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# **DESIGN OF LINKS IN HYPER VIDEOS**

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### ABSTRACT

Hyper videos introduce the possibilities of navigating and controlling the flow of information in a nonlinear information structure to videos as we know them from hyper texts. In this paper we are going to analyze the design of links in hyper videos by showing the possibility of representing links in and the design options in a linkage scenario. In a linkage scenario links can be presented by means of effects or as explorative links. Links by means of effects can be represented by frames, by contrast in color, by three-dimensional objects or by illumination effects. Explorative links have to be discovered by the user in a scene. Explorative links can be represented by words on objects, by signs on objects, by striking objects and by doors. A usability test has been designed to evaluate the usability of explorative links in hyper videos. We are going to present the results of this usability test in this paper.

#### **KEYWORDS**

Hyper video, design of links, explorative links

## **1. INTRODUCTION**

The main quality the computer has brought into the use of media is the interactivity. Especially texts have been influenced by this and in the age of the World Wide Web hyper texts have become an important media. A lot of research has been done to discuss the possibilities of structuring texts and the design of links in hyper texts. The interactivity has made reading texts active and the user of hyper texts is no longer only a recipient but a

participant, who controls the bits of information presented to him on the screen. Until now the interactivity has had more or less no impact on time-depending media like videos and audios in the consumer market. The only impact seems to be an interaction with a virtual correspondence of a video recorder. This is the current situation even if digital television broadcasting, hard disk video recording and the use of digital projection techniques in cinemas have brought traditional movies and computer technology close together. If we analyze the relation between cinema on the one side and the so called new media on the other side Lev Manovich identified a vector which goes from computer to cinema [1]. Beside the digitization of movies and the use of computers in the production, according to Manovich, this vector includes new forms of a computer-based cinema as the use of hypermedia interfaces for a movie as well as interactive movies or games. In the last decades there has been a slow development to integrate interactivity in videos in science and in arts. One result of this development are hyper videos. Hyper videos offer the possibilities of navigating and controlling the flow of information in a non-linear information structure to videos as we know them from hyper texts [2], [3]. In hyper videos the nodes contain video scenes or other media objects like pictures, diagrams, texts or audio clips. These nodes are combined with each other via hyper links. The user can activate a link while a scene is played or after the movie has been stopped. Following these links the user can control the plot of the movie. A hyperlink is represented by an anchor e.g. placed spatially in the actual scene or in a separate space beside the movie window. Each anchor contains a reference to another hyper node.

Hyper videos enable the audience to control the plot of a movie within given possibilities. The audience can watch a movie from different perspectives (e.g. an observing camera or a subjective camera). A crime story can be told parallel from the perspective of the detective and the one of the murderer and the audience has the possibility to switch between these perspectives at pre-defined points in the plot. Further application domains for hyper videos are e.g. educational videos, virtual tours through exhibitions or museums, travel advertisement videos and digital television channels. The experimental moviemaker Graham Weinbren says that the fundamental breakthrough the computer technology has brought into cinema is the random access to data [4]. The random access allows the sequence of images to be determined at the time of presentation, rather than fixed during the production process. This implies that the viewer can determine the sequence as it is possible in hyper videos. There are already several examples for the interactive narration with movies. As a first example for this kind of narration the movie "One Man and his Jury" was shown in 1967 in the Czechoslovakian pavilion at the World's Fair in Montreal [5]. With this movie interactivity is realized without a technical support. In case of interaction the operators have to change the movie spools manually. In 1992 Oliver Hirschbiegel picked up this thread and produced the crime story "Mörderische Entscheidung" [5] which was broadcasted simultaneously in two versions on two German television channels so that the viewers can switch their perspective of viewing by their remote control. In 1991 the Cinematrix Software was presented at SIGGRAPH electronic theater and in 1994 this software was used by Loren and Rachel Carpenter to realize interactive games played by a large audience on a big screen at the Ars Electronica Festival in Linz. One of the pioneers of interactive cinema is Grahame Weinbren, whose laser disks "Erl King" [6] and "Sonata" [7] are classics of this new genre. In continuation of these early productions there has been a continuous development around the interactive combination of movie-like sequences in movies and computer games.

To present hyper videos to an audience several technical solutions have been developed. As already mentioned the Cinematrix Software enabled interactivity in videos in 1991. In

1997 HyperCafe [8] presented a new form of presentation of multimedia documents by using temporal, spatial and associative characteristics for both text and video. HyperCafe places the user in a virtual cafe, composed primarily of digital video clips of actors involved in fictional conversations in the café. HyperCafe allows the user to follow different conversations, and offers dynamic opportunities of interaction. Another category of software that makes use of interactivity in videos are detail-on-demand videos. Girgensohn et al. [9] designed Hyper-Hitchcock, an authoring and playing interface, which allows producing multiple video summary levels of an entire video. Girgensohn et al. use the interactive video as a representation for their detail-on-demand video. Their approach generates a hyper video composed of multiple video summary levels and navigational links between these levels. Beside special player software, movie file formats like QuickTime and SMIL offer possibilities of realizing hyper videos, too. Apple's QuickTime [10] offers support for wired sprites that react to user interaction by registering mouse events. The Synchronized Multimedia Integration Language (SMIL) [11] developed by the World-Wide Web Consortium provides a standard for scripting multimedia presentations that can be used to develop interactive videos on the web.

In our approach we have realized our hyper videos as DVDs which can be played by standard DVD-players. This includes that the user doesn't have to be in front of a computer screen and to control the movie with a mouse or a keyboard. Instead we assume in our approach a typical living-room environment scenario and the interaction with the movie is realized by a standard remote control.

## 2. LINKAGE SCENARIOS IN HYPER VIDEOS

### 2.1 Representation of Links

### Presentation of links outside the video window

The easiest way to realize links in hyper videos is to present them outside the original movie window. The links can be e.g. placed at the bottom of the movie window as it is shown in figure 1. HyperCafe offers this possibility of presenting links as pictures or texts outside the movie window. Hyper-Hitchcock also makes use of this kind of presentation. In Hyper-Hitchcock this concept is extended and the links are placed on a time line. This approach allows the user to activate also links which are not shown in the actual scene but which have been shown in the short past.



Figure 1. Links represented outside the window movie

The advantage of presenting links outside the movie window is that the presentation of the movie is not disturbed by the presentation of the links. The disadvantage of this approach is that the user's attention is continuously drawn from the story presented in the movie window because he has to observe the area where the links are presented continuously. In such an approach the links must be designed conspicuously so that the viewer easily notices them. From our point of view our familiar experience of watching a movie is disturbed by the presentation of links outside the movie window. Therefore in our approach we focus on the presentation of links in the ongoing story within the movie window.

#### Temporal spatial representation of links by hot spots in hyper videos

We call the area on the screen in a hyper video, where the user can interact, a hot spot. A hot spot could be represented by framing an object with a line as shown in figure 2. Such hot spots represent the links in hyper videos [12]. Hot spots can be distinguished by effects and other design possibilities. Such effects show the user that an object is not a normal object in the scene, but an interactive one. If a link is selected e.g. by a mouse over event, the effects can be emphasized or changed to signalize the user that he has hit the link anchor. Furthermore links can be designed in such a way that they only appear as a link in case of a mouse over event. Links represented by a hot spot must be selected in a first step by an input device like a mouse or a remote control. In a second step a selected link is activated and the new node in the hyper video is shown.

The advantage of this approach is that it is easy for a user to recognize if he is in a linkage scenario. The concept is comparable to the representation of links in hyper texts. There is still one question, which hasn't been answered yet: How long must a linkage scenario be presented to the user so that he can identify it as such and reliably activate the link. It is presumably depending on the scene where the linkage scenario is embedded in. The disadvantage of this scenario is that the presentation of the hot spots disturbs the aesthetics of the scene it is embedded in.

The representation of links by hot spots is a second possibility, which Hyper Café offers. Hot spots in hyper videos can also be realized with QuickTime, SMIL and as a DVD.



Figure 2. Links represented by hot spots

#### **Representation of links by visual areas**

In hyper videos the links needn't be tied to an object which is shown in a scene as we know it from hyper texts. In a hyper text typically a word, a sentence, a button or a picture represents the anchor of a link. Beside this way of representing links, in hyper videos links can be assigned to a visual area within a scene. The different bend offs at a junction of streets could represent links as it is shown in figure 3. Each bend off could be selected by the navigation keys on the remote control. If the user wants to turn into the right bend off he presses the "right arrow"-key on the remote control and the movie control only by pressing one key. These links are difficult to be controlled by a mouse. The right arrow key selects and activates the link in one interaction step. Links represented by visual areas are used when the narration of the story shall not be interrupted by the presentation of additional frames.

The advantage of this way of representing links is that in contrast to links represented by hot spots there is no need for an extra layer and the links do not disturb the aesthetics of the ongoing movie. The disadvantage of this approach is that it is not easy to identify whether a scene is a linkage scenario or not. The representation of links by visual areas can be realized with QuickTime, SMIL and as a DVD.



Figure 3. Links represented by visual areas

#### **Explorative links**

In our approach we have extended the idea of representing links by visual areas and combined them with the idea of the hot spot approach where the links are explicitly highlighted. The results are explorative links. Objects representing an explorative link are not obviously identifiable in a scene. The links are not presented in a special layer like hot spots. They are represented as a unit within the scene. Watching the video the user has to follow the narration of the movie and he has to look for links. A mysterious chest could represent a link, which can be opened by interaction. A second example could be a door, which can be opened by the user, and the narration continues passing this door when he is interacting. Explorative links have advantages on two levels. On the one hand they do not interrupt the flow of the narration. The narration does not have to be stopped to present the linkage scenarios. On the other hand the design of the movie has to be taken into account. The movie design includes e.g. actors, properties, languages and camera perspective.

Special layers as we have seen them before would interfere with the presentation on the screen. Explorative links do not need such a special layer. Therefore explorative links should be used for hyper videos where the narration of the movie shall not be interrupted by the presentation of the links. Explorative links should be subordinate to the movie narration and the movie design.

The representation of explorative links can be realized with QuickTime, SMIL and as a DVD.

## 2.2 Design of a linkage scenario

We distinguish between two types of linkages scenarios. In a static linkage scenario the links are presented to the user during the period when the links are active at the same place on the screen. In a dynamic linkage scenario the objects which represent a link move on the screen.

#### Static linkage scenarios

In static linkage scenarios the links are represented by an object which does not move through the scene. The camera does not move in relation to the objects (tracking shot or a pan) either. Links in a static linkage scenario can be represented by a visual area in which the movie is interrupted for the presentation of the linkage scenario e.g. a bend off at a junction. Static linkage scenarios in hyper videos are comparable to the presentation of links in hyper texts. Similar to the links in hyper texts static linkage scenarios are used to present a menu structure to the user or give the user the possibility to choose deliberately how the movie shall continue.

### **Dynamic linkage scenarios**

In a dynamic linkage scenario an object which represents a link moves by itself or the object moves on the screen because the camera moves in relation to it. A bird flying through a scene can represent a link which indicates a look at the scene from a bird's eye view. Dynamic linkage scenarios do not interfere with the narration of the story because the movie does not have to be interrupted or be frozen to present the links. They integrate the possibilities of a non-linear presentation of information in a movie. Dynamic linkage scenarios give the user the possibility to explore the non-linear information structure, which is formed by the scenes of the video. The dynamic linkage scenarios can be compared with the navigation bar in a hyper text. As pointed out the dynamic linkage scenarios do not interfere with the narration of the movie. Therefore they can be used for all genres of hyper videos.

### 2.3 Composition of a linkage scenario

A linkage scenario is presented for a special period to the user. You have the possibility to choose a link and activate it. A linkage scenario can be subdivided into two phases. In the first one the linkage scenario is announced. In this phase the user's attention is drawn to the fact that he will enter a linkage scenario and he will have the possibility to control how the story shall continue. An example could be a car representing a link. In the first phase the car drives from the horizon to the foreground. In the second phase the user has the possibility to activate one of the presented links. In our example the link represented by the car can be activated if the user can identify it in detail when being in the foreground. In some cases the two phases can overlap or can be the same.

An introduction phase is important if there is a linkage scenario in which - in a first step - a series of links are presented to the user. At the end of the presentation of this series the user has the possibility to activate one of these links. An introduction phase is also important if the link itself can not easily be identified within a scene.

If the movie stops for the presentation of the linkage scenario or if the linkage scenario is realized as a loop, the linkage scenario has no predefined length, but the user can control the length of the scenario.

## 3. DESIGNING INTERACTIVITY FOR DIFFERENT GENRES OF FILMS

In the following paragraphs we are going to categorize films on the basis of the genres they belong to and analyse the requirements concerning the design of links we can derive for these genres. As genres of film we are going to consider information films, explorative films, educational films and traditional films.

## **3.1 Information films**

Information films are typically realized as presentations on TV or Internet settings. The convergence of TV and Internet and the convergence of computer systems and television systems to a multimedia information unit as e.g. Multimedia Home Platform (MHP) enable hyper video-based information films. In information films the user can get information with more details if he activates the corresponding link. One example could be soft news about each soccer player which can be activated individually on demand during a soccer game [12]. A second example could be the activated by corresponding links. During a TV report about current events the user can be offered a link where he can get background information. If he needs this background information he can interrupt the TV report and look at the background information. At the end he will come back to the original TV report.

### Design of links in information films

The presentation of links in information films must be obvious for the user so that he can identify a link easily. The best way to realize links for information films is to highlight the anchors of links by special effects so that the user can select and activate them by moving a frame on the screen. The structure of information films depends on the topic. Additional information can be realized in the form of cycles. The user bends off into a cycle when he activates the corresponding link. If the film should be interrupted to present a linkage scenario or if the links should be presented in the ongoing film depends on the general design of the film.

## **3.2 Explorative films**

In explorative films the user has the possibility of discovering objects or topics on his own. One kind of example belonging to this genre of film is a video based tourist guide. These video based tourist guides accompany the user either on a predefined walk through a city or a walk the user plans himself. At places of interest the video based tourist guide presents background information corresponding to the place the user is in. In these explorative tourist guides the interactivity of hyper videos is combined with the concept of encyclopaedias [12]. The places of interest are typically presented to the user via a subjective camera perspective so that he feels like the discovering person. With the help of links he can choose to get more information about special buildings or to get an inside view of special buildings. In a similar way trips through a museum or an exhibition can be realized as a hyper video.

### **Design of links in explorative films**

Two categories of links in explorative films can be distinguished. In the first category links represent junctions of trails or bend offs to other trails. Bend offs can be indicated by a subjective camera. The designers have to decide whether the link has to be activated on the move or if the film must stop so that the link can be activated. In the second category the links represent sights. Activating such a link the visitor will be led to a sight or the sight is on his way. If the user reaches a sight, the film should stop giving the user the possibility to make his choice whether he wants to get some background information, an animation or a look into the inside of the sight. For a detailed choice the main object should be subdivided into special regions to activate special aspects. A sensitive area represented by a door indicates a link which leads the user on a trail into the inside of the sight. The sensitive area of a bird could represent a link which indicates a look at the sight from a bird's eye view. Hypermedia-based explorative films are typically hierarchically organized or organized as a net. Digital travel guides typically have some main linear trails where the user can bend off for some detailed information.

## **3.3 Educational films**

Educational hyper videos are a new medium for learning to combine the advantages of presentations in films and the non-linear explorations in hyper media [12]. Typical educational films make use of the potentials of audio-visual representations of contents and illustrate the learning objects. Such educational films can be enriched by the integration of interactivity. Hyper videos can be used in individual learning settings and do not fit into group sessions, because it is not clear which link shall be activated. A special category of educational films are interactive instructions for use or hypermedia-based documentations.

#### **Representation of links in educational films**

In educational films navigation menus are used. They interrupt the film to give the user the possibility of choosing carefully how he wants to continue the film. An interactive instruction should be structured the way that each step of instruction is introduced to the user and the user has the possibility of skipping each step if he is already familiar with this step. In hyper videos we can distinguish between experienced and inexperienced users. For these groups of users different trails have to be presented. If a link leads to secondary information e.g. encyclopaedically information or illustrative animations or graphics these links can be represented by a subtitle or a symbol which is inserted in the film. If the user activates such a link he should have the possibility of coming back to the point where he has left his original trail without much effort.

## **3.4 Traditional films**

In traditional narrative films the hyper video concept is introduced as an innovative and experimental method of video-based story telling. The hyper video concept extends and renews traditional story telling and gives new potentials to films. The most important categories of traditional films are science fiction, action, horror, detective stories, thrillers and dramas.

### **Representation of links in traditional films**

Designing links for traditional films we must have in mind that on the one side the flow of the film and on the other side the aesthetical look and feel of the film should not be interrupted by the presentation of the links. The flow of the film includes the continuity of the story and the dynamical flow of a film we are used to. To ensure the dynamical flow of the film the film should not stop in linkage scenarios. The design of links should be subordinate to the design of the film. Therefore the links should not be represented by special effects. Special effects like highlighting or conspicuous frames introduce an additional layer into the film which artificially pushes them to the fore. For traditional films therefore explorative links are an interesting way of designing links. The different genres of traditional films give interesting possibilities for the design of explorative links. In fantasy films kobolds or magical lightening can represent links. Patterns like mirror worlds or counter points are interesting ways to structure a traditional film.

## 4. DESIGN OF LINKS

## 4.1 Representation of links by means of effects

The representation of links by means of effects is known from traditional hyper media. The transfer of this concept to hyper videos has the advantage that most of the users are familiar with this kind of link representation. The representation of links by means of effects is often realized in linkage scenarios where the links are structured as sensitive areas on the screen. Each object in a sensitive area is marked so that it is recognizable for the user. First the user

has to select a link by an input device and then in a second interaction he has to activate the link. If the user hits a sensitive area to select a link, it changes its appearance or the effect is strengthened. Some links only appear when the user hits them because they can't be made out easily. It is possible that the effect only appears because the user has hit the link by chance. In this case the user can easily miss the link. The user has to search actively on the screen for links with his input device. This representation of links should only be used for linkage scenarios where the movie stops for the interaction. Otherwise the user does not have enough time to discover the hidden links in such a scenario. In dynamic linkage scenarios the link must be identifiable on the first glimpse. That is why the scenario should be labeled by an effect during the complete period while being on the screen. If a link is selected the properties of the link object are changed a little bit to symbolize the user that he has hit the link. In a situation of a mouse over event the boundary frame of a link can be highlighted or the lid of a chest can be opened.

### **Representation of links by frames**

The easiest way to represent the links in a linkage scenario is to frame the objects which represent the links as shown in figure 4. If the objects move through the scene the corresponding frames follow these objects. If the objects change their size by a zoom in or zoom out, or a change of the perspective, the corresponding frames are adapted so that they fit to the objects.



Figure 4. Representation of links by frames

### **Representation of links by contrast in colours**

The identification of objects representing links can be realized by objects which are emphasized by a colour highlighting. The object representing a link must have a colour which is in contrast to the scene so that the user can easily identify the link. Effects which appear in case of a mouse over event can be designed in different ways; one example could be a change of the colour of the link object.



Figure 5. Representation of links by contrast in colours

### Representation of links by three-dimensional objects

Link objects can be highlighted in a movie scene by the three-dimensional presentation of artificial objects in a scene representing links. These objects must be illuminated differently from the illumination of the original scene they are integrated in. The camera perspective must be similar to the camera perspective in the original scene. If a pan or zooming effect is used in a scene so that the objects in a scene themselves are changed, the camera model for the virtual object must be synchronized with the original camera. On a mouse over these objects could give a feedback by highlighting the object.



Figure 6: Representation of links by three-dimensional objects

### **Representation of links by illumination effects**

Link objects can be highlighted in a scene by illumination effects. The object itself could shine or only the border of the object shines as shown in figure 7. If the object moves through a scene the corresponding highlighted border must also move. On a mouse over event on an object the shining of the object itself or the shining of the border is strengthened.



Figure 7. Representation of objects by illumination effects

## 4.2 Design of explorative Links – Discovering links in a scene

Explorative links are not explicitly highlighted as links as we know it from links realized by means of effects. They are part of the narration of the story. Signs or striking objects in a scene could represent such a link. The user has to search actively for links on the screen. In case that he wants to activate a link he does not have to hit a sensitive area on the screen. It is sufficient to hit a button on a remote control, a mouse button or a button on the keyboard. The selection and activation of a link done by is one interaction step. Explorative links should be used for dynamic linkage scenarios because the narration does not have to be stopped to present the linkage scenarios.

### Links represented by words on objects

In this category links are represented by words on objects in the scene. As an example the word "exit" on the wall of a car park could indicate a link to leave this car park. A second example could be the word "Dresden" on a train as shown in figure 8 moving from the left to the right in a scene representing a link. If the user activates this link, he will be taken to the city of Dresden and the movie will continue there. If the user does not interact, the scene will not change.



Figure 8. Representation of links by words on objects

Other examples of this type of link could be words painted on objects or advertisement slogans. Words on objects representing a link must be striking so that the user can easily percept them. Besides the content of the expressions should give the user a hint about the target they are pointing to so that the user already gets a hint what to expect when activating the link.

### Links represented by signs on objects

Arrows painted on the street or arrows on a street sign could represent a link as shown in figure 9. Other examples for links represented by signs could be the sign at a bus stop or the sign at an underground entrance. Arrows on the street could give the user the possibility to bend off into the direction of the arrow if the user e.g. activates the corresponding key on the remote control. The signs must be easily recognizable for the user and must be consistent with the story.



Figure 9. Links represented by signs on objects

### Links represented by striking objects

Objects which do not fit into a scene or which are unusual in the shown environment could be used to represent a link. The objects must be self-describing so that the user can easily identify that he can interact with the object. The user should not only be able to identify the possibility of interaction, but also get an idea what he can expect when activating the link. One example for a striking object representing a link could be a beggar holding a piece of paper in the focus of the camera. As the beggar does not ask for some donations, the user knows that there is a link. This scenario is shown in figure 10 where the link to the zoo is shown on the piece of paper. Although being used to beggars begging for money, the user sees at once the word "zoo" and knows that this is a link. Another example could be a striking woman wearing clothes of loud colours. If the user wants to follow her he has to activate a link. A third example could be a scene of an exhibition in a museum. The camera is panned to a board with information and focuses this board. Once again the user is expected to interact so that the information is presented to him in detail. Switches or machines which are focused by the camera can also represent links and if the user activates the link, the switch is turned on or off or the machine is activated.



Figure 10. Links represented by striking objects

### Links represented by doors

Open doors stimulate the users to enter the room behind the door. But also a closed door awakes the curiosity of the users to explore the room behind it. So if a door is focused by the camera it could again represent a link. If in a scene the hero of the story reaches a car and the camera focuses the door of the car, the user can interact and force the hero to get into the car. The same procedure is also possible for a train. If the hero observes a train and a door of the train is focused by the camera, the user again has the possibility to get on the train and travel by it.

## 5. USABILITY TEST

A usability test has been designed to evaluate the identifiability, the self-descriptiveness and the reliability of explorative links in hyper videos belonging to the category "explorative films". The basis for this usability test is the hyper video "UWE" which has been produced especially for this usability test. This hyper video contains several explorative links. In this hyper video the user accompanies the hero of the story who is called "Uwe" to several places of the city of Dresden like the main station, the zoo or the university campus. In each linkage scenario in this hyper video the user can choose between two ways of how to continue the story: On the one side the story can be continued by default, if the user does not activate any link. On the other side the user can press the "Enter" button to get an alternative sequel of the story. The hyper video starts at the main station of Dresden. Uwe walks around through the area of the station. On his way he passes different types of explorative links. At each link the user has the possibility to control Uwe to leave his tour and move to other places. The tour through the main station is a cycle. If the user does not choose any link on Uwe's way through the station Uwe comes back to the starting point of the movie and the cycle starts again. The structure of the tour around the main station is shown in figure 11.

At the main station the hero passes nine explorative links, at the zoo there are even nine links realized and on the university campus the hero passes eight linkage scenarios.



Figure 11. Structure of the hyper video UWE at the main station

In a usability lab the demonstration hyper video was shown on a computer screen. The screen output was captured and also the key events were recorded. An external camera observed the test persons. The test persons were asked to think aloud and their comments were also recorded.

The usability test was done by nine test persons. These persons belong to the group of an age between 21 and 27. The average age is 24. One person is female and eight persons are male. None of our test persons had any pre experience with hyper videos.

At the beginning of the usability test all test persons were familiarized with the concept of explorative links, e.g. they were shown the linkage scenario shown in figures 8, 9 and 10. The introductory course of the users included all types of links used in the demonstration video. But no link used in the video was shown during the introductory course.

The test persons were asked to go through the video and enter a linkage scenario if they wanted to follow a link by activating the Enter-Button on the keyboard. In case of identifying a link but not wanting to follow it they were asked to say aloud that they had identified a link.

## 5.1 Links represented by words on objects

On average 89% of the links representing words on objects have been identified as a linkage scenario by the test persons. Two of the links have been identified by all test persons. The results in detail are shown in figure 12.



Figure 12. Links represented by words on objects

The counter part of this excellent result is that 30 times additional scenes of the movie have been identified by our test persons as additional linkage scenarios belonging to the category "words on objects". Scenes which have been identified as potential additional links are shown in figure 13. Typically these scenes are used as short interludes. To reduce the error rate the designers have to be very careful when choosing potential motives during the recording of a hyper video, because they have to avoid objects in the scene which could be identified as potential links.



Figure 13. Movie scenes which have been suspected as a link belonging to the category "words on objects"

## 5.2 Links represented by signs showing arrows

All links belonging to the category "arrows in space" have been identified by our test persons. The results in detail are shown in figure 14. This result indicates that arrows in space are excellent representations for explorative links. Only one test person has identified one scene as an additional link which is not meant as a link. So again, this category of links is an excellent category to realize explorative links if there aren't any further arrows which don't represent a link.



Figure 14: Links represented by signs showing arrows

## 5.3 Links represented by striking objects

73% of all striking objects have been identified by our test persons. The results in detail are shown in figure 15.



Figure 15:. Links represented by striking objects

In 85 additional cases the test persons have suspected a link where no link is intended. Some of these scenarios are shown in figure 16. Striking objects are the links with the lowest rate of identification and the highest rate of errors in our test. The test indicates that the designing of objects representing a link must be done very carefully. The objects must be selfdescribing as a link and the expectation of the user that a special object does not fit into a scene and therefore must be a link is not easy to realize. The error rate indicates that users suspect several objects not to fit into a special scene. Again interludes have been identified as potential linkage scenario.



Figure 16. Movie scenes which have been suspected as a link belonging to the category "striking objects"

## 5.4 Links represented by doors

In this category the links have been represented by doors of trams, elevators, public buildings etc. 92% of all links have been identified by the test persons. The results in detail are shown in figure 17.



Figure 17. Links represented by doors

Only in eight cases the test users have suspected a link in a situation where no link is intended. In hyper videos where this category of link is used the designers should avoid to record doors in an emphasized way.

### Links represented by striking signs

86% of the links represented by striking signs have been identified by the test persons. The results in detail are shown in figure 18.



Figure 18. Links represented by striking signs

Striking signs are also suitable for representing explorative links. The test persons have identified every linkage scenario belonging to this category. They haven't found additional ones. Striking signs are not really often found in real life so that it is easy to identify and to distinguish scenarios where such a link is used. The high rate of identification of links and the existing low error rate indicate that this kind of representation is very suitable for explorative links.

## 6. FINAL REMARKS AND FUTURE WORK

In our usability test we demonstrated that persons who are looking for explorative links in our hyper video "Uwe" can easily identify these links. Our major problem was that on average the test persons have identified 14 links in situations where no link is represented. This error rate can be reduced if no object is shown in the movie which could be identified as a possible link. The presentation of objects representing links, the self-descriptiveness and the expectations of the user how links of a special category should be designed should be kept in mind when recording a movie with explorative links. The introductory course at the beginning of the test has been very important because the test persons need to build up a mental model of explorative links. The results shown in this paper have been produced with the help of one special hyper video. This hyper video belongs to the category "observing a person on a tour visiting special places". It will have to be shown in future tests, if these results can be transferred to other categories of hyper videos, like educational movies or narratives.

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