Duchamp, Marcel.
1912. *Nude Descending a Staircase, No. 2*. Oil on canvas. Philadelphia Museum of Art, Philadelphia.

Elliot, Edward Lee.
1993. "Watch, Grab, Arrange, See: Thinking with Motion Images via Streams and Collages." Master's thesis, Massachusetts Institute of Technology.

Elliot, Edward Lee.
n.d. *Streamer Box No. 8*. Printed video-cube installation.

Fels, Sidney, Eric Lee, and Kenji Mase.
2000. "Techniques for Interactive Video Cubism." In *Proceedings of the Eighth ACM International Conference on Multimedia*, 368–70. ACM. https://doi.org/10.1145/354384.354535

Fels, Sidney, and Kenji Mase.
1999. "Interactive Video Cubism." In *Proceedings of the 1999 Workshop on New Paradigms in Information Visualization and Manipulation in Conjunction with the Eighth ACM International Conference on Information and Knowledge Management*, 78–82. ACM. https://doi.org/10.1145/331770.331789

Ferguson, Kevin L.
2015. "Volumetric Cinema." *[In]Transition: Journal of Videographic Film & Moving Image Studies* 2 (1). Video essay. https://doi.org/10.16995/intransition.11331

Ferguson, Kevin L.
2019. "Volumetric Cinema." In *Debates in the Digital Humanities 2019*, edited by Matthew K. Gold and Lauren F. Klein, 335–49. University of Minnesota Press. https://muse.jhu.edu/book/65227

Frampton, Hollis, dir.
1971. *(nostalgia)*. Short film.

Havardtl.
2017. "Serranía de Hornocal near Huamahuaca, Jujuy Province in Argentina." August 18, 2017. Photograph. Wikimedia Commons.

Hitchcock, Alfred, dir.
1958. *Vertigo*. Paramount Pictures.

Huhtamo, Erkki, and Jussi Parikka, eds.
2011. *Media Archaeology: Approaches, Applications, and Implications*. University of California Press.

Jaschko, Susanne.
2002. "Space-Time Correlations Focused in Film Objects and Interactive Video." In *Proceedings of ISEA2002, 11th International Symposium on Electronic Art*, 32–34.

Kitasenju Design.
2022. "Structure of Slit-scan." Video. https://kitasenjudesign.com/slitscan/structure/

Kreten, Tobias, and Marta Kipke.
2025. "CineSearcher: A Multimodal Film Exploration Workspace." In *Proceedings of the 7th International Workshop on Analysis, Understanding and Promotion of Heritage Contents* (SUMAC '25), 51–60. ACM. https://doi.org/10.1145/3746273.3760207

Kubrick, Stanley, dir.
1968. *2001: A Space Odyssey*. Metro-Goldwyn-Mayer.

Ledesma Villon, Patricia.
2021. "Indeterminable Frames: Exploring Digital Humanities Approaches and Applications for the Moving Image." *Cinergie – Il Cinema e le altre Arti* 20: 125–38. https://doi.org/10.6092/issn.2280-9481/13055

Levin, Golan.
2005. "An Informal Catalogue of Slit-Scan Video Artworks and Research." Updated 2015. Online catalogue. http://www.flong.com/archive/texts/lists/slit_scan/index.html

Lüsebrink, Dirk, and Joachim Sauter.
1997. *The Invisible Shape of Things Past*. Interactive installation. Presented at Prix Ars Electronica, Linz.

Manovich, Lev.
2012. "Media Visualization: Visual Techniques for Exploring Large Media Collections." In *The International Encyclopedia of Media Studies*, 1st ed., edited by Angharad N. Valdivia. Wiley. https://doi.org/10.1002/9781444361506.wbiems144

Manovich, Lev, and Jeremy Douglass.
2009. *Slice visualization of Time magazine covers*, 1923–2009. Digital visualization.

Manovich, Lev, Sergie Magdalin, Tara Zepel, and Kedar Reddy.
2009. *Media Species*. Poster/visualization. Presented at SIGGRAPH Info-Aesthetics Art Gallery. https://www.flickr.com/photos/culturevis/4119105812/

McLaren, Norman, and Evelyn Lambart, dirs.
1960. *Lines Vertical*. National Film Board of Canada.

Moviebarcode.
2011. *Moviebarcode*. Tumblr blog. https://moviebarcode.tumblr.com/ Accessed April 27, 2026.

Muybridge, Eadweard.
1887. *Female Nude Motion Study*. Chronophotograph.

Parikka, Jussi.
2015. *A Geology of Media*. Electronic Mediations, vol. 46. University of Minnesota Press. https://www.upress.umn.edu/9781452944579/a-geology-of-media/

Redfern, Nick.
2021. "Colour Palettes in US Film Trailers: A Comparative Analysis of Movie Barcode." *Umanistica Digitale* 5 (10): 251–70. https://doi.org/10.6092/issn.2532-8816/12468

Reinhart, Martin, and Virgil Widrich.
1998. "tx-transform." Webpage. https://www.tx-transform.com/ Accessed April 27, 2026.

Rodriguez, Dave.
2020. *Particles in Space*. Accessed February 10, 2026. https://drodz11.github.io/particlesinspace/collection/

Ruiz Gutiérrez, Tania.
2000–2003. *Spatio-temporal Objects*. Video/sculptural work.

Ruiz Gutiérrez, Tania.
2004. "Études sur le temps et l'espace dans l'image en mouvement: Tissage vidéo, objets spatio-temporels, images prédictives et cinéma infini." PhD diss., Université Paris I.

Smith, William.
1815. *A Delineation of the Strata of England and Wales, with part of Scotland*. Map. William Smith's Maps Interactive. http://www.strata-smith.com/map/ Accessed April 27, 2026.

Tang, Anthony, Saul Greenberg, and Sidney Fels.
2008. "Exploring Video Streams Using Slit-Tear Visualizations." In *Proceedings of the Working Conference on Advanced Visual Interfaces* (AVI '08), 191–98. ACM. https://doi.org/10.1145/1385569.1385601

Tour of Slovenia.
2022. "Results Stage 2." June 16, 2022. PDF document. https://tourofslovenia.si/storage/app/media/2022-files/TOS2022_Results_Stage_2.pdf Accessed April 27, 2026.

Utterback, Camille, and Romy Achituv.
1999–2001. *Liquid Time Series. Interactive installation*. First exhibited publicly in Tokyo, 2001.

Vertov, Dziga, dir.
1928. *The Eleventh Year [Одиннадцатый]*. Kyiv: VUFKU.

Waveluke [Pat Cunn].
2020. "Slitscan Self Portrait." *discuss.pixls.us* (forum). April 26, 2020. https://discuss.pixls.us/t/slitscan-self-portrait/17823

Welles, Orson, dir.
1941. *Citizen Kane*. RKO Radio Pictures.