Combination of data mining and artificial intelligence algorithms for efficient web page recommendation

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Abstract---Due to the obvious unstable increase in information, the web is saturated with data, which makes the data search a complicated task. Existing web-based recommendation systems include shortcomings such as a lack of capability as well as scalability when dealing with online data, and blockages created by traffic while utilising the website during peak hours. Web recommendation systems help consumers find the right content and make the

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information search process easier. Web usage mining is regarded as the primary source for web recommendation, and it is used in conjunction with association rule mining and the C4.5 algorithm to recommend online pages to the user. The Google search engine has been widely enhanced the likelihood on the system's suggested structure. A web log is created when a user enters a search query into a search engine. This query would be compared to the web logs by the proposed system. The associate rule mining technique helps in matching the user's search query to the online log. The C4.5 algorithm is linked to a priority based on reviews, which obviously ranks the search based on priority for greater validation result. The maximum average precision, recall, F1score, and accuracy for the proposed system employing movie lens and 10k data sets are around 53.16%, 27.92%, 36.63%, and 80.77%.

Keywords---data mining, artificial intelligence, web mining, recommendation techniques, associate rule mining, C4.5 algorithm.

Introduction

In present era, data has no bounds and becoming massive and overburdened. Getting the appropriate information from a vast volume of data has become a major challenge. The web recommender system assists in recommending the appropriate information at the appropriate time. The web recommender system has lowered the workload for searching products while making it easier to search. Many data analysis techniques are utilised for data management, but the approach behind promoting goods is the user's significance placed on each platform they visit. Web recommender systems are used in a range of applications, including movie recommenders such as Netflix, social recommenders such as Facebook, news content recommenders such as Yahoo and Google, online course offerings such as Coursera, and computational advertisements such as Facebook.

Web page recommendation has grown in popularity, but is displayed as links to news events, academic sources, or the most visited pages. The goal of a Web-Page Recommender System (WPRS) seems to be correctly predicting which webpage or sites are frequented out of a set of web-pages. When designing and implementing a WPRS, several issues must be considered, such as how to skilfully gain knowledge from accessible past information, industry experience and user interface components patterns, how to effectively model then use the data, as well as how to ensure efficient web-page suggestions based on the collected data [1]. Machine Learning is a powerful breakthrough that enables online applications to adapt over time by observing and learning from clients' proclivities, eccentricities, and preferences. Since the applications are becoming more intelligent, the client experience improves [2]. An increasingly difficult challenge for adopting toolboxes is that the product requires additional customization in order to comprehend the explicit ideas in a specific application environment. These toolboxes are designed to be globally beneficial starting points for understanding daily dialect

developments, and they may not be sufficiently plain to parse the space explicit ideas or the standard tasks that website visitors may wish to accomplish [3].

Web development is rapidly expanding, with an emphasis on improving user experience. We all know that most people nowadays use their mobile devices to access the internet. This means those websites with improved user interfaces will remain at the top of the pyramid, while the others will see a significant rise in their chances of gaining consumer trust. Many IT organisations are attempting to apply AI and some of the functions that are being considered include conversation, speech, and profound face recognition [4]. Data mining techniques are extremely rich and powerful in their respective fields. However, these techniques have limits as well. Based on the quality of the information, various methodologies differ significantly. However, following advantages exist: adaptability, variety, field complexity, comprehensive analysis, review and prioritising of derived rules, exploitation of background information, and data cleansing. Some algorithms require noise-free data, which is a reasonable assumption. This entire data analysis procedure is time intensive and complex. The data to be analysed may be partial, contradictory, noisy, or have missing values. As a result, data preparation is now required. To improve web-based information retrieval, data mining methods are being adapted to the domain of something like making the web smarter has recently emerged as a research priority [5]. To begin, the current study provides a theoretical and analytical framework for data mining methodologies and their evaluation in order to construct and design new models. Second, it provides a comprehensive summary report of existing approaches and hybrid models as predictors and classifiers in terms of accuracy, recognition rate, execution time, and other factors. This research may be used to choose the optimal performance evaluators for classifiers from a pool of statistical measures.

Related work

Web-based recommendation systems are one of the most popular topics of research and a topic of interest to many academics because there are still some crucial concerns and problems linked with the system that require an efficient technique or system to resolve. According to Abel *et al* [6] most of the existing work portrayed in previous research studies lacks capability and scalability when dealing with real-time and search-driven websites. Furthermore, a few critics have noted that present systems lack quality and accuracy in such contexts. The key difficulty that has been identified is that existing systems lack instantaneous user requirements and information, which affects the viability of web-based systems. Furthermore, Aher *et al* [7] noted that few recommendation systems generate a large amount of blockages due to system computation load when managing scaled websites during peak hours or user visiting time, which significantly slows down the suggestion process. This criticality in recommendation systems is also one of the problems that have clearly existed in previous research studies, which has significantly motivated the researcher to conduct the specific study on web-based recommendation system by proposing a new model with a combination of data mining technique and artificial intelligence algorithm. According to Bodilla *et al* [8] the difficulty of scalability in web-based recommendation systems has been highlighted in previous research. Furthermore, in order to address the issue of

scalability, they offered a mix of pattern matching and online pattern for delivering real-time recommendations, such as the decision tree method. In this context, such a combination also failed and was major evidence in the literature since it failed to assess user information in real time and was relied on prior data. As a result, this work has been thoroughly evaluated for minimising scalability concerns using a web-based suggestion system in order to remedy historical gaps and issues.

Hsu *et al* [9] highlighted another issue: visiting the website rather focused on current queries. In such a case, the proposed suggestion system aids in the delivery of actual browsing processes that are in line with the user's immediate needs. Furthermore, the suggested recommendation system has a comparatively high quality and precision rate when compared to other existing systems in resolving key issues in the context of web searches and data mining. Lu *et al* [10] suggested that the difficulties of blockages produced by system computational load are quite severe during peak user visiting hours. This difficulty would also be alleviated by the suggested recommendation system, which would analyse the stream data of active users and match such information to the customer's specific group in order to produce a variety of real recommendations to the customer.This, in turn, would undoubtedly aid in the development of a scalable tool capable of overcoming the blockage problem seen in existing recommendation systems. Furthermore, this recommendation system aims to personalise information provisioning systems by incorporating effective filtration and extraction of information based on interests and expectations.

According to Majid *et al* [11], there are various problems linked with usage-based personalization, particularly in a few cases when new pages are incorporated while the website is being modified. Such portrayal is not properly handled in the web log, hurting its viability in relation to mine patterns. Yang *et al* [12] developed a combination of data mining techniques and artificial intelligence algorithms to assure efficacy and efficiency, allowing users to obtain relevant information at the correct time. Based on this, the suggested recommendation system would greatly alleviate such an issue and provide users and web-based organisations with the ability to control information based on their requirements and expectations. The suggested model would incorporate mining web context as well as web structure along with the association of usage statistics, to improve the appropriateness of the tailored route, which is lacking in present systems. Furthermore, variety of strategies used in traditional recommendation systems causes various problems due to a lack of heuristics as well as the incorporation of unsuitable assumptions. Strategies used in traditional recommendation systems engrossed various problems owing to the lack of heuristics as well as the incorporation of incorrect theories and techniques, which has been considerably reduced in the suggested model. Rutzalo *et al* [13] claimed that, due to the rapid rise of web development, the volume of web pages used by users to get and share information based on their needs has also increased. Furthermore, meeting the requirements of a large number of people by distributing knowledge available on the internet is explicitly increasing complexity. This, in turn, significantly increases the complexity of handling a huge number of web pages and presenting appropriate information to consumers based on their priority and need on the internet. Based on this observation, the researcher plans to create a web-based recommendation system

that will reduce the difficulty in locating acceptable web pages by filtering and extracting useful information on the basis of priority.

According to Yao *et al* [14] a WPRS is an important tool that helps users to obtain relevant information based on the specific web page that is being supplied to the users that requires authenticity and accuracy as well as access at the right moment. Based on this background, this work suggests a specific search engine that would be integrated with artificial intelligence and data mining techniques in order to create a noble web-based recommendation system. Furthermore, the suggested recommendation system has a better viability than previous systems since it compares user queries entered into a search engine with site logs utilising an associate rule mining technique. The primary use of WPRS is online environment personalization, which provides a record of entries based on the users' needs. To maintain this level of enjoyment, it is critical to learn important information about the users as well as their entries in attempt to provide a number of plans. In this regard, the goal of this research is to provide consumers with an effective recommendation system based on web data mining that will increase user happiness while also delivering relevant information at the correct moment.

According to Zhang *et al* [15], web-based organisations are strongly encouraging to use a solution that would assist in analysing the online browsing behaviour of web users in order to study their actions as well as reply to interests promptly in their specific browning sessions. The major patterns obtained using data mining approaches alone could not predict the imminent browsing patterns of users because it decreased the matching rate of directions as well as browsing behaviour of users, resulting in a massive gap. Based on this issue, they created an effective recommendation system using both online data mining, notably association rule mining, which is centred on a user's navigational pattern, and an artificial intelligence algorithm. This, in turn, would undoubtedly give substantial recommendations to the users' present prerequisites for meeting their expectations and quality of surfing.

Finally, the suggested recommendation system would deliver a recommendation to users in relation to the present navigation pattern, eliminating any wasted time spent on obtaining the proper information, as seen in earlier systems that displayed irrelevant choices to users.The purpose of this paper is to develop an efficient system that will ensure effective web page recommendation to consumers by combining data mining and artificial approaches.The primary goal of this research is to create a novel recommendation system for web mining that incorporates artificial intelligence approaches to provide relevant options for users. By integrating C4.5 artificial intelligence technique and associating rule mining as a data mining technique for validating the purpose and aim of the research, the proposed model would undoubtedly mitigate each problem that has been analysed based on previous literature and existing recommendation systems.

Materials and Methods

This section presents detail description of the realization and implementation of WPRS. Here a technique developed to establish the web usage of a specific search engine and to establish a web mining and artificial intelligence algorithm for sorting the web pages on the basis of the priority and to design and devise an effective recommendation system for web pages.

Data preparation

Pre-processing techniques are required for web logs to retrieve information from them. Web log data are usually stored in Web Servers (Web Logs for all users), Proxy Servers (Retained Anywhere), or/and Browsers (Web Logs for the particular client). There are various formats for web logs.

W3C extended log file format

Date: Logging the date and time of the first log entry
Software: The version of IIS that is currently in use
Version: 1.0 - log file format
Elements: Structure contains various fields like, version, protocol, date, time, method, client IPAddress, URI stream, protocol version, and protocol status.

NCSA common log file structure

NCSA stands for National Center for Supercomputing Application format. As a result, NCSA is the remote host name, HTTP status code, request type, and number of bytes led by the server. Furthermore, because NCSA is a fixed format, it cannot be customised. It is not available for File Transfer Protocol (FTP) site but it is available for website. Year is formatted as DD/MMM/YYYY. Space separates the parameters and time is local time.

Data collection

The first step in web usage pre-processing is data collection. Web logs can be gathered from a web server, a proxy server, or a client machine. Server logs provides additional decisive and unified utilization of statistics to server equipped by chunk dossier. Cached pages visited are not recorded by the log file. Web server need to be secured as log files have data that are sensitive. After Receiving Hyper Text Transfer Protocol (HTTP) protocol request from client, proxy server passed it to web server. Responds from the web server as a result passed to client by proxy server. Proxy server works as an intermediate between client and web server.

Click stream data pattern

By using equation (1) click stream data pattern is transformed into user access matrix X wherein users are represented in tuples and pages of web sites are represented in attribute. Let X (V, Q) be matrix X (V, Q) depict the association between web logs as well as users approaching web pages. However, the element

b_{ij} of X (V, Q) shows density of the user V_i of V visit the page Q_j of Q amid the specified time duration.

$$b_{ij} = \begin{cases} Hits\ (V_i,\ Q_j), & if\ Q_j is\ visited\ by\ V_i \\ 0, & Otherwise \end{cases} \tag{1}$$

Here, the density count of user V_i accesses the page Q_j amid a given time frame is given by Hits (V_i, Q_j).

Data filtering

During the loading of web page, browser appeals for all the objects included in page. Data filtering employs duty of investigating suffix of Uniform Resource Locator (URL) name and can achieve filtering process. For instance, all log entries containing filename suffixes gif, jpeg, JPEG, GIF, JPG, jpg, as well as map are evacuated. In inclusion, one can also remove frequent scripts such as count.cgi.

User recognition

There is a need to differentiate between different users before user behaviour is prototyped as a user may have visited a site many times. Generally, user activity is defined as the series of movements completed by identical user during distinct sessions. Through registration one can recognize user. In such scenario, for logging into the website, every user has user ID. It is advantageous to collect additional demographic information about the users. Usually, users not keen to see his interest in scanning of website, which asks them for registration and logins due to privacy concerns. Sometimes, registered users may provide misleading information.

Path expiration

Path expiration is accountable for filling page references not logged in log file because of caching of browser and proxy server. Whenever client came back to page already downloaded amid identical session, alternative access to that page will bring previously downloaded variant of it without posting any new appeal to server. Absence of appeal from the browser brings about missing reference in log files. Based on learning of site architecture and referrer data from server logs, path expiration accumulated missing references due to caching. Based on the scope of the present study, Python is selected as a particular tool for conducting the sampling. In addition to the Python tool, the researcher has used techniques such as Associate Rule Mining and C4.5 for developing the plan of work and proposed web recommendation system. The proposed model is depicted in Figure 1.
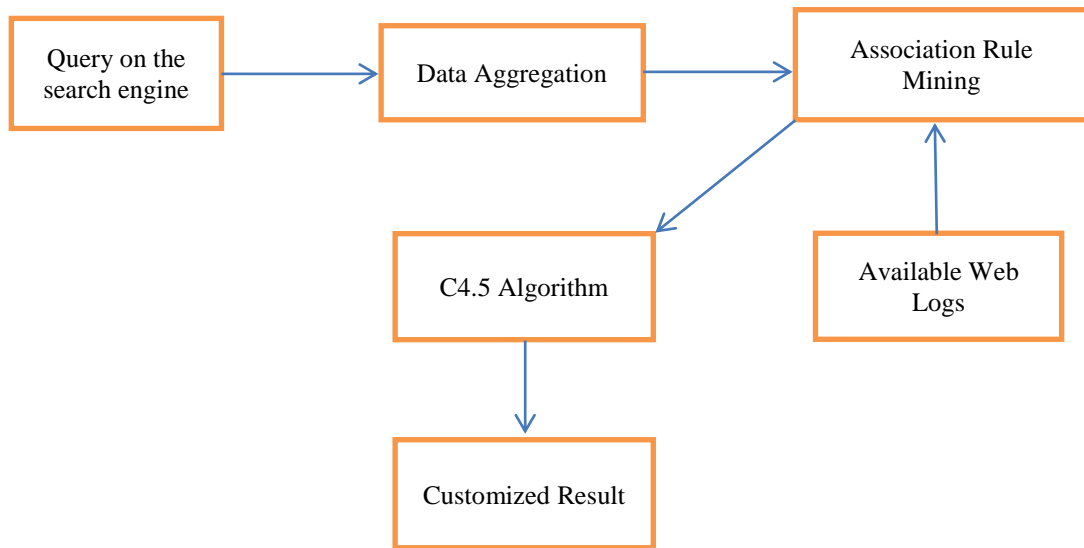
Figure 1. Proposed WPRS Model

Based on the proposed structure of the WPRS, the inclusion of the Google search engine has been highly validated. In addition, a web log would be put forward when a query has been inserted by the user on the search engine. This query would be used by the proposed system and would be compared with the web logs. Furthermore, the use of associate rule mining technique has assisted to compare the search query put forwarded by the user with the web log. On the other hand, the C4.5 algorithm is integrated with a priority for instance, on the basis of the reviews which evidently sort the search on the basis of priority which in turn offers the result significantly. This technique has highly assisted to develop an efficient web recommendation system.

Data aggregation is the process of gathering raw data and presenting it in the form of an overview for data analysis. Data aggregation can be achieved by modifying using specialised software known as automated data aggregation. Aggregations are generated by various algorithms in recommendation systems, where an only one algorithm is defined as ah and a set of n existing algorithms is defined as B = {b_1, b_2,...,b_n}. Each of the algorithms ah B produces a ranking c, and the set of all n produced rankings is defined as R={c_1, c_2,..., c_n}. Furthermore, all algorithms that generate recommendations use the matrix M as an input. In this matrix, each row represents a user $D_i \in V$, and each column represents an item $k_l \in I$. The value of this matrix $M_{k,l}$ corresponds to the user D_i's rating of the item k_l.

One of the most significant data mining methods, association rule mining, seeks out intriguing relationships between items in a given data set. The discovery of association rules indicating attribute-value conditions that occur frequently together in a given set of data is referred to as association analysis. An association rule is made up of two Boolean propositions that state that if the left side (the inference) is true, then the right side (the subsequent) is also true. A probabilistic rule, on the other hand, states that the RHS is true with probability

p if the LHS is true. In reality, two main criteria, support and confidence, are used to generate association rules. The percentage of transactions that contain both P and Q is referred to as support. And confidence is the percentage of payments that contain both P and Q. Lift is another criterion that indicates the strength of the relationship between items P and Q. A positive association is indicated by a lift value greater than one, whereas a negative association is indicated by a lift value less than one.

C4.5 algorithm

Assume *t* as the training sample, *i* as the class label, and i=1, 2,...,M class. Let *freq*(i,t) represent the number of samples in *t* that belong to a class (out of the M possible classes), and |S| represent the number of samples in the training set *t*.

- Step 1: Look for possible base cases.
- Step 2: Determine the best split attribute for splitting that maximises information gain.
- Step 3: Find the best split using two measures (Entropy and Information Gain).

Entropy is used to calculate the homogeneity of a sample and to measure impurity. The entropy of the set *t* is then calculated as follows:

$$E = \sum_{i=1}^{M} freq(i,t)/|t|*\log_2 freq(i,t)/|t| \qquad (2)$$

Information gain tells us how important a given attribute is.

$$gain = (t) - \sum_{j=1}^{d} |t_i|/|t|*(t_i)$$

$$(3)$$

- Step 4: Compute the ideal splitting attribute is one that provides the most information gain.
- Step 5: A decision tree is generated using the attribute that provides the most information gain.
- Step 6: The same steps are then repeated for each impure node in the tree. When all nodes are pure, the C4.5 algorithm comes to a halt.

Experimental results

Data analysis is performed on the clickstream dataset which is collected from *MSNBC.com*. Table 1 shows all parameter values after each progression. The number of seeds (biclusters) has been set to 118. As shown in the table, the average volume of all biclusters produced increases with bicluster age and avaricious search procedure. The volume of the biclusters formed after hereditary calculation is greater. The wrapping degree is proportional to the type of

biclusters generated. Increment in wrapping degree increases the quality of biclusters. After each progression, the Average Correlation Value (ACV) estimation of all biclusters grows. A high ACV value indicates that the bicluster is unambiguously clear [16].

Table 1
Outputs for Average Correlation Value (ACV)

Constraints	Bi-Cluster	Greedy search results after implementation	Results of genetic algorithm
Seeds	118	118	118
Average Volume	473.693	1738.0	12543.091
Overlapping Degree	0.0	0.0190045	0.1335
ACV	0.42643174	0.71118836	0.77778

Table 2 shows all parameter values after each progression with the MSR evaluation function. The number of seeds (biclusters) has been set to 118. The average volume of all biclusters produced increases with bicluster age and avaricious search procedure. The volume of the biclusters formed after hereditary calculation is greater. The wrapping degree is proportional to the type of biclusters formed. Increment in covering degree increases the quality of the biclusters. The MSR estimation of all biclusters is also decreasing with each progression. A low MSR value shows that the bicluster is unambiguously rational [17]. A low MSR value signifies biclusters as robustly comprehensible [18].

Table 2
Outputs of Mean Square Residue (MSR)

Factors	Bi cluster	Greedy Search Calculations Found	Genetic Algorithm After Completion
Seeds	118	118	118
Average Volume	473.693	1738.0	12543.091
Overlapping Degree	0.0	0.0190045	0.1335
MSR	0.42643174	0.71118836	0.77778

Final recommendation graph

Figure 2 depicts the most recent proposal created for the site. The ideal bicluster produced after the hereditary calculation are used to determine the outcomes. The chart's X-axis refers to the page classifications of the Microsoft National Broadcasting Company's (MSNBC.com) website. The diagram's Y-axis refers to the last level of clients who have visited specific page classes on the site. This chart can assist the site in determining the most popular site pages visited by clients. It also indicates how many clients, as a percentage of all clients, are viewing their pages. It distinguishes clients who have comparative interesting site pages with a high level of uniformity. This data can then be used by organisations to improve

their marketing efforts, as well as their accomplishment, web utilisation classification, customer screening, and content - based recommendation structures.
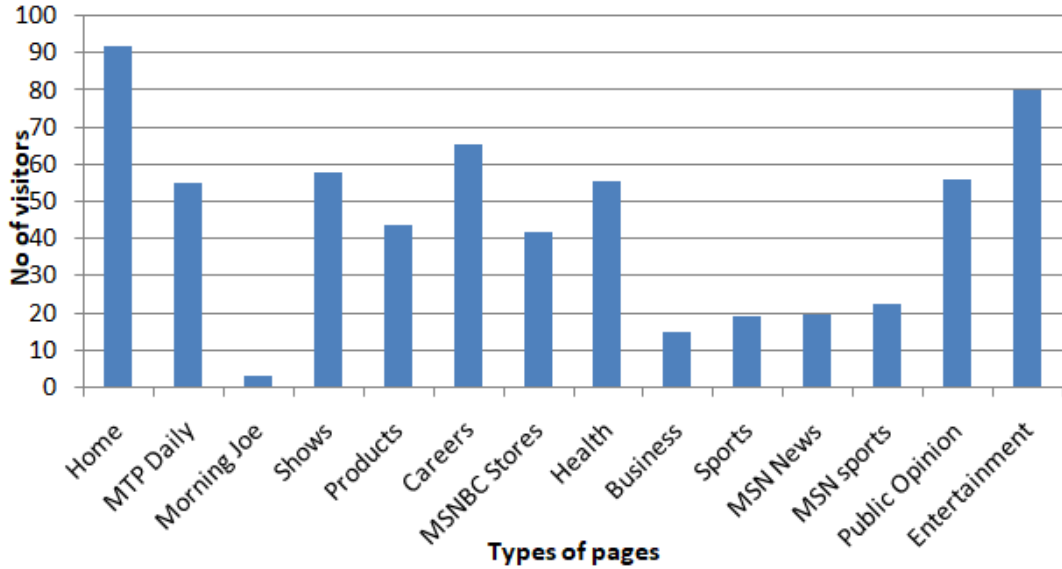

Figure 2. Final Recommendation Graph

Evaluation metrics of proposed recommendation system

Top-N recommendation is evaluated using two metrics: recall and precision. Minor changes has been made to the definitions of recall and precision. Our strategy is to distribute the products into two groups: test and top-N. The hit group includes products that appear in both groups. Recall is defined as: recall is exemplified by a chunk of the compelling documents that are firmly regained.

$$\mathrm{Re}\,call = \frac{|\{\text{relevant document}\} \cap \{\text{retrieved document}\}|}{|\{\text{ relevant document}\}|} \qquad (4)$$

Precision is defined as a chunk of conquered documents that are strongly related to the query.

$$Precision = \frac{|\{\text{relevant document}\} \cap \{\text{retrieved document}\}|}{|\{\text{retrieved document}\}|} \qquad (5)$$
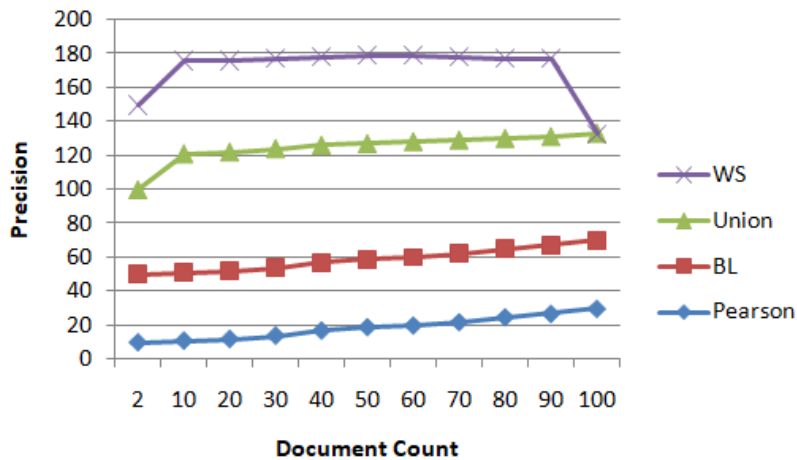
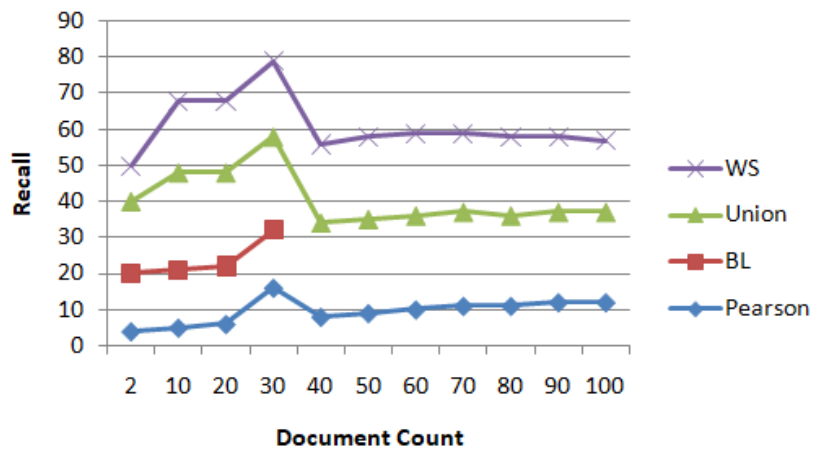Figure 3. Variation of Precision with Document Count

Figure 4. Variation of Recall with Document Count

Figure 3 and 4 shows improvement in the efficiency of proposed method for various algorithms. Doing analysis of results, more precise results received in proposed method confines accomplished recommendations.

Table 3
Proposed system results

Dataset	Method	Accuracy	RMSE	Precision	Recall	F-measure	NDCG
Movie Lens 10k Dataset	User Based	80.77	80.61	53.16	27.92	36.63	45.87

To compare the quality of the basic recommendations of the proposed recommendation system, it has been developed another recommendation system

using threshold neighbourhood similarity in a large space to form a neighbourhood and referring recommendations top-N. By analyzing the efficacy of the proposed recommendation system's system-based hypothesis, it can be assumed that training assessments defined in a hybrid approaches suggestion tool engage the nearest Pearson algorithm. The Pearson correlation similarity measure was used by the researcher in both approaches for neighbourhood case construction because, in the case of low dimensional proximity, correlation measurement is only done by calculating the correlation [18]. The average precision of the recommendations, by recommendation strategy and by similarity measure, is presented in Figure 3. The maximum average precision, the recall and the measurement of the F1 are around 53%, 27%, 36% for the fuzzy logic-based recommendation system (FLRS) compared. 55%, 38% and 38% for the proposed method and 48.5%, 39.2% and 37.9% obtained for the CSM approach (based on overall similarity) [19].
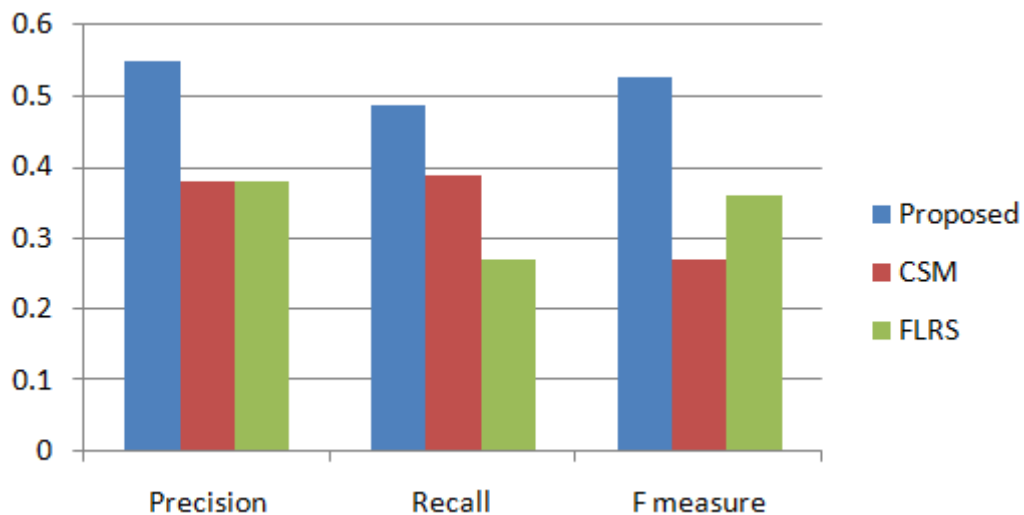

Figure 5. Average/Mean recommendation performance in context to similarity measure

Conclusion

The objective of proposed effective web pages recommendation system using artificial intelligence and data mining algorithms is to understand users' navigation behavior and to recommend the web pages of users' interests at a shorter span of time. Recommender system is a part of machine learning, which automatically learns from the experience rather than the predefined data. This recommender system utilizing coherent biclustering is more effective than corresponding recommender system. Enormous group of web mining can be executed this way. The advancement of recommender systems utilizing coherent biclustering structure with Genetic Algorithm to distinguish overlapped meaningful (coherent) biclusters from the clickstream information designs. An efficient web page recommendation technique is developed by using web usage mining as a source and applies special pre-processing techniques to make the web usage data consistent and identify the user interest level. Clustering and

association rule mining techniques are applied to the pre-processed web usage data to discover the interesting patterns. This research worked with the format of web access log file to collect the clickstream data from it. The system could work with other web log file formats as well as we have occupied two limitations from the log file in this case, such as, page categories visited by user and user IP address. In this manner, a dynamic system that prompts and accepts user inputs at all times can be created. In the future, this technique could be improved to be a tool that supports the entire pre-processing, pattern matching, and visual analytic phases. A web personalized web page recommendation technique may be developed for more customer satisfaction.

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