RETRIEVAL INTERFACES FOR SUPPORTING EXPLORATORY SEARCHES

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ABSTRACT

Many search engines do not effectively support searches with imprecise or open information needs, such as in the case for exploratory video searches. The information seeker's lack of domain knowledge in exploratory searches convolutes the search process. Search interfaces are generally developed to support high-level search activities like query formulation. The purpose of this study is to gather ideas and opinions from experts from different fields to develop design concepts and interface features for exploratory video search interfaces. The findings suggest that visual maps can be used to present the structure of the domain of interest and to support exploration of the concept of interest. These maps also support knowledge construction and hence aid in the extension of concepts in the search.

KEYWORDS

Exploratory Video Search, Visual Maps, Query Formulation, Knowledge Construction

1. INTRODUCTION

Online information search has become an integral Internet activity. Search activities are broadly classified into lookup and exploratory (Marchionini, 2006). Lookup searches are basic and often return specific and precise objects or resources. Internet search engines have increasingly become more robust and adequately support most searches when information needs are clear and well defined. Through these search engines, information seekers typically issue a query through an interface and search engine returns a set of potentially relevant resources, adopting the query-response paradigm for lookup searches (Ryen W. White & Roth, 2009). Internet search engines cater well to this paradigm, affording effective lookup searches.

Exploratory search is multifaceted as it can get intertwined with other search activities as well as multiple information seeking tasks simultaneously (Ryen W. White & Roth, 2009). Exploratory searches are hence complex and begin with imprecise or open information needs that may become clearer over time (Kim, 2009). Researchers attempt to operationalize exploratory search tasks using two facets: search goal, and complexity (Athukorala, Głowacka, Jacucci, Oulasvirta, & Vreeken, 2016). Exploratory search tasks have vague and open-ended search goal with multiple search paths. During the start of an exploratory search, the information seeker usually lacks the domain knowledge and contextual awareness to formulate adequate queries. When presented with the search results, the information seeker of the complex search problem can be overwhelmed by the selection of resources. Based on the query-responses paradigm, information seekers inability to form adequate queries can lead to an overload of search results that convolutes the search process. The *de facto* standard for Internet search engines - simple keyword or natural language input facility does not adequately support exploratory search. Marchionini (2006) suggested that learning and investigative activities are pertinent in exploratory searches and lookup search can be embedded in exploratory search. This makes exploratory search more complex and cognitively loaded as compared to lookup search. Beyond query specification and results selection, exploratory search tasks require more synergy and interaction between the information seeker and the search system as they learn and improve their knowledge on the domain of interest. Researchers from diverse communities such as information retrieval, user interface design, computer science and library science, are working to improve and evaluate exploratory searches effectiveness. Studies that extend the information seeker's knowledge on the domain of interest during exploratory search are promising (Marie, Gandon, Giboin, & Palagi, 2014; Musetti et al., 2012). The

extension of the domain knowledge helps reduce the uncertainty faced by exploratory searchers. The use of visual tools offer the potential to support learning and exploration of the domain of interest.

Videos are heavily used to support learning. The use of multimedia and videos in classrooms change teaching practices (Ottenbreit-Leftwich et al., 2012) and encourage learners to seek videos to support their informal learning (Tan, 2013). The video is useful in supporting learning where a video strengthens learning effectiveness through interactivity (Zhang, Zhou, Briggs, & Nunamaker, 2006). Public available video platforms, such as YouTube, are accepted as part of learner's personal learning environment (Dabbagh & Kitsantas, 2012). While the use of the Internet to seek resources is prevalent, exploratory searches remain challenging for information seekers as they used more trial and error strategies to acquire the resources (Ng, 2012). The advent of user-generated content and the lack of gatekeepers for much of such content compounded the challenge in finding adequate resources to support learning. Learners are often lost in the convoluted exploratory video search due to insufficient support during query formulation (Papadakis, Armenatzoglou, Kopidaki, & Tzitzikas, 2012). Much of the work on exploratory search were done on textual resources. While video retrieval has undoubtedly benefited from these work, the distinctive characteristics of video demand for some work to adapt the findings and ensure applicability. Some work on the exploratory search can be extended from textual resources to video resources. The traditional retrieval interfaces such as keyword and natural language search are ineffective for exploratory search due to uncertainty in expressing the information need and lack of knowledge of the domain.

This paper describes part of a doctoral study that explored the development of video retrieval interfaces and features that support exploratory video searches for learning. Interviews were conducted with academics and industry experts from various fields such as learning and pedagogy, multimedia and information retrieval, learning design, and content development. This study addresses the following research questions:

RQ1: What interface features can support exploratory searches by reducing the uncertainty of searchers during query formulation?

RQ2: What interface features can support the exploration and navigation of the domain of interest?

2. RELATED LITERATURE

People conduct searches to narrow and plug information gaps. Lookup search includes tasks such as fact-finding and searching for known-item. Such searches use specific queries that yield precise results. Using the lookup search model, information search behavior models were developed to promote the understanding of information retrieval. Many of the database management systems and commercial Web search engines used these models to develop their interaction interface and features (Ryen W. White & Roth, 2009). Driven by information retrieval metrics such as precision and recall, these retrieval systems provide perfect results with a well-specified query as in a lookup search. For more complex search tasks, formulating well-specified queries to a level for the retrieval system to handle effectively is challenging (Aula, Khan, & Guan, 2010).

An exploratory search occurs in an information-seeking context that is open-ended with multiple possible aspects. The information seekers in an exploratory search may lack the domain knowledge or contextual awareness to formulate adequate queries with keywords search facility or even navigate through the information space (Ryen W White, Kules, & Drucker, 2006). This results in a complex information seeking process that becomes increasingly challenging as exploratory search involves learning and investigation (Marchionini, 2006) as opposed to searching for known-items. In an exploratory search, the information seeker has a complex search situation and starts with a poor understanding of the domain of interest and information space. Exploratory search often combines several strategies to stimulate learning and investigation to reduce uncertainty (Ryen W. White & Roth, 2009). The information seekers submit a tentative query to navigate the results and explore the information space. As the exploration proceeds, the problem context becomes clearer. This was suggestive of a strong interaction between the search process and problem context when reducing uncertainty.

Interface and features support the interaction between information seeker and retrieval systems. Interface and features make exploratory search more effective by affording a broader range of functionality to aid learning and investigation. Input interface features allow the information needs or intent to be presented to

the retrieval system. It is an important interface in the exploratory search for information seekers to overcome the difficulties in specifying the needs and identify the directions for the search (Ruotsalo et al., 2013).

An empirical study showed that information seekers performing exploratory search tasks using a faceted catalog spent more time looking at facets than looking at the query (Kules, Capra, Banta, & Sierra, 2009). Faceted search and categorized overviews support the complex exploratory search by using structured overviews to assist in topical navigation and exploration. The browsing of facets in an image retrieval system allowed image seekers to learn more about the collection (Yee, Swearingen, Li, & Hearst, 2003). Developing search user interface that supports different macro-level stages of complexity, exploratory search tasks, Huurdeman, Wilson, and Kamps (2016) used keyword search textbox and a complementary of input features such as filter using categories, keywords suggestion. This feature reduced the usage of textbox but increased the number of terms per query, suggesting that exploratory activities of the search tasks have improved the understanding of the domain and hence generates more terms when refining the search. Taken together, these studies suggest that faceted search aids exploration and discovery within a collection. However, the design of facets for subject domains that are large and complex might not be as effective.

Keywords search are now the de facto facility in many retrieval systems. The use of natural language to express information needs is common. There is numerous work done on interface and features to support keyword search facility that help information seeker evolve information needs. A study attempted to model the intent of search to direct exploratory search using an interactive visual map with the input of initial keywords (Ruotsalo et al., 2013). These features support information seekers to articulate query statements in exploratory searches based on different techniques, allowing information seekers to visualize the search topic in order to formulate or refine adequate search queries. These studies corroborate that the management of keywords fosters learning and investigation in the domain of interest, citing support in the expression of information needs for exploratory searches.

3. METHODOLOGY

An inductive research approach to explore video retrieval interface and features that can support exploratory video searches for learning was used in this study. Academics and experts from the industry were invited through email to be interviewed to discuss their ideas and perceptions on the development of interface and features for video retrieval system. One-to-one semi-structured interviews were conducted face-to-face or via Skype. The recorded audio were transcribed and were analyzed through thematic analysis. Expert interviews were used in this study as it allows the probing of the experts for in-depth understanding of the ideas for interfaces and features that can support exploratory searches. Based on their domain expertise and experience, new ideas were developed and discussed.

3.1 Selection and Procedure

The selection of interviewees is integral to the research. The success of interview-based research largely depends on how much the interviewees can fulfil the expectations, how well the interviewees understand what is needed, and the extent to which they can articulate their responses (Bogner, Littig, & Menz, 2009). The experts were recruited in several ways. First, the profiles of the experts were studied through published sources such as websites (e.g. academic staff profile in institute websites, industry professionals profile in organization websites). The invitation was extended to academics and experts from the industry who have experience with video or multimedia related work.

The first group were researchers or academics whose research interest is within the field of video and multimedia. They are relevant as their research puts them at the forefront of multimedia processing and indexing landscape. The second group were professionals working in the industry as system developers, web designers and/or user-experience designers who are motivated by practical market demands. These professionals provide insights and ideas from practical perspectives. Subsequent experts were identified by referral through the expert interviewees.

A total of 20 academics and experts from the industry were recruited for the study and interviewed. 6 of the 20 interviews were conducted via Skype. The sample size of 20 balances the resources needed to conduct and analyze in-depth interviews against the return of new insights and ideas from getting more interviewees.

An interview schedule that listed the core and supporting probes was developed to guide the one-on-one interview. The questions from the interview schedule were designed based on the findings of a prior study that investigated the challenges encountered when young adults performed exploratory searches for their learning (Loke, Foo, & Majid, 2017). The interview schedule started off with two opening questions inviting interviewees to share their video related involvement as well as their experience with exploratory video searches. Table 1 lists the core questions asked in the interview.

Table 1. Core interview questions

1	Videos are multi-dimensional, consisting of audio channel and moving images channel as well as is temporal. Do you think the multi-dimensional makeup of video can have richer interface features to be developed to support exploratory video searches for learning?
2	With more complex information needs, expressing exploratory searches can be challenging. For example, a user may be looking for a video but cannot properly define the problem, and/or there is no single correct video. For instance, the user might want to look for video(s) that shows the design factors for a car to have a balance between stability and speed. What new video interface features can allow input and refinement of such exploratory information needs for learning better?
3	Very often, videos can be quite long and there can be so many videos presented in the results list. How can video seekers, be acquainted to the content of the video more efficiently and sufficiently so that they can decide whether the video is relevant for their learning?

The basic protocol is as follows: Permission was sought to audio record the interview session. With face-to-face interviews, an unobtrusive voice recorder was placed between the interviewer and the interviewee. A software that records Skype conversation was used in the Skype interviews. The basic profile of the expert is first collected. Then the research background and objective of the study were explained. The interview began with the core questions according to an interview schedule. The semi-structured interview allowed the experts to share interface design ideas that centered upon their domain expertise.

3.2 Data Analysis

For each interview session, the audio recording was transcribed and the field notes were added to the transcriptions in parenthesis. The transcriptions were guided by seven transcription principles (Mergenthaler & Stinson, 1992) for reliability and quality. A total of 755 minutes of audio recording or 54,939 words was transcribed. The portion of the transcripts discussing on interface and retrieval features were highlighted and extracted. These represented the core of the individual interviewee statements and were coded.

Thematic analysis was conducted to analyze the extracted transcripts (Auerbach & Silverstein, 2003) to identify patterned meaning related to the research questions. Similarly coded sentences were collected from the interview transcripts according to the research questions to form major themes as the interface concepts. The themes were synthesized to propose interface features for the exploratory video retrieval.

4. FINDINGS AND DISCUSSION

The purpose of this study is to synthesize the ideas and opinions of experts within the field of video and multimedia to propose design concepts for interface and features that can improve exploratory video searches. Nine themes that are related to design concepts for video retrieval systems in an exploratory search context were derived from the analysis. The themes are summarised in table 2. Due to the length of the paper, this paper focuses on findings related to the first two themes. Interface features were developed from the themes derived. These themes are presented in this paper focus on the query and input features as well as providing more granular interactivity with videos in the retrieval process.

Table 2. Summary of themes

Improving knowledge on topic of interest	To support information seekers in improving their knowledge in the domain of interest so that better queries can be formulated for exploratory searches.
Video segment interaction	To have more granular video interaction for more focused sense-making of video.
Managing keywords for input	To provide support for handling keywords challenges such as synonyms and homonyms.
Using non-textual input	Options varied means to query the video collection by taking advantage of multi-modal nature of video.
Multiple sources for recommendations	To include different types of recommendations so that different perspectives can be formed.
Richer interaction with video content	Multimodal nature of video offers many means of interaction to cognize video content effectively.
Seeker profile in searching	Having user profile provides support to the preference and possibly context of search.
Relationship between query and video result list	Making sense of the video lists and query relationship allows the exploration of resources more effectively.
Varied input options	Provide exploratory search with advanced search fields and dimensions.

4.1 Improving Knowledge on Topic of Interest

We asked the interviewees for their observations and perspectives on the challenges in performing exploratory searches in learning and how may retrieval systems better support exploratory searches. 14 of the interviewees (IM2, IM3, IF4, IF5, IM6, IM11, RM2, RF3, RM4, RM5, RM6, RM7, RM8, RM9) felt the need for features to support learners in interaction, understanding and exploration of the topic. Visual tools were suggested to present the topic structure can support and refine queries for exploratory searches.

IF4 elaborated on how the visualization of the domain or content area can support her in expanding the search using related terms in the topic. The expert described her idea as *‘some kind of content organizer. A visual framework or conceptual framework that I can see and interact with. That might make it easier for me to see how things are associated... That can help me to drill down to the level and content that I need.’* Her experience in developing multimedia learning content allowed her to share how visual organization can aid people in extending the boundaries of existing knowledge. This view is similarly shared by 8 interviewees (IM1, IM2, IM6, IM9, IM10, RM1, RF3, RM4).

RM1 suggested presenting the structure of knowledge in that topic or domain based on initial words available, similar to the semantic web. IM3 felt that semantically related concepts can prompt learners in refining the search: *‘For example, when I type “design”. The system could pair me with keywords like “learning”, because of “design learning”, it could also be “Interior design”.’* The presentation of semantically related terms allows the learner to establish semantic relationships. Using the semantic relationships, the learner can explore the domain area and navigate towards more specific information gaps.

RM2 proposed the use of concept maps as a modality to navigate information space. He suggested that concept maps support the learners *‘to define the key topic that they want to study on a concept map and then use that as a starter to bring them to the right video’*. Based on the initial input of concepts, the visual map presents an overview of the topical structure. From this initial reference concept, the visualization of relationships between sub-concepts in the domain of interest allows the exploration of other related concepts to formulate subsequent queries. A knowledge structure, such as concept maps, can be integrated to the video retrieval system to visualize and allow the exploration of semantic relationships. Keywords extraction is achieved by parsing the query phase to a web application interface. Keywords from the search query are extracted to generate a concept map. A prototype was developed to demonstrate this feature (see Figure. 1).

Different visual maps offer different benefits for learners to explore and understand the domain of interest. Concept and mind mapping has been reviewed on the effectiveness in supporting learner in improving learning of a topic or domain in high education (Kinchin, 2014). Some researchers (Davies, 2011; Eppler, 2006) suggested the integration of various visual mappings in order to leverage on the strength of each method. While the integration of various visual mappings could offer combined benefits from the individual mapping method, further evaluation to understand the effectiveness of different visual maps in extending keywords for information seekers on exploratory searches is required.

A hierarchical classification of a topic can provide the support to explore the specific topical space. For example, Dörk, Riche, Ramos, and Dumais (2012) designed a faceted interface to encourage exploration and make serendipitous discoveries. Visual maps provide an overview of the core concept and the relationships between the main concept and related concepts. A visual map also act as a learning tool that provide opportunities to improve a learner's understanding on the domain of interest. The possible integration of visual map could provide support in exploring domains and improve query formulation.

Figure 1. Keywords to concept map

Figure 2. Video progress bar (A) indicating segments emphasizing concept of interest and (B) indicating segments that have high views

4.2 Video Segment Interaction

A video is multimodal and has a temporal dimension. Making sense of the video content can often be time-consuming, especially for long videos. 13 of the interviewees (IM2, IF5, IM8, IM9, IM10, IM11, RM1, RM2, RF3, RM5, RM7, RM8, RM9) suggested various means for more granular video interaction. Video segmentation is an area in the domain of digital video processing research. Their responses indicate that the interaction with video segments can alleviate the temporal dimension challenge encountered with long videos. Using video segments, there were suggestions from the interviewees on how the video segments are searched, displayed, located, represented and managed.

Due to the temporal nature of videos, several interviewees (IM2, IM9, RM1, RM8, RM9) suggested an interface to retrieve video segments rather than to retrieve the whole video. This is summed up by RM8: ‘.. very often, I am not going to need the entire video at the end of the search. In an exploratory search, I want very specific information because when I am new to the subject, I want to look at the key things that are going to help me learn more and progress in my understanding. So that does not always come chronologically in a video.’ This granular retrieval allows the learner to locate specific video segments more effectively for their exploratory search. Automatic video segment segmentation strategy has been performed on movies based on logical story units (Hanjalic, Lagendijk, & Biemond, 1999) and more work on segmenting learning videos based on sub-topics is needed. This feature is useful when the learner is able to be more specific in the latter stages of the exploratory search with the interface to support segment retrieval.

RF3 suggested in pre-processing the video and have an abstract representation for each video segment so that the video segments are treated as individual documents. When the video segments are treated as individual documents, existing retrieval interfaces may be enhanced to be used by the learners. Finding keyframes to represent the video segment is useful for learners to visually assessment to segment content (RF3, RM5). Leveraging the temporal nature of video, have dynamic keyframes to represent the segment can improve browsing effectiveness as suggested by RM5: ‘Let’s say from a 1-minute video, you have five keyframes. ... But I think because of the keyframes made playable, temporal nature will be better....’ This point reveals the use of visual cues for exploratory assessment of the content effectively.

Video segments can be marked or indicated in the video, similar to the index of a book. ‘The first thing is that certain videos might be too long and it is very hard to pinpoint exactly on the video where the essence that you want is.... Whereas in a book, I would say that it is well-organized into chapters’ (IM8). The video segments containing the core search concept is marked on a video progress bar, allowing quick navigation to the video segments that have an emphasis on the concept of interest (see Figure. 2(A)).

The number of video views is a common social metadata in video retrieval systems. For more granularity in the interaction, RM8 suggested indicating segments of the video that has high viewing interaction: ‘... when I am watching a makeup tutorial and people are always moving back and forth at a particular part of the video. If that is highlighted to me ..then I would know that part of the video is the part where most people find that it is important.’ Using bars of varying height to indicate the relative number of views for the segments, the bars are embedded within the video progress (see Fig. 2(B)). This interface allows learners to know which parts of the video are viewed the most. When the learner synthesizes the two progress bars, the segments that are both viewed extensively and contains the core concept could potentially be the most useful video segment to begin viewing. As the interaction with videos become granular, the need to keep track of the video segments that have been interacted becomes germane. RM7 and RM8 suggested for the video retrieval to be able to keep track of viewed video segments and save video segments when needed. The segmenting of video resulting in more granular interaction can lead to more effective retrieval and learning. This was supported by a study which found that undergraduates achieved better results when using segmented video clips over non-interactive videos (Zhang, Zhou, Briggs, & Nunamaker Jr, 2006).

5. CONCLUSION

Exploratory search tasks often occur during learning. It presents fuzziness and ambiguity as the information seeker ventures into new and unknown domains. Searching for information to support learning is common. People regularly use keywords-based search utility when searching on the Internet. Being not fully conversant with the domain, learners could benefit substantially from some aids or support in their query formulation using their existing knowledge. The objective of this study was to explore the interface and features that can better support exploratory search for video resources in learning. Experts from various fields gave their ideas in the design of retrieval interfaces to alleviate the challenges in exploratory searches.

Visual features such as visual maps is proposed to be potentially useful in supporting learners for understanding the domain of interesting and extending concepts in the search. This reduces the uncertainty in exploratory searches and helps learners to navigate the domain of interest. In visual maps, the display of the relationships between concepts in domain may reveal links to prior knowledge and support deeper learning. More investigations are needed to understand the effectiveness of visual maps during exploratory searching.

The effectiveness of keyword searching is highly dependent on the quality of indexing. Using keywords to represent concepts, language semantic can create confounds during searching. The use of tools like a thesaurus helps define the appropriate concepts to use for the query formulation. This management of keywords helps in reducing fuzziness when refining the queries as well as provide suggestions for similar concepts to extend the search query. Segmented video interaction allows more specific parts of the video to be located, retrieved and manage. Many of the existing video interfaces and features can be used with video segments. However, there is a need to segment the videos logically to prevent incongruence in content otherwise it may be more detrimental.

As part of future studies, the rest of the themes will be synthesized to produce a corresponding list of desirable video retrieval interface and features. Based on the design concepts a prototype on the interface and features will be developed. Subsequently, the interface and features will be evaluated for its effectiveness in supporting the exploratory search for learning. As the number of people using public video repositories to support their learning increases, self-directed learners will find video retrieval more effective with the implementation of appropriate interface features.

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