Calculus video recommender system

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Abstract. Mathematics had been taught from the lower level of education to the higher level of education. Basic mathematics had been exposed since pre-school to give a good foundation on mathematics so that they can learn better in primary school and also in secondary school. At a higher level of education, the basic calculus is offered and it is one of the core components in mathematics that needs for technical studies. With the advancement on information technology, the students are no longer bound to the face-to-face learning. A plenty of online sources are available to help them learn anytime they want. The text based documents and tutorial videos can be accessed easily. In this research, we had studied the existing recommender system features and the recommendation techniques. Here, we had emphasized on finding the tutorial video based on the user’s preferences particularly on basic calculus topics. A YouTube API is used to retrieve the basic calculus online videos. The YouTube API will send back a list of videos based on the searched keywords. The content-based recommendation technique known as keyword-based vector space model has been chosen because the results tend to show lots of similar videos than any other recommendation techniques. The keyword-based vector space model will convert the video title into a vector space and it will calculate the cross multiplication of the term frequency and the inverse document factor and it will also determine the closeness of the title by using the cosine similarity. The aim of the video recommender system is to help the students in searching an online video tutorial from the internet especially from YouTube and also to give a recommendation of a video based on it’s suitability.

1. Introduction

Mathematics has been taught from the lower level of education to the higher-level education. Basic mathematics are being exposed since pre-school to give a good foundation of mathematics so that they can learn better in primary school and secondary school. At a higher level of education, the Calculus subject is offered and it is the core component of mathematics which needed for technical studies [1].

For learning and teaching, e-learning may have the potential to address the common issues in mathematics education [2]. Students can easily access the information to study anytime and anywhere while the teacher can use the Internet as a medium to share the knowledge. For example, there is plenty of tutorial educational video on the Internet, which can help students to boost their understanding about the subject.

Calculus can be taught in many different ways. One of it is by learning it online because there is a lot of relevant information and tutorial videos across the Internet. However, to search for a suitable yet relevant information may take time and may be inaccurate or out of scope [3]. Usually, the students
will have to surf several websites just to search for the information that may help them to learn. It is clear that a video search engine and recommendation system is needed to help the students to search the video in a more efficient way [4]. To solve the students’ problem, a web recommender system is needed by searching and extracting data from the Internet especially YouTube and also give recommendation by its suitability.

The web recommender system can reduce the time in finding relevant information. The information is taken from various websites and recommended by the system based on its suitability. Moreover, it allows the students to learn at their own pace as the students can repeat the topics that are hard for them and videos based tutorial will surely help students to learn faster. Lastly, it also encourages students to self-learn as the students can easily access the information of the Calculus online. In this study, we intend to identify the existing recommender system features and recommender techniques. We would like to develop a recommender system to help students revise their Calculus topics.

2. Related work

The recommender system provide personal recommendation of services or item and help on finding relevant item on a large collection of data [5]. The recommender system in present digital world is considered necessary and useful tools. Utilizing various data sources and huge amount of data to predict customer interest is the main goal of recommender system [6]. Since the 1990s, when it is first introduced, many types a recommender system have been developed for e-commerce and it also suitable to be used in educational area.

The recommender system has been proven useful because of the effectiveness as personalization tool in the E-commerce environment. For example, it can increase the revenue of an online shopping as the users are interested to buy recommended items. Recommender systems can be categorized into different categories based on the information needed to make recommendations of products or items to users.

The web recommender has different approach depending on the problem or data that need to be filtered. Each of the method has its own used and functionality. The main technique is, content-based recommendation, collaborative recommendation and hybrid recommendation. Table 1 shows the different of the recommender recommendation approaches.

| Technique               | Features of Item | Other user preferences | Previous History |
|-------------------------|------------------|------------------------|-----------------|
| Content Based Recommendation | ✓                | ✓                      | ✓               |
| Collaborative Recommendation    | ✓                | ✓                      | ✓               |
| Hybrid Recommendation      | ✓                | ✓                      | ✓               |

The features of Item are the meta-content of the item. For example, the meta-content for the Video is the title of the video, tags, and caption. It can be used as a feature of the video. The content-based recommendation technique used this feature to make recommendation. For the other user preferences features, it contains user video history or rating with similar interest with the user. For example, User A and user B like to watch mathematics videos. User B likes to watch science video too, so the system will recommend science video to User A as they have the similar interest, which is mathematics.

The Previous History will be the history of watched video. This is required to implement the recommendation, as it will be counted as user preferences. All of the recommendation techniques used these features. The content-based recommendation has been chosen in this project because of several reasons. One of it is, the result of recommendation tends to be more relevant. This is because content-based recommendations use characteristics and metadata of the objects, so the result of it would be highly relevant to a user’s interests. The algorithm and the data science of content-based system is relatively straightforward and can produce a result without having a cold start problem which is a problem for the other technique as the system needs some initial inputs from users to start making recommendations.
2.1. Techniques in content-based approach

In content-based recommendation approach, there are few algorithms and methods that were used to produce the recommendation by using the user profile and preferences. Some of the methods are Rocchio Algorithm (Relevant Feedback), Decision Tree, Artificial Neural Network, Cluster Analysis, Naïve Bayes Classifier and Keyword-based Vector Space Model [7], [8].

2.2. Youtube API

API also known as application programming interface. It is a set of functions and procedures allowing the creation of applications that could access the features or data from an operating system, application or other services. YouTube can be considered as a huge medium to share video with so many users and video uploaded every day [9]. YouTube API allows developers to access video statistics and YouTube channels’ data. By using YouTube Data API, the users can integrate their program with YouTube. It allows the users to perform many operations such as searching for video, see related content and retrieve standard feeds.

By using the YouTube API, a program can be authenticated as a user to modify user playlists, upload videos and more. Moreover, this type of integration has been widely used for a variety of uses. One of it is for developing a web application to allow users to upload video to YouTube using other program across different platform. Access to user information and videos are given when accessing the data API. Personalizing an application or a website with user’s existing information can be done as well as performing normal activities like rating and commenting in a video. The YouTube API also provides a function that allows the user to search a video based on keyword input. The YouTube API will then return a list of links that is relevant to the keyword.

3. Similar work

Recommender system has been widely used to provide consumers with personalized recommendations based on the user own-profile preference or other user relevant preference. There are several systems that used the same concept of online learning and recommendation system across the Internet. The following is the comparison of all of the system based on several aspects. Table 2 shows the comparison of the system.

| Name                  | Web Based | Type of Recommendation Technique | Video Search | Recommendation function |
|-----------------------|-----------|----------------------------------|--------------|-------------------------|
| Youtube #Education    | √         | Hybrid                           | √            | √                       |
| MathTV.com            | √         | -                                | -            | -                       |
| Internet Archive      | √         | -                                | √            | -                       |
| Teacher Tube          | √         | -                                | -            | -                       |
| WatchKnowLearn        | √         | -                                | √            | -                       |

All systems are web-based system. Only YouTube #Education, Internet Archive and WatchKnowLearn provide video search functions. Only Youtube #Education provide recommendation capabilities which applied hybrid technique.
4. Research methodology
The flowchart is used to illustrate the process or flow of the system. Each of the symbols brings different meaning and has its own operations. Figure 1 shows the flowchart of the Calculus Web Video Recommender system.

![Flowchart of the system](image)

**Figure 1.** Flowchart of the system.
The flowchart illustrates the system will display a list of Calculus topics and the user needs to choose one of the topics. The system then searches the chosen topic through YouTube API. After the system searches the video, a list of video will be displayed to the user. The system will give video recommendation for the video that the user has added to favourite. The system will automatically store the information of the favourite video for future references.

Project architecture is the planned and designed conceptual model of a project. Figure 2 shows the architecture of the Calculus Web Video Recommender system. In this project, the system will display a list of topic for the user to choose. Then, the system will make a query and search the video through YouTube API. Next, the system will save all the search result in a database (in this project, we used SQLite DB) and display a list of twenty videos for the user to watch. The system will start the recommendation function when the user adds a video to favourite video list. A recommendation is made through Content based recommendation technique which uses the video title similarity to make the recommendation.

![System Architecture Diagram](image)

**Figure 2.** System architecture.

### 4.1 Keyword-based vector space model algorithm

Vector Space Model is based on similarity. It is an algebraic model for representing text documents as vectors of identifiers, such as index terms. By using the Keyword-based Vector Space Model Algorithm technique, it allows us to do video recommendation according to its title. When the user adds the video into the favourites video list, the video title will be saved into the database. The system will then use the cosine similarity to calculate the video title similarity and it will be used to recommend another video for the user to watch.

The following are the steps in using the algorithm:

1. Convert the video title into a set of data frame.
2. Calculate and normalize the Term Frequency.
3. Calculate the Inverse Document Frequency.
4. Calculate the cross multiplication between Term Frequency and Inverse Document Frequency.
5. Measure the similarity of the item using cosine similarity.
4.2 YouTube API using Javascript
In order to send a request to YouTube Data API, some steps need to be completed, as it is the prerequisites of the YouTube API, where you need to
- Have a Google account.
- Request YouTube API developer key
- Web server (localhost)

When YouTube Data API is turned on, the next steps are as follows:
1. Create a new project in Google Developers Console and turn on the API.
2. Under Credentials tabs, get the YouTube API developer key.
3. Run the local host web server.
4. Customize the search function so that in return desired information.
5. The YouTube API are now workable can return any video, playlist or link according to the customize filter.

4.3 User interface design
The user interface is the medium between the user and the system. Its goals are to ease the user in understanding the flow of the systems and the design of it must be effective yet attractive enough. The interface of the systems is quite simple as the user only need to choose the topics and video that they want to watch. Figure 3 shows the interfaces of the system.

![Calculus Web Video Recommender Interface](image)

Figure 3. Calculus Web Video Recommender Interface.

5. Results
The Homepage consists of three columns grid as shown in Figure 4. Each of the column has it owns functions. The first column on the left contains a panel that displays all of the Calculus topics. The second column at the centre contains the search fields for the user to search specific video and will return twenty video from YouTube that a relevance to the search key. The third column contains video recommendations panel that display three recommended video for the user to watch based on the three latest user’s favourite video.
The user will be provided with the top three videos on the list. The video has the highest similarity score with the video title. The score is calculated by using the Content-based recommendation technique, which is calculating the cosine similarity of a document or data. In this project, the data that are being used to calculate the similarity is the title. The user can click the “Previous page” button to get back to the earlier list.

6. Discussions
Why online learning has gained much attention from the current students? One of the possible answers is that they cannot pay attention during the class or the lecture session. Instead, their attention alternates between being engaged and non-engaged in a very short cycle throughout a lecture segment [10], [11]. How can we assist them to catch up? Let them study on their preferred time with guidance and proper material. It will encourage self-regulated learning [12]. Self-regulated learning proven to have some positive impact on student academic performance in the subject [13]. Previous study by [14], [15] concentrated on online text material, here, we extend the work by expanding the search on video.

There are some limitations of this project especially on the web system. The first limitation is the result of the searched video is limited. This is because the main page will have a slow response if there are too many video output produced at the same time. So, it needs to be limited into twenty video per search. The second limitation, some of the video cannot be played if the user that posted the video on YouTube does not allow a video playback on other website other than YouTube, however, most of the YouTube video is playable.

Currently, the systems only use YouTube API to retrieve the video that has been searched and requested by the user. However, in the future, other web video API such as Vimeo and Metacafe can be used to increase the number of relevant video for the user. The system can be some kind of a web video aggregator that helps students to search for educational video across multiple platforms of video-sites with ease.

7. Conclusion
We have analyzed the existing system and identify the suitable features and recommendation technique for the project. A recommender system has been developed using content-based recommendation technique. The system used YouTube API to retrieve the educational video and
Keyword-based vector space model to get the video recommendation that are suitable and similar with the video title. This can helps student by reducing the time needed to search for related video as the system can give the video recommendation. Besides that, the student can also save the video into favorites video list and watch the video later when needed.

References
[1] M. Doorman, P. Drijvers, T. Dekker, M. van den Heuvel-Panhuizen, J. de Lange, and M. Wijers, “Problem solving as a challenge for mathematics education in The Netherlands,” *ZDM Int. J. Math. Educ.*, vol. 39, no. 5–6, pp. 405–418, 2007.
[2] A. Bray and B. Tangney, “Technology usage in mathematics education research – A systematic review of recent trends,” *Comput. Educ.*, vol. 114, pp. 255–273, 2017.
[3] M. Abbas, M. U. Riaz, A. Rauf, M. T. Khan, and S. Khalid, “Context-aware Youtube Recommender System,” pp. 161–164, 2017.
[4] T. Ambekar and V. Musande, “A novel approach to personalize the healthcare video search,” *Proc. - 1st Int. Conf. Intell. Syst. Inf. Manag. ICISIM 2017*, vol. 2017-Janua, pp. 212–216, 2017.
[5] Y. Park, “Recommender Systems : An Overview,” pp. 1221–1230, 2010.
[6] F. Mansur, V. Patel, and M. Patel, “A review on recommender systems,” *2017 Int. Conf. Innov. Information, Embed. Commun. Syst.*, no. 1, pp. 1–6, 2017.
[7] D. Asanov, “Algorithms and Methods in Recommender System,” 2011.
[8] L. Zhang *et al.*, “A Personalized E-Learning Based on Recommender System,” *Other Conf.*, vol. 1, no. 2, pp. 417–444, 2015.
[9] M. Brbić, E. Rožić, and I. P. Žarko, “Recommendation of YouTube Videos,” *2012 Proc. 35th Int. Conv. MIPRO*, pp. 1775–1779, 2012.
[10] D. M. Bunce, E. A. Flens, K. Y. Neiles, and U. States, “Study of Student Attention Decline Using Clickers,” *J. Chem. Educ.*, vol. 87, no. 12, pp. 1438–1443, 2010.
[11] N. A. Bradbury, “Attention span during lectures: 8 seconds, 10 minutes, or more?,” *Adv. Physiol. Educ.*, vol. 40, no. 4, pp. 509–513, 2016.
[12] N. L. Adam, F. B. Alzahri, S. Cik Soh, N. Abu Bakar, and N. A. Mohamad Kamal, “Self Regulated Learning and Online Learning: A Systematic Review,” in *Advanced in Visual Informatics*, 2017, pp. 143–154.
[13] Z. Sun, K. Xie, and L. H. Anderman, “The role of self-regulated learning in students’ success in flipped undergraduate math courses,” *Internet High. Educ.*, vol. 36, pp. 41–53, 2018.
[14] N. L. Adam, M. A. Zulkafi, S. Cik Soh, and N. A. Mohamad Kamal, “Preliminary Study on Educational Recommender System,” in *IEEE Conference on e-Learning, e-Management and e-Services (IC3e 2017)*, 2017.
[15] N. L. Adam, M. A. Zulkafi, and S. Cik Soh, “Personalized Recommender System for Calculus using Content-Based Filtering Approach,” *Int. J. Eng. Technol.*, vol. 7, pp. 110–113, 2018.