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Educational Video Ecosystems: An Interactive Mind Map-Driven Approach

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ABSTRACT

In an era where digital learning is becoming increasingly vital, the need for effective educational tools that can adapt to the demands of diverse learners is becoming more urgent. The speed of the Internet has improved dramatically owing to the growth of Internet-based technologies and networks, which has made video content the most significant medium for distributing information. Additionally, advancements in online video sharing and production platforms such as YouTube, TikTok, and Instagram, have made it easier for individuals to create and share videos. Research shows that video-based learning can increase engagement, critical thinking, and knowledge retention when aligned with learning objectives and interactive elements. But with numerous videos being produced on these sites, finding videos which provide the information they need has become increasingly difficult for users. In this paper, we present a video search platform built on a mind map architecture. The mind map is an effective and efficient tool and a valuable method for promoting critical thinking. It helps people to start exploring and expanding the topics in a way that mirrors the brain's natural processes. We developed MVP (Mind Map-Based Video Searching Platform), a service that allows users to create mind maps and upload videos to each node within the mind map as well as learners to search for mind maps created by other users or generated by AI.

1. Introduction

Ac The speed of the Internet has improved dramatically as a result of the growth of Internet-based technologies and networks, and video content has emerged as the most significant information distribution medium. Individuals can now easily produce videos thanks to advancements in online video sharing and production platforms. As more experts in different fields produce videos about content relevant to their fields of work, the importance of the knowledge found in the videos has increased significantly. Users can search for videos by using a tag or video title, and platforms often provide a service that uses a complex algorithm to suggest videos that users may be interested in. Nevertheless, the countless videos created by many users every day make it difficult to perform searches. In addition, it is even more challenging to find a specific piece of information within a video. Two main factors identified on Wikipedia could help address this issue. To begin, Wikipedia provides a table of contents that provides an overview of the topics that the user has searched for. This table of contents allows users to quickly navigate to topics of interest, in a similar fashion to a car's navigation system that guides users to their destinations. If users have some background knowledge of the subject they are looking for, the information can be easily found by means of links in the content table instead of reading the complete text. Secondly, links in the text in Wikipedia provide information that is either directly or indirectly relevant to the subject. These links, like the recommendation system of an online video-sharing site, can often pique users' interest in exploring additional details. Figure 1 shows a guide to becoming a front-end developer using a mind map structure [1]. However, since the nodes of the mind map are not directly linked to their detailed information, users must go through the hassle of

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searching for additional information for each node.

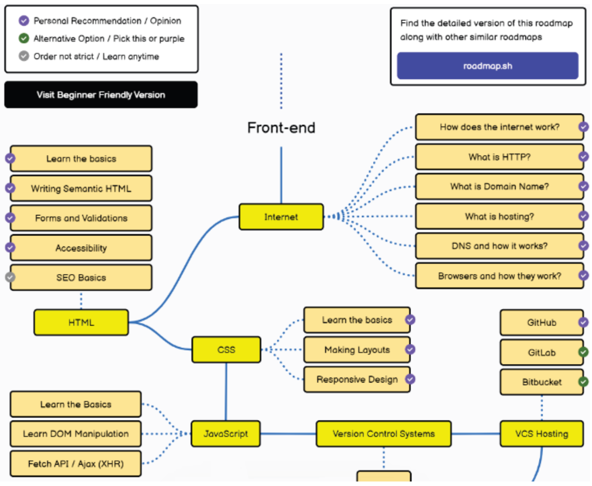

Figure 1: Roadmap of a frontend developer using a mind map structure.

In this paper, we have developed an online sharing and searching platform with an architecture of mind maps. Rather than creating an effective video searching algorithm, we focused on adopting a mind map tree structure to develop a well-defined repository architecture to store videos. The remainder of the paper is structured as follows: Section 2 describes the motivation of the paper and reviews context information and literature references. Section 3 describes requirements and functionalities of the developed platform. Section 4 depicts the platform's implementation as a proof-of-concept and as a basis for further research to demonstrate the platform's efficacy. Section 5 concludes the paper.

2. Related Work

As online video-sharing platforms are getting more attention and popularity, the number of videos posted online has been exponentially increased. Online video-sharing platforms are utilizing keyword tagging and searching for users to find videos they are interested in [23, 11]. However, the extreme growth and distribution of video on the Internet has made searching for specific videos that satisfy users' expectation using simple text and keyword-based queries a significant challenge. These existing indexing, tagging, and searching has a limited capability as computer AI's image recognition and linguistic analysis still have some limitation to perfectly understand images on videos and human language. In order to efficiently and effectively retrieve relevant videos from the enormously large video database, various techniques have been developed and implemented.

Temporal Localization with Natural Language: Hendricks et al. [5], Shao et al. [20], Zhang et al.~\cite [25], and Zhao et al. [26] addressed the problems of retrieving a temporary segment from a video for a given natural language query. These schemes don't require any pre- or post-processing of the video for effective moment localization. This is a challenging problem as each moment may have different semantics. Learning discriminative features out of videos requires an ability to deal with its flexibility and complexity of moment description. They mainly focus on retrieving a specific temporal segment from a video, but the feature could be simply extended to video retrieval systems.

Video-Text Embedding Models: Miech et al. [18] proposed a model that learns video-text embeddings from heterogeneous data sources. Similarly, Mithun et al. [19] and Liu et al. [17] proposed a novel framework that utilizes available multi-modal cues from videos for the cross-modal video-text retrieval task. For effective video retrieval, [19] used a fusion strategy and those multi-modal features include different visual characteristics, audio inputs, and text. They also proposed a new loss function that further exploits the multimodal correlation. [17] framework effectively uses embeddings from different scene, objects, actions, etc. by learning their combination in order to render them more discriminative. The framework retrieves video contents using a free-form text query that may contain both general and specific information.

Content-Based Video Retrieval (CBVR): In order to tackle the limitations of keyword-based video search, content-based video retrieval techniques have been proposed [10, 21, 9, 16]. CBVR systems can retrieve a list of videos by various types of queries such as query by objects, query by location, query by example, query by sketch, query by natural language, etc. In this paper, we propose a simple but innovative way that utilizes a mind map [7, 8] for efficient and effective video retrieval search engine. Mind maps have been adopted and used in various ways such as a learning strategy [22, 15, 27], a user modeling and recommender system [6, 12], document summarization [24, 14], etc. Our proposed platform uses a mind map in a way that mimics users' flow of conscious when they need to search certain videos. This paper discusses the limitations of the current video information retrieval systems, a new way to use a mind map, and the technical requirements for implementing a flow of human consciousness-based search engine. To the best of our knowledge, our work is the first to implement a video search platform using a mind map and to tackle and overcome challenges and issues in implementing the platform. Our platform allows users to organize (index and search) videos based on the flow of human consciousness (thinking process) via mind maps.

3. The Functionalities and UX Design of the MVP

To design an effective and efficient video search platform, we first elicited user and external interface requirements. The majority of video search sites, such as YouTube, provide search and recommendations based on the user's viewing and search history. These platforms are concentrating on improving their search and recommendation algorithms. However, a user cannot figure out whether the video includes the information the user needs until he/she watches the entire video. According to the statistic [2], users tend to watch short videos, and shorter videos are particularly engaging when they offer educational and insightful content [3]. The details found in the video becomes easier to locate and clearer as the video's duration is reduced. The users will not always be able to specify the information they need. Even if the user searches based on incomplete information, the platform must be able to navigate to the information the user ultimately wants, like the navigation system in a car. The user requirements are summarized in Table 1.

Table 1: User and external interface requirements

1.	The platform should provide videos that deliver knowledge for educational purposes.
2.	Users can easily search for information contained in videos (not the videos themselves).
3.	The mind map ecosystem should be managed and enhanced through collective intelligence, similar to Wikipedia.
4.	The platform is able to recommend the videos to users based on the relationship between the information in the video. When user watch informative videos like tutorial, knowledge guide, learning, and academic classes videos, it should not recommend video based on the user or other user's search history.

We propose MVP (Mind Map-Based Video Searching Platform) that implements the requirements listed above. The tree-like structure of a mind map is suitable for representing knowledge structured in a hierarchical manner, such as the table of contents in Wikipedia. In MVP, a video should be divided and saved according to the mind map's hierarchical detail. It allows users to search for information when moving through the mind map's hierarchical structure, allowing them to easily locate the information they need without having to use complicated search algorithms. The subject that users are investigating appears as a root node in the mind map, but it may actually be a sub-topic of another piece of material.

3.1 UX design of MVP

When users search for videos, instead of searching for individual videos, the platform displays an information ecosystem (Mind Map) that contains the desired information through a mind map. To meet the requirements defined in Table 1, the interface is designed as shown in Figure 2 and the functionalities of the mind map is summarized in Table 2.

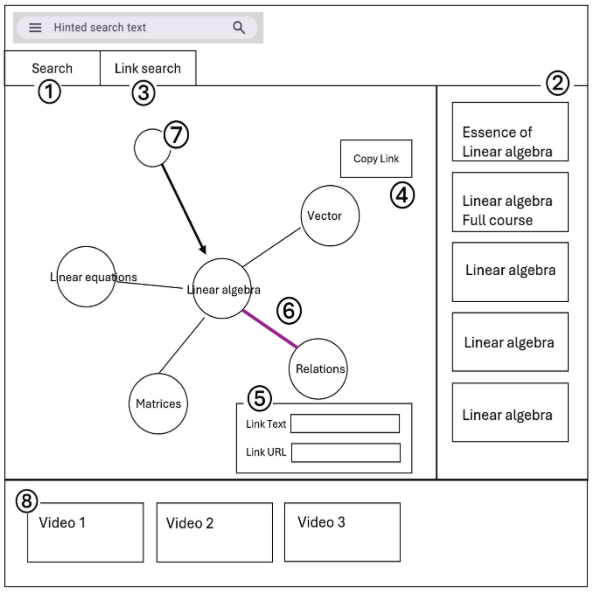

Figure 2: UX design diagram of the mind map.

Table 2: Functionalities of the mind map

Number in Figure 2	Description
1	Search mind maps created by individual users.
2	The search results are listed in Section 2.
3	The layout of the Search tab and the Link Search tab is identical. The search tab is used to find and extract link information for related mind maps when connecting a node in the current mind map to others.
4	When connecting related nodes from other mind maps, it extracts link information using the "Copy Link" button.
5	Users can use the extracted link information to create new sub-nodes in the mind map they are currently using.
6	When users navigate nodes in the mind map to find desired information, the frequency of traversals is represented by the color and thickness of the lines.
7	User search for other mind maps that reference the current mind map.
8	When a user clicks a node in the mind map, the videos associated with that node are listed in Section 8.

Smartphones have overtaken as the most popular device for watching videos. According to a statistic, mobile devices account for 70% of overall YouTube watch time [4].

We have designed and built a video search platform using a mind map architecture for mobile devices. The number of sub-nodes shown on the screen is limited to

10 due to the smartphone's screen size, and sub-nodes with more than 10 are not shown on the screen but run in the background. However, the user can navigate through hidden sub-nodes by rotating the sub-nodes left and right (placed at #5 in Figure 3). Also, the buttons that create the root node and the sub-nodes have been separated and positioned in the upper left corner to avoid unintended actions that may occur due to incorrect screen touch.

Functionalities of the mind map in MVP is summarized in Table 3.

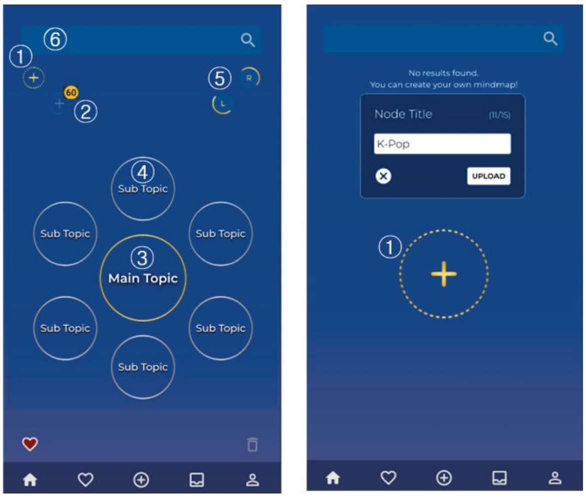

Figure 3: UX design of the mind map in MVP.

Table 3: Functionalities of the mind map for mobile devices

Number in Figure 3	Description
1	Create a root node of a mind map
2	Create a sub-node of a mind map
3	Root node
4	Sub-node
5	Rotate sub-nodes around the root node
6	Search a mind map

3.2 Searching process of MVP

The user must create a mind map that functions as table of contents. If other users have already created a mind map for the same topic, the user can either upload a video using one of the existing mind maps created by others or create a new mind map of their own. Users can generate multiple mind maps for a single topic using the MVP. Even if the main topic is the same, the way the sub-contents are arranged and organized will differ. As a result, when users are looking for a specific mind map, the structure of the mind map can be used as a source of information. For example, in Figure 4, JPA (Java Persistence API) is a collection of classes and method that allows easy interaction with database instance. When a user searches for a mind map using the keyword "JPA", they can navigate all mind maps that contain a "JPA" node. In mind maps where JPA node is used as the root, the user can get an overview of the details needed to learn JPA from the structure of the mind map. If the "JPA" node is a sub-node in a mind map, the user can explore how JPA relates to other technologies and topics.

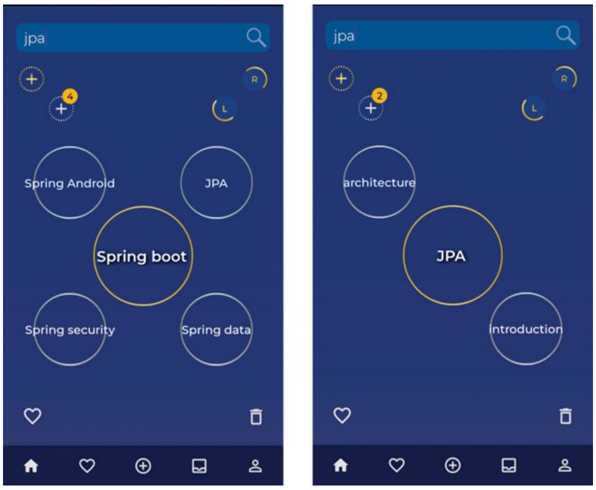

Figure 4: Mind map search outcome of MVP.

3.3 Mind map integration and division

Mind maps help users to see the entire picture by connecting one topic to the next. Users can create their own knowledge map that shows where a video can be found. To compose a refined mind map, MVP provides a function for dividing or integrating the mind maps as shown in Figure 5.

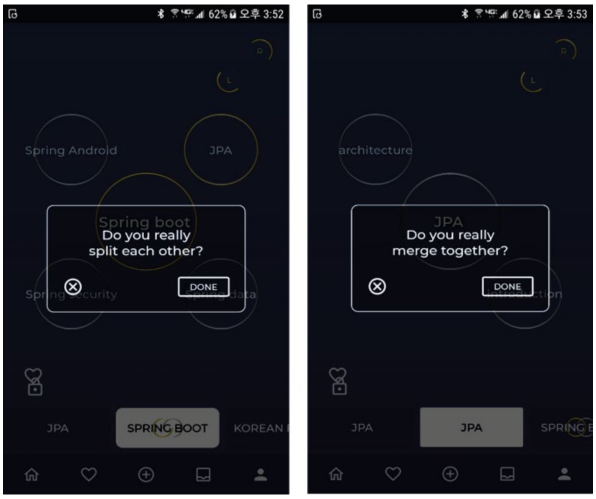

Figure 5: Integration and division of mind map in MVP.

4. Implementation

To collect data to verify the efficiency of MVP as a video sharing platform, the application is implemented using android with Kotlin and server-side APIs are developed using PHP. The MVP has restricted video length to 5 minutes to ensure that each video contains only the essential information [13]. Additionally, dividing the content into smaller nodes within a mind map helps users locate information more quickly and effectively. The operating environments are summarized in the Table 4. Figure 6 shows the entity diagram for creating a mind map. Every node has a unique id, and, if a node is a sub-node in the mind map, it can be identified with the parent node and depth of the node in the MindMap table. When a video is uploaded to Amazon Cloud Storage, it records the file name, title, description of the video, URL where a video is stored, etc.

Table 4: Operating environments of MVP

Amazon Server	Description
EC2	Hosting server
ELB	Elastic load balancing
RDS1	MySQL 8.0.15 Community – Master database
RDS2	MySQL 8.0.15 Community – Read replicas
S3	Secure cloud storage for videos
EleasticCache	Session server – Cache

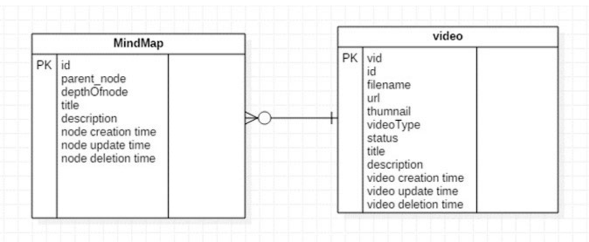

Figure 6: Entity diagram for mind map in MVP.

As illustrated in Figure 7, a desktop-based mind map application was also developed as a proof-of-concept to demonstrate its feasibility and functionality. The interface displays the searched mind map is displayed at the center and related videos are listed at the bottom when a user selects a node on the mind map. Users can customize the mind map by adding additional videos or deleting nodes as needed. For the desktop version, the backend was implemented as a RESTful API using the Spring Boot framework, leveraging the Java Persistence API (JPA) for object-relational mapping and data management, with H2 configured as the database. The frontend was developed with ReactJS, providing a dynamic and user-friendly interface for an enhanced user experience.

5. Conclusion

For the digital generation, videos are a more interactive medium. Owing to the long-term COVID-19 pandemic, many people have become accustomed to taking classes online. So far, videos for basic amusement have dominated the mainstream online video-creation platforms. The demand for educational and insightful videos to obtain information, on the other hand, is also steadily rising. MVP (Mind Map-Based Video Searching Platform) was created to provide a more effective and efficient way to store and share videos with the help of mind maps. When users search for new content for learning or educational purposes, they often rely on keyword searches based on fragmented information. This can lead to loss of interest or difficulty in acquiring the desired information, especially if they lack sufficient background knowledge. In the age of information overload, mind maps can leverage collective intelligence to build a high-level video ecosystem. By showing information relevance during the search process, mind maps enable users to easily grasp the overall structure of the information, even when they only have fragmented details.

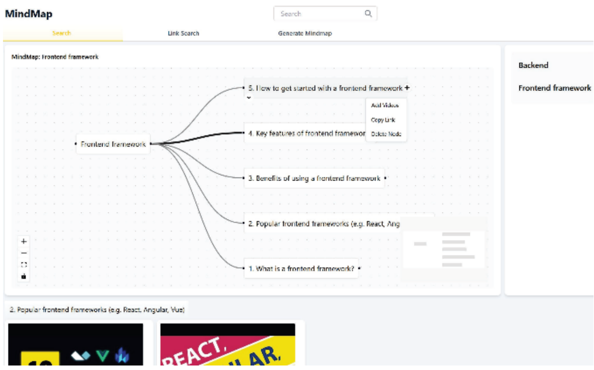

Figure 7: Desktop interface of MVP.

6. Future Work

When learners search for topics, the results will include two types of mind maps: those generated by humans and those created by AI. By comparing the AI-produced results with those created by users in an educational context, learners are encouraged to engage in analytical thinking about the outcomes rather than simply relying on AI-generated results. This process stimulates their creativity and curiosity. We will quantitatively and qualitatively evaluate the impacts of this feature of our platform.

Additionally, to ensure the consistency and integrity of stored mind maps, we will develop conflict resolution mechanisms, data validation processes, and version control features. These measures will maintain data reliability across the system as users modify and expand their mind maps.

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