DMSVIVA 2022

Proceedings of the 28th International DMS Conference on Visualization and Visual Languages

June 29 to 30, 2022
KSIR Virtual Conference Center
Pittsburgh, USA
PROCEEDINGS

DMSVIVA2022

The 28th International DMS Conference on Visualization and Visual Languages

Sponsored by

KSI Research Inc. and Knowledge Systems Institute, USA

Technical Program

June 29 to 30, 2022

KSI Research Virtual Conference Center, Pittsburgh, USA

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KSI Research Inc. and Knowledge Systems Institute, USA
FOREWORD

On behalf of the Program Committee of the 28th International DMS Conference on Visualization and Visual Languages (DMSVIVA2022), we would like to welcome you. This conference aimed at bringing together experts in visualization, visual languages and distributed multimedia computing and providing a forum for productive discussions about these topics.

It is our pleasure to announce that by the extended deadline of 20 May 1 2022, the conference received 14 submissions. All the papers were rigorously reviewed by at least two members of the international Program Committee, and most of the papers were reviewed by three members of the PC. Based on the review results, 6 papers have been accepted as regular papers with an acceptance rate of 43%. We would like to thank all the authors for their contributions. We also would like to thank all the Program Committee members for their careful and prompt review of submitted papers.

One special feature of this year’s conference is that we have arranged to have three highly interesting and relevant keynotes. We thank the three keynote speakers: Professor Gennaro Costagliola, Dr. Gianni.Pantaleo and Dr. Tiansi Dong for their contributions.

We would like to thank the Steering Committee Chair Professor Shi-Kuo Chang for his guidance and leadership throughout organization of this conference. The assistance of the staff at KSI Research and Knowledge Systems Institute is also greatly appreciated, which made the review process smooth and timely.

Bernardo Breve, University of Salerno, Italy; Program Co-Chair
Jun Kong, North Dakota State University, USA; Program Co-Chair
DMSVIVA2022
The 28th International DMS Conference on Visualization and Visual Languages

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Using Visual Feedbacks in an Augmented Video-based Learning Tool

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Abstract

In this paper, we face the problem of using video-based learning with multimedia content, which is expected to assume a prominent role in the post-pandemic world. In this respect, we have investigated the possibility of developing new services with suited visual interfaces, to further exploit its potential. Such novel services want to integrate the knowledge extracted from multimedia materials into educational applications. To do this, our approach is that of extracting the theoretical concepts included in a video lesson and describing the prerequisites relations between them, according to the knowledge base of the subject matter of the video itself. Such an addition of knowledge allows creating augmented video lessons and providing learners with new methods to browse videos and perform a non-linear navigation of their learning materials, by means of visual feedback methods. To this aim, we designed a custom web-based video player to support video-based learning, implementing these ideas. From the relevant literature we argue that this approach can be effective from an educational point of view but such effectiveness can be achieved only if the proposed video player is an easy-to-use tool, thus, we made a preliminary evaluation to assess the usability of the proposed system and results are presented.

Index terms— intelligent user interfaces, visual feedback, hypervideos, MOOCs

1. Introduction

Presently, both in the overall context of the human society, and in the specific field of education, we can observe that a “deep virtualization” process is ongoing, which is the outcome of a long evolutionary path that is leading communications and human interactions to be more and more mediated from the computer, through telematic channels and specific applications on both mobile and non-mobile ad-hoc devices. In particular, we want to make reference to the varied world of education and we observe that online learning has been becoming increasingly a very common practice for millions of students all over the world, which could lead to substantial and permanent modifications in current learning and teaching practices and methodologies. Indubitably, one of the main enablers of this change is the ever-increasing ease of production, recording, transmission and consumption of videos, which are more and more gaining popularity among users, at the expense of other media formats. This is true in e-learning too, where learners and teachers are following the long wave of the recent experience with Massive Open Online Courses (MOOC), which allowed finding both critical issues and advantages of using video lessons.

Now, to improve learning experiences, thus to make individuals’ education and training more efficient, we are seeking novel tools that can change the way of using video lessons, hence to enhance their effectiveness. To achieve this goal, we have to face common problems that occur in the realization of learning activities based on the use of educational videos, which include, e.g.,: (i) their length, (ii) the difficulty of navigation, (iii) the difficulty of exploration, (iv) the unstructured nature of the information within, (v) the difficulty of highlighting the most significant parts, (vi) the difficulty of identifying parts purely discursive and poor in content, thus becoming useless and time-consuming. To overcome some of these limitations, the solution that we propose is based on the use of concept maps, studied before in education, which has already proved its worth and validity, demonstrating that its adoption can improve the learning experience of students, also including the ones with special needs [7, 12].

This paper presents the outcome of the activities carried on in the first stage of a larger project called Edurell, which aims to automatically derive concepts from within video lessons. Moreover, the extracted concepts of a specific matter are classified on the basis of their relationships in terms of prerequisites. The whole system should be considered a hyper-video service and can be managed through an ad-hoc visual interface.
In a broader vision, the project aims to spread the use of augmented video services within educational frameworks. In fact, despite the effectiveness of augmented video services has already been demonstrated for the students [25, 23], they are not widely adopted, due to the fact that their development is time-consuming and requires a huge manual effort of subject matter experts. More precisely, in this paper we propose the use of two types of visual feedback: (i) augmented text (from the video transcript), and (ii) a dynamic concept map (concept map flow) and we evaluate them as methods to enhance the capability of understanding videos in specific learning contexts taken in consideration as use cases.

The remainder of the paper is organized as follows: In Section 2 we present a selection of related works to support our design decisions, in Section 3 we present the proposed hypervideo model; next, Section 4 describes possible use cases and scenarios, while the results of the first evaluation through experts are outlined in Section 5. Conclusions follow in Section 6.

2 Related works

The use of video-based education over the last decade has been quite extensive, thanks mainly to the success of the MOOC platforms. Prior to the Covid-19 pandemic crisis, the digital transition promoted the rise of a blended learning approach [10] [14], but the pandemic situation forced institutions to move quickly to a full remote model. As a consequence, during the last two years, video production in the educational field has grown exponentially and numerous related studies have been performed to understand the point of view and the engagement of students. Recent studies show that video-based learning positively fits into the student’s perception, also taking into account the variables of gender and digital inequality [24]. However, the lack of engagement is still an open issue, especially when watching a video is a passive activity and with little chance of interaction. Numerous solutions have been experimented in research to overcome this limitation, such as, e.g., the possibility of building suited environments for collaborative annotation [6], the use of self assessment quizzes to verify learning [18, 8], the adoption of interactive annotation to encourage soft skills learning [21].

The direction taken by video-based learning is that of the so-called hypervideo (HV). The definition of HV has a long history [20], as early as 2004 Zahn et. al. [33] identify the HV as a “combination of digital video and hypertext, which draws largely upon audiovisual media as central parts of their structure. They consist of interconnected video scenes containing ‘dynamic’ hyperlinks that are available during the course of the video scenes and that refer to further information elements (such as texts, photos and graphics)”. Although the definition of HV has not yet been fully formalized, it is now common practice to refer to HV when there is some reference to interactivity such as, e.g., with control features, hyperlinks, collaboration options [5, 4, 29, 25]. Besides, the need to provide video augmentation services is closely related to another line of research that had a discrete success, owing to its positive impact on learning, that is the use of knowledge or concept maps. The research in this field has extensively tested that the application of concept maps both in different scientific domains [28, 11, 31, 9] and at different levels of education (from primary school to university) [3, 1] can have a positive impact on learners, even in the context of students with special needs and specific learning disorders [7, 12]. The way concept maps are integrated into hypervideo services is strictly correlated to the issue of information visualization and to the importance of the content presentation, in order to have a certain effectiveness, in the consolidated perspective that even in the educational field the learner can be considered as a prosumer [16]. Many projects based on a data driven approach have explored the different possibilities for improving the navigation experience, such as data-enhanced transcript search and keyword summary, automatic display of relevant frames, a visual summary representing points with high learner activity [17], non linear consumption of videos using personalized fragment navigation [32], exploration of e-learning contents via small screens [27]. The idea of using concept maps to support video navigation is already present in works at the beginning of the new millennium [13] but, at the best of the authors’ knowledge, the novelty of this contribution can be identified in the possibility of automating the creation of concept maps, hopefully going in the direction of creating an on-the-fly service. In our project, the concept map supporting the video must be regarded as “interactive” and not static, as it is strictly related to the contents presented within the video, which are automatically highlighted within a relevant graph of knowledge, underlying the system and describing the contents within the video lesson.

3 Description of the system

The proposed application is an enhanced viewer for students watching video lessons, which offers additional functionalities in side panels, to enrich the learners’ experience. In fact, aside the main video player, one can find (i) the transcript of the speech with important concepts highlighted (see Fig. 1), and (ii) a knowledge graph representing the prerequisites relations between such concepts (see Fig. 2). Put brief, this acts as a contextual help for the concepts explained by the lecturer who recorded the video, allowing students to navigate in the subject on the basis of their individual level of knowledge. To this aim, the knowledge
The system is made available online on a local development server and anyone can access upon free registration to test its functionalities. Guest users who register can enhance the current library of video lessons by providing YouTube links to their lessons, and exploit the functionalities of the system creating their own graphs and maps, making the relevant annotations.

The major contribution with respect to the literature is that, since concepts evolve as the video flows (as their explanation goes deeper), they are initially presented with lower complexity, resulting in a contextual help, which shows a simple knowledge graph. Later on in the video, the same concepts may be deepened with additional notions (concepts) that will have been expressed in the meantime. This is reflected in the dynamic contextual help, where the graph knowledge is progressively enriched and becomes more complex (see Fig. 3). Thus, concepts do not have a static set of prerequisites during the whole video and, consequently, their contextual help evolves dynamically, in accordance to the video flow. This has relevant potential applications towards personalized contextual help, when the domain knowledge graph is matched against the knowledge graph of the learner.

4 Use cases and scenarios

To assess the validity of the proposed solution, we identified different scenarios, outlined in the description of possible user-stories. Specifically, we considered the cases depicted in the following situations.

4.1 First time viewing

Imagine you are a bachelor’s degree student in Archaeology. Within your course of study, face-to-face courses, online lessons and courses on MOOC platforms (as additional activities to get credits) are provided. Then you decide to attend the “Forensic Archaeology and Anthropology Course” in autonomous mode. The Edurell platform, with its hypervideo functionalities, will provide support to follow the course on your own. In this case, specific features of the application (e.g., browsing with fragment navigation, see below) can improve your browsing experience of a video.
with educational content (intra-video issues). Specifically, the tasks to be performed are:

- **Login**
  1. sign-into the Edurell platform or sign-up creating a new account. The login screen is shown in Figure 4 and presents a preview of the internal system with a relevant description in the text balloons;
  2. Look for the video you want with the Search feature or find the video in your dashboard; Figure 5 shows the welcome page with the browsing history of the user and a list of other videos available within the system. Access the first lesson of the “Forensic archaeology and anthropology” course;
  3. After creating your profile and logging in, select the video in question.

- **Browse the video by using the Fragment Navigation feature.** Actions required are:
  1. Follow the lesson of the video-course. At the first viewing of the video lesson, you may need some features to be able to review unclear parts of the video or deepen a specific concept. Instead of random scrolling the video, jumping from one point to another without a criterion, with fragment navigation you can reach effortlessly the more useful portions of the video;
  2. Start the video and reach minute 5:30;
  3. Browse the video and reach the fragment of the video that explains the “Preauricular sulcus”;
  4. Now, return to the exact moment you left the video during linear viewing.

- **Browse the video by using transcript: continue watching the video, but you will be able to use the transcript to carry out your research on the concepts.** Actions required are:
  1. Expand the transcript panel;
  2. Reach minute 4:35 of the video through the transcription panel;
  3. Look inside the transcription for the concept “Femoral”; 
  4. Reduce the size of the Transcript panel.

- **Browse the video with the graph view:** you are following the course and now you want to exploit the knowledge graph. The panel on the right of the screen will allow you to take advantage of numerous features to browse the video and deepen some concepts. Actions required are:
  1. Expand the Interactive Knowledge Graph panel;
  2. Follow the video and write in the notes panel what are the prerequisites of the “Sciatic notch” concept (appearing at minute 2:30);
  3. Guess what is the meaning of the edges in the Knowledge Graph?
  4. Go back to minute 1:08 (in the way you prefer, i.e., with the transcript or with the navigation bar), which concepts are red coloured in the graph? Write them in the notes panel. Why are they colored?
5. Click on the “pelvis” node to see what happens on the navigation bar;
6. Click on the red dot. Guess what’s the meaning of the red hotspot?
7. Now, click on the yellow dot. Guess what’s the meaning of the yellow hotspot?
8. Reduce the size of the Graph panel.

• Concept search: After having watched the complete video you may want to deepen some concepts. Now you can take advantage of the Concept search functionality. Actions required are:
  1. Use the bar for the concept search, type the name of a concept “sciatic notch”;
  2. Once the concept is found and the graph displayed, use the filters to obscure the parts of the graph you are not interested in, in order to show on the screen only the concept you are looking for and its prerequisites;
  3. Now, use filters to show only the concept you are looking for and all the nodes that depend on it;
  4. Within the Concept information Panel find the information relating to the minute in which the concept is explained;
  5. Click on this link;
  6. Return to the video lesson.

4.2 Second time viewing

In the same scenario as before, you have already followed all the videos of the course and now you want to browse again the contents of video number 1 because you need to review some concepts. The tasks to be performed are:

• Login. Actions required are:
  1. Log-into the Edurell platform with your registered account;
  2. From within your dashboard access to the “Forensic archaeology and anthropology - Part 1. Sexing a skeleton” video.

• Browse the video: Start following the video lesson. Since you have already seen the video, now you want to deepen some more difficult concepts. Actions required are:
  1. Browse the video exploiting the Fragment Navigation and reach the “Preauricular Sulcus” fragment;
  2. Expand the Interactive Knowledge Graph panel;
  3. Follow the video and write in the notes panel what are the prerequisites of the “Acetabulum” concept;
  4. Click on the “Acetabulum” node and take advantage of the functionality to click on the occurrence of “Acetabulum”.

• Concept search. Actions required are:
  1. Use the bar for the concept search, start by typing a concept you want to learn more;
  2. Use the filters to obscure the parts of the graph that do not interest us, in order to show on the screen only the concept you are looking for and its prerequisites;
  3. Use filters to show only the concept you are looking for and all the nodes that depend on it;
  4. Exploiting the Concept Information Panel click on the link of another video lesson of the same course, within which the concept you are looking for is explained;
  5. Take advantage of all the intra-video features to deepen the concept you wanted to understand better;
  6. Go back to the lesson N.1.

4.3 Third scenario

You follow the “Forensic archaeology and anthropology - Part 1. Sexing a skeleton” video on Youtube, without any hypervideo support. Afterwards, you will follow the “Forensic Archaeology and Anthropology - Part.2: Estimating Age at Death - Infants and Juveniles” video, within the Edurell platform, taking advantage of hypervideo functionalities. We are wondering which features allow the student to better understand the concepts and the relationships between them in an educational video. The tasks to be performed are:

• Follow the video course without hypervideo functionalities. Actions required are:
  1. Start following the “Forensic archaeology and anthropology - Part 1. Sexing a skeleton” video;
  2. Follow the video till the end, without interruption;
  3. After watching the entire video, try to provide a description of “Preauricular sulcus” concept, writing it within the notes panel;
  4. Try to write in the notes panel what concepts you need to know to understand the “Preauricular sulcus” concept;
5. What are the more advanced concepts of which Preauricular Sulcus can be considered a propaedeutic concept? Write them in the notes panel.

- Follow the video course with knowledge graph visualization. Actions required are:
  1. Login into Edurell platform;
  2. From within your dashboard access to “Forensic Archaeology and Anthropology - Part.2: Estimating Age at Death - Infants and Juveniles” video;
  3. Browse the video and reach the fragment x;
  4. Take advantage of Concept search to deepen your knowledge about specific concepts;
  5. After watching the entire video, try to provide a description of “Preauricular sulcus” concept, writing it within the notes panel;
  6. Try to write in the notes panel what concepts you need to know to understand “Preauricular sulcus” concept;
  7. What are the concepts of which Preauricular Sulcus can be considered a propaedeutic concept? Write them in the notes panel.

5 Evaluation through experts

The novel concept of the interactive knowledge graph representation that we introduced, required the realization of suited functionalities induced by such a new hypervideo interpretation. To enable users navigating videos according to a variety of criteria, we designed a suited user interface (UI) to fully exploit such new capabilities.

Specifically, the proposed UI merges different canvases (see Fig. 1 and Fig. 2), i.e.,

- the player for the main video;
- a frame for the video transcripts;
- an area to access the interactive knowledge graph;
- a bar for navigating the video through indexed fragments;
- a suited space for students’ to take notes.

Moreover, the progress bar of the video player was enhanced with some markers in correspondence of video highlights and links to the concepts represented in the knowledge graph.

To assess the validity of such a solution, we must evaluate both the effectiveness of the proposed process for knowledge management and discovery, and the usability of the UI that we designed to this aim. Hence, for the latter, we decided to perform some usability tests based on experts’ reviews. In this context, we observe that the definition of a specific set of usability heuristics would be required, tailored to the specific domain. This is due to the fact that, by their nature, traditional heuristics will not be able to evaluate the specific characteristics of our particular applications with its peculiarities related to the specific domain of education. For this reason, a new set of heuristics specifically thought for the application domain of e-learning with hypervideo will be designed, after a first phase of experimentation, devoted to identify possible causes of general usability problems.

For now, we will rely on the standard set of usability heuristics, based on the renown Nielsen heuristics model [22].

Recalling that usability is typically defined as the “ability to be used” [2] and, therefore, there can be no mathematical methods to make rigorous and accurate measurements, let us consider the case in which it is assessed through a series of usability inspections or usability tests. In this respect, one of the most widely used techniques is to carry out a heuristic evaluation to find any usability problems. This method is based on the so-called “heuristic principles” or “usability heuristics” to evaluate usability. As mentioned, each specific domain should have an adequate set of usability heuristics since the more generic or traditional ones will not be able to correctly evaluate the specific characteristics of the different types of software and applications.

Making reference to the ISO 9241-11 standard, we can give an accepted definition at international level on what is usability and its application in different fields of application [2]. In practice, this standard defines usability such as “the extent to which a product can be used by specified users to achieve specified objectives with effectiveness, efficiency and satisfaction in a specific context of use” [15].

Furthermore, we point out that there are several potentially ambiguous terms related to usability, such as, e.g., effectiveness, efficiency and completeness, and for all of these, we will use the definitions given in the ISO standard, which are as follows [15]:

- User: person who interacts with the product;
- Objective: expected result;
- Effectiveness: accuracy and completeness with which users obtain specified goals;
- Efficiency: resources spent in relation to accuracy;
- Completeness: with which users reach the objectives;
- Satisfaction: freedom from discomfort and positive attitudes towards the use of the product.
• Context of use: users, activities, equipment (hardware, software and materials), and the physical and social environments in which a product is used.

However, there is still no generally accepted definition of usability, since its complex nature is difficult to describe in a definition [19] and also the mentioned standard is still under review, in order to include new lessons learned on usability since 1998 and new elements that have emerged in relation to the very concept of usability [26]. Despite that, there is a general agreement about the usefulness of adopting the heuristic evaluation method to identify a priori any usability problems before performing extensive usability tests with final users [30]. We followed this approach, according to the model proposed by Nielsen and Molich [22] involving usability experts who inspect the product interface for possible usability issues. The authors conducted a heuristic study based on the evaluation of 5 experts [30]. The experts were provided with the description of the scenarios and left free to use the web application as they preferred. Then they were asked to follow Nielsen heuristics, that we are going to recall in the following, for the sake of the readers’ comfort. After collecting the reviewers’ remarks and concerns with the current release of the system, we analyzed them carefully. Below we summarize their impressions as follows, where we present the emerged issues and possible actions to counteract the highlighted problems.

5.1 Results from the experts’ evaluation

1. Visibility of the system status. – *The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.*

Issues: At the first attempt, the platform does not provide information nor a catalog neither a preview of the available videos. Users must search the videos within the system through a search bar and then, when typing, automatic suggestions appear. Only when you are registered and have already watched some videos, recent videos are shown in “your history”. A short description is missing in general, and for watched videos, some more information should be shown such as, e.g., watched, watching, or even progress within the timeline.

Suggestions: Such an issue can be fixed by adding a visual catalog on the start screen, presenting videos as cards with short synopsis and making search available as a second choice. Furthermore, users should have personalised home pages with their favourites and most popular videos (possibly per category), as well as the recently seen ones. This will also resolve the problem of having an empty starting page.

2. Match between system and the real world – *The system should speak the users’ language, with words, phrases and concepts familiar to the user, rather than system oriented terms. Follow real world conventions, making information appear in a natural and logical order.*

No issues were reported by none of the reviewers, comments agreed that the used language is not too technical, nor ambiguous, neither chaotic.

3. User control and freedom – *Users often choose system functions by mistake and will need a clearly marked “emergency exit” to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.*

Issues: escape routes are missing after search results are presented. Suggestions: an emergency exit should be provided by adding a “This is not what you were looking for?” on the results page. Also, a “Back to previous page” command should be helpful.

4. Consistency and standards – *Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.*

Issues: The navbar includes a “Home” button but the logo is not a link to the home page.

Suggestions: While the ”Home” button is still useful for a certain class of users, the link to the logo should be added.

5. Error prevention – *Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error prone conditions or check for them and present users with a confirmation option before they commit to the action.*

Issues: buttons in the navbar are too much near each other

Suggestion: redesign the navbar and adding a hover effect on suggested videos, to clarify the current position.

6. Recognition rather than recall – *Minimize the user’s memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.*

No issues were reported by none of the reviewers

7. Flexibility and efficiency of use – *Accelerators unseen by the novice user may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.*
Issues: given the small number of functionalities, such feature is completely missing, apart for the chronology in home page.

8. Aesthetic and minimalist design – Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

No issues were reported by none of the reviewers

9. Help users recognize, diagnose, and recover from errors – Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution. Issues: such feature is completely missing. Suggestion: it is good practice to design tools keeping in mind that errors can occur at every time, e.g., when selecting a video, it should be made possible to make changes or deleting from own history.

10. Help and documentation – Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user’s task, list concrete steps to be carried out, and not be too large. Issues: such feature is completely missing

Besides: exporting data from the platform is possible in the json format. Depending on the browser/OS combination, it may happen that the file is not downloaded, yet visualized on the screen, which results in a blank page. Moreover, in the current release, not all of the functionality are fully available, hence, this assessment is only partial.

6 Conclusions

In conclusion, we can observe that the visual feedback methods has been designed with the goal of improving video-based learning by providing a structure to video content. By increasing the immediate understanding, we could expect an improvement in the efficiency of the learning process. However, further research is needed to make a more precise assessment on the real usability of this tool. Results collected from this first round of evaluation have given us good advises to improve the overall functionalities of the system.

References


