

# Web Mining for Personalization: A Survey in the Fuzzy Framework

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**ABSTRACT---** *Web mining is the use of data mining techniques to automatically discover and extract information from Web documents and services. When comparing web mining with traditional data mining, there are three main differences to consider: Scale, Access and Structure. Web personalization is the process of tailoring content that web user experiences according to his needs, goals and preferences. In this survey paper we have discussed various researches done in the field of web mining for personalization in last fifteen which used fuzzy as their framework for study. We also discussed a fuzzy c-means clustering algorithm which we will consider in our further research.*

**Keywords---** web mining, personalization, fuzzy, clustering.

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## 1. INTRODUCTION

Web Mining is that area of Data Mining which deals with the extraction of interesting knowledge from the World Wide Web. Web mining has been explored to whole new levels and different techniques have been proposed for a variety of applications that includes Web Search, Classification, and Personalization etc. Most research on Web mining has been from a 'data-centric' point of view.

The increasing popularity of the Internet and the exponential increase in the number of its users has led to the creation of new paradigms of knowledge discovery, like Web personalization, mining bookmarks, mining e-mail correspondences, recommendation systems, and so on. These are grouped as Web Usage mining. Mining typical user profiles and URL associations from the vast amount of access logs is an important component of Web personalization that deals with tailoring a user's interaction with the Web information space based on information about her/him.

The steps of a Web personalization process include: (a) the collection of Web data, (b) the modelling and categorization of these data (pre-processing phase), (c) the analysis of the collected data and (pattern analysis) (d) the determination of the actions that should be performed (post-processing phase). The methods that are employed to analyse the data collected include content-based filtering, collaborative filtering, rule-based filtering and Web usage mining and fuzzy based clustering.

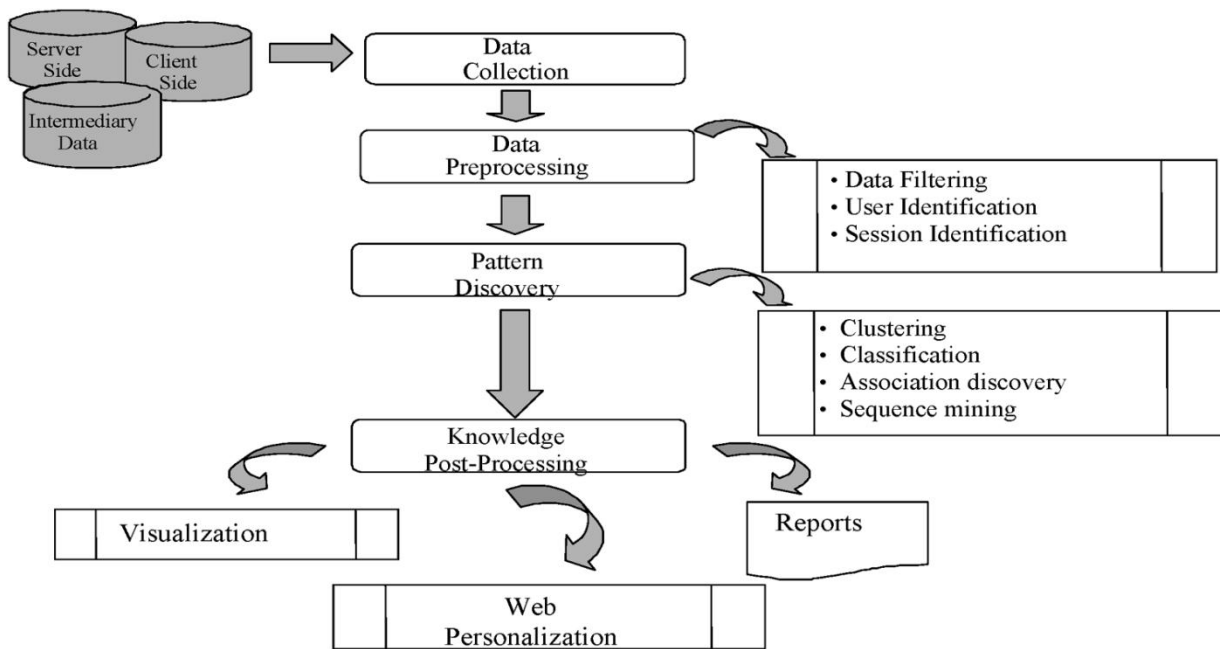


Fig 1: process of web mining

Due to the involvement of human interaction in Web information (like text, image, sound, and linkages between them), new tools, techniques and methodologies need to be extended in order to deal with the incomplete or imprecise information. Web personalization, navigational Web, semi structured and structured data information are some of the major issues under Web mining. Due to the inherent vagueness of human beings while expressing information in natural language Semantic Web also becomes a target for data mining research using fuzzy logic. Considering the Web as a large distributed multimedia database, an extension of methodologies to deal with them and their mining algorithms can be considered under image mining. The huge volumes of compressed and uncompressed information stored in images, and their subjective evaluation by humans in interaction with the Web, is another focus of current data mining research requiring proper fuzzy treatment.

## 2. LITERATURE SURVEY

Dragos Arotariteia and Sushmita Mitrab presented a survey on the available literature on fuzzy Web mining [1]. The different aspects of Web mining, like clustering, association rule mining, navigation, personalization, Semantic Web, information retrieval, text and image mining are discussed under the existing taxonomy. The role of fuzzy sets in handling the different types of uncertainties or impreciseness is also highlighted. A hybridization of fuzzy sets with genetic algorithms (or any other soft computing tool) is described for information retrieval. An extensive bibliography is also included in the research paper, “A methodology for dynamic data mining based on fuzzy clustering” [2] says that we need different methodologies for dynamic data mining. In this paper, they present a methodology for dynamic data mining based on fuzzy clustering. Using the implementation of the proposed system its benefits are showed in two application areas: customer segmentation and traffic management. Another interesting paper suggests [3] a Low-Complexity Fuzzy Relational Clustering Algorithms for Web Mining presenting a new algorithms—fuzzy cmedoids (FCMdd) and robust fuzzy c-medoids (RFCMdd)—for fuzzy clustering of relational data. The main objective functions are based on selecting  $c$  representative objects (medoids) from the data set in such a way that the total fuzzy dissimilarity within each cluster is almost minimized. they also showed a comparison of FCMdd with the well known relational fuzzy c-means algorithm (RFCM) concluding that FCMdd is more efficient. Several applications of these algorithms to Web mining is also discussed that includes Web document clustering, snippet clustering, and Web access log analysis etc.

Kyung-Joong Kim and Sung-Bae Cho [9] in their work proposed a system that provides users with personalized results derived from a search engine that uses link structures. The fuzzy document retrieval system is constructed from a fuzzy concept network based on the user’s profile personalizes the results extracted from link-based search engines with the preferences and requirements of the specific user.

Fuzzy and rough sets provide the ability to deal with incomplete and approximate information. Fuzzy set theory has been shown to be useful in three important aspects of web and data mining, namely clustering, association, and sequential analysis. Clustering is an important part of web mining that involves finding natural groupings of web resources or web users since; the clusters and associations in web mining do not necessarily have crisp boundaries. The genetic algorithms

based clustering may not be able to handle the large amount of data typical in a web mining application, a variation of the *K*-means clustering algorithm based on properties of rough sets can be used to represent clusters as interval or rough sets [25]. The paper by Pawan Lingras, and Chad West describes the design of an experiment including data collection and the clustering process which is later used to create interval set representations of clusters of web visitors.

Limin Ren [23] proposed a Web document classification algorithm based on fuzzy reasoning with comprehensive weights and Web search result clustering based on fuzzy logic and neural networks are presented for Web data mining to obtain easily understood, robust and low-priced solutions by exploring the greatest possible extents of imprecision, uncertainty, fuzzy reasoning and partial correctness. This Web document classification and clustering framework was more accurate, more credible and more rapid than the previous methodologies being used.

There is another interesting aspect related information-gathering behaviour of the users presented by Bo Pang and Lillian Lee [22]. With the growing availability and popularity of opinion-rich resources such as online review sites and personal blogs, new opportunities and challenges arise as people now can, and do, actively use information technologies to seek out and understand the opinions of others. The sudden eruption of activity in the area of opinion mining and sentiment analysis deals with the computational analysis and processing of opinion, sentiment, and subjectivity in text. Their survey covers techniques and approaches that promise to directly enable opinion-oriented information-seeking systems. They proposed methods that try to address the new challenges raised by sentiment-aware applications, as compared to those that are already present in more traditional fact-based analysis. Sentiment analysis and opinion mining of the users can provide great perspective in the field of personalization.

Francisco Herrera used genetic algorithms for designing fuzzy systems to provide the learning and adaptation capabilities and is called genetic fuzzy systems (GFSs) [26]. We also studied a methodology for dynamic data mining based on fuzzy clustering. Author stated the use of fuzzy *c*-means but any other fuzzy or any other clustering technique can also be used as well [20]. The web log files register the activity of the user when navigates for a certain web site. These files are mined using a fuzzy clustering process.

There was an interesting research in which Fuzzy logic is used with one of the web mining technique i.e. clustering [2]. Another way to provide personalisation can be using fuzzy rules [5], the data are fuzzified and fuzzy rules are generated by applying decision trees. Using fuzzy rules, the search pages are labelled to aid grouping of user search interests.

A survey “web mining: a survey of current research, techniques and software” [27] provided a more current evaluation and update of web mining research and techniques available till 2010. Unlike previous investigators, they divided web mining processes into the following five subtasks: (1) resource finding and retrieving, (2) information selection and pre processing, (3) patterns analysis and recognition, (4) validation and interpretation, and (5) visualization. This paper also reports the comparisons and summaries of selected software for web mining.

The use of fuzzy techniques has been considered to be one of the key components of data mining systems because of its accordance with human knowledge representation. Chunlai Chai and Biwei Li discuss a hybridization of fuzzy sets with genetic algorithms for Web mining in their paper, “A Novel Association Rules Method Based on Genetic Algorithm and Fuzzy Set Strategy for Web Mining” [4]. It is based on a hybrid technique that combines the potential of rough set theory and genetic algorithm. The role of fuzzy sets and logic in handling the different types of uncertainties and impreciseness is discussed with Experimental results indicate that this adaptive method can significantly improve the performance in Web mining and can bring a whole new level of revolution.

“A Survey of Fuzzy Clustering “ paper is a survey of fuzzy set theory applied in cluster analysis [14] . In this paper, we give a survey of fuzzy clustering in three categories: the fuzzy clustering based on fuzzy relation, the fuzzy clustering based on objective function and a non parametric classifier that is the fuzzy generalized *k*-nearest neighbour rule.

Clustering is the partitioning of a data set into subsets (clusters), so that the data in each subset shares some common features. The two most famous clustering techniques: Fuzzy *C*-mean (FCM) algorithm and Subtractive clustering algorithm are compared based on validity measurement of their clustering results. Highly non-linear functions are modeled and a comparison is made between the two algorithms according to their capabilities of modeling. A training algorithm is also needed to accurately generate models using FCM. However, subtractive clustering does not need training algorithm. FCM has inconsistency problem where different runs of the FCM yields different results. On the other hand, subtractive algorithm produces consistent results [13].

Pooja Mehtaa, Brinda Parekh, Kirit Modi, and Paresh Solanki discussed various Web personalization categories and their research issues in their paper, “ Web Personalization Using Web Mining: Concept and Research Issue”[17]. Broadly there can be three areas in which web data mining should be done for personalization:-

- i) Web content mining ( text , images and multimedia files)
- ii) Web structure mining (hyperlink structures)
- iii) Usage mining ( web log data)

Future efforts require more investigating architectures and algorithms which can exploit and enable a more effective integration and mining of content, usage, and structure data from different sources. This paper focused on Extraction of useful patterns and rules using data mining techniques in order to understand the users' navigational behaviour, so that decisions concerning site restructuring or modification can then be made by humans in various application areas.

There is another work which also supports the usage of fuzzy clustering for web usage mining. Neelam Sain and Sitendra Tamrakar in their work in “ A Survey of Web Usage Mining based on Fuzzy Clustering and HMM” [10] paper presents a survey of over 34 research papers dealing with Web usage Mining technique based on Fuzzy clustering and HMM (Hidden Markov Model) . The advantage of the technique is that it can measure the similarity efficiently among the users on the basis of their browsing characteristics and it also accurately predicts the user patterns.

There is another type of fuzzy clustering algorithm known as [15] Type-2 fuzzy clustering algorithm which integrates Type-2 fuzzy sets with Gustafson-Kessel . The proposed Type-2 Gustafson-Kessel algorithm (T2GKA) is a combination of probabilistic and possibilistic clustering schemes. T2GKA is less susceptible to noise than the Type-1 GKA. The T2GKA ignores the inliers and outlier interruptions. The clustering results show that the proposed T2GKA is very robust since a reasonable amount of noise data does not affect its clustering performance. The experimental results show that the T2GKA can learn suitable sized cluster volume along with a varying dataset structure volume.

In associative classification method, the rules generated from association rule mining are converted into classification rules. The concept of association rule mining can be extended in web mining environment to find associations between web pages visited together by the internet users in their browsing sessions [24]. The weighted fuzzy association rule mining techniques are capable of finding natural associations between items by considering the significance of their presence in a transaction. In this paper by Binu Thomas and G. Raju they presented a novel web classification algorithm using the principles of fuzzy association rule mining to classify the web pages into different web categories, depending on the manner in which they appear in user sessions. The finally represented results in the form of classification rules are concluded better than the famous Boolean Apriori association rule mining algorithm.

Web search represents a significant portion of Web activity. There are three basic approaches to web search are: i) Search Engines ii) Web Directories and iii) Hyperlinks. [5] Personalized Web search mechanism effectively obtains the user's real time required information. The user browsing data is collected using an established customised browser designed to suit personalisation. This cumbersome task of classifying users according to their web search can be achieved using a fuzzy based user classification model to suit a personalised web search environment [5]. The data are fuzzified and fuzzy rules are generated by applying decision trees. Evaluation of the proposed approach proves to be better when compared with the Bayesian classifier.

A paper on “web usage mining through efficient genetic fuzzy C –means” [7] uses fuzzy c-means algorithm for knowledge discovery from any web-log unstructured dataset. In this paper again a hybrid approach is proposed that uses Genetic algorithm in Fuzzy c-means algorithm to select initial center point for clustering in FCM. This paper provides an optimum initial solution for FCM with the help of genetic algorithm to reduce the error rate in pattern creation which is later used in post processing phase.

We studied a thesis that discussed the usage of Fuzzy Logic in pattern recognition. There are different fuzzy approaches to recognize the pattern and the structure in data. The fuzzy approach that we choose to process the data is completely depends on the type of data. Pattern reorganization involves various mathematical transforms so as to render the pattern or structure with the desired properties such as the identification of a probabilistic model which provides the explanation of the process generating the data clarity. They primarily focused on the ways in which Fuzzy Logic is applied to pattern recognition and knowledge of the results which can be further used for web personalization field.

Another discussion about soft computing based web intelligence is done by Ankit R. Deshmukh and Sunil R. Gupta in “Data mining based soft computing methods for web intelligence” [18] states the possible areas for implementation of data mining based soft computing approaches for web intelligence. Web Intelligence (WI) combines artificial intelligence and advanced information technology in the context of the Web, and goes beyond each of them. It addressed the key problem of finding useful hidden patterns for better application by using various soft computing techniques like Neural networks, Fuzzy Logic, Support Vector Machines, Genetic Algorithms in Evolutionary Computation. This paper also proposed the hybrid approach to discover hidden information and usage pattern trends which could help Web managers to improve the management, performance and control of Web servers.

Another survey by M. Gomathi “A Survey on Web Mining Using Fuzzy Logic” [19] also features the same view. It reviews the techniques about Fuzzy Web Content Mining, Fuzzy Web Usage Mining and Fuzzy Web Structure Mining. Information retrieved from various web resources as Web data sets, consist of imprecise, incomplete, and uncertain data. Thus, efficient approaches are needed to identify useful, meaningful, and interesting patterns to users. Fuzzy-set theory has been applied to handle these datasets and provide better solutions than traditional approaches. The main highlight of this paper is that the process of fuzzy Web content mining and fuzzy Web structure mining are not as same as those in

fuzzy usage Web mining. More research in these two directions is required. Furthermore, efficiently and effectively handling big data and heterogeneous data has always been an inevitable issue in web mining.

During online processing, the subset of web pages associated with the cluster in any particular user domain is used for the recommendation for effective personalization of web search. This recommendation of web pages continues till the search is personalized to the information need of the user. Suruchi chawla proposed another methodology [6] that uses the genetic algorithm to perform the cluster wise optimization of clicked web pages for better personalizing the Web Search of the user. In order to identify web pages that are not only relevant but also have high internal dissimilarity in order to cover the wider representation of a cluster domain we can identify those relevant documents up in ranking which otherwise has low ranking and could not be clicked. Experimental study was conducted in the research on the data set of web query sessions captured in three domains Academics, Entertainment and Sports. The experimental confirms the effectiveness of cluster wise optimization of web pages for better personalizing the Web Search of the user.

Web mining has several new challenges that demands the development of new techniques for robust fuzzy clustering that can handle noisy, uncertain, vague, and incomplete information [8].

### 3. FUZZY CLUSTERING ALGORITHM AND HARD CLUSTERING ALGORITHM

Data clustering is an important area of data mining. This is the process of dividing data elements into different groups (known as clusters) in such a way that the elements within a group possess high similarity while they differ from the elements in a different group. Clustering can be classified as: Soft Clustering (Overlapping Clustering) & Hard Clustering (or Exclusive Clustering). In case of soft clustering techniques, fuzzy sets are used to cluster data, so that each point may belong to two or more clusters with different degrees of membership. Fuzzy C-means (FCM) is a data clustering technique wherein each data point belongs to a cluster to some degree that is specified by a membership grade. The main advantage of fuzzy c – means clustering is that it allows gradual memberships of data points to clusters measured as degrees in [11]. This gives the flexibility to express that data points can belong to more than one cluster. FCM Algorithms are best described by recasting conditions in a matrix- theoretic terms [16]. FCM Algorithm is more suited to data that is more or less evenly distributed around the cluster centers. It is based on minimization of the following objective function:

$$J_K = \sum_{i=1}^n \sum_{j=1}^c \mu_{ij}^m \|x_i - c_j\|^2$$

$$1 \leq m \leq \infty \dots\dots\dots [1]$$

Where m is any real number greater than 1,  $\mu_{ij}$ , is the degree of membership of  $x_i$  in the cluster  $j$ ,  $x_i$  is the  $i$  th of d-dimensional measured data,  $c_j$  is the d-dimensional center of the cluster, and  $(x_i - c_j)$  is any norm expressing the similarity between any measured data and the center. Fuzzy partitioning is carried out through an iterative optimization of the objective function shown above, with the update of membership  $\mu_{ij}$ , and the cluster centers  $c_j$  by:

$$\max_{i,j} \{ |u_{i,j}(k+1) - u_{i,j}(k)| \} < \epsilon$$

$$c_j = \frac{\sum_{i=1}^n \mu_{ij} x_i}{\sum_{i=1}^n \mu_{ij}}$$

$$u_{i,j} = \frac{1}{\sum_{k=1}^c \left( \frac{\|x_i - c_j\|}{\|x_i - c_k\|} \right)^{2(m-1)}} \dots\dots\dots [2]$$

This iteration will stop when  $\max_{i,j} \{ |u_{i,j}(k+1) - u_{i,j}(k)| \} < \epsilon$  where  $\epsilon$  is a termination criterion between 0 and 1, whereas k are the iteration steps. This procedure converges to a local minimum or a saddle point of  $J_m$ .

The algorithm is described with the following steps:

1. Initialize  $Y = [u_{i,j}]$  matrix,  $U^{(0)}$
2. At k-step: calculate vectors  $C^K = [C_j]$  with  $u^{(K)}$

$$C_{i,j} = \frac{\sum_{i=1}^n \mu_{ij} x_i}{\sum_{i=1}^n \mu_{ij}}$$

3. Update

$$u_{i,j} = \frac{1}{\sum_{k=1}^c \left( \frac{\|x_i - c_j\|}{\|x_i - c_k\|} \right)^{2(m-1)}}$$

4. If  $\|u^{(k+1)} - u^{(k)}\| < \epsilon$  then stop; otherwise return to step 2.



#### **4. CONCLUSION**

Web mining is the use of data mining techniques to automatically discover and extract information from Web documents and services. There are three general classes of information that can be discovered by web mining: Web activity, from server logs and Web browser activity tracking; web graph, from links between pages, people and other data; Web content, for the data found on Web pages and inside of documents. In our survey paper we discussed major researches made in the field of data mining for providing personalized experiences to users based on their needs and preferences. We also studied various fuzzy methodologies being used for personalization and various hybrid options available to achieve better and most user satisfaction.

Hard fuzzy clustering(e.g. k- means clustering algorithm) is not suitable for web mining personalization since data received is imprecise and uncertain, difficult to decode hence its better to use soft clustering algorithm (e.g. c-means clustering ) where users can be classified to more than one clusters. In our next research we aim to propose personalization by the use of a fuzzy technique- fuzzy c- means clustering. Fuzzy c-means clustering gives best result for overlapped data set and comparatively better than k-means clustering. It also allows a data object to belong to more than cluster centres. The results obtained can be used to recommend new pages to the users. We aim to obtain majorly two types of clusters- page cluster and user clusters for our recommendation system. Studying new hybrid methods like applying genetic algorithm with fuzzy clustering can also be an interesting area of research to capture uncertainty and vastness of World Wide Web and its users.

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