

Hypervideo Expression: Experiences with Hyper-Hitchcock

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ABSTRACT

Hyper-Hitchcock is a hypervideo editor enabling the direct manipulation authoring of a particular form of hypervideo called “detail-on-demand video.” This form of hypervideo allows a single link out of the currently playing video to provide more details on the content currently being presented. The editor includes a workspace to select, group, and arrange video clips into several linear sequences. Navigational links placed between the video elements are assigned labels and return behaviors appropriate to the goals of the hypervideo and the role of the destination video. Hyper-Hitchcock was used by students in a Computers and New Media class to author hypervideos on a variety of topics. The produced hypervideos provide examples of hypervideo structures and the link properties and behaviors needed to support them. Feedback from students identified additional link behaviors and features required to support new hypervideo genres. This feedback is valuable for the redesign of Hyper-Hitchcock and the design of hypervideo editors in general.

Categories and Subject Descriptors

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems – *video*. H.5.4: Hypertext/Hypermedia – *navigation, user issues*.

General Terms

Design, Experimentation, Human Factors.

Keywords

Hypervideo, Hypervideo Editing, Hypervideo Structures, Link Behaviors, Interactive Video.

1. INTRODUCTION

Hypertext systems have included media other than text since the earliest systems and exploration of hypervideo has been underway since the Aspen Movie Map [9]. Most systems, even those that emphasize the variety of media they support, use a “pages of multimedia content” model where content other than text is placed

on a page as components together with links to other pages of content. This model is embodied in the Web today and results in authors creating structures of content that mirror those of other page-based hypertext regardless of the media involved.

These structures are not indicative of the structures people would create when links are placed between nodes of media content without a page metaphor. We are interested in the characteristic structures and links of hypervideo to provide insight into how links directly between time-based content (e.g., from audio to audio, or from video to video) might result in alternative structures and generate the need for additional representational and interface functionality.

Hyper-Hitchcock was developed to explore these issues. Authors can use an interactive editor to create a form of hypervideo that is deliberately limited to a single outgoing link attached to a video passage instead of a moving anchor inside a video display. This representation simplifies authoring and viewing while still retaining sufficient expressive power to create useful and enjoyable hypervideos.

To test the expressiveness of our approach and system, we used Hyper-Hitchcock as part of a class project where teams of students created hypervideos on a variety of topics. They used camcorders to film or record up to one hour of source video and then edited the video with Hyper-Hitchcock to design and author a hypervideo on a topic of their own choosing. Their experiences with Hyper-Hitchcock and the resulting hypervideos provide insight into the strengths and weaknesses of both the hypervideo representation and the authoring interface.

The next section describes Hyper-Hitchcock, including its hypervideo representation and its authoring and viewing interfaces. After this is a description of hypervideos authored by students in a Computers and New Media class. These hypervideos are categorized based on their genre and their use of links. We then present feedback from students on their experience and discuss the roles of links in hypervideo and how the link representation and these roles impact the structure of hypervideo. We conclude with a discussion of what these hypervideos and feedback imply for further work on hypervideo representations, editors, and viewers.

2. HYPER-HITCHCOCK

The Hyper-Hitchcock system includes a representation for a particular type of hypervideo and authoring and viewing interfaces for such hypervideos. The goal of the overall design is to enable a broad community of authors to create hypervideos that present material more effectively than linear videos.

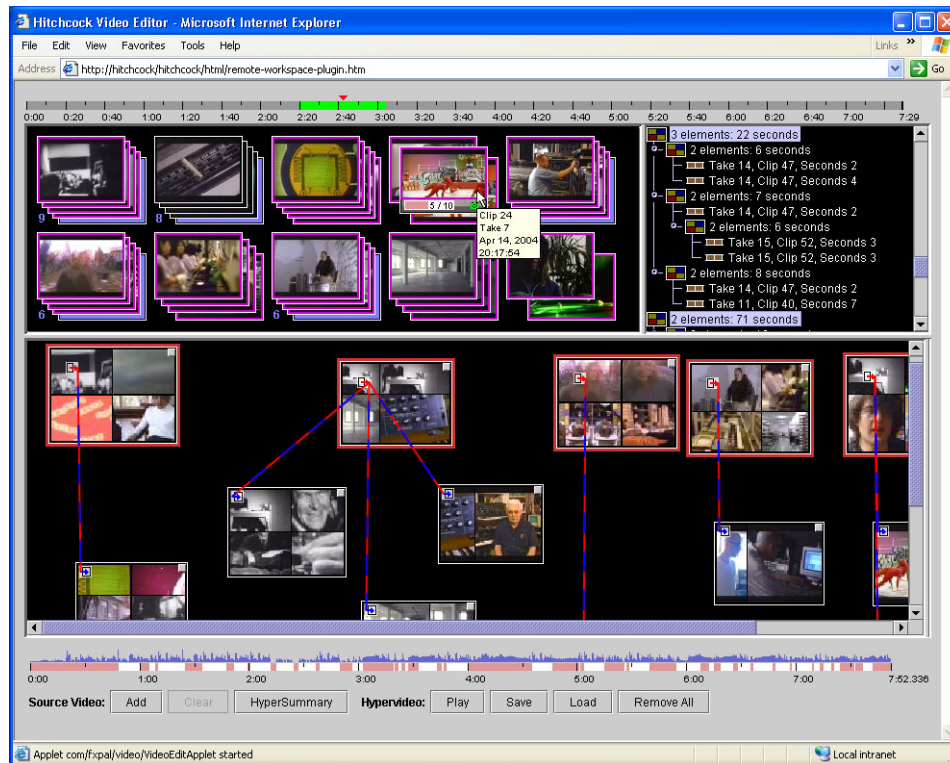


Figure 1: The Hyper-Hitchcock editor showing the segments of source video in the upper left and the authoring workspace below.

2.1 Hypervideo Representation

The representation of hypervideo chosen for Hyper-Hitchcock is a deliberately limited class of hypervideo that allows a single active link out of a video at any given time. This is in contrast with much of the research into hypervideo concerned with object tracking in video to support the availability of multiple links [3, 7, 8, 13]. This restriction is intended to make both authoring and navigating the hypervideo easier, with the eventual goal that the hypervideo could be watched on a DVD player with a remote.

We call the particular representation “detail-on-demand” video because of its applicability to informational videos where links from a given point in the video would provide more detail on the topic currently being presented. The prototypical application for this form of hypervideo is a “how-to” video where individuals can navigate to the level of detail appropriate for their current level of knowledge and task.

The hypervideo representation consists of video clips grouped together into ordered composites that represent linear video sequences. Composites can contain other composites, so that the end result is a containment hierarchy of clips and composites where each container represents a single linear video sequence.

Links can exist between any element, clip or composite, and any other element in any containment hierarchy with the restriction that each clip or composite can have at most one out-going link. If nested elements each have out-going links, the link originating from the innermost element is active during video play-back. Links can have offsets into the element specifying the start and end time of the source anchor. Links also include a text label and separate

return behaviors (e.g., return to the point when the link was taken or to the end of the link’s source anchor) for when the viewer watches the destination of the link to its completion or aborts playback (e.g., by hitting the equivalent of a back button). For more information on this representation see [12].

2.2 Authoring Interface

Most available examples of hypervideo are authored in scripting languages such as Macromedia Flash. With the exception of MediaLoom [14], which allows users to create links between existing video files but does not support video composition, there has been little interest in making hypervideo authoring easy.

The Hyper-Hitchcock authoring interface allows the rapid construction of hierarchies of video clips via direct manipulation in a two-dimensional workspace rather than requiring scripting languages or other complicated tools that are unsuitable for a broad user base. Authors pull clips of video from the selection pane in the upper-left corner of Figure 1 into the workspace at the bottom. There, the length of the segment of clip to be included in the edited video may be changed by resizing the image of the clip. The audio energy of the selected video clips is visualized above the timeline at the bottom of the workspace. For a selected video clip, the in/out points can be adjusted easily in the timeline such that they line up with a long enough silence for a sentence boundary. Clips grouped into video composites are visualized as collages of up to four keyframes for clips included in the composite.

Navigational links can be created between any two elements in the workspace. Once created, links are visualized as colored arrows between clips or composites. Line placement provides information



Figure 2: The Hyper-Hitchcock player provides labels and keyframes for links in the currently playing linear video with the timeline and a list on the left of the source anchors of the links taken by the viewer.

about whether the link is into or out of an element in the workspace and the location and color of the link indicate if the link is connected to the whole element in the workspace or one of its components. [11] presents a more detailed description of the Hyper-Hitchcock authoring interface.

Novel aspects of the hypervideo editor include the ability to author hypervideo without programming and features that balance the automation possible via signal processing with author control over the final product. Hyper-Hitchcock includes methods for the automatic segmentation of source videos into video clips likely to be of value and automatic selection of in-out points in source video clips based on video quality as the user resizes the clips. These methods were originally developed for authoring linear video in Hitchcock [5]. Hyper-Hitchcock adds the ability to generate an initial hypervideo summary of a linear video based on these methods. For more information on automatic hypervideo summaries see [12].

2.3 Viewing Interface

We have created a series of viewing interfaces for Hyper-Hitchcock [6]. These interfaces vary in their complexity and the requirements they place on the player. The most recent, shown in Figure 2, is the result of a series of user studies.

We found that visualizing links in the timeline without labels or keyframes was confusing to users. However, putting link labels inside the timeline caused confusion between the actions of link following and skipping within the current video sequence. To address these issues, we decided to place keyframes for all links along the timeline and to make all links available via keyframes and not just the link attached to the currently playing video segment. Users can follow the links by clicking on link keyframes or labels without having to wait for or move the video playback to be in the appropriate place. The keyframes for the links currently inactive are reduced in size with faded link labels. The area of the

active link, defined to be the innermost source anchor currently playing, is emphasized in the timeline and separators between links in the timeline are made stronger. The keyframe for the link under the mouse is also enlarged and the link is emphasized even more than the active link to indicate that mouse clicks will select it.

We display a stack of keyframes representing traversal history in the top-left of the player window. We scale down the keyframes for the older jump-off points to enhance the history view. All keyframes are clickable, thus enabling the user to backtrack through several links at once.

3. HYPERVIDEOS

Graduate students in a Computers and New Media class used Hyper-Hitchcock as part of one and two-person projects to design and author a hypervideo on a topic of their own choosing. Their experiences with Hyper-Hitchcock and the resulting hypervideos provide insight into the strengths and weaknesses of both the hypervideo representation and the authoring interface.

3.1 Setup

Nine hypervideos were authored by sixteen students. Filming and authoring tasks were shared by the students on two-person teams. They used miniDV camcorders to film or record up to one hour of source video, which was then transferred to the Hyper-Hitchcock server. All but one group decided to shoot their own video rather than recording video from an existing source. Once on the server, preprocessing was performed to automatically compute the goodness value of their video and segment the video into clips. Students then loaded the processed video into the Hyper-Hitchcock authoring tool to construct their hypervideo.

Data concerning the use of Hyper-Hitchcock was collected via versioned hypervideo files showing the authoring process, log files indicating used and unused interface functionality, and anonymous

surveys of the students concerning their satisfaction, suggestions, and experience more generally.

An unfortunate hardware problem with the cameras and cables postponed transfer of the collected video to the server, resulting in most teams having about one week to author their hypervideo.

3.2 The Hypervideos

The nine hypervideos authored can be placed into four categories: documentaries, how-to hypervideos, home hypervideos, and music hypervideos. These categories are based on the topic of the hypervideo but are mostly independent of the overall structure of the hypervideo and its use of links. As it is not possible to provide access to the hypervideos, each of the projects is described briefly to give a sense for similarities and differences.

Documentaries

There were four hypervideo documentaries created. Three are related to geographic or spatial exploration, one representing a drive down a major avenue, one providing scenes of and around bridges, and the third describing buildings on Texas A&M University (TAMU) campus. The fourth documentary is an overview of an international dance festival.

Of the three hypervideos allowing virtual trips to geographically distributed areas, the trip down University Drive in College Station, Texas includes the most literal mapping from geographic structure to hypervideo structure. This hypervideo's main spine shows a car turning onto University Drive and what you would see driving down this street. Major establishments along the road are brought into the camera's view for a period of time and these shots are used as anchors for navigating to video of visiting that establishment. The video of the establishments contained links for greater detail, with the deepest structure including an interview with the manager of an art gallery.

The bridges of Texas hypervideo includes scenes from the bridges between College Station and Austin, Texas. The main spine of the hypervideo shows a view of the top of each bridge which acts as an anchor to alternative videos of or around that bridge. Links take the viewer to video of the underside of the bridge, to wildlife near the bridge and to the landscape near the bridge. Wildlife shots give a sense of the flora and fauna found around the bridge while the views of the underside show aspects of the bridges' construction and what is stored beneath it.

The third geographic hypervideo presents "in danger" buildings at TAMU. These are buildings identified for demolition on the long-term development plan for the campus. The main video provides a series of shots of the outside of each of these buildings to show their architecture and to give a bit of their history. These external shots act as anchors to video of the interior of these buildings. Further links are used to provide choices while navigating within a building.

The last of the documentaries presents an international dance festival. The main spine of this hypervideo provides scenes from different dance performances at the festival. These scenes act as anchors to additional scenes by the same group of dancers and to similar or related performances by other performers. Unique among the documentary hypervideos, this hypervideo includes links from the most detailed video in one section of the hypervideo to the somewhat detailed contents of the next portion of the hypervideo. A portion of this structure is shown in Figure 3. This

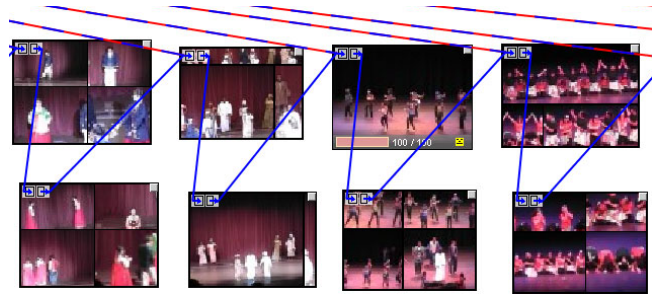


Figure 3: Links that jump to the next topic of the hypervideo.

allows viewers to easily jump forward to the next portion of the dance festival. The same behavior could have been achieved by making the middle level of the hypervideo a single composite and by specifying a link return behavior of returning to the end of the anchor. The hypervideo authors might not have been aware of that possibility or might have considered the explicit link with a keyframe as a more intuitive alternative.

Instructional or How-to Hypervideos

The three instructional or how-to hypervideos make up the second common genre of hypervideo created by the students. These include hypervideos showing how to play a video game, how to get ready for a visit by the in-laws, and how to make a sandwich.

The most straight-forward structure of these is for the video equivalent of a common how-to document found on the web — the computer game walkthrough. The main spine in this hypervideo showed the game, *Need for Speed*, being played by a player. The player of this game makes choices on which race course to drive and which route to take through the race course. At each branch point, the player in the hypervideo stops the car for a few seconds, after which the car continues along the main path through the race course. The video of the car slowing down and idling is used as anchor points for links to video showing the car proceeding down the alternative route. Thus, the hypervideo allows the viewer to select the route for the car, as they would were they playing the game, without having to control the car by steering, accelerating and decelerating.

The second how-to hypervideo shows a man getting his house ready for a visit by the in-laws. The main stream of this hypervideo concerns activities in cleaning the house and making dinner. Links in this hypervideo are used to provide greater detail into the current activity, such as how to prepare the ingredients when making homemade bean soup, and to alternative activities, such as putting away objects cluttering the living room. This results in the tree structure shown in Figure 4. Unique for this hypervideo is the constant audio commentary of the main character. This audio content requires link in and out points to coincide with sentence boundaries in the commentary.

The third how-to hypervideo is a humorous description of how to make a sandwich. The viewer of this video watches the preparation of a sandwich, the selection of side dishes, and the resulting meal's consumption. Links in this hypervideo are mostly used to present alternatives, with a few presenting details. Links take the viewer to the grocery store where additional links allow the selection of sandwich components (e.g. white, wheat or rye bread), and the type of chips and soda to go with the sandwich. Further links

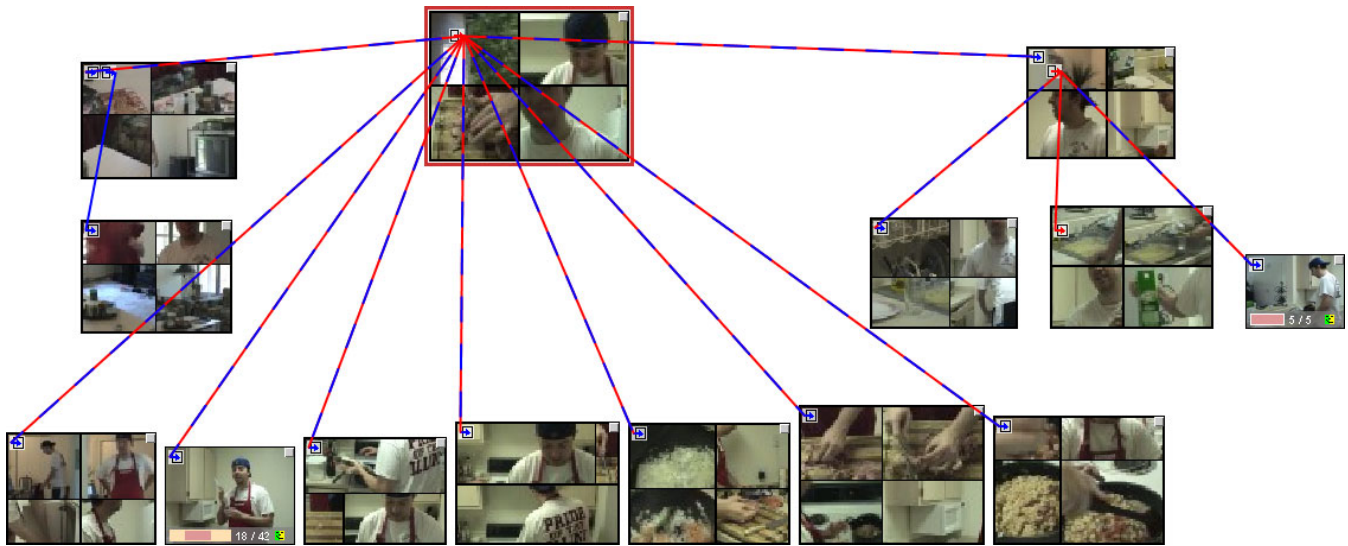


Figure 4: The tree structure of this hypervideo is representative of many of the documentary and instructional hypervideos.

provide alternatives for with whom to eat the sandwich. There are also links presenting reference materials, such as how commercially-baked bread is made.

Home Hypervideos

One video that does not fit into either the documentary or instructional genres has home video of a family as its source material. The material included scenes from normal activities and a trip to a rodeo. The links in this hypervideo take the viewer to other scenes of the family.

The structure of this hypervideo is highly idiosyncratic. Some of the links show additional content related via a theme, such as the activities at the rodeo, but other links leave the viewer wondering how the source and destination material are related and why the link exists. The resulting hypervideo makes sense to the members of the family but not to the casual viewer.

Music Hypervideos

The final hypervideo is unique in that it takes existing public domain video from four documentaries and recomposes their content into a music hypervideo about recombination. The main spine of this hypervideo was authored in a linear video editing package to allow for the layering of remixed audio over the video content. Links within this main spine take the viewer to additional material relating to recombination. This example shows the conflicting desires for author and viewer control. The author created cuts between the content of the four original documentaries to invoke a reaction in the viewer. While the links provide viewers with the ability to see additional content, they break up the experience of the highly-crafted primary stream of video.

3.3 Feedback on Hyper-Hitchcock

At the end of the hypervideo authoring activity, students were provided with anonymous questionnaires asking about their experience. Return of the questionnaires was voluntary and seven of the 16 students filled out and returned the form.

The first part of the questionnaire consisted of fifteen questions evaluating the hypervideo representation, the editing and viewing

tools, and their subcomponents. A seven-point Likert scale was used with 1 being “strongly disagree” and 7 being “strongly agree”. Table 1 shows the summaries of the responses.

It is the tendency of respondents to provide positive feedback to system evaluators. For this reason, the overall responses are discussed by comparing the results between questions. The average rating for the 15 7-point Likert-scale questions was 5.1.

The averages of questions 2, 3, 7, and 15 were substantially more positive than average. The first three of these questions concern the usability of the hypervideo player, the video clips, and the interface for creating composites. Question 15 concerned whether the simple spatial parser correctly interpreted the desired order of playback of clips.

The average to question 10, concerning the value of link labels, was 5.5 and so somewhat higher than average. This result was likely influenced by whether the hypervideo authors decided to attach link labels to links in their hypervideos. Five of the nine hypervideos used link labels and four did not.

Questions 5 and 12 were substantially more negative than average and had relatively low standard deviations. Clearly, the students were not impressed with how the automatic segmentation of their video into clips and the automatic selection of in/out points aided their task.

Questions 7, 8, 13, and 14 were somewhat lower than average and had high standard deviations. The first two concerned ease of manipulating composites and creating links. Both of these interfaces were also mentioned by at least one respondent in the open ended portion of the questionnaire as having usability problems. Question 13 concerned the value of the audio energy graph. This feature was considered very valuable by some and of little value for others depending on whether their video content had human speech in its audio component. In general, subjects needing to identify sentence boundaries found it useful while others did not. Question 14 concerned the playback of the currently selected clips — while the ordering of the selected clips by the spatial

Table 1. Results from Likert-scale portion of questionnaire.

	Statement	Mean	Standard Deviation
1	The Hyper-Hitchcock editor was easy to use.	5.14	1.07
2	The Hyper-Hitchcock player was easy to use.	6.29	0.95
3	Video clips were easy to use during editing.	6.43	0.53
4	Grouping of clips in selection area made sense.	5.14	2.04
5	Automatic segmentation provided useful clips	4.14	1.77
6	Composites were easy to create.	6.00	1.41
7	Composites were easy to manipulate.	4.57	1.81
8	Links were easy to create.	4.57	1.99
9	Link return behaviors were useful.	5.00	1.63
10	Link labels were useful.	5.57	1.27
11	Manipulating in/out points on clips was easy.	4.86	1.68
12	Automatic selection of in/out points was useful.	3.71	0.95
13	The audio energy graph for clips was useful.	4.57	2.23
14	Playback of selected clips was intuitive.	4.29	2.29
15	Playback of selected clips occurred in correct order.	6.00	1.00

parser was correct (question 15) the interface for asking a set of clips to play was not intuitive.

The second portion of the questionnaire consisted of five questions to gather comments related to the subject’s experience with the system and their activity. The first two questions asked about the system. The first asked users to describe system “bugs” they experienced and the second asked for three features that should be added to Hyper-Hitchcock. There was also an “other comments” question that subjects used to provide more suggestions for features and usability issues. Most of the bugs reported related to system stability and low-level interface design. One bug identified, namely that return behaviors were being overwritten for some video clips, affected the structure of the resulting hypervideos.

One subject commented that the authoring of the two separate structures — the composition of video clips into linear videos, and the creation of links between segments of these linear videos — was not clear. This comment was confirmed by a large number of questions during the performance of the activity. Hyper-Hitchcock uses navigational hypertext authoring techniques for the link structure and spatial hypertext authoring techniques for the compositional structure [11]. While this keeps the expression of the two structures independent, many people need more explicit explanations as to how these two different structures interact. Another comment on the questionnaire indicating a difficulty with understanding the structure of the hypervideo said that the visualization indicating links from/to components of a video composite was unclear.

Features suggested by users that concerned hypervideo capabilities included the ability to have more than one link available at a time (3 of 7) and the ability to specify that the video should stop playing at branch points to force the viewer to interact with the playing

hypervideo (1 of 7). Another set of suggested features concerned editing the linear videos that made up the hypervideo: the ability to edit the audio separate from the video (3 of 7), and the ability to add text overlays and fading and other effects (1 of 7). The other features suggested were not related to the hypervideo representation or video expression but ease of use and distribution (e.g., for the editor to work with more video formats, to enhance save and load functions, and to put the tool on the Web).

The fourth question attempted to get at what students saw as the aspect of their hypervideo that needed the most work by asking what they would do if they had two more weeks to work on their hypervideo. Three wanted to shoot more video to add to the content of the hypervideo, three wanted to do more on editing the linear video components, and one wanted to fix transitions and return behaviors for the links in the hypervideo.

The final question asked what uses they had use hypervideo. Answers included educational videos (x3), more interesting home videos (x3), narratives with multiple perspectives (x1), and hypervideos published online for gaming communities (x1). These partially overlapped hypervideo applications found in the research literature: educational environments [4], news summaries [2], and narrative storytelling [10].

The students were successful at authoring a variety of hypervideos that provide examples of use. Most of the hypervideos were either documentaries or instructional content. This was influenced by the students having read prior papers on Hyper-Hitchcock describing its use to author detail-on-demand videos. The use of hypervideo for home video and music video pointed out additional opportunities as well as issues with such uses. The next sections discuss the roles of links and the common structures in hypervideo.

4. ROLES OF HYPERVIDEO LINKS

Links in hypervideo serve many of the same purposes they serve in hypertext. They provide opportunities for accessing details, prerequisite knowledge, and alternate views for the current topic. Unlike hypertext, the effectiveness of the hypervideo link is affected by link return behaviors, or what happens after the destination video has been watched or its playback aborted. The students did not make as much use of return behaviors in their hypervideos as was expected, often retaining the default “return to navigation point” for both completed and aborted playback of the destination. Discussions with students indicated that this was in part due to the bug causing return behaviors to be lost but was also impacted by the students not knowing how to use return behaviors to achieve their goals.

Understanding the roles of links and their likely return behaviors can aid us in providing better authoring support in the future. The following discusses five roles for links that are found in the hypervideos authored by the students. These roles are not meant to be exhaustive or completely independent.

4.1 Detail Links

In detail-on-demand hypervideo, links generally form a tree or directed acyclic graph that takes viewers from a higher-level discussion of a topic to a more detailed presentation on the same topic. This structure matches with the original intentions for Hyper-Hitchcock to support instruction and training.

Detail links have destination anchors presenting longer descriptions of the content found in the link’s source anchor. In such a case, the most likely return behaviors are returning to the end of the source anchor if the viewer watches the whole detailed description as this avoids duplicate presentations of the same material. If the viewer aborts playback, use of the return behavior for restarting playback at the point of navigation is appropriate.

There are numerous examples of detail links in the students’ hypervideos. When travelling down University Avenue or visiting TAMU buildings scheduled for destruction in the documentary hypertexts, the detail links provide opportunities to get more information about the locations being shown. Similarly, detail links describing food preparation are provided in the how to get ready for the in-laws and how to prepare a sandwich hypervideos.

4.2 Prerequisite Links

Similar to detail links, prerequisite links are likely to form a tree or acyclic graph. Prerequisite links take the viewer to content that should be understood prior to watching the content in source video. As the content of the destination is meant to enhance comprehension of the content in the source video, a user who watches the content of the destination to completion may want to return to the beginning of the source anchor so as to better understand the content based on the prerequisite knowledge.

There are a few instances of prerequisite links in the student hypervideos. One example is a link to a video segment showing how to cut an onion during a description of how to make bean soup. Another example is a link to a segment on how to use the hypervideo player early in the international dance documentary.

4.3 Related Information Links

Related information links point to video segments that are not part of the main hypervideo and where the content is neither a more



Figure 6: Parallel structures for the bridges hypervideo show the construction of the bridge (top), nature surrounding the bridge (middle), and the nearby landscape (bottom).

detailed presentation of content in the source video nor a of prerequisite knowledge. They are similar to sidebars in written publications. An example from the student hypervideos is a link in the how to make a sandwich hypervideo to video on how companies make bread. This is neither a link to more detailed information about making a sandwich nor information necessary for making a sandwich. The impact of the alternative role of the link is that the reasoning behind returning to the end of the source anchor for detail links and for returning to the beginning of the source anchor for prerequisite links are not valid. Thus, this type of link would likely default to returning to the point of departure.

4.4 Alternate View Links

Another role of links is to provide an alternate perspective on the current topic. This use of links is found on DVDs that allow choosing a camera angle, perspective, or alternate audio track. Since the content is duplicated in the source anchor and destination anchor, the desired link return behavior is likely to return to the end of the source anchor if the viewer watches the whole destination anchor and to switch back to the primary view at the current playback time for aborted links. The closest example to alternate view links from the student hypervideos are the links between the content for the bridges between College Station and Austin. Figure 6 shows part of this mirrored structure for each bridge. The video segments provide alternate topics for each of the bridges (construction, wildlife, and terrain). As these do not duplicate content in the source video they may be better categorized as links to related information where the resulting structure is regular.

4.5 Action Choice Links

The final role of links found in the student hypervideos are those that let viewers make choices on action in the video. For example, the game walkthrough hypervideo allows the viewer to choose the race course and the path of the car through the race course. A similar use of links exists for selecting sandwich ingredients in the how to build a sandwich hypervideo. Given the choice results in



Figure 5: The structure of a home hypervideo shows a wide variety of paths through the material.

alternative action, the return behavior for a completed destination defaults to return to the end of the source anchor although this assumes that the next segment source video makes sense after the choice of the link. In the case of the game walkthrough, where the alternate routes through the race course merged, this was true. For picking the sandwich ingredients, this was not true. In such a case, the hypervideo author has to shoot video consistent with all possible user choices and if the choice points do not allow for re-merging the lines of video, the appropriate return behavior is to not return at all but just stop at the end of playback of the link destination.

5. HYPERVIDEO STRUCTURE

As with hypertexts, common structures for particular forms of expression appear in hypervideo. The patterns of hypertext found by Bernstein [1] are likely to have similar structures for hypervideo. The difference is that readers in a hypertext may or may not be expected to return to the source of a link after having read all the material in the destination of the link. The above roles of links in hypervideo and their expected return behaviors impact hypervideo structure. These effects are explored in the variations of Bernstein's sieve, mirrorworld, counterpoint, split/join, and tangle patterns found in the student hypervideos.

Detail links form sieves as a more general video of a larger activity or topic is successively broken down into videos showing subactivities and subtopics. Prerequisite links also result in sieves when the main topic of the hypervideo is based on many more basic concepts. While most hypervideos are on a single top-level theme, a hypervideo tutorial on a topic such as math may form an inverse sieve since many different advanced activities or topics require understanding of the same prerequisite knowledge. Sieves are common for the documentary and instructional hypervideos authored. Figures 1 and 4 shows examples of pure sieves and the

hypervideo in Figure 3 has an overall sieve structures but includes links connecting the detailed content in hypervideo outline.

Related information links are the least constrained and thus tend to be the most idiosyncratic. They can be used to create tangles that indicate the authors belief in relationships between the various pieces of content. Such links may not provide the viewer with much of an expectation as to the outcome of taking the link. Indeed, the relationship may still be unclear after following the link as is the case for many of the links in the home hypervideo shown in Figure 5.

Where hypervideo structures created in Hyper-Hitchcock differ from Bernstein's hypertext structures is for split/join structures. This difference can best be seen with action choice links. Action choice links create sieve structures or split/join structures in hypertext depending on whether both options in the choice are consistent with the same follow-on content. In the case where the content is not consistent the structure becomes a sieve as early choices result in changes to the later content. This is true for both hypertext and hypervideo. When further content is consistent for both of the available choices, the structure will rejoin in hypertext, creating a split/join or mirrorworld structure. Such rejoining is expressed via return behaviors in Hyper-Hitchcock. Selecting the return to end of source anchor behavior causes the two separate paths to rejoin while selecting do not return keeps the paths from merging. Thus the structure still looks like a sieve, as seen in the game walkthrough structure shown in Figure 7.

Alternate view links are likely to generate mirrorworld or counterpoint structures. Whether used to present content from different camera positions or different characters' perspectives, the content (in terms of both video and links) of the different views need mirroring to preserve the effect of choosing the alternate view. Crosslinks between the alternate views allow for rapid point/counterpoint access. The bridges of Texas hypervideo starts



Figure 7: Structure of game walkthrough shows three choices for which race course to take and two to four decision points within each of these three race courses.

to provide such a structure but was made difficult by the limit of one active link at any given time in the detail-on-demand hypervideo representation. The student chose to use the links to create parallel structures for each bridge. Another potential structure would have been to connect the construction-oriented segments, the wildlife segments and the landscape segments to provide paths parallel to the main video stream showing the tops of the bridges.

6. DISCUSSION

Digital video libraries are becoming more common with the falling costs associated with shooting, recording, and storing digital video. The desire for the ability to author interactive presentations of this content is growing although most current authoring tools either limit the representation to the menu structure found on common DVDs or require programming in a scripting language.

Hyper-Hitchcock provides a direct-manipulation authoring environment that falls between the ease of use and limited expression of DVD authoring tools and the increased expressiveness and need for programming expertise of scripting environments such as Macromedia's Flash. The detail-on-demand video representation limits the author to having one link available at a time. This was found limiting by a number of the students that used Hyper-Hitchcock and was partly the reason why almost all of the resulting hypervideos took the form of sieve structures.

The flexibility of link return behaviors in Hyper-Hitchcock was another cause of the resulting sieve structures. As the source video defaults to continuing playback after the viewer has watched the destination anchor video, links enabling the joining of separated views or paths are not required. The majority of the links that crossed between tree-like portions of the sieve structure jumped directly to a detailed view of the next section of content. This indicates that a link behavior that could accomplish this, or the ability to specify "fast forward" links in addition to the existing navigation links might be helpful.

Adding representational expressiveness is likely to generate additional confusion regarding authoring. The students had some problem understanding the difference between the hierarchic

structure created by grouping video clips into linear videos and the navigational structure of links between components of these linear videos. Several of the students found the interaction between the temporal structure of the video segment hierarchy and the effects of the navigational structure of links and their return behaviors confusing.

The analysis of link use in the hypervideos resulted in five roles for links being identified. These roles are not comprehensive or completely independent but do provide insight into the use of links and the logical defaults for return behaviors in these uses. Further enhancements to the detail-on-demand video representation and Hyper-Hitchcock that supported such defaults could both ease the authoring process, reduce confusion between the temporal and navigational structures, and improve resulting hypervideos.

Beyond the relatively small hypervideos described here, support for authoring larger hypervideos may be supported by providing explicit support for common hypervideo structures. Larger and longer-term evaluations are needed to determine how common hypervideo structures relate to common hypertext structures and how hypervideo structures may be determined by or help determine the roles of links within these structures.

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