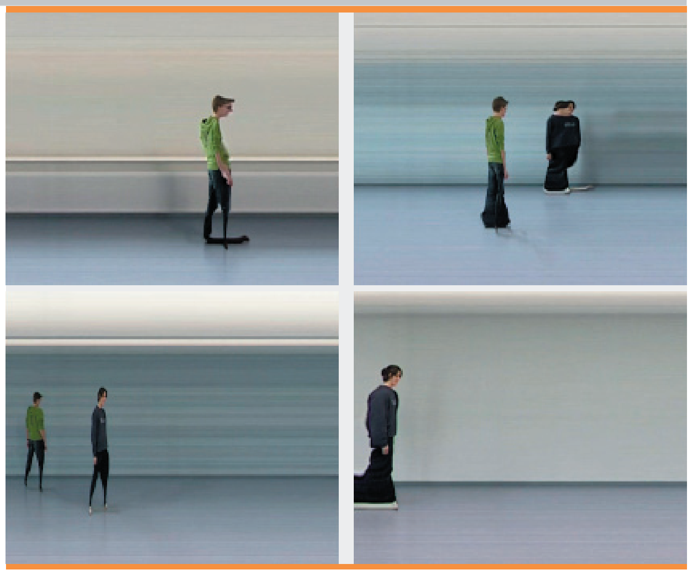
Publikationen zu Wissenschaftlichen Filmen



WERNER GROSSE

Time Tilting

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IWF Wissen und Medien gGmbH
Nonnenstieg 72, 37075 Goettingen
Fon: +49 (0)551 5024 0
www.iwf.de

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Time Tilting

Abstract

If we see a film, we experience the passing time in two ways. On the one hand, it is conveyed as the time in which the film action takes place – felt as "lived" time. On the other hand, via camera travels and movements of objects vertically to the picture plane, time is perceived – in a much more indirect way – as a vehicle for representation of spatial depth. It is this link between space and time where the method of "time tilting" introduced here sets in.

When a film scene is "time-tilted", one of the spatial dimensions (here the horizontal direction of the picture plane) is interchanged with the time dimension: In a first step, the pictures of the scene are digitalized. Then, the thus gained pixels of all pictures of the scene are arranged into a three-dimensional data field. Finally, a new series of pictures is read out, along one of the two former picture axes, which is then shown as a scene of moving pictures. The resulting film will present optical phenomena which are, on the one hand, aesthetically appealing and, on the other hand, informative for film analysis. First examples demonstrate how the procedure operates on basic movements in space as well as on camera travels in space.

The Method

In the following, I will deal with "pictures" and "moving pictures". At first, for better understanding, I will define these terms more precisely: A two-dimensional picture is to be understood as an instruction assigning an optical quality (e.g. colour, brightness) to each point of a surface in a way that significant parts of this surface (sets of points) will recognizably have a gestalt.[1]

Accordingly, two-dimensional moving pictures are to be understood as two-dimensional pictures plus the additional dimension of time. That is, the respective instruction includes a time variable, which allows to assign to each point an optical quality varying over time. With respect to time, too, gestalt qualities[2] are to exist.

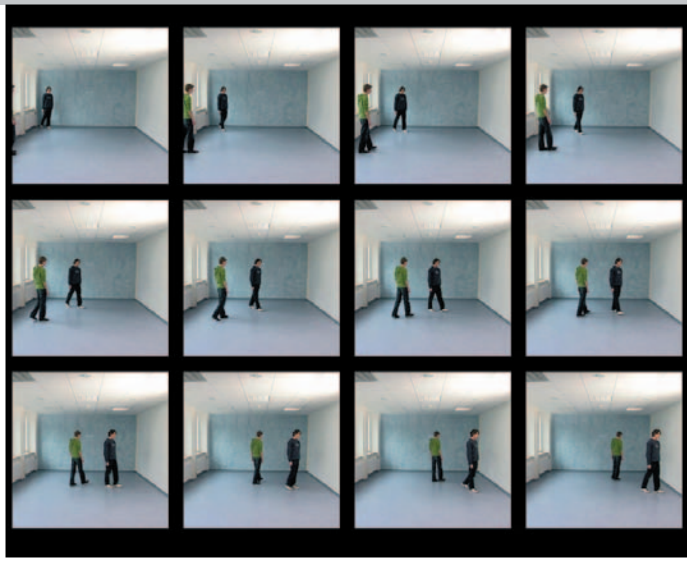

Figure 1: A film scene is decomposed into its individual pictures.

There is hence a slight but fundamental difference between the actual defining "instruction" and its potential "executions", objectifications of the form of "prints". As long as these facts are not mistaken, however, I will refrain from this distinction and talk about a "picture" even if one of the common objectifications is meant.

These definitions of "picture" and "moving picture" cover usual forms of pictures like drawings, photographs, and films, but also allow to extend theoretical observations beyond the currently used formats and techniques if need be. With regard to pictures that are encoded as digital bitmaps or as functions of real numbers (vector graphics), this option has already to be made use of.

Basically, the above-mentioned surfaces, times, and colour scales can be understood as unlimited and, above all, as continua – qualities that picture media in the so far existing practice do not have. Hence, for pragmatical reasons and in favour of an easier description of the method of time tilting, we will at first talk about discretized – i.e. digitalized – and finite surfaces, time segments, and colour palettes. Later, we will see that the basic idea of this article is independent of such a restriction.

Let us now imagine rectangular pictures composed of m times n pixels, each of which is assigned one out of r different colours. Let us further imagine a film scene composed of s such pictures. It should be kept in mind that these pictures and the scene are to have gestalt with respect to space and time (see fig. 1)

Let us make the further restricting assumption that the pictures be squares and the film scene be composed of a number of pictures equalling the numbers of pixels in one of the picture dimensions. In the above-introduced mathematical terms, this would be expressed as $m = n = s$.

[1] Max Wertheimer: Über Gestalttheorie. Lecture to the Kant-Gesellschaft, Berlin, December 17, 1924. Reprint in: Gestalt Theory, vol. 7 (1985), No. 2, pp. 99–120, Opladen: Westdeutscher Verlag. http://web.archive.org/web/20040708041053/http://www.geocities.com/HotSprings/8609/gestalttheorie.html

[2] Christian von Ehrenfels: Über Gestaltqualitäten. Vierteljahresschrift für wissenschaftliche Philosophie, 4, 1980, pp. 249–292.

In information-theoretical terms, we have thus a spatial and a temporal raster with identical numbers of discrete pixels in each dimension. We may imagine the film scene as being arranged to a cube by piling up its individual pictures in the direction of spatial depth.

This cube can be placed into a three-dimensional coordinate system $K = \{x, y, z\}$ in a way that the picture width runs parallel to the x-axis, the picture height runs parallel to the y-axis, and the piling direction is parallel to the z-axis. In this representation, the z-axis assumes an uncommon role, as it actually represents the time axis of the film (see fig. 2).

At this point, I will insert an excursion of crucial importance for the continuation of the article: Most people seem to be unaware of the fact that a film consists of individual, discrete pictures. This fact means that each film realized so far and recorded on a storage medium is digitalized with respect to time. Its individual pictures stand still, not only during their storage but in particular during their screening. Whoever once had a film reel in his or her hands should actually be surprised that the screen action is kept available by means of a classic solid body, massively and voluminously.

From the beginning, film-makers had the problem to spatially file the great number of individual pictures (amounting to a magnitude of hundreds of thousands in a feature film). Piling them up like in the example above meant that they could be leafed through as a kind of flip book, but resulted in optical and mechanical problems. Arranging them in the picture plane, e.g. as stripes or in circles on disks, meant that limits of physical extension were soon reached. As we know today, the solution was: reeling them up. But this presupposed a flexible and transparent material, which was provided in a satisfying way only with the invention of celluloid.

If we do not interpret the z-axis of the coordinate system as the time axis but as the third spatial axis, our cube gains a new significance. It then does no longer represent a film scene but instead a three-dimensional still picture (see fig. 3).

By extending the above-given definition of a two-dimensional picture to three, four or more dimensions, we get the following general definition:

An n-dimensional picture is to be understood as an instruction assigning an optical quality to each point of an n-dimensional space, where at least some sets of points have to show gestalt quality.

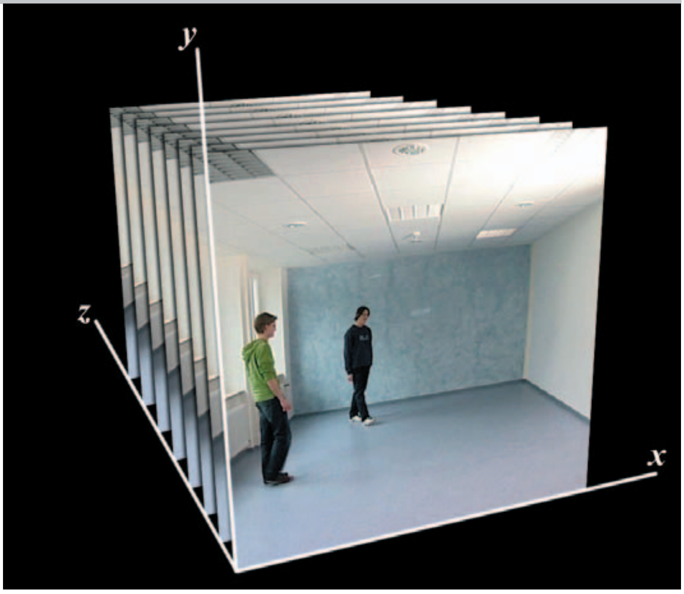

Figure 2: The individual pictures of the film are piled up to a cube and placed into a coordinate system in the following way: The picture plane of the film lies in the x-y-plane, while the running time of the film is arranged along the z-axis.

Figure 3: Of the sequence of two-dimensional pictures, a cube has been formed, which can be interpreted a three-dimensional picture. In this interpretation, the former time axis has become another spatial axis.

Seen in that way, our cube is a three-dimensional digital picture, rastered in voxels (three-dimensional pixels). We can easily produce a concrete model of such a cube by cutting apart some hundreds of pictures of a film strip, piling them up, and welding them together. This will result in a block of plastic material which, on the one hand, contains in its interior all picture information of the original film strip and, on the other hand, is a three-dimensional picture. The picture information cannot easily be looked at, it is true. But this holds for any "print" of a three-dimensional picture. Of course, you may slice the block, layer by layer, and look at the surfaces thus produced, one after another. If you do that fast enough, you will see the original film.

There is thus an equivalence relation between the terms "two-dimensional moving picture" and "three-dimensional still picture". In general, the following holds:

Any n-dimensional moving picture can be understood as an (n+1)-dimensional still picture, and vice versa. This equivalence relation consists in the simple interchange of the time dimension with another spatial dimension.

For current media practice, this insight is neither new nor of great relevance. We have a wide culture of two-dimensional moving pictures (movies), their three-dimensional counterparts, however, are not suited to look at pictures, though indispensable with regard to storage techniques. One-dimensional moving pictures, on the other hand, are not at all interesting and therefore rare, while their two-dimensional counterparts in the form of paintings or photographs are widespread. Finally, a "print" of a three-dimensional moving picture does not exist so far[3], and its counterpart in the form of a four-dimensional still picture would be too much for our senses.

The abilities of the human senses and the human brain include little capacity as to dimension leaps. Since Edwin A. Abbott's "Flatland"[4], many attempts have been made to understand, by means of mental experiments, at least the dimensionalities zero to four in some way or other. Einstein's model of the world as a space-time continuum[5] proved, however, that although thinking in four dimensions and ideas about the equivalence of space and time are necessary and possible for an understanding of the world, a collective dislike to such insights and learning processes is still strong, even in highly structured knowledge societies.

3 Although the production and representation of a moving 360-degree holograph would technically be feasible, it has never been realized so far, as far as I know.
4 Edwin A. Abbott: Flatland – A Romance of Many Dimensions. 1884
5 Albert Einstein: Zur Elektrodynamik bewegter Körper. 1905

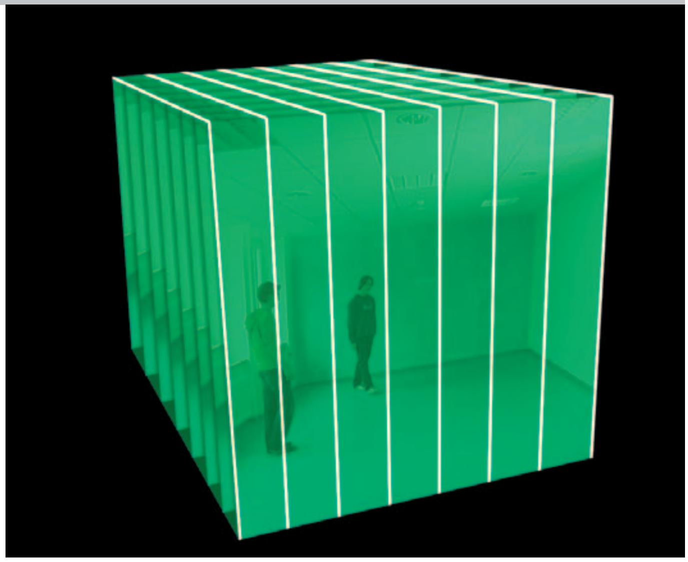

Figure 4: By slicing the cube in parallel to the y-z-plane, we will obtain new two-dimensional pictures.

The Experiment

For decades, I have been preoccupied with a mental experiment, which has regularly shown me the limits to my imagination. In this experiment, I mentally transform an actual film scene into a three-dimensional picture and place the latter into an *x-y-z*-coordinate system, as described above. Depending on the contents of the film, this may be of varied difficulty. Then, I try to generate a new film scene by following the *x*-axis and, for each value of *x*, looking at the respective pictures in the *y-z*-plane (see fig. 4). Formally spoken, I make the *x*-axis the time axis and have the former *z*-axis represent the width of the newly generated pictures. The *y*-axis, now as before, represents the height of the pictures. As a mathematical operation, this process is a triviality, but imagination is challenged by such a task (see fig. 5).

Due to technical obstacles, I have hesitated for long to perform this mental experiment in reality. Meanwhile, the necessary media technique has become so simple that I can check my visualizations with the help of the following test design:

At first, a film scene in Video-PAL format is imported into the editing programme Adobe Premiere 6.0, is trimmed at its sides to a square picture format (576 x 576 pixels), and shortened to a sequence of 576 pictures – which corresponds to a running time of 23.04 seconds. The scene prepared in that way is then exported as a bitmap sequence. The 576 bitmap pictures the size of 576 x 576 pixels are stored in a folder. This folder hence contains the information regarding a three-dimensional picture consisting of nearly 200 millions of pixels, or, in other words, it contains a virtual cube.

The operation of time tilting means to rearrange the pixels. To this end, my colleague Jan-Eric Herting wrote a programme in C+, which is very easy to handle, can be run on any PC, and produces 576 new bitmap pictures that are stored in another folder. One further attractive feature of this programme is the fact that it is not restricted to processing series of 576 pictures the size of 576 x 576 pixels but is able to identify size and number of the pictures put in.

The newly calculated pictures are re-imported into Adobe Premiere, where a new film scene is generated (see fig. 6). When I viewed the first of the thus generated scenes, I noticed that what I had envisaged differed greatly from the actual result. I showed the scene to colleagues and students, with the effect that most of them started thinking about this phenomenon. Seldom did I see people start thinking so spontaneously. Many of them held their heads bent to the side a little and closed their eyes. Others developed rules, which they discarded immediately afterwards. I presented different scenes and had people speculate about what the transformation would make of them. In this context, the term "Zeitkippen" (time tilting) was created, suggested by Nicole Holzhauser.

The result

At first, there is the question whether the time-tilted scene has gestalt at all, and if so, what kind of gestalt this will be. If, in the original scene, only one pixel travels along the picture diagonal, from the top left corner to the bottom right one, in the tilted scene we will see a pixel travel diagonally from the top right corner to the bottom left corner of the picture. If the diagonally travelling pixel leaves a permanent trace, in the tilted scene a horizontal line will travel from top to bottom, constantly shortening until it ends as a point in the bottom left corner. A clock pendulum will, after transformation, perform a strange straddle, and a ball bouncing at one spot will, for a short period (depending on its diameter), appear as a sine curve.

Thus, new gestalt may emerge from gestalt. But do shapes resemble each other in the sense that a tree will still look like a tree, a running child still like a running child? Once you have worked out an idea about how the transformation of time tilting operates, you will tend to prognosticate transformation results for more complex scenes as well. With little success, though.

If, for instance, the original scene portrays a speaking person with common mimic expressions and gestures of the hands, we may ask whether the time-tilted scene,

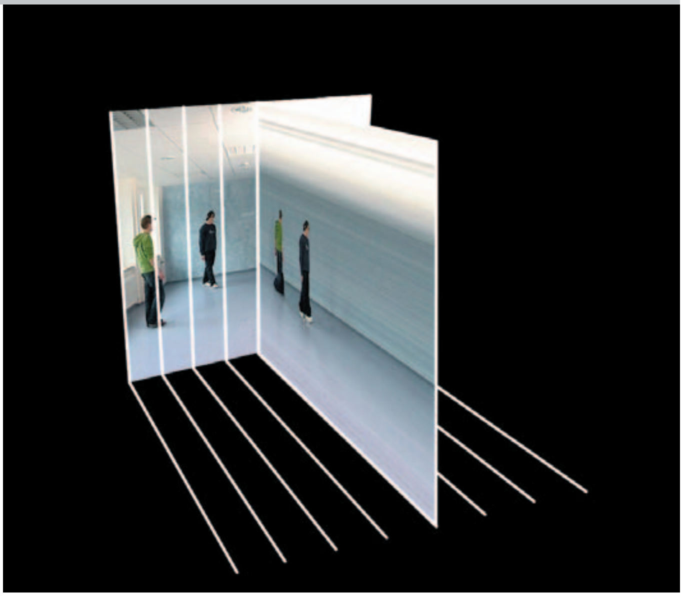

Figure 5: At first sight, it is surprising what gestalt the thus generated pictures have.

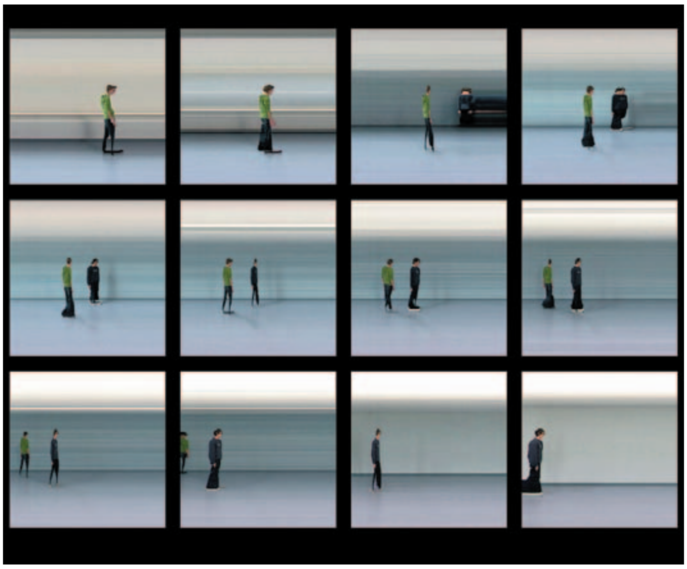

Figure 6: The sequence of pictures can be presented as moving picture. The thus generated film scene is "time-tilted" with respect to the original scene.

too, will show something human in one way or other. Or more precisely: will the person somehow be recognizable in the tilted scene? The answer is yes and no. What is at first surprising and then well explainable is the fact that the degree of recognizability strongly depends on the movement patterns of the original.

If the scene, for instance, consists of a passport photograph not moving over time, the time-tilted scene will show a pattern of horizontal stripes varying in colour and width in the course of the scene. Almost nothing will be transferred of the gestalt of the face. If parts of the picture move up and down, such as lips or a gesturing hand, the stripes will be undulated and will remind of frequency spectra as they are known from Fourier transformations in acoustics. And indeed, an upward-downward movement performed by the original person will be transformed into a sine curve. So far, at least for a viewer trained in mathematics or physics, everything is clear – or, in the jargon of these sciences, “trivial”.

If, however, the whole head is rotating or moving sidewards or if the camera pans horizontally, the face will temporarily appear within the pattern of stripes of the time-tilted scene, even though like in a distorting mirror. Since in particular recognition of face gestalt is very dominant in our perception system, the viewer will rapidly get the impression of recognizing the face, even if the apparition seems spooky and from another world. It is, however, no longer that trivial to rationally understand the observed phenomena as the result of time-tilting.

Is the whole experiment an optical play, a kind of digital succession of the hall-of-mirrors? Or will it provide insights? Could it possibly be of practical use for film analysis?

What happens to the depth of space?

In all examples discussed so far, movements were considered that essentially take place in the picture plane. According to the above given definition, a two-dimensional moving picture was interpreted as a three-dimensional still picture, from which, by choosing another axis as time axis, a new moving picture was gained.

Yet the film shots of a real scene – in the following called real shots – include a further dimension, the depth of the real space, the dimension vertical to the picture plane of the film. It is mapped, according to the optical system of the camera, as central perspective distortion. In most cases, viewers of a film are not aware of that, since they are used to interpret this distortion more or less automatically as depth, in particular if the camera moves in space. This corresponds with the natural process of seeing, in which, too, a viewed scene is reduced to a two-dimensional projection – its map on the retina of the eye – of which then, via perceptual processes in the brain, the three-dimensional picture is reconstructed.

It cannot be expected that with time-tilting the perspective mapping of depth will be preserved or that even a new impression of depth will be generated. What then, however, will happen to the information encoded by perspective?

Let us at first have a fixed camera film into an empty room, in the direction of the depth of the room. The floor, the side walls, and the ceiling will then appear as trapezium-shaped surfaces whereas the back wall will appear as a rectangle. With time tilting, they will be represented as horizontal stripes changing in their height, colour and position over time. Again, the mathematician’s comment will be: “trivial”.

Let us now have a person diagonally walk through the room, from the left front corner to the right back one. I held out awards for correct prognostications of what would be the result of time tilting of this scene – and I did not have to pay much.

The most surprising fact at first: You see the person “walk”, but strangely enough, he “walks backwards”, and his “height” changes. As for the rest, he has gestalt, and he shows movement patterns which we do not know from our real world: He appears out of nothing and disappears again. He changes his shape like an amoeba to get along. Sometimes, he appears simultaneously at two different places.

When looking at this scene, most viewers at first stop their analysing. They are too preoccupied with merely perceiving the phenomenon. Then, they usually comment on the aesthetics of the presented scene, which seems strange and familiar at the same time. Some examples resemble surrealist paintings, like Dalí’s “Ghost of Vermeer”.[6] The person’s body becomes flat and wide, then again thin as a rake, legs end in stubs, and feet are severed or overlarge. But unlike with surrealistic paintings, you somehow guess where these dreamlike appearances come from. The surreal extension into the unconscious has a real background in time.

Finally, we moved the camera. In our room, we filmed a travel (no zoom, no pan) in the line of sight. Side walls, floor, and ceiling gradually disappear from sight until only the back wall is visible. We positioned three persons in the room, who stayed at their places, while slightly moving (dangling their arms, rotating their heads). With the camera travel, they, too, disappear at the left or right side of the picture. The time-tilted scene is even more confusing than those of the examples before. The room appears as being cylindrically curved, and the camera travel appears as a pan, at first accelerating to the left and then decelerating to the right, with the moment of the change of direction remaining unclear to perception. The persons appear out of nothing, with heavy deformations, and disappear again.

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6 Salvador Dalí: The Ghost of Vermeer of Delft which can be Used as a Table. 1934. Salvador Dalí Museum, St. Petersburg, Florida, USA.

Camera Travels Through a Solid Object

The following example will illustrate that, understood as a mere transformation of coordinates in a mathematical perspective, time tilting is not too rewarding. It is of relevance only with respect to human perception of space and time.

Let us take a three-dimensional solid, non-homogeneous object, e.g. a piece of marble. We cannot directly perceive its inner structure but only its two-dimensional surface. If the surface is not even, our two-eyed vision and the resulting stereo effect will provide us with a kind of three-dimensional picture of it. This picture is, of course, far from being identical with the three-dimensional picture which the object actually represents.

If we slice the object layer by layer, we will get a series of even surfaces, which we can photograph and store as digital pictures. The entirety of these pictures then forms a three-dimensional digital picture of the object, with the thickness of the slices determining the resolution with respect to depth. Presentation of the picture series as a film will show a travel through the object and – integrated over time – its complete three-dimensional picture. It has to be admitted, though, that we get almost no spatial impression but rather an optical illusion of the form of even, continually changing shapes.

The time-tilted sequence is almost identical with the one we would have obtained by slicing the object in a plane rectangular to the former one. Inevitably, this fact has to be expressed in conditional tense, since in practice, the object will be destroyed by the picture-producing procedure. Complete identity, by the way, would be reached with infinitely high resolution of the pictures as well as infinitely thin slices. Insofar, theoretically the experiment is also rewarding in an analogue, i.e. non-digital, way.

If you frequently enough look at two such travels through a solid object perpendicular to each other, you will start to visualize the three-dimensional picture. This effect is by no means a necessarily occurring one, and even less it is a visual one like the stereo effect. Presumably, it is not evolutionarily founded in our perception, or at best in a very weak way, as it is based on perceptual inputs that can only be produced artificially.

What happens to the Implicit Information on Depth?

Let us think again of the picture information which is produced by a camera travel through a room and how this information, vice versa, inevitably evokes an idea of the room in the viewer of the film.

For reasons of simplicity, let us assume that space be mainly structured by cubes with parallel edges. Think of motives as they were preferred by the painters of the early renaissance since they allowed them to apply their newly acquired technique of perspective representation with the greatest possible exactitude – as, e.g., in Crivelli's "Annunciation"[7] –, or think of Manhattan with its street canyons laid out like a chessboard and with its cube-shaped skyscrapers.

A camera travel through such a space will yield a series of individual pictures with changing perspectives. From one picture to the next, angles will widen and narrow, edges will topple or rise, and surfaces will grow out of nothing to oversize before they disappear from the picture towards all sides. If this series of pictures is represented as a film, almost nothing of all this will still be consciously perceived. Instead, viewers will get the illusion of a ride across rectangular street crossings, past vertical edges of houses and horizontal flights of windows, just as if an eye had followed the travel of the camera through the real space – with emphasis on "one" eye, irrespective of the fact that the film is viewed with two eyes.

The effect produced by an actual travel of the camera has been well analyzed in both technical and psychological respects, and it differs fundamentally from the effect produced by a camera zoom. The information on depth implicitly stored in the individual pictures is perceptually decoded as travel into the depth of space only if the pictures are actually presented as a film, not if they are just viewed as individual pictures. If the time axis is interchanged with one of the picture axes, it is not to be expected that there will still be an impression of depth. But what will happen to this information with the operation of time tilting? Does it adopt some structural quality, or will it become just a kind of noise in the transmission of information?

With time tilting, everything (i.e. all pixels) ever to be seen at the left margin of the original scene will simultaneously appear in the first picture of the tilted scene, arranged from right to left according to their former chronological appearance. Analogously, what had been positioned at the right side will appear last. Since with a camera travel intense perspective changes occur at the margins of the picture, the time-tilted scene will show intensely structured sequences of pictures at its beginning and then at its end.

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[7] Carlo Crivelli: «The Annunciation, with St. Emidius». 1486. National Gallery, London.

At the centre of the pictures of the original scene, however, the camera produces a rather constant map of the vanishing point and its surroundings. Consequently, the "events" observable in the middle of the tilted scene will be less structured.

Knowledge versus Aesthetics

The invention of photography and film technology was driven primarily by an effort to be able to store and evaluate visual information. But in its wake, immediately artistic design aspects became important. Since those pioneer times, both aspects are pursued with equal ardour, but seldom are they linked in a productive way. The question arises whether the operation of time tilting will support either of these approaches or even both. On principle, time tilting does not change the information content of a film scene, at least not in information-technical terms of bits and bytes. With respect to perceived information, however, the extraordinary changes are striking. With some training, you will begin to understand temporary and spatial contexts. What is more: you will develop inner moving pictures that you will be able to call up in different versions from a space-time construct.

Similar experiences and abilities are evoked, for example, if you frequently enough look at two-dimensional moving pictures of a four-dimensional cube. To this end, a rotating four-dimensional cube is at first, by means of a parallel projection, mathematically reduced to three dimensions and then, by a perspective projection, mapped onto the picture plane of a film and thus visualized.

Another example of space-time visualizations of higher-dimensional processes is, e.g., the method of the Poincaré sections to represent complex dynamic systems, which is not to be discussed here in more detail.[8]

Is the operation of time tilting hence to be seen as one of those image-generating or image-transforming procedures that current sciences constantly use to visually gain or convey insights? Or is it rather a design tool which, in an artist's hand, may help to generate aesthetically attractive results? As with related issues like the one of filmic slow motion, both aspects will probably apply to some degree.

The core issue of the matter, however, is a literally deeper one and is related to our world view: Perception and cognition are, in particular, related to our visual abilities – or their restrictions and deficits. As mentioned already, we need mental auxiliary constructs, like those of stereo effects or effects of moving pictures, as well as abstract mathematical mental processes, to form a picture of the world from the merely two-dimensional retina picture of the eye. We see the three-dimensional objects of our surroundings in an only "superficial" way, and "from a front perspective". If we want to understand them completely, we have to add the time dimension, have to wander around them or scan them by pieces or slices with our eyes, ears, or hands. It is only on the basis of the sequence of many sensory inputs that we reconstruct the object in its spatial qualities.

A four-dimensional being would not have respective problems. It would be able to view the interior of stones, hearts, and even the earth without cutting them, in the same way that we are able to view the interior of two-dimensional structures.

Our picture media (understood in the sense of the above-mentioned "prints" of objects) are basically flat, in contrast to their real counterparts. Since the times of cave painting, we execute our picture ideas in a two-dimensional way, leaving it to the viewer's brain to think of more. Since the renaissance, we are capable of perspective representation that suggests a spatial impression. It is only since the 19th century that we create pairs of – still flat – pictures in the form of stereo photographs, which almost force the viewer to have spatial concepts.

And it is since the end of the 19th century that, with film, we have a media technology at our disposal which allows us, by means of very long sequences of – still flat – pictures to map time and space. In this "and", by the way, time has a noticeable double role. On the one hand, it represents itself as time. In that respect, real time and film time correspond in the movement of objects. On the other hand, time operates as an auxiliary to represent depth. In that respect, the camera moves in space, and with its movements, the perspective elements in the flat film picture change. In almost any contemporary film scene, time takes both roles. It is this space-time dynamics that made film the leading medium of our era. In how far future 3-D media techniques will strengthen or weaken this double role of time remains to be seen.

The procedure of time tilting introduced here provides at least a simple technique to make the always existing link between space and time evident to eyes and brain, in a playful and experimental way.

author: werner.grosse@iwf.de
translation: gisela weise

8 Richter, P.H., H.-J. Scholz, and Inst. Wiss. Film: Das ebene Doppelpendel – The Planar Double Pendulum. Film C1574 of the IWF, Göttingen 1985. Publication of P.H. Richter and H.-J. Scholz, Publ. Wiss. Film., Sekt. Techn. Wiss./Naturw., ser. 9, No. 7/C1574 (1986), pp. 10–11