Analysis of Book Preferences Among Visitors in Library System

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Abstract **– Library is a place that contains various resources and materials. Many invaluable knowledge can be found in the library. By analysing the library's data, it is possible to obtain information that can further improve its services. This research aims to extract information from Multimedia University (MMU) library and present insightful visualization of the information to enhance the library administration. At present, the library does not have information on the book preferences of the library users. The book preferences statistics can be relatively helpful as the library will know what books can be imported in the future. By doing so, more people will visit the library and they will have more related books to use as reference or to read. In addition, there are no existing dashboards to display information on all borrowers, no visitor. In the absence of this, this research adopts the data science methodology to determine the book preferences of library users by using machine learning techniques such as clustering and classification. Lastly, a dashboard will be developed to display all the findings which includes statistics on the visitors and book preferences.**

Keywords **– Library, book preferences, analysis, recommender system, dashboard.**

DOI: 10.18421/TEM131-44
https://doi.org/10.18421/TEM131-44

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Received: 24 September 2023.
Revised: 29 December 2023.
Accepted: 19 January 2024.
Published: 27 February 2024.

1. Introduction

Different type of libraries ranging from national libraries to community and private libraries can be seen in many places in different countries, people often visit the library to read books or find information that they need. Most universities have their library which allows university students and staff to have a place to spend time, read books or loan various books if they wish to read them at home. People can save up money for other purposes while still able to gain and strengthen the knowledge that they are interested in since borrowing from the library is completely free as long as it is returned before the due date.

A large number of people will visit the library every year, thus there will be a huge amount of data collected. Without the use of technology, it can be difficult to derive useful insights from the data since it is very large and might contain missing values or inconsistencies. This research aims to study and analyse demographic details of the visitors of Multimedia University (MMU) library, to predict or determine book preferences of the visitors of MMU library and create a dashboard to display all the findings. By analyzing the data, useful information such as the demographic details of visitors and book preferences can be obtained. The data can also be used to predict what are the possible future book preferences of the visitors so that the library can import it accordingly. With the help of these insights, the number of people that will go to MMU library will increase and they will be happy as they are able to find more books that they like to read and gain more knowledge.

2. Literature Review

In this section, there will be background studies and literature review on works done by other people that are related to this research. Besides, there is also a table that summarizes all the methods along with their advantages and disadvantages.

2.1. The Role of Machine Learning in Library System

Organisations widely use machine learning to perform predictions and classifications [1], [2]. Machine learning is also used on library data to obtain useful information.

Zhu and Zhang [3] used Decision Tree C4.5 algorithm to find out factors that are restricting users from using digital library resources and analyse university library users' needs effectively. Decision trees are a supervised learning method for classification and regression. It is a tree map of possible outcomes through a series of related choices and predicts the best choice based on their cost, benefit, and probability. In [4], several tree classification methods were employed. A survey was conducted on 200 university students' library usage, and the data was used to determine the correlation between features and outcome. The methods used were decision tree, random forest, cross-validation and bootstrap aggregating. These methods were tested with various parameters, and the elimination method on features was used to find the best prediction parameters. The result indicated that using the random forest method would be the best choice.

Besides decision tree methods, clustering methods were frequently used in most research. In [5], K-means algorithm was used to cluster the borrowing books data and analysed the clustering characteristics of readers and books. The category and sample count in the K-means clustering technique are often arbitrarily determined. The Euclidean distance equation may be used to determine the similarity distance between the samples and the data. One of the findings of this result is that book categories like computer technology, Chinese literature and art have a high utilization and borrowing rate, yet low collection volume. As such, this library can increase the purchase quantity of these categories of books.

2.2. Application of Big Data Technology

Big data refers to a dataset that includes structured, semi-structured, and unstructured data that is large and diverse. It is beyond the ability of traditional databases to handle these data with low latency. Big data technology means using professional algorithms to get useful insights from huge amounts of data. The larger the data, the more useful information can be obtained during analysis.

In [6], the research promotes big data application in academic libraries. It analyses the plight of library big data applications and proposes a library big data model based on large-scale network analysis methods. The library data contains the characteristics of big data as it includes various data formats, such as structured and unstructured data.

Besides that, paper [7] also mentioned that although a huge amount of library data has been digitalized, big data technology was not used on them. Big data technology can be handy when it comes to making full use of library data and extracting helpful information. This paper aims to review the research that has used big data technology in libraries to provide a basis for further work in the future. Some of the big technology methods mentioned are analyzing data for decision-making, integrating online resources, data standardization and modelling, data visualization and user behaviour study.

2.3. Application of Exploratory Data Analysis

Exploratory Data Analysis (EDA) involves investigating and analyzing data to uncover meaningful patterns and conclusions. The insights obtained from performing data analysis are effective towards decision-making [8]. The exploratory data analysis process includes data collection, transformation, cleaning, examination, and modelling.

Study [9] has researched information technology services for aged library users. The authors used questionnaires and actual interviews to gather data to conduct the research. After analyzing the data, they know the demographic of elderly library users, the frequency of elderly users visiting the library, their purpose, and their concerns about library information. Furthermore, [10] used EDA to determine university students' reading habits and medium preferences. The result revealed that printed materials for academic-related activities are still much preferred by students since printed materials enable more concentration, while digital material could be distracting and cause eye strain.

Studies [11] and [12] focused on performing analysis using social media data to understand more about the public needs of public and community libraries. Data was collected through online questionnaires with users and visitors of a public library and also through social media [11]. Furthermore, interviews were also conducted with the librarians from the same library. The data collected are then analysed and calculated to examine how the library was affected by the COVID-19 pandemic. The statistics of the responses are presented in the result section. Their research has summarized several considerations to determine where and how to build library in places that are deficit in cultural infrastructure. It also suggested how libraries should go according to users' needs during a pandemic.

2.4. Book Recommender System

A recommendation system contains algorithms that are created to suggest relevant items to users. Some of the applications of it are recommending products to buyers, generating playlists for music and video services, and content recommendations for social media platforms like Facebook, Instagram, and Twitter. A book recommender system recommends similar books to users based on their interests. It is widely used in libraries and e-bookstores to allow library users and buyers to find more books they like.

2.5. Collaborative Filtering (CF)

Collaborative filtering (CF) technique is commonly used in a recommender system. The two classes of collaborative filtering are user-based and item-based. User-based means the similarity between users while item-based refers to the similarity between the similar users rated items. User-based collaborative filtering (UBCF) was used by [13] in their recommendation system to recommend books to a user based on similarity measures. The dataset is 'Goodreads-books', which was obtained from Kaggle. The dataset contains the book names, authors, and titles along with their ratings. The proposed methods then represent the user-related data as a list of numerical ratings in a user-item matrix. It then computes the similarity matrix for every user, getting the k nearest neighbors of a target user and generates a matrix of candidates, calculates the predictive scores, and generates the top n recommendations.

In addition, paper [14] proposed a book recommendation system combined with content-based filtering (CBF) technique to produce more effective recommendations. CBF is used to separate and filter books from one another based on the content while CF is used to suggest based on the quality of the book by considering multiple parameters like ratings. By combining both of these methods, the book recommendation system will be able to suggest better choices to library users.

Besides that, [15]'s collaborative filtering book recommendation system targets students who have never borrowed books from the library. The research aims to solve the cold start problem of target users without records in the recommendation system as it could not provide any book recommendations to them. The paper has compared the result of using different parameters in the algorithm and Jaccard similarity performs the best compared to Euclidean distance and cosine similarity algorithms.

Apart from that, the author of study [16] applied a time sequential collaborative filtering technique to their personalized book recommendation system.

The algorithm takes in two parameters, books borrowing time sequence information and its circulation time. A cold start problem often exists in a recommendation system which is the system that could not recommend items to a new user with no records. To solve this problem, the author added a corresponding processing module into the system and the dataset will be books that students from the same major as the targeted users first borrowed. This is because the personalized recommendation system also took students' learning trajectories into account. The result has shown that the system satisfy college students' needs in learning.

2.6. Other Methods

Besides collaborative filtering, other algorithms are used in recommender systems. For instance, the Upper and Lower-Level Relations Model (ULLRM) was used by [17] to build a book recommender system which is based on the Chinese Library Classification method. The ULLRM method was used to determine library users' potential interests by analyzing their behaviours. They also combined Dominant and Recessive Feedback Methods (DRFM) to constantly update the database of users' interests, which can change occasionally. From the result of this research, it can be concluded that the algorithms used did help to improve the accuracy of the system.

Besides that, [18] conducted a study to analyse different algorithms used in the book recommendation system. This paper has discussed existing methods like collaborative filtering, content-based recommendation system, matrix factorization and logistic regression. Moreover, it has also mentioned some new techniques such as AutoRec, Deep Crossing, and Deep Domain Recommendation, neural collaborative filtering, reinforcement learning, and few-shot learning. The author included both advantages and disadvantages in the paper for all the new and old methods mentioned earlier.

Next, some papers researched book recommendation systems using the apriori algorithm. Finding a way to utilize the material in a library fully is a common problem in most libraries [19]. To solve this problem, the authors generated reports by performing descriptive analysis for the library data and applied an apriorism algorithm for book recommendations [20]. Finally, [21] implemented an apriori algorithm in the book recommendation algorithm along with data cleaning. This is due to uncleaned data that will produce outliers and it can significantly increase the running time of the apriori algorithm. Moreover, the apriori algorithm will filter the item set and transaction set, reducing the number of items to be analysed. This will save time and memory as well as have a huge improvement.

3. Methodology

The methodology that will be used in this research is the data science methodology, which is shown in the flowchart below. The data science process involves data collection, cleaning, analysis, modelling and visualization as depicted in Figure 1. Firstly, data will be collected from different sources. In the research, the data will mainly be obtained from the library. The data will then be pre-processed and cleaned. Then, data analysis and data modelling will be performed. Finally, the results will be visualised for better understanding.

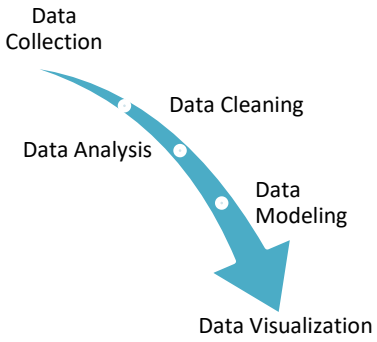

Figure 1. Flowchart of proposed data science methodology

3.1. Data Collection

Data collection is gathering data from different sources to perform other procedures later on. Data can come in structured, semi-structured, and unstructured forms. Structured data has a predefined format and is easily organizable. One example of structured data is relational data. Unstructured data comes in various formats: images, audio, and video. Semi-structured data has some defining characteristics but is less rigid than a relational database. Some examples of semi-structured data are emails, XML, and other markup languages.

3.2. Data Cleaning

Data cleaning is an important process as the quality of data will affect the results obtained. Data often comes in an unorganised state. There will be inconsistent, incomplete, and duplicate data. The presence of outliers tends to affect the model's performance as well. At this stage, the data obtained will need to be processed accordingly for further analysis. The data pre-processing stage involves data cleaning, integration, and transformation. Data cleaning deals with missing values, inconsistencies and outliers, while data integration combines different data from multiple sources. Lastly, data transformation is a technique to transform raw data into usable data for modelling. It is done to ensure the computer treats all of the variables equally.

3.3. Data Analysis

Data analysis aims to find out useful information from the dataset. In this stage, the dataset will be analysed, and as many insights as possible that can be helpful will be extracted. The technique that will be used during this stage is exploratory data analysis (EDA). Performing EDA can help identify errors, detect outliers, and better understand the patterns within the data before proceeding with the rest of the analysis.

3.4. Data Modelling

Data modelling is a stage where machine learning algorithms will be used to make predictions on a particular dataset. This includes building models and pattern mining. After pre-processing the dataset, it will be split into two sets: the training and test sets. A training set is used to train a model, while a test set is used to test the trained model. The commonly used ratio of the training and test set is 80:20 but 70:30, 60:40 and even 50:50 can be used too.

Two categories of machine learning techniques exist: supervised and unsupervised. Supervised learning relies on labelled data to predict outcomes for new data. Some examples of supervised learning are classification and regression. Common types of classification algorithms are decision trees, support vector machines, and random forests. The common ones for regression are linear and logistic regression. On the other hand, unsupervised learning analyses and clusters of unlabeled data. It is mainly used for dimensionality reduction, clustering, and association. Some examples of unsupervised learning are hierarchical clustering, k-nearest neighbours, principal component analysis, and association rule mining.

3.5. Data Visualization

Visualization will come in handy when presenting the results. After performing all the analysis and modelling, the results will be displayed using graphs and charts for better and easy understanding. In Python, many powerful libraries can be used for visualization. Some of them are 'seaborn', 'matplotlib', 'plotly', and 'ggplot'. These libraries allow users to create bar charts, line charts, boxplots, scatter plots, heatmaps, and histograms with just a few lines of code. The process is fast and easy to pick up.

3.6. Implementation

The main programming language used in this research is Python. Python provides many powerful libraries that can be used in the analysis.

Packages like 'numpy' and 'pandas' are useful for the pre-processing part of the dataset. Jupyter NNotebook and VSCode will be used as the main integrated development environment (IDE) of this research. Jupyter Notebook provides code and markdown cells which users can code and explain in detail. It is also very convenient as you can run the cells one by one and see the output accordingly. Meanwhile, VSCode is an IDE that supports multiple programming languages such as Python, HTML, PHP, Java, C++ etc. Moreover, 'Dash', a PPython open-source library will be used to create the main dashboard to visualize all the findings of this research. In the beginning, the dataset will be checked for null values and duplicates. After the datasets are cleaned, additional columns will be added accordingly. For instance, calculating the age, classifying the study level according to their program, and identifying the races of the library users. Besides that, the book titles are cleaned by removing the author's name, stopwords, and punctuation to perform clustering. Some of the titles like the name of the library reading area will be removed since it is not needed.

After cleaning the titles, it is passed into the TF-IDF vectorizer to transform into a meaningful number representation. A popular approach for determining a word's relevance to a document within a collection of documents is called TF-IDF, or Term Frequency Inverse Document Frequency. The process of TF-IDF involves multiplying the number of times a word occurs in a document by the inverse document frequency of that same term throughout the corpus. A line plot is plotted to find out what is the best k-value that can be used for the clustering. The ideal k-value is 5 and the transformed title values are passed into the K Means clustering model.

Besides that, an algorithm is written to categorize the books into categories. This machine learning method is referenced from a GitHub user named akshaybhatia10. The purpose of this method is to classify books based on only titles. An existing book dataset 'book32-listing.csv' is used. This dataset contains 207,572 books from amazon.com in 32 categories. It also contains the book cover image, title, author, and category. Logistic regression, one of the common supervised learning techniques, is used as the predictive model for this classification. SVM and multinomial naïve Bayes were tested but the results are not as good as compared to logistic regression. The x and y variables are split into a training set and a test set. 60% of the data will be used as the training set while the remaining 40% will be the test set. Train and y_train are then passed into the logistic regression model for training. The accuracy of this model is about 63%.

An example text 'Python programming for beginners' is passed into the predictive model and the category returned is 'Computers & Technology'.

4. Results

In the following section, the result of each part will be discussed. This includes results for visitor analysis, book borrowing analysis, and book recommendations. Charts will be included to aid in the explanation

4.1. Visitor Analysis

There are a total of six charts from the MMU library visitors' analysis. From Figure 2, it can be seen that most of the library users are in the age group of 19 to 21. This is most likely due to students who tend to pursue tertiary education after getting their SPM results which is during the age of 18 to 19. Figure 3 shows that the Chinese race has the highest number of visitors and foreigner has the lowest count. Most of the MMU library users are from Selangor and second are from Melaka. This is due to MMU's campuses.

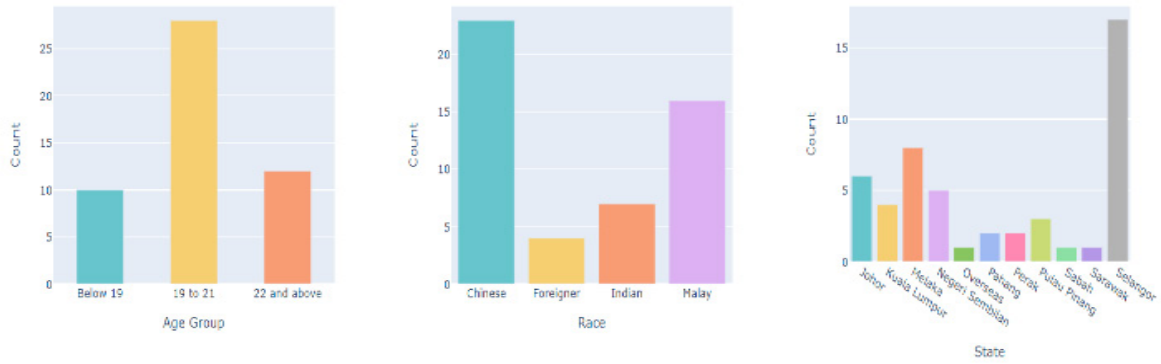

Figure 2. Chart for visitor analysis

According to study level (Figure 3), most of the MMU library users are currently studying degree programs while diploma students have the lowest count. Next, the Faculty of Information Science & Technology (FIST) has the highest number of library users.

Faculty of Computing & Informatics (FCI) and Faculty of Creative Multimedia (FCM) rank second. Lastly, most of the library users are from the Cyberjaya campus.

Figure 3. Chart for campuses analysis

4.2. Book Borrowing Analysis

Moving on to the results of the analysis of the book borrowing data. Figure 4 shows that most of the books are borrowed from MMU Melaka Library and MMU Cyberjaya Library since they are MMU's main campuses.

Academics such as lecturers and professors tend to visit the library to borrow books more often. Many undergraduate students also borrow books or materials related to their major to help them in their studies. Overall, MMU staff borrows more than the students.

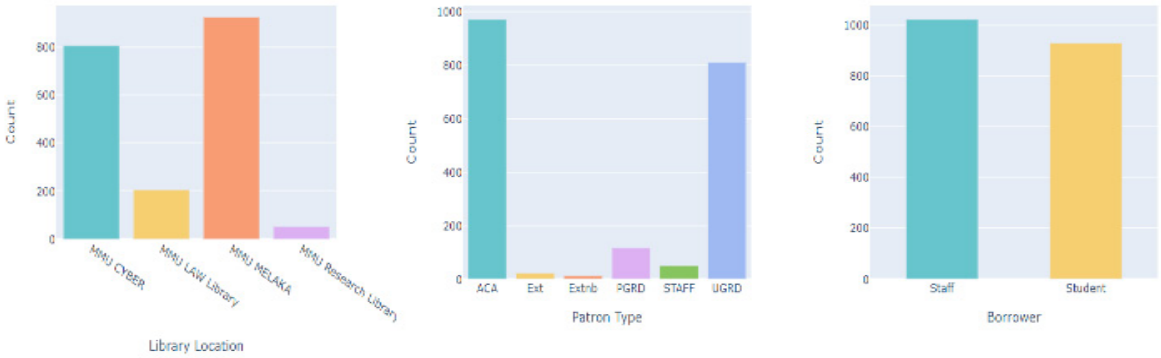

Figure 4. Chart for book borrowing analysis

Next, is the analysis result on the book categories as shown in Figure 5. The chart below shows the top 5 most borrowed book categories. Books in the category of 'Computer & Technology' has the highest count indicating that these books are most frequently borrowed by library users. The subsequent rankings are books in the 'Business & Money' category, 'Science & Math' category, 'Law' category and 'Politics & Social Sciences category. Besides that, the next chart shows which faculty the book borrower belongs to. Faculty of Business (FOB) has the highest number of borrowers followed by Faculty of Computing & Informatics (FCI), Faculty of Law (FOL), Faculty of Engineering (FOE) and Faculty of Information Science & Technology (FIST).

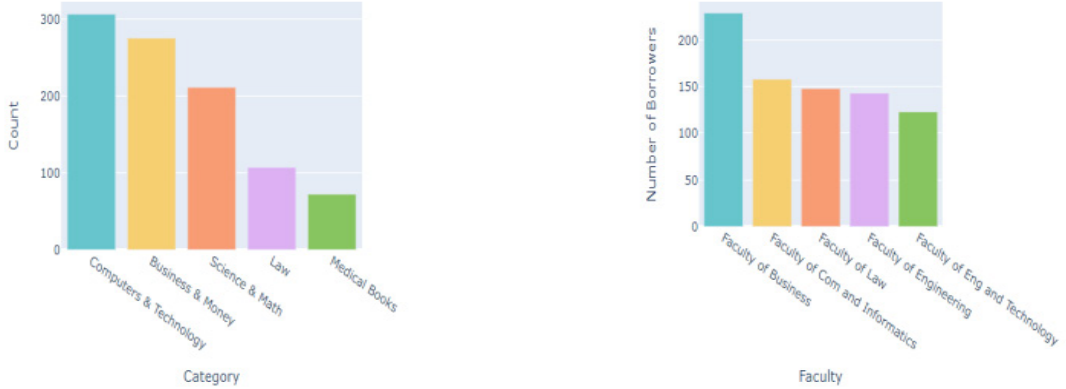

Figure 5. Chart for book category analysis

The next part of this analysis is the top 10 borrowed books for the 4 categories with the highest book borrowed count (Figure 6). The most borrowed book for the Computers & Technology category is 'Discovering Statistics Using IBM SPSS Statistics' by Andy Field followed by 'Machine Learning: An Algorithm Perspective' by Stephen Marsland. For the Business & Money category, the most borrowed book is "Basic Econometrics" by Damodar N. Gujarat followed by "Issue and Crisis Management: Exploring Issues, Crisis, Risk, and Reputation" written by Tony Jaques. Moving on to the next category which is Science & Math, the most borrowed book is "Statistical Rethinking: a Bayesian Course with Examples in R and Stan" by Richard McElreath and Max Planck Institute. "Shipping Law" by Simon Baughen and "Unjust EEnrichment in Commercial Law" by Simone Degeling and James Edelman are the most borrowed books for the last category of Law.

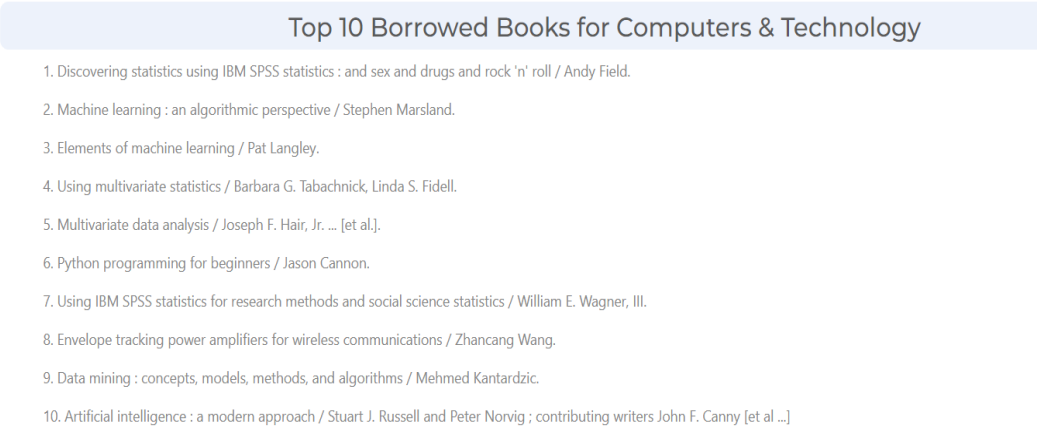

Figure 6. Top 10 most borrowed books for the Computers & Technology category

Moreover, there is a section showing the results of clustering the book titles. A total of 5 clusters have been displayed in the dashboard (Figure 7). Cluster 1 contains keywords like applications, circuits, and signals. Cluster 2's keywords are research, methods, and business. As for Cluster 3, the main terms are communication, handbook, and essentials. Next, engineering, tribology, and science are from Cluster 4. Lastly, for Cluster 5, the keywords are management, resource, and issues.

Figure 7. Clusters of the book titles

The last part of this dashboard is a word cloud. The larger the size of the term indicates there are more occurrences for that particular term. From Figure 8, we can see that the word 'research' appeared the most among the book titles, followed by 'guide' and 'method'. There are also books related to 'business', 'law', 'analysis', and 'introduction' which means introductory books.

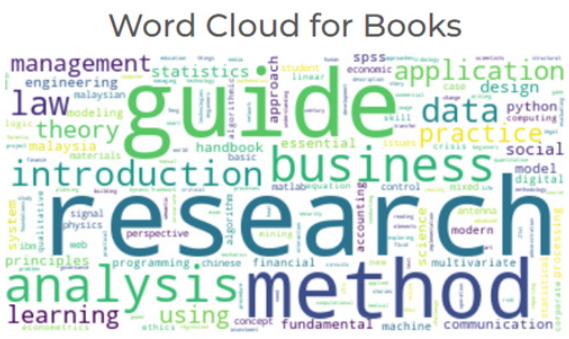

Figure 8. Word Cloud of the book titles

4.3. Book Recommendations

The third section of the dashboard is the book recommendations (Figure 9 and Figure 10). It will recommend similar or related books to a user based on the search term entered. In this case, the search term used is 'calculus'. Book data will be obtained from GoodReads and Amazon. There are a total of 20 books with 'calculus' in their book title, as well as their respective ratings. Both of the results will then be combined into one single data frame. The analysis will be performed on the book's data. Duplicated books will be removed from the data frame. Finally, the top 10 related books with the highest ratings will be returned. The figures below show the result displayed on the dashboard. One uses the search term 'calculus', and the other uses the search term 'python'. It can be seen that the recommendation function has returned relevant books. A total of 9 books are displayed to the user.

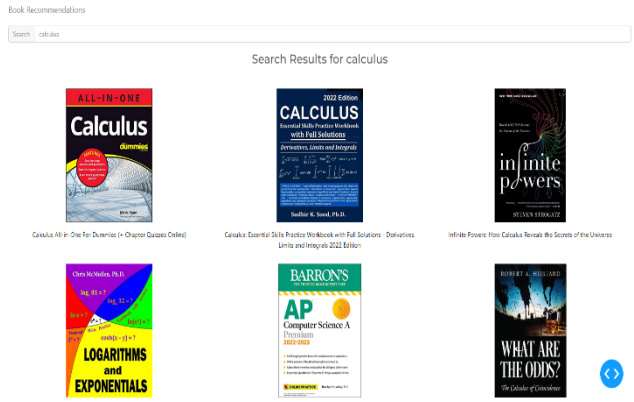

Figure 9. Part of the book recommendations for term 'calculus'

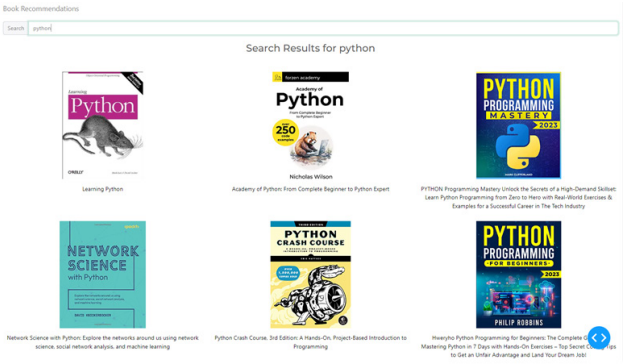

Figure 10. Part of the book recommendations for term 'python'

5. Conclusion

By conducting this research, useful information is obtained by analyzing the library data and these statistics can improve the library service as well as the experience of library users.

For the first part of the dashboard, the results of visitor demographic details analysis can be seen. As for the result for book borrowing analysis, most of the book borrowers are undergraduates and academians. Linear SVC was used to classify the book titles into categories. 'Business & Money' and 'Computer & Technology' are the categories that library users often borrow. Moreover, most of the books borrowed contain the word 'research' in it. Top 10 most borrowed books section was included to give more insights about the data. Some of the limitations of this research is that the system can only analyse one file at a time and if the page is switched the previous result will be gone. The accuracy of the classification model can be further improved. Lastly, the possible future work for this research is to connect the system to a database so that the results can be saved and viewed anytime.

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