



**University of
Zurich**^{UZH}

**Zurich Open Repository and
Archive**

University of Zurich
Main Library
Strickhofstrasse 39
CH-8057 Zurich
www.zora.uzh.ch

Year: 2014

Digital images and computer simulations

Flückiger, Barbara

Other titles: Properties of Digital Images and Computer Simulation

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-169968>

Book Section

Accepted Version

Originally published at:

Flückiger, Barbara (2014). Digital images and computer simulations. In: Gaafar, Rania; Schulz, Martin. Technology and desire : the transgressive art of moving images. Bristol: Intellect Press, 137-150.



**University of
Zurich**^{UZH}

**Zurich Open Repository and
Archive**

University of Zurich
Main Library
Strickhofstrasse 39
CH-8057 Zurich
www.zora.uzh.ch

Year: 2014

Digital images and computer simulations—————

Flückiger, Barbara

Other titles: Properties of Digital Images and Computer Simulation

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-102263>

Book Section

Accepted Version

Originally published at:

Flückiger, Barbara (2014). Digital images and computer simulations—————. In: Gaafar, Rania; Schulz, Martin. Technology and desire : the transgressive art of moving images. Bristol: Intellect Press, 137-150.

Digital Images and Computer Simulation¹

Barbara Flueckiger

In the wake of William J. Mitchell's influential text *The Reconfigured Eye* (1992) the discussion of digital images has focused mainly on the ethical implications of their truth claims. This text will focus on some different aspects, namely the process of digital image construction and its underlying representational and epistemological principles. Or to put it differently, not on the question of how digital images 'distort' what they represent, but on an understanding of how digital images 'construct' their representations.

Mitchell diagnosed a profound crisis in representation, which has its origin in the blurred truth status of digital images. However, in his statements Mitchell implicitly includes at least three different types of digital images: compositing, image processing, and computer-generated imagery (CGI):

Although a digital image may look just like a photograph when it is published in a newspaper, it actually differs as profoundly from a traditional photograph as does a photograph from a painting.

(Mitchell 1992: 4)

The traditional origin narrative by which automatically captured shaded perspective images are made to seem causal things of nature rather than products of human artifice [...] no longer has the power to convince us.

(Mitchell 1992: 31).

Furthermore, he barely mentions semio-pragmatic aspects of image reception, i.e. the culturally coded frame in which an image is presented. But this frame deeply shapes the viewer's response. Most CGI is used in contexts that are clearly marked as fictional – motion pictures or advertisements – and which therefore call for a different culturally determined mode of perception and interpretation. One of the best examples to illustrate this fact is *Forrest Gump* (USA 1994, Robert Zemeckis), which draws much of its fascination from the wit and irony of addressing a double consciousness in the viewer. While the viewer certainly knows that he is watching a fiction film and that the fictional character Forrest never encountered Kennedy, at the same time he marvels at the perfect illusion which unfolds on the

¹ This paper presents some findings of my research project *Analog/digital. Hybrid forms of cinematic representation* that was funded by a grant from the Swiss National Science Foundation, published as *Visual Effects. Filmbilder aus dem Computer* (2008).

screen. This kind of compositing triggers admiration, similar to how we feel when watching a perfectly executed magic trick without knowing how the trick was performed. In his reflections on “trucage” Christian Metz already referred to this play with duplicity (*duplicité*) (1971: 181), asking whether we should not regard cinema as one big special effect (1971: 187).

Unfortunately, following the publication of Mitchell's text a very narrow discussion has emerged, which does not take into account that Mitchell himself has also considered the continuity of the development from analogue to digital images. For instance, he uses Robert Capa's famous snapshot from the Spanish Civil War to discuss traditional photography in Roland Barthes's terms: as a floating signifier whose meaning can be changed by montage or by anchoring it with text.

Despite the sophisticated reasoning by Mitchell himself, many scholars have treated digital images as pure deception. The German media scholar Friedrich Kittler, for example, has claimed that they are pure forgery, because they fool the eye with their pixel structure that does no more than evoke the appearance of an image (Kittler 1998).

A framework for the classification of digital images

In my research project on CGI in film (Flueckiger 2008), I devised a framework for the classification of different types of digital images according to their production technology. While these types vary greatly, they share some common properties which will be the topic of my further investigation. Beyond the variations in digital image production as established in the framework, my research project has yielded a model of underlying principles that govern this exceedingly hybrid field, namely: recording, modeling and painting. In this paper I will also investigate computer simulation as a special, but arguably the most illuminating, case of digital image production, both with regard to the epistemological questions connected with CGI and in comparison to analogue modes of representation.

As indicated in the introduction, digital images are heterogeneous: not only in their mode of production but also – and as a result – in their very different relationships with the depicted objects and/or scenes, and their differing aesthetic appearances and functions.

Much of the confusion in the discourse on digital images stems from the fact that there is no digital image as such, but a plurality of images which we can attribute to the following variations:

1. Photography:
digital image acquisition by a camera; produces images that are hardly distinguishable from analogue photographs.
2. Scanning:
digital conversion of analogue images (photographs or paintings) into digital ones; these images are marked both in function and aesthetics by their analogue origin.
3. 2D drawing:
creation of digital images with a graphics tablet and the use of tools such as “brushes” or “pens”, etc.; with these techniques one can emulate almost any look of traditional painting, but also deviate greatly from anything possible in the analogue domain.
4. 2D image processing:
corresponds to classic forms of retouching, although – of course – the range of possibilities is much greater with digital means of processing.
5. Computer-generated imagery (CGI):
objects and scenes built by the use of 3D modelling and animation software in the computer and then rendered as 2D images, whether still or in motion; these images can be rendered according to the rules of photography or in non-photographic, deliberately stylized fashion; in most cases the term “digital image” is meant to denote CGI.
6. Compositing:
integration of various image parts from different sources; compositing can either provide fully illusionistic, seamless images or heterogeneous ones that clearly stress the fact that they are forms of image montage, and anything in between these two extremes.

Often the variations 3, 4 and 6 are all labelled as “image processing”.

In most cases, though, based on its aesthetic properties it is quite simple to determine which process an image has been produced by. Until now it is rarely the case that we confuse CGI with digital photographs. Only very few high-level renderings are so photo-realistic that we do not notice their origin in the computer. Furthermore, the fact has to be stressed that we do not judge images on the basis of their appearance alone, but include our knowledge of the world to decide whether or not an object or a scene could really have existed. When we see the grazing dinosaurs in *Jurassic Park* (USA 1993, Steven Spielberg), we are fully aware of the fact that these creatures were added digitally, not only because the press material and the making-of film informs us about it, but also because we know that they became extinct millions of years ago.

Common properties of digital images

Despite their great variety, digital images share some common features. Most of them are

raster graphics which consist of horizontally and vertically organized pixels. These pixels are coded by a binary value consisting of 1 and 0. This value has to be defined by a filtering process that maps the continuous phenomena of the real world onto discrete steps – a process that is called quantization and that relies on an arbitrarily devised relationship between the phenomena and their codification. In contrary to digital signals, analogue representations can continually adopt an infinite number of values. Mitchell (1992: 4) has illustrated this difference as follows: “Rolling down a ramp is a continuous motion, but walking down stairs is a sequence of discrete steps – so you can count the number of steps, but not the number of levels on a ramp.” In fact, however, this distinction is currently in the process of becoming obsolete or at least questionable – since digital systems provide a resolution which far surpasses the range of analogue representation and the scope of perceptive differentiation by humans. To put it differently: Are there still steps, if we perceive them as a ramp? For example, high-quality scans of analogue photographs depict every single grain, therefore the pixel structure is less visible than the grain structure of the original material.

According to Mark J.P. Wolf (2000: 31) the binary coding system was invented in 1670 by the Spanish Cistercian monk Juan Caramuel y Lobkowitz. In general, however, its invention has been attributed to Gottfried Wilhelm Leibniz, who in 1701 conceived it as a universal principle of metaphysical dimension between being and non-being. This metaphysical dimension received additional support when Leibniz learned from a missionary that the Chinese book *I Ching* also relied on the binary system. With the invention of Boolean algebra by George Boole in 1854, complex mathematical operations became available to the binary coding system, which are the foundations of today’s image processing by the computer. In Nelson Goodman’s (1968: 161) terminology, binary coding is described as an explicit notation system, a fact that will be considered later.

As mentioned above, before binary values can be calculated they have to be mapped onto a scale consisting of discrete units which are integers of a fundamental one. Such filtering and mapping occur in human perception in many domains, for example in colour perception, as Eleanor Rosch (1973) has shown in her famous study, or in the social construction of time and space, as Norbert Elias (1988) has demonstrated.

In digitization this filtering and mapping calls for an explicit protocol that governs the conversion process and defines the phenomenon-data relationship as well as the data themselves. This includes the assignment to a definite position in time and space. The values of each section of this space-time grid, i.e. for each pixel, define their tonal and colour

information. In order to form an output on a display these data have to be recombined, which means an assembly of an analogue output in accordance with the requirements of the human perception system.

In other words, what is at work here is a combination of analysis and synthesis (cf. Le Grice 1999: 210). And this combination of the two complementary processes is the very foundation of computer simulation, as I will show in the corresponding paragraph.

With the binary coding system, digital data enter a universal digital ecosystem. Wolf (2000: 15f.) has compared this coding system to a currency which allows for the circulation and conversion of money. In a similar fashion, digital data's common code supports transmission, i.e. feeding into a variety of media, and transformation, i.e. the conversion or processing of digital data. Random access, a further specificity of the digital domain, is based on the possibility of directly addressing the mathematically coded elements. Unlike linear coding systems such as text or films, these data are distributed equidistantly in the time-space system. As Vilém Flusser has pointed out in his essay "Krise der Linearität" ("Crisis of Linearity", 1988), random access is the foundation of network structures, such as the Internet, and in turn leads to non-linear thought models.² But in contrast to other scholars, Flusser stresses the historical, culturally determined process that started in the early Enlightenment, with its preoccupation for mathematically substantiated descriptions of processes in terms of zero-dimensional, numerical entities. According to this view, what we witness now is not a digital revolution, but an evolution that began several centuries ago: a notion that proposes a historical model of feedback loops instead of a linear, teleological techno-determinism. In a similar fashion, Wolf (2000) suggests that digital technology was developed on the basis of an encompassing quantization of life that has emerged in many domains. In turn, this technology now supports a quantizing way of thinking and thus exerts an influence on the perception of the world. In consequence we should conceive this development as a complex, dynamic interaction of technology with socio-cultural forces.

CGI between recording, painting, and modeling

In addition to the classification framework mentioned above, computer-generated images can also be classified on a deeper level according to their connection to the world they depict. In my research on the different technical strategies and their epistemological foundations, I have

² For a more detailed investigation on Flusser's analysis and the impact of non-linearity in digital culture see Flueckiger (2012).

devised three basic modes, namely: recording, painting, and modeling. A fourth one is measurement, which usually plays a minor role, but is of prime importance in computer simulation, which will be the target subject of the study presented here. Measurement means the gathering of explicit data, for example to reconstruct objects or architecture in the computer.

By recording I understand the translation of a physical structure according to an implicit or explicit protocol. We can assign digital photography to this category, but also motion capture as the recording of motion data in a 3D space. A further technological strand includes all the image-based approaches whose prime proponent is Paul Debevec. Image-based modelling is a technique to extract 3D data from a series of photographs (Flueckiger 2008: 70 et seq.), while image-based lighting calculates light values for the rendering process based on a photographed light dome (Flueckiger 2008: 164 et seq.). These approaches gain increasing importance when complex structures of the real world are to be imported into the 3D space of CGI, most prominently so in the construction of digital characters (Flueckiger 2008: 417 et seq.).

Painting refers to image generation and processing with emulated tools such as brushes and pens. It is used in CGI, for example in the creation of texture maps which describe the colour distribution on the surface of objects.

Model building³ is the dominant practice in CGI. It is a rule-based, explicitly formalized system to generate 3D objects and animations. The rules apply either mathematical or physical principles or stem from empirical observation and reconstruction. Examples of such model building processes are procedural animations of flocks of animals like birds and crowd animation (Flueckiger 2008: 131 et seq.). Furthermore, procedural approaches include the modelling of landscapes and plants based on algorithms from fractal geometry – for example the L-systems by the biologist Aristid Lindenmayer that apply the formal grammar of plant growth (Flueckiger 2008: 65 et seq.). And finally, all the rendering algorithms that calculate the interaction of light with objects to provide the final image of a 3D scene are all based on model building (Flueckiger 2008: 101 et seq.). By their very nature models are simplifications of complex phenomena. They suppress those details which are deemed unimportant or work with shortcuts that simply deliver the required results while neglecting some aspects.

³ The German term “Modellbildung” (literal meaning: model building) is more accurate than modeling, because the technical process of modeling may include painting and recording, which are distinct in the system proposed here.

In fact, most CGI are hybrid composites of the strategies differentiated here. For example, animation can be based on motion capture – a recording process – while the texture maps might be painted, and all the rendering processes belong to the category of model building. But model building remains at the core of CGI and especially of computer simulation. It is this principle that divides CGI most fundamentally from other, earlier forms of representation such as painting. While painting emulates phenomena and their perception based on observation, model building requires an explicit understanding of the physical principles. However, there is a small field wherein formalized knowledge is required in painting: the construction of the central perspective. As I have analyzed in a text about the depiction of cities in film, early bird's eye views – like the famous woodcut view of Venice (1500) by Jacopo de' Barbari and Anton Kolb – necessitated a deep understanding of geometrical relationships because, like maps, they depict a view that was not available to observers at the time (Flueckiger 2009).

Computer simulation – A case study

According to Paul Humphreys (2004: 104 et seq.), computer simulation is a subset of computational science to serve the purpose of “modeling, prediction, design, discovery, and analysis of systems”. Most scholars (Norbert Wiener 1948 in Dotzler 2003, Humphreys 2004, Hartmann 2005) define simulation's underlying principle as a system that is mathematically equivalent with another one. As Boehm (2007: 135) has suggested, it is an analogy with little or no similarity. Boehm (2007: 135–136) illustrates this relationship with a beam balance, where one puts an object – for instance a fruit like an apple – on one side, and an often dissimilar, other object – a standardized weight made of metal – on the other side.

Furthermore, computer simulations are most often dynamic and time-based. Therefore they depict their results in the form of computer animations, which we can understand as rule-based imitations of processes from the real world (cf. Flueckiger 2008: 279). In many respects, this use of the term “simulation” differs distinctively from Jean Baudrillard's conception of simulation's deceptive function in a decadent postmodern society where it denotes images without a referent. As we will see, the kind of simulation discussed in this paper is defined by an explicit, albeit complex relationship to the phenomena of the real world. The question of how computer-generated images refer to and produce knowledge is of great concern in a period of the iconic turn, called for by proponents such as art historian Gottfried Boehm or William J. Mitchell. Both Hartmann (2005) and Humphreys (2004) have investigated the functions of computer simulation in natural and social science, where they

serve as a heuristic tool to “develop hypotheses, models and theories” or “support experiments” (Hartmann 2005: 6). The computer simulations discussed here have a similar function, but do not apply in such a profound way to general theories as formulated in natural or social science. Rather they picture certain situations, processes or events. Familiar examples would be 3D visualizations of architecture, which allow planners to explore or show buildings while they are not yet built, or computer reconstructions of crime scenes, which serve as forensic evidence in the court room. Mark J.P. Wolf (2000: 262) has described such computer simulations as “subjunctive documentaries” because they represent “what could be, would be or might have been”. As early as 1988, Vilém Flusser wrote that CGI creates “Vorbilder”, a German term meaning both “role models” and “pre-images” of possible objects or events, like blueprints.

In a close analysis of a specific computer simulation, I will discuss some exemplary aspects of this form of depiction. In the broadcast *Peter Jennings Reporting: The Kennedy Assassination – Beyond Conspiracy* (2003) for ABC News, a portion of journalist and 3D artist Dale K. Myers’ reconstruction *Secrets of a Homicide: JFK Assassination* was shown. This computer simulation served to investigate and illustrate the Kennedy assassination that took place on November 22, 1963 in Dallas, at Dealey Plaza.⁴ The most important source for Myers’s reconstruction of the events at Dealey Plaza was the film shot on regular 8mm by Abraham Zapruder, known as the Zapruder film.⁵

As is usually the case, a variety of additional sources were applied, according to Dale K. Myers:⁶

- A survey map of Dealey Plaza, prepared by Drommer & Associates for the House Select Committee on Assassinations in 1978, was used to plot the layout of the plaza in 3D space.
- Blueprints of the Texas School Book Depository, prepared by Burson, Hendricks & Walls for the Dallas County Depository restoration project in 1978, were the basis for the 3D model of the infamous warehouse.
- The original body draft of the modified 1961 Lincoln convertible, prepared by The Hess & Eisenhardt Company, served as a guide in modeling the presidential limousine.

⁴ Information from Dale K. Myers related to the construction of the computer simulation can be found on the following website: <http://www.jfkfiles.com/> [last access: June 3, 2009]. The broadcast is available on YouTube: <http://www.youtube.com/watch?v=DSBXW1-VGmM> [last access: June 29, 2012] or on DVD.

⁵ The Zapruder film is available on YouTube: <http://youtu.be/1q91RZko5Gw> (a version that includes out-of-frame area between the sprocket holes) [last access: June 29, 2012]

⁶ Information taken from <http://www.jfkfiles.com/> [last access: June 3, 2009].

- More than 500 personal photographs and measurements gathered by Myers during multiple trips to Dallas, Texas were utilized in the construction and placement of all fixed structures, including the records, Criminal Court, and Dal-Tex Buildings. Contemporary photographs were studied in order to ensure that the model matched Dealey Plaza circa 1963.
- The model of the Texas School Book Depository was based on blueprints and took three months to create. Dallas Police Crime Lab photographs and local TV news film were used to position over 5,000 boxes on the Depository's sixth floor.
- The presidential limousine began as a digitized model of a 1961 Lincoln convertible. The resulting computer model was then modified to match the dimensions of the presidential limousine's original body draft, provided by Hess and Eisenhardt. Details were created based on a multitude of photographs taken during the 1963 Dallas motorcade. Particular attention was paid to the seating arrangement as depicted in photographs taken by the Secret Service and FBI in the White House garage the night of November 22, 1963.
- Sculptor Mark Stuckey was commissioned to create life-size clay busts of President Kennedy and Governor John B. Connally. Rubber molds and plaster castings were created from these sculptures.
- Once the virtual model of Dealey Plaza was completed, the process of recreating the path and motion of the presidential limousine and its occupants began, based on the Zapruder film and other evidence recorded during the event.

All this information and source material was analyzed and selected to reconstruct the incident using the software LightWave 3D with modelling, texturing, animation, lighting, and rendering. The rendering process allows the selective use of details and the omission of parts of the 3D geometry. Finally, a commentary was added with an affirmative tone supplied by expressions such as “exactly the way they were” or “an accurate representation of exactly what happened.”

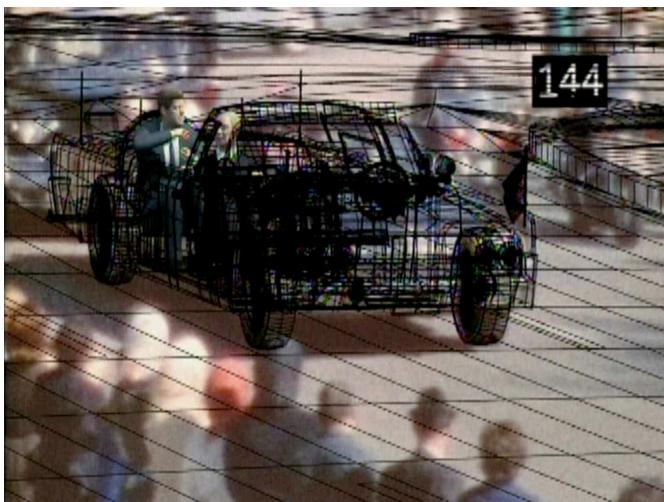




Fig. 1–3: Stills from the computer simulation of the Kennedy assassination

It is very interesting to compare this computer simulation to the Zapruder film. Abraham Zapruder's short film manifests a set of aesthetic features which are almost universal in this kind of documentation captured by a casual bystander. It consists of 486 frames⁷ that unfold in one uninterrupted take of 26.56 seconds at the original frame rate of 18.3 fps, or in other words, it captures the event as a *plan-séquence* or a long take which – as André Bazin argued in his essay “The Evolution of the Language of Cinema” (1950) – enhances the impression of reality. Furthermore, Zapruder worked with a handheld camera, thus producing shaky images. In these shaky images both the excitement of the bystander and the close body-camera connection are present. They produce a lively, anthropomorphic view of the events, thus indicating the presence of an actual witness. Many images are blurred: an effect enhanced by the low-resolution of the regular 8mm stock. In fact, it is often difficult to discern clearly what

⁷ The individual frames are available as magnifications on <http://www.assassinationresearch.com/v2n2/zfilm/zframe001.html> [last access: June 3, 2009], also the source for the illustrations of this text.

was really happening in front of the camera. The blurriness in conjunction with the low resolution add to an aesthetics of the sensational which is often also found in paparazzi footage (cf. Ullrich 2001: 90). Finally, important and critical events occur behind a traffic sign or foliage or between individual frames, for example between frame 223 and 224 where – as Myers explains in the broadcast – Governor Connally's jacket pops open. In sum, although the Zapruder film has been used as a principle source of evidence not only for the computer simulation put under scrutiny here, but for the whole process of investigation, it actually hides and omits crucial information, a fact which is even more relevant given the absence of acoustic information in this film shot without sound.

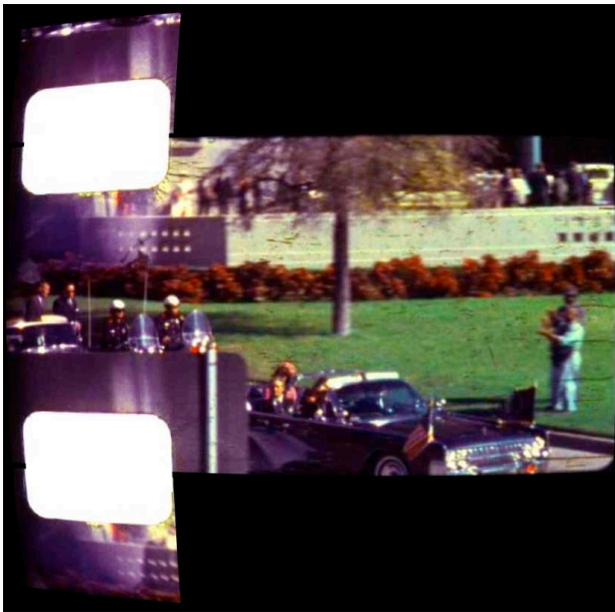


Fig. 4: Frame 223 from the Zapruder film

In contrast to the Zapruder film, one of the most remarkable properties of the computer simulation is the great flexibility with respect to the space-time coordinates of the event depicted. The virtual camera defies all the constraints of a physical camera and offers multiple perspectives. A similar flexibility is also at work in the very selective use of details and their partial omission in the rendering process: for instance the car in the computer simulation, which is only indicated as a wire frame, and the addition of argumentative relationships like the arrow which shows the trajectory of the bullet.

Photorealism would be an option in principle, but while Myers claims his animation to be “hauntingly realistic”,⁸ it operates – like most computer simulations – with a rather crude style of visualization. It also avoids integrating analogue artefacts like grain, depth of field or

⁸ <http://www.jfkfiles.com/jfk/html/models.htm> (last access: July 11, 2009)

motion blur, which are an important part of photorealism (cf. Flueckiger 2008: 334 et seq.). The surface structures of the objects, the buildings and the landscape are greatly simplified. In sum, it aims to a greater or lesser degree at abstraction, and it exposes the origin of the images from the computer – a fact that has to be considered later.

At the core of the construction process of computer simulation is an interplay of analysis and synthesis. It thus mirrors on a macro-level what has been described as a characteristic of digital images on the micro-level of each pixel. As has been shown, a vast amount of information from different sources – photographs, maps, blueprints, films etc. – has to be considered and evaluated before the reconstruction of the dispersed data can be carried out. According to Nelson Goodman (1978) these complementary strategies form part of our everyday cognitive activity in constructing our understanding of the world:

Much but by no means all worldmaking consists of taking apart and putting together, often conjointly: on the one hand, of dividing wholes into parts and partitioning kinds into subspecies, analyzing complexes into component features, drawing distinctions; on the other hand, of composing wholes and kinds out of parts and members and subclasses, combining features into complexes, and making connections.

(Goodman 1978: 7)

Furthermore a selection process that governs the combination of analysis and synthesis is necessary. We can consider this selection process as filtering and cleaning of the data with regard to the specific aims of computer simulation. While some data are suppressed or sorted out as irrelevant, others are emphasized. This selection process becomes instantly obvious in the above-mentioned image of the beam balance proposed by Boehm (2007: 135–136), where only the weight of the two objects is selected as a criterion of reference. Such selection processes guide both our cognitive operations in perception, and any scientific observation and interpretation of data:

And even within what we do perceive and remember, we dismiss as illusory or negligible what cannot be fitted into the architecture of the world we are building. The scientist is no less drastic, rejecting or purifying most of the entities and events of the world of ordinary things while generating quantities of filling for curves suggested by sparse data, and erecting elaborate structures on the basis of meager observations.

(Goodman 1978: 15)

Selection results in a more or less obvious level of abstraction which appears to be cleansed of anything not necessary for the task to be accomplished. The key concept for the discussion of

the range between abstraction and a fully photo-real depiction is resemblance. While “resemblance” is a controversial concept in the theory of representation, it remains useful for the discussion of computer simulation. As Nelson Goodman (1968), who questioned the concept vigorously, has pointed out, resemblance must always be put in relation to something, for example the weight in the beam balance metaphor.

In the case of the computer simulation of the Kennedy assassination, surely the most important frame of reference is the photographic image as depicted in the Zapruder film. In comparison with photographs, however, modelled images can cover a range from strong to weak resemblance. If these representations were purely abstract, they would need contextual support – be it a text, or a specified protocol that defines the relationship between the depiction and the objects depicted, as is the case with diagrams. For example we could generate a computer simulation of the migration and evolution of a reindeer population, where each individual animal would be represented as a shiny dot on the screen. When such a high degree of abstraction is applied, additional – usually linguistic – information is necessary to explain the relationship between an object, for example the reindeer, and its representation, the dot. A similar case in point is the flu spreading simulation depicted here (fig. 5).

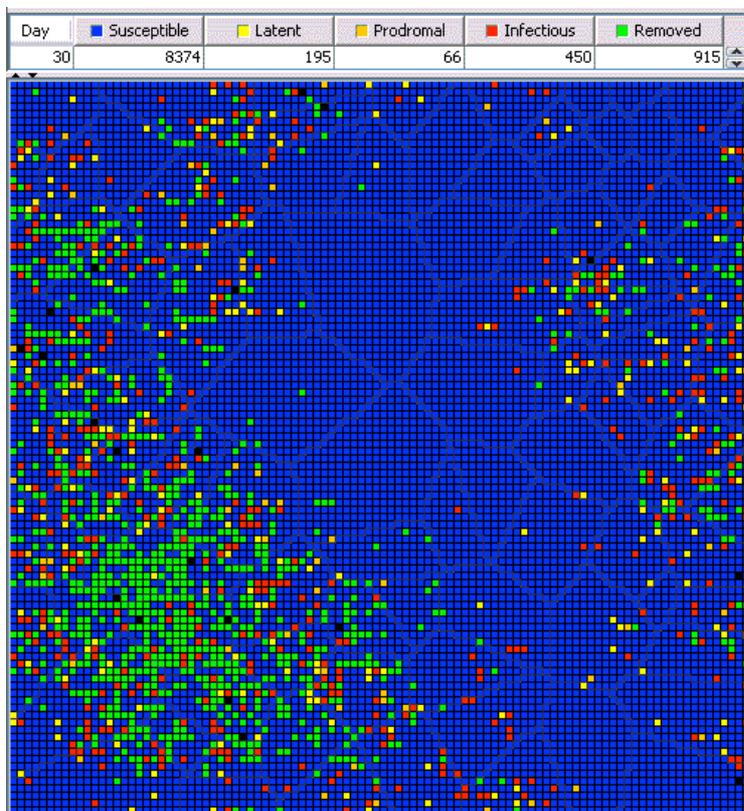


Fig. 5: Flu spreading simulation

In addition to the range of abstraction, photographs and computer simulations differ in regard

to their connection with the objects and events depicted. While photographs – like all other forms of recording mentioned above – rely on their mechanical and physical connection to the scene in front of the camera, computer simulations often involve a myriad of distributed references – like the maps, photographs, blueprints, films and other sources in the case of the Dealey Plaza simulation. Regardless of whether the resemblance is weak or strong, then, the relationship between the objects and their representation is highly mediated. It ranges from a mediated iconicity in the case where we recognize the objects, to a symbolic relationship in the case of pure abstraction. Thus computer simulation is very autonomous vis-à-vis the depicted world. It is marked by an obvious loss of details; it is – one could say – purified of the complexity of the real world. It presents generic information rather than particulars. It expresses more an understanding of the world and its underlying principles than a pictorial representation of actual things or events. “Any definable range of phenomena including definable characteristics of human psychology or social relationships can be given values and be mapped into a virtual, multidimensional space” (Le Grice 2001: 284). But even the most abstract representation needs an anchoring in mental schemes to communicate something and not be perceived as mere patterns. As early as 1968, the computer and Internet pioneer J.C.R. Licklider described this relationship between technical principles and cognitive operations in communication:

[...] Modelling, we believe, is basic and central to communication. Any communication between people about the same thing is a common revelatory experience about informational models of that thing. Each model is a conceptual structure of abstractions formulated initially in the mind of one of the persons who would communicate, and if the concepts in the mind of one would-be communicator are very different from those in the mind of another, there is no common model and no communication.

(Licklider et al. 1968: 22)

Following Mitchell, the autonomy of CGI has been compared to paintings or written texts. But while paintings are highly subjective interpretations of actual or imagined phenomena, computer simulations rely on a formalized and rule-based description that materializes not as written texts, but as images. It has become clear, that these images differ profoundly from paintings when one considers both the construction process and its results.

Like film, computer simulation offers multiple perspectives. In contrast to film, however, these multiple perspectives cover the whole range of space-time coordinates present in the constructed scene. Space and time therefore become navigable dimensions. In this respect computer simulation possesses the flexibility of cognitive operations with random access to

any point in the space-time system. While in film the space-time representation consolidates as a definite trajectory, in computer simulation it remains potentially fluid – as is most evident in the real-time rendering of video games. In other words, the space-time system remains open as a field of potentialities that may or may not materialize as animation.

Surely the most important aspect of computer simulation is its potential to transcend both the scope of human perception, and of recording by a technical apparatus. It thus allows us to observe the unobservable, something that lies beyond direct access to the senses whether because of time constraints – an event can have happened in the past or might be projected into the future – or because of constraints in scale, be it that the scale is too small or too big to be grasped by human perception or by traditional systems of image recording.

References

Baudrillard, Jean (1981): *Simulacres et simulation*. Paris: Editions Galilée. (*Simulations*, translated by Paul Foss, Paul Patton and Philip Beitchman, New York, Semiotext(e), 1983)

Bazin, André (1950): ‘The Evolution of the Language of Cinema,’ in: Leo Braudy, Marshall Cohen (eds.) *Film Theory and Criticism. Introductory Readings*. New York, Oxford University Press, 1999.

Boehm, Gottfried (2007): *Die Macht des Zeigens. Wie Bilder Sinn erzeugen*. Berlin: Berlin University Press.

Dotzler, Bernhard J. (2003): ‘Simulation,’ in: Karl-Heinz Barck et al. (Eds.): *Ästhetische Grundbegriffe. Historisches Wörterbuch in sieben Bänden*. Stuttgart: J. B. Metzler.

Elias, Norbert (1988): *Time. An Essay*. Transl. by Edmund Jephcott. Oxford: Blackwell, 1992.

Flueckiger, Barbara (2008): *Visual Effects. Filmbilder aus dem Computer*. Marburg: Schüren.

Flueckiger, Barbara (2009): ‘Städtebilder aus dem Computer,’ in: *Cinema*, No. 54.

Flueckiger, Barbara (2012): iPhone Apps. A Digital Culture of Interactivity. In: Pelle Snickars und Patrick Vonderau (Hg.): *Moving Data. The iPhone and the Future of Media*. New York: Columbia University Press.

Flusser, Vilém (1988): *Krise der Linearität*. Bern: Benteli. (English translation: *Crisis of Linearity*, translated by Adelheid Mers, 2006.)

Goodman, Nelson (1968): *Languages of Art*. Indianapolis: Hackett Publishing Company, 1976.

Preprint version (2012) of

Flueckiger, Barbara (2014): Properties of Digital Images and Computer Simulations. In: Rania Gaafar, Martin Schulz (eds.): *Technology and Desire. The Transgressive Art of Moving Images*. Bristol & Chicago: Intellect Press, pp. 137–150.

Goodman, Nelson (1978): *Ways of Worldmaking*. Indianapolis: Hackett Publishing Company, 1990.

Hartmann, Stephan (2005): *The World as a Process. Simulations in the Natural and Social Sciences*. (<http://philsci-archive.pitt.edu/archive/00002412/>, last access: June 5, 2009)

Humphreys, Paul (2004): *Extending Ourselves. Computational Science, Empiricism, and Scientific Method*. Oxford: Oxford University Press.

Kittler, Friedrich A. (1998): *Computergraphik. Eine halbtechnische Einführung*.

(= <http://hydra.humanities.uci.edu/kittler/graphik.html>, last access: June 29, 2012)

Le Grice, Malcolm (1999): 'Digital Cinema and Experimental Film.' In: Yvonne Spielmann und Gundolf Winter (Hg.): *Bild – Medium – Kunst*. München: Wilhelm Fink Verlag.

Le Grice, Malcolm (2001): *Experimental Cinema in the Digital Age*. London: BFI.

Licklider, J.C.R.; Taylor, Robert W. (1968): 'The Computer as a Communication Device,' in: *Science and Technology*, April 1968.

Mitchell, William John (1992): *The Reconfigured Eye. Visual Truth in the Post-Photographic Era*. Cambridge, Mass.: The MIT Press.

Rosch, Eleanor (1973): 'Natural Categories,' in: Noel Sheehy and Anthony J. Chapman (Eds.): *Cognitive Science*. Aldershot: Edward Elgar.

Ullrich, Wolfgang (2002): *Die Geschichte der Unschärfe*. Berlin: Klaus Wagenbach.

Wolf, Mark J. P. (2000): *Abstracting Reality. Art, Communication, and Cognition in the Digital Age*. Lanham, Md.: University Press of America.