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Research Paper

Data Mining: A Book Recommender System Using Frequent Pattern Algorithm

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ABSTRACT: *The increasing power of computer technology has dramatically increased data collection, storage, and manipulation ability. As data sets grow in size and complexity, direct "hands-on" data analysis has increasingly been augmented with indirect, automated data processing.*
Over the years, libraries in universities and other educational institutions have gathered a lot of data on books borrowed by students, yet the valuable knowledge embedded in these data has remained untapped.
In many cases, students do not find required books in the library or probably the books have been borrowed by some other students. There are even a lot of books that have never been read by students. In many other cases, library management are faced with the challenge of what book to buy that would maximally benefit the students, and also how to place these books in shelves. There is therefore an urgent need for systems that can help the library management make informed decisions so as to address these issues.
This paper presented a book recommender system that mines frequently hidden and useful patterns from the book library records and make recommendations based on the pattern generated using associated rule mining technique. Data pre-processing and analysis was carried out using frequently pattern growth algorithm to generate frequent patterns.
Keywords: *Data Mining, Association Rule. Frequent Patterns, FP-Growth, Recommender system*

I. INTRODUCTION

The manual extraction of patterns from data has occurred for centuries. Early methods of identifying patterns in data include Bayes' theorem (1700s) and regression analysis (1800s). The proliferation, ubiquity and increasing power of computer technology has dramatically increased data collection, storage, and manipulation ability. As data sets have grown in size and complexity, direct data analysis has increasingly been augmented with indirect, automated data processing, aided by other discoveries in computer science, such as neural networks, cluster analysis, genetic algorithms (1950s), decision trees (1960s), and support vector machines (1990s). Data mining is the process of applying these methods with the intention of uncovering hidden patterns in large data sets. It bridges the gap from applied statistics and artificial intelligence to database management by exploiting the way data is stored and indexed in databases to execute the actual learning and discovery algorithms more efficiently, allowing such methods to be applied to ever larger data sets.

Generally, data mining (sometimes; called data or knowledge discovery) is the process of analyzing data from different perspectives and summarizing it into useful information that can be used to increase revenue, cut costs or both. Data mining software is one of a number of analytical tools for analyzing data. It allows users to analyze data from many different dimensions or angles, categorize it, and summarize the relationships identified. Technically, data mining is the process of finding correlations or patterns among dozens of fields in large relational databases. Library sometimes waste a lot of money stocking unwanted books, so there is a need to find solution to such a waste brought about the application of association rule mining in library management. Association rule mining is an effective data mining technique to extract interesting patterns from transactional databases. This technique is usually used for market analysis that is to find out which items are purchased together, so that the management will be able to make effective decisions. It can also be applied in schools for mining of data such as books borrowed in library e. Other important aspect of association rule mining is

frequent pattern mining which can be used to generate the frequent patterns of data fields in relational and transactional databases.

Recommendation engines, in simpler terms are programs that are data intensive and involve complex pattern matching on a set of predefined parameters and they become efficient with the increase in the size of the content being fed to them. Recommender systems represent user preferences for the purpose of suggesting items to purchase or examine. They have become fundamental applications in electronic commerce and information access, providing suggestions that effectively prune large information spaces so that users are directed toward those items that best meet their needs and preferences. This paper therefore applied association rule mining technique to generate frequent patterns that serves as a recommender for the University's library data.

Statement of the problem

Library provides an essential element for the betterment and progress of the student career. We have often heard of cases whereby students do not find required books in the library or probably the books have been borrowed by some other students while other books are there that have never been borrowed. The three basic challenges are as follows:

- Insufficiency of some books in the library
- Difficulties in finding required books
- Redundancy of some books in the library i.e. the level of usage is low.

Objective of the Study

Themain objective of this paper is to design a system that mines frequent patterns of borrowed books and serve as a recommender of borrowed books in the library for the librarian and the users.

The specific objectives are to:

1. design a system that will generate frequent patterns of borrowed books using the Frequent Pattern growth algorithm and

2. use the patterns generated to recommend books to the librarian and the users.

Significance of the Study

Mining of useful patterns of the library's data would enable the management of books in the University library to be more efficient, resourceful and also assist the management make informed decisions about the demands of students.

II. LITERATURE REVIEW

Human history has shown that man is always interested in finding patterns from data since the beginning of life [1]. Data mining has a long history, having really strongroots in statistics, artificial intelligence, machine learning, and database research [2].

The manual extraction of patterns from data has occurred for centuries. Some early methods of discovering hidden patterns in data include Bayes' theorem (1700s) and regression analysis (1800s).

The increasing power of computer technology has dramatically increased the rate at which data is been collected, stored, and manipulated. As these data sets have grown in size and complexity, direct "hands-on" data analysis has increasingly been augmented with indirect, automated data processing which was aided by other discoveries in computer science, these discoveries include neural networks, cluster analysis, genetic algorithms (1950s), decision trees (1960s), and support vector machines (1990s). Data mining is the actual process of extracting hidden predictive information from large databases [3].The data collected from different applications requires proper mechanism of extracting knowledge and information from large repositories for better decision making. This is also known as knowledge discovery in databases (KDD) [4]

Association rule mining

Association is the discovery of association relationships or correlations among a set of items. This problem was introduced in [5]. It aims to extract interesting correlations, frequent patterns, associations or casual structures among sets of items in the transaction databases or other data repositories. Association rules are widely used in various areas such as telecommunication networks, market and risk management, inventory control etc. [6]. Over the last several years, the problem of efficiently generating large numbers of association rules has been an active research topic in the data mining community [7]

Mining for association rules can help in business decision making, and the development of customized marketing programs and strategies [8],

Generally according to [6], an association rule mining algorithm contains the following steps The set of candidate k itemsets is generated by 1-extensions of the large (k 1)item sets generated in the previous iteration.

- Supports for the candidate k itemsets are generated by a pass over the database.

- Itemsets that do not have the minimum support are discarded and the remaining itemsets are called large k itemsets.

This process is repeated until no larger itemsets are found

III. EDUCATION RULE MINING

The education domain offers a fertile ground for many interesting and challenging data mining applications. These applications can help both educators and students, and improve the quality of education [9]. There are increasing research interests in using data mining in education. This new emerging field, called educational data mining, concerns with developing methods that discover knowledge from data originating from educational environments [10].

Educational data mining is an interesting research area which extracts useful, previously unknown patterns from educational database for better understanding, improving educational performance and assessment of the student learning process [11].

Related works on educational data mining

[12] extracted useful knowledge from graduate student's data collected from the college of Science and Technology – Khanyounis. The data included fifteen years' period [1993-2007]. After preprocessing the data, they applied data mining techniques to discover association, classification, and clustering and outlier detection rules. In each of these four tasks, they presented the extracted knowledge and describe its importance in educational domain.

[13]used the data mining processes, particularly classification, to help in enhancing the quality of the higher educational system by evaluating student data to study the main attributes that may affect the student performance in courses. [14] analyzed the potential use of one of the data mining technique called association rule mining in enhancing the quality of students' performances at Post Graduation level. They mined association rules to reveal various factors like student's interest, curriculum design; teaching and assessment methodologies that can affect students who have failed to attain a satisfactory level of performance in the Post-Graduation level.

[15]described how to apply the main data mining techniques such as prediction, classification, relationship mining, clustering, and social area networking to educational data.

[16] demonstrated a data mining tool that uses association rule mining and collaborative filtering in order to make recommendations to instructors about how to improve e-learning courses. This tool enables the sharing and scoring of rules discovered by other teachers in similar courses.

[17] used the classification task on student database to predict the student's division on the basis of previous database. As there are many approaches that are used for data classification, the decision tree method was used here. Information's like Attendance, Class test, Seminar and Assignment marks were collected from the students' previous database, to predict the performance at the end of the semester.

[18] used the CHAID prediction model to analyze the interrelation between variables that are used to predict the outcome on the performance at higher secondary school education. The features like medium of instruction, marks obtained in secondary education, location of school, living area and type of secondary education were the strongest indicators for the student performance in higher secondary education

Educational rule mining application in the library

Library is a source of all knowledge and learning. Libraries are also generating large volume of data, but data mining techniques have to be used for dynamically analyzing the library database and to make strategic decisions for managing the library in an efficient manner. Library provides an essential element for the betterment and progress of the student career. It enables the students of a college/university to get updated in the academic subjects. Mining in educational environment is called Educational Data Mining, it is concerned with developing new methods to discover knowledge from educational databases like library, sports, health etc. Library management is concerned with the management of resources which basically includes books, manuscripts, journals etc. and providing effective and efficient services to its users. Since management of books manually and other resources in a library and keeping track of every books of the library accessed by the user is tedious job and hence often technological support is expected [19]. Further, to keep track of the books issued and returned across the counters, journals, periodicals and manuscripts consulted by the users and so on needs additional book keeping on additional parameters and are generally not done in a typical library which operates manually. The situation becomes acute when the library does procurement of resources.

Over the past few years' library professionals have been trying for the integration of data mining in different library and information services called bibliomining by [20].

Application of association rule mining techniques allows strategic decisions to be taken for library management. [21] worked on library management system using association rules where they clearly explained

the modules involved in the mining [22] used an association rule mining technique in finding relationship between the most frequent books that are taken by the students for a particular semester based on the conditions of stipulated time period and maximum books issued. [23] also made use of the data mining association rule to analyze the books of the same cluster borrowed by the students.

[22] also explored the hidden information in the database of a digital library using an association rule mining technique. [24] applied data mining technologies in the development of a Library Decision Support System (LDSS) to aid in the library management's decision making It can also be used to analyze student's trends and behaviours towards particular subjects when in-close with examinations [22] with information deep and enough on management in library maintenance system will provide the student's to achieve quality objectives in their academic curriculum, data mining methodology when used in Library Management can help bridging this knowledge gaps in higher education system.

[25] proposed a method of applying Apriori association rules to classify and analyze library circulation data. He studied the circulation data collecting, processing and classifying methods and analyzes the actual circulation data of NLC from 2012 to 2014 with the java programs. Finally, some suggestions for improving the service quality and meeting the readers' reading requirements are given through the analysis results

[26] provided a recommendation system architecture to promote digital library services in electronic libraries. In the proposed architecture, a two-phase data mining process used by association rule and clustering methods is designed to generate a recommendation system. The process considers not only the relationship of a cluster of users but also the associations among the information accessed.

[27] made use of association rule algorithm to explore the relationships in data preprocessing finds some circulation rules about literature books and language books, etc. Through analyses a conclusion was drawn from the perspective of providing a useful reference for management, which is very helpful to guide the students' reading behavior

IV. RECOMMENDER SYSTEMS

Recommender Systems (RS) are software tools and techniques providing suggestions for items to be of use by the user. Recommender systems have evolved since the early 1990's as a response to increasing information overload. These systems help users to identify a subset of items within a large information space. Unlike ordinary keyword search systems, recommenders attempt to find items that match user tastes and the user's sense of quality [28].

There are various types of recommendation techniques which include;

- Content based recommendation [29].
- Collaborative based recommendation [30]
- Demographic based recommendation [31]
- Knowledge based recommendation [32].

Related book recommender systems

[33] proposed a book recommender system that uses content based approach for recommending item to a particular use. In the approach they embedded a new
dimension called temporal dimension using a counter for each item which gets update withpassage of time and thereby improving the whole recommendation process.

[34] proposed a recommendation using collaborative filtering hybrid to increase the efficiency of algorithm. Item-based collaborative filtering algorithm form the association between item to item. Pearson's correlation algorithm was used to determine the association between user to user, so the hybrid algorithm of this techniques guide to personify the result of recommendation.

[35] discovered a variety of approaches to recommendation in the library domain that have been attempted, the prevalence of systems in public access catalogues remains low. This suggests that library professionals remain to be convinced that such systems offer enough value to users to justify their implementation

[36] gave a comprehensive and critical review of the literature on recommender systems. A classification mechanism of recommender systems is proposed. The review paid attention to and covers the recommender system algorithms, application areas and data mining techniques published in relevant peer-reviewed journals between 2001 and 2013

[37] presented MyMediaLite, a versatile library of recommender system algorithms for rating and item prediction from positive-only feedback. MyMediaLite is currently one of the most complete free/open source recommender system frameworks in terms of recommendation tasks, implemented methods, efficiency, features, flexibility, and documentation.

V. METHODOLOGY

Data mining is an integral part of Knowledge Discovery in Databases (KDD), which is the overall process of converting a series of transformation steps, from data preprocessing to post-processing of data mining results. Figure 1 below shows the process of knowledge discovery in databases.

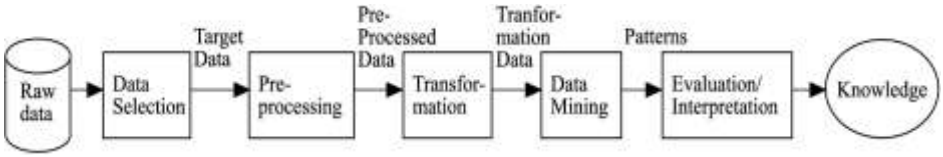


Figure 1: Process of knowledge discovery

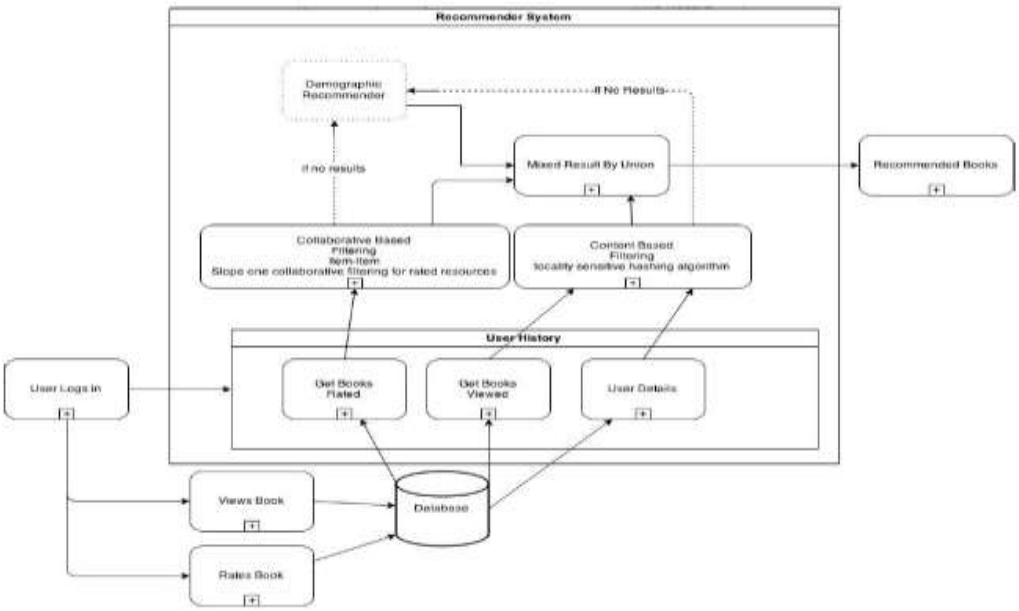


Figure 2: Framework of Recommender System [38]

Data Gathering and Description

This actually states how data used was studied, collected and organized. The main aim of the project was to see relationships between students and the books in the library and as such discover the hidden patterns in them which enabled the recommender system built make informed decisions.

The data were collected from the book of records of an online Library book of records. The data consisted of records of attributes such as student no, book no, book name, borrowed book, date borrowed etc.

Different analysis was carried out on the data to discover hidden and important patterns which greatly assisted the library staff in making informed decisions about the needs of student and staff concerning the books really needed in the library.

Data Pre-processing

The data was collected from the online library book of records. The data collected consist of the date books were borrowed, the books borrowed, frequency of the books and books borrowed together.

During data collection, the relevant data was gathered. Once the data has been assembled, its quality must be verified. Incomplete (lacking certain attributes of interest, or containing only aggregate data), noisy (containing errors, or outlier values that deviate from expected), and inconsistent (for example, discrepancies in the codes used to categorize items) Data cleaning routines attempt to clean the data by filling in missing values; smoothing noisy data, identifying or removing outliers, and resolving inconsistencies. Finally, the cleaned data are transformed into a format suitable for data mining.

Data Discretization

This is a process of converting continuous data attribute values into a finite set of intervals with minimal loss of information. Discretization of values was done by assigning numbers to the codes above so as to enable the use of the algorithm to produce a mining model.

VI. FP-GROWTH ALGORITHM

The FP-Growth Algorithm is an alternative way to find frequent itemsets without using candidate generations, thus improving performance. The core of this method is the usage of a special data structure named frequent-pattern tree (FP-tree), which retains the itemset association information.

This algorithm works as follows: first it compresses the input database creating an FP-tree instance to represent frequent items. After this first step it divides the compressed database into a set of conditional databases, each one associated with one frequent pattern. Finally, each such database is mined separately. Using this strategy, the FP-Growth reduces the search costs looking for short patterns recursively and then concatenating then in the long frequent patterns, offering good selectivity.

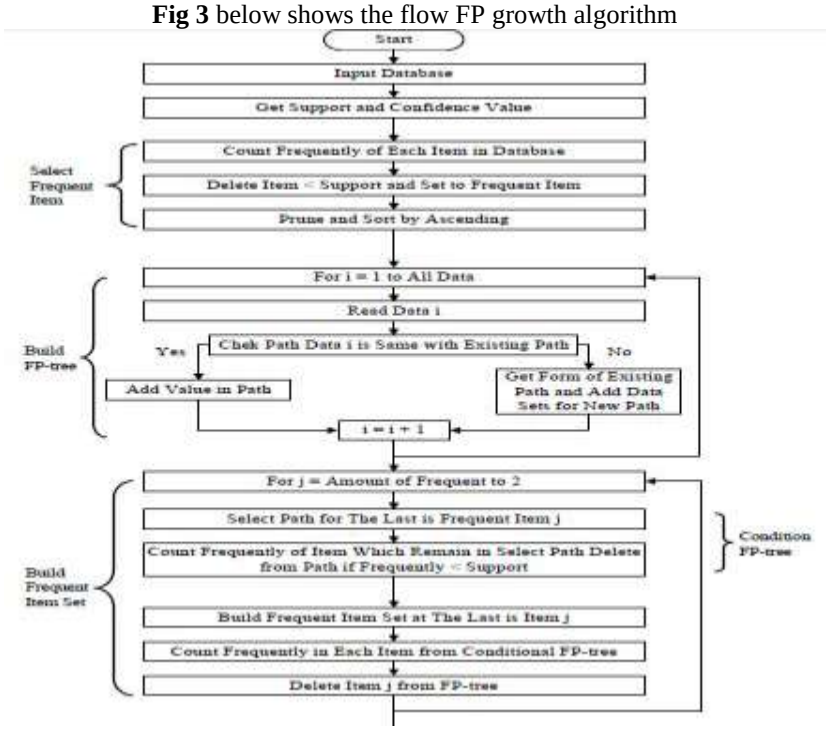
FP-Tree Structure

The frequent-pattern tree (FP-tree) is a compact structure that stores quantitative information about frequent patterns in a database.

One root labeled as "null" with a set of item-prefix sub trees as children, and a frequent-item-header table Each node in the item-prefix sub tree consists of three fields namely:
Item-name: registers which item is represented by the node;2
The algorithm is as follow:
Step 1: Input: A transaction database DB and a minimum support threshold.
Step 2: Output: FP-tree, the frequent-pattern tree of DB.
Step 3: Method: The FP-tree is constructed as follows.
Step 4: Scan the transaction database DB once.
Step 5: Collect F, the set of frequent items, and the support of each frequent item. Sort F in support-descending order as FList, the list of frequent items.
Step 6: Create the root of an FP-tree, T, and label it as "null".
Step 7: Do for each transaction Trans in DB do the following:
Select the frequent items in Trans and sort them according to the order of FList.
Let the sorted frequent item list in Trans be [p|P] where p is the first element and
P isthe remaining list.

Next
Step 8: Count: the number of transactions represented by the portion of the path reaching the node.
Step 9: Links to the next node in the FP-tree carrying the same item name, or null if there is none.
Step 8: End

Fig 3 below shows the flow FP growth algorithm



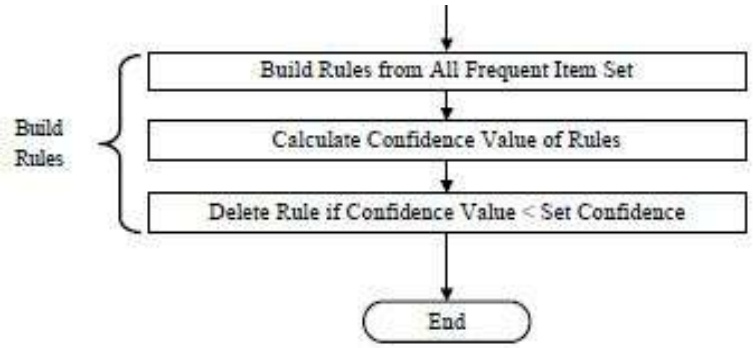


Figure 3: Flow Diagram of FP Growth Algorithm

VII. SYSTEM DESIGN

The system consists of six main modules which are describe as follows:

1. Administrative module: This module was used to authenticate the users of the system
2. Student module: used for student user registration
3. Book module:This module was used by the system administrative users to add books details to the database.
4. Association module: This module is used for association rule data
5. Collection module: This module is used for collection of results of query data in the database
6. Transaction module: This module is used for transaction data

Use case diagram

A use case diagram is a graphic depiction of the interactions among the elements of a system. A use case is a methodology used in system analysis to identify, clarify, and organize system requirements.
The use case diagram of the developed system showing the actors and their activities is illustrated in the diagram below.

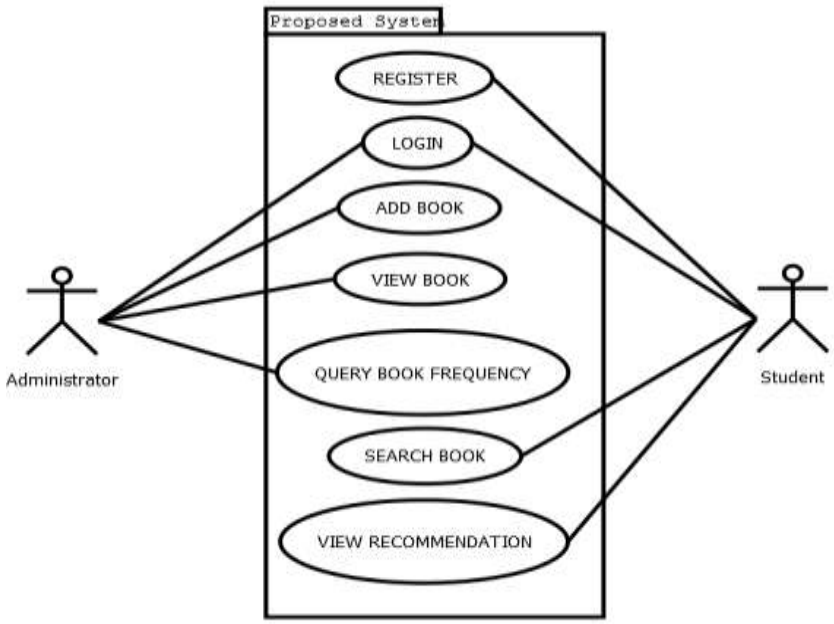


Figure 4: Use Case Diagram

Entity relationship diagram

An ER model is an abstract way of describing a database. In the case of a relationaldatabase, which stores data in tables, some of the data in these tables point to data in other tables. The entity relationship model of the developed system is displayed below:

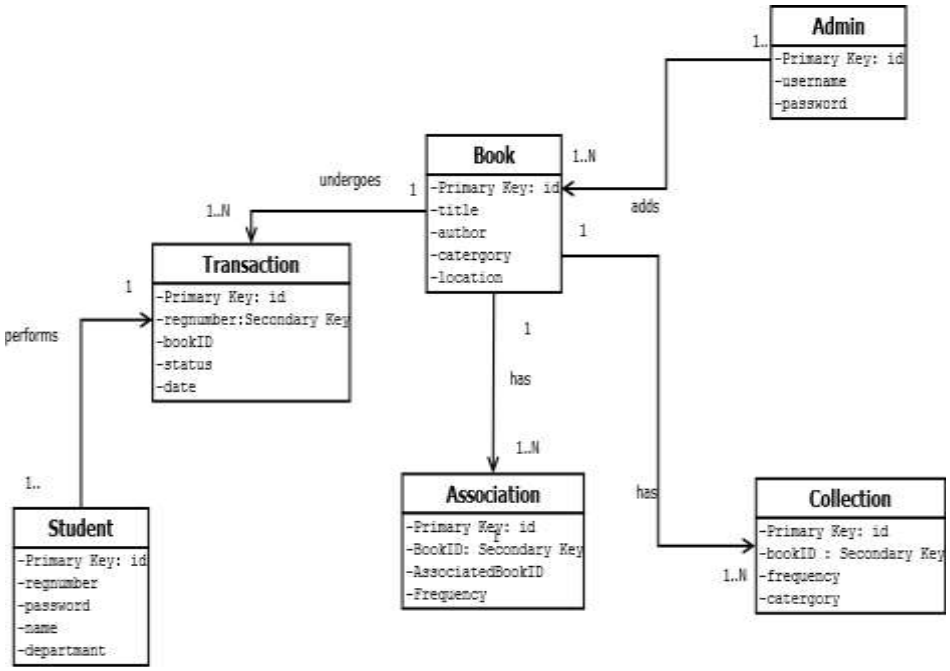


Figure 5: Entity Relationship Diagram

The system flowchart is depicted in Figure 6 below:

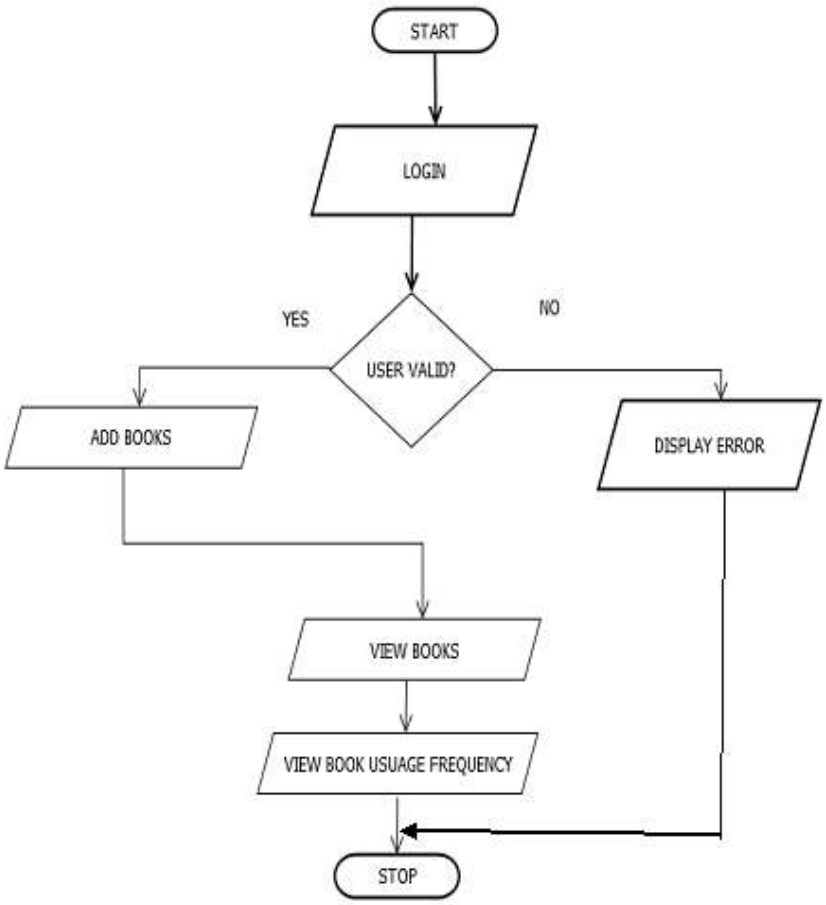


Fig.6. Administrative user flowchart

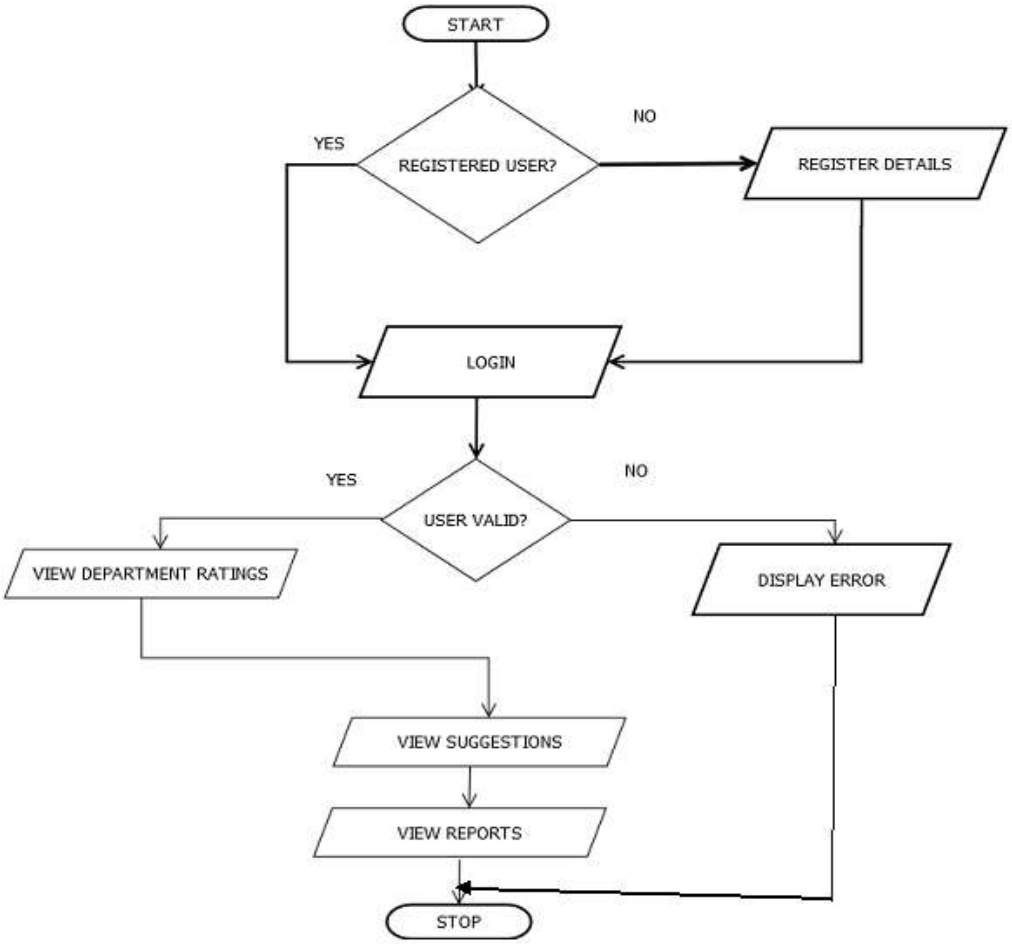


Fig.6: Student user operation flowchart

VIII. SYSTEM IMPLEMENTATION

The system consists of the following pages; home,administrator, add book, student view book, administrator view recommended book, student view recommended book, student view book list, book query page, student registration page, book search page, and view book list page

The new system is an online web based application that was developed for two sets of users. These are highlighted below:

i) The Library Administrative Staff: These users can perform the followingfunctions:

- Add books in the school library to the database
- View the list of books available in the database
- Make search queries for the frequency of books borrowed in each book category
- View Recommendations of similar books based on their original selection

ii) The students: These users can perform the following functions:

- Register and login to the online platform
- Search for books based on their category
- View Recommendations of similar books based on their original selection

The snapshots of the system are shown below:

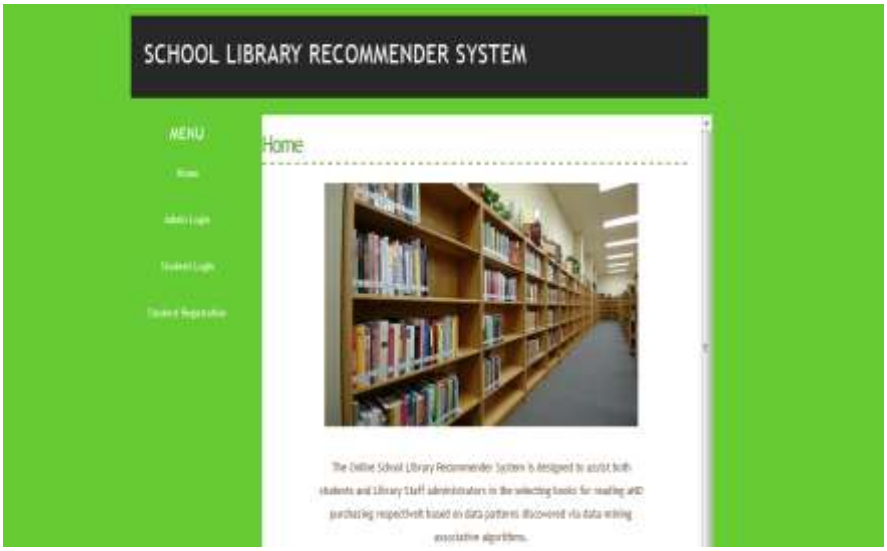


Fig.8 Home page of a book recommender system

Fig.9 Administrator login page

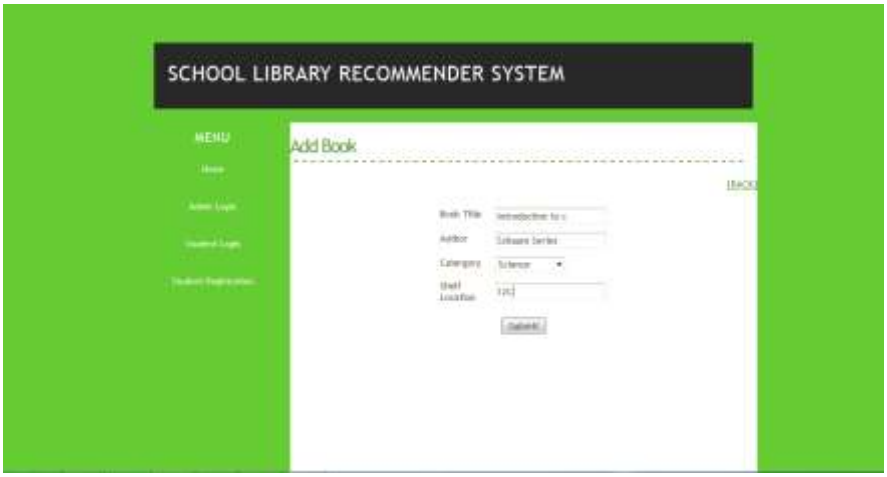


Fig.10 Add Book page

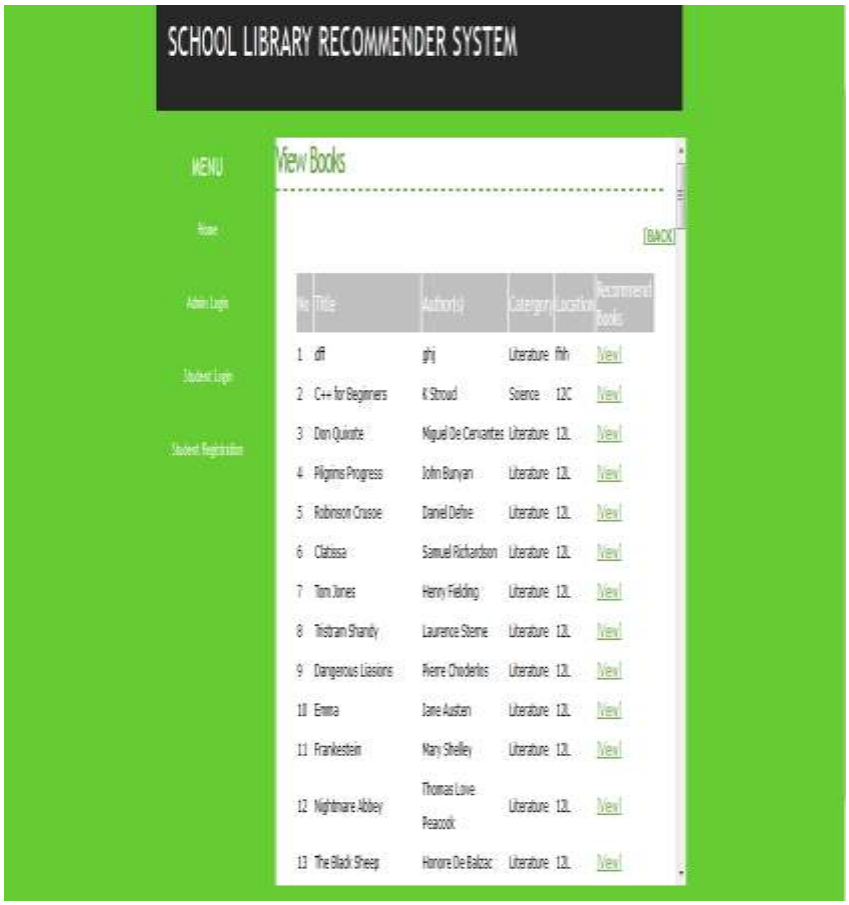


Fig.11 View book page

Fig.12 Recommended book page

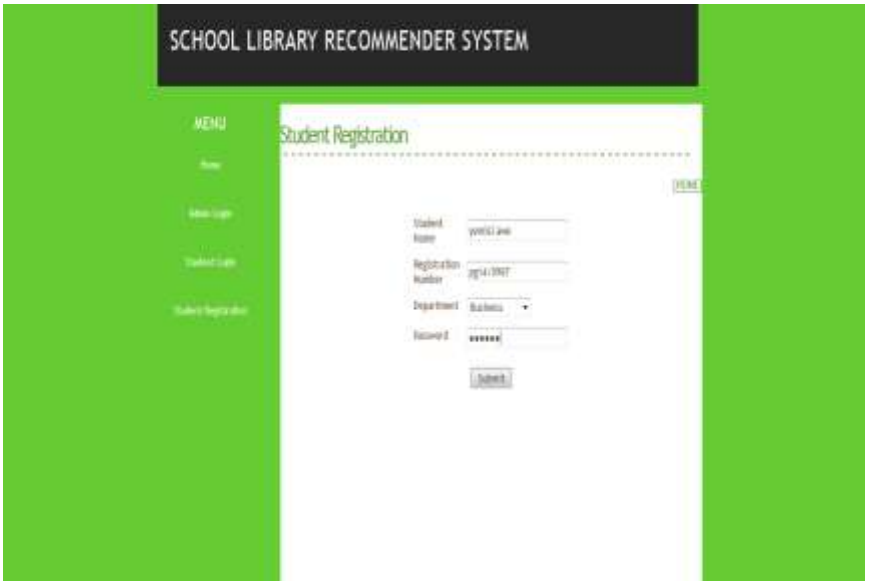


Fig. 13 Student registration page

IX. CONCLUSION

This study focused on the design and implementation of a Book Recommender System for the Library using data mining techniques. The data mining technique used in the design of this system was the Frequent Pattern Growth Algorithm that makes effective book recommendations to the users of the library i.e. The Librarian and the users

In future, we proposed that software engineers should be able to develop a system that not only recommends but also prompts a user as soon as there is a new recommendation based on the user former preference, and also a system that not only recommends books, but all materials in the library, and finally, a hybrid system of association and classification algorithms in building a recommender system.

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