Journal of
Engineering, Computing and Architecture ISSN 1934-7197
Volume 1, Issue 2, 2007

Internet Applications with Fuzzy Logic and Neural Networks: A Survey

H. Chris Tseng, Professor, Computer Science Dept., San Jose State University, CA, USA
tseng@cs.sjsu.edu

Abstract

Many internet applications need to deal with large amount of data collected from non-technical users and is imprecise and incomplete in nature. Well structured rules are hardly available in general applications and the nature and the pattern of the users can never be fully accounted. Soft computing techniques like fuzzy logic and neural network are ideal for coping with this type of problems. We survey recent internet applications using these techniques from 2003 to present and summarize the applications in several categories. The survey finds these soft computing techniques are suitable for internet applications.

1. Introduction

Internet applications are also commonly known as Web applications. We shall refer to them interchangeably in this paper. The World Wide Web (or the "Web") is a system of interlinked, hypertext documents that runs over the Internet. With a Web browser, a user views Web pages that may contain text, images, and other multimedia and navigates between them using hyperlinks. The Web was created around 1990 by Tim Berners-Lee and Robert Cailliau working at CERN in Geneva, Switzerland. (137) Since then, we see an ever growing number of applications that range from eCommerce to information search.

Typical Web applications are characterized by large amount of data that is growing in size and categories on a daily basis. Unlike other engineering problems where the issues and the size of the problem remain fairly constant, web applications present a new challenge to researchers. As of 2005, it is estimated that there are more than 11 billion web pages and the number is expected to be even higher and keep on growing today(138). How to effectively retrieve information from the web and guide users through this maze like information jungle can hardly be handled with few ad hoc rules. Business transaction over the internet has evolved from the B2B(Business-to-business), B2C(Business-to-consumer), to the current C2C(Consumer-to-consumer) protocol due the emerging P2P popularity. eCommerce has new issues to deal with, ranging from personalized recommendation to product recommendation. From the web deployment perspective, how to classify internet users and their usage pattern is a must in ensuring proper content is being delivered to the right user. Other related applications that will find soft computing techniques useful include network routing, internet traffic classification, and internet video game.
We begin by presenting an overview of fuzzy logic and neural networks techniques and how they can be useful in internet applications. Web information retrieval and eCommerce are two of the most important internet applications and we describe how fuzzy logic and neural network are useful in such applications in section 3. In section 4, classification and clustering problems in internet applications are presented together with solutions using neurofuzzy methodologies. Miscellaneous categories, including network routing, internet video game, internet medical, etc., are presented in section 5. The promise of soft computing techniques for open issues in internet applications is presented in the conclusion.

2. Fuzzy Logic and Neural Networks for Internet applications

2.1. *Fuzzy Logic*

The ability to model imprecise and qualitative knowledge and handle uncertainty are distinguished characteristics of fuzzy sets. Fuzzy logic is capable of addressing approximate or vague notions that are inherent in many information retrieval (IR) tasks. For the top internet application, i.e., internet search engines, users typically are not domain expert and therefore cannot articulate the search with the

intended keywords as inputs to search engines. Fuzzy search engines are a natural solution to this challenge.

In eCommerce and many other internet applications, they system needs to translate users' qualitative preference of product and personal profile into relevant quantitative variables for best match or personalization. Relating linguistic variable to numeric variable is a must in such designs and Fuzzy logic is ideal for this requirement. Figure 1 illustrates how a quantitative price value can be associated to, typically multiple, qualitative variables to be used in eCommerce and other internet application rule engines. The ever growing number of data and data types online inevitably leads to duplicated information in many internet applications. Treating information in a non-crisp way in fuzzy logic makes it ideal for such scenario.

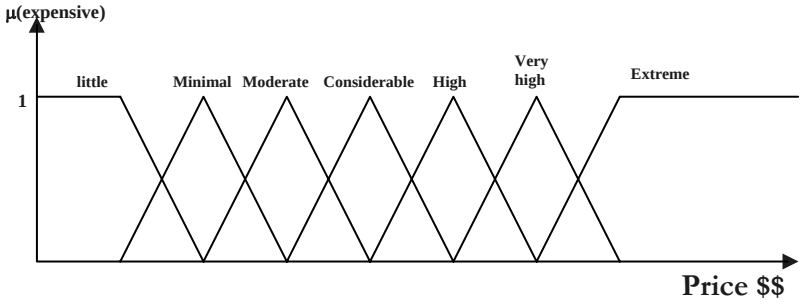

Figure 1 Relating numeric values to linguistic variables in rule engine

Classifying web pages has become an important and challenging jobs. This is due to the fact that web pages are growing in number and typically contain unstructured or vague information. One other challenge is the possibility of duplicated or seemingly related web pages. Fuzzy models can be used to represent information that are seemingly related so that meaningful and useful relationships between webpage and internet information can be established. Despite a growing trend in automating internet applications in a crisp way, numerous real life applications can hardly be represented in such manner without scarifying the usability. This is typical in translating linguistic domain and rule sets to internet solution engine. Fuzzy sets are inherently suitable for coping with linguistic domain knowledge and producing more interpretable internet solutions. The role of fuzzy sets in different internet applications is categorized in sections 3-5.

2.2. *Neural Networks*

Neural networks were earlier thought to be unsuitable for deduction because of their inherent black-box nature. This is, however, its strength as well. No information in symbolic form is needed to train the neural network for subsequent classification and/or deduction beyond its domain of training. There has also been active research aimed at extracting the embedded knowledge in trained networks in the form of symbolic rules. This serves to identify the attributes that are needed in performing classification. Many internet applications that need to be classified do not have explicit symbolic rules. One example of such is the internet user classification problem where abundant data is available although no explicit rules can be easily formed. Unlike fuzzy sets, the main use of neural nets in internet applications are in the area of rule extraction and clustering. Lately, game players demand a more realistic and changing environment and they are no longer satisfied to play in situations generated from preset rules or a variation of such. The adaptive ability of neural network to react to new situations and generalize training sets is an ideal match to extend internet games beyond the traditional settings and can help to create a new generation of games that adapt to different play styles.

3. Information retrieval and eCommerce applications

Information retrieval over the internet has always been the key application of internet. It is a challenging problem as the data structure is typically not available to the information seeker. Much of the work has focused on how to do a more effective search as well as mining web pages. The need to recover information from system with no clear structure is an ideal task for neural network. Use of fuzzy semantic to extend the search scope for a better result has also been conducted. eCommerce has been the main interest of internet applications and various new techniques have been researched in recent years to solve emerging problems like automated help in finance process, personalized product recommendation and self-guided shopping process. Numerous neural network and fuzzy logic based designed have shown to be helpful in all these eCommerce processes.

3.1. *Web content mining and search*

As one of the important fields in data mining, Web mining refers to the use of data mining techniques to retrieve, extract and evaluate information from Web documents and services. Web mining typically addresses semi-structured or unstructured data, e.g., Web and log files, and are often represented by imprecise or incomplete information. This implies that neural networks are a useful instrument to mine knowledge from such data. We have seen the use of neural network in web page mining problem and the result appears to be promising though higher precision rate is still not quite attainable (16, 17, 128, 131). An approach in Figure 2 using RBF(Radial Basis Function) neural network for classification is more efficient than other available classifiers. When testing with 1000 Web pages from several popular web sites, RBF neural network can classify Web documents into five categories – News, Sports, IT, Education, Other - with 80 percent accuracy and has 10 percent higher than BP (Back Propagation) model.

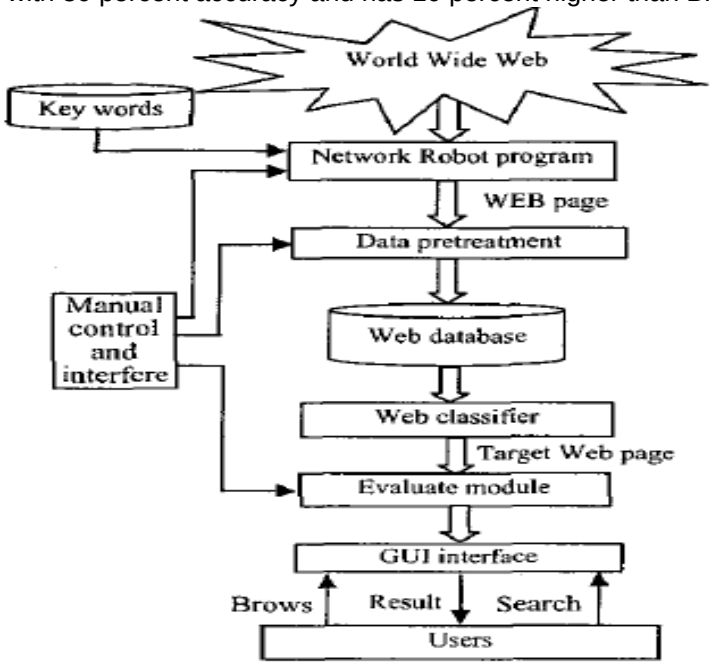

Figure 2 Web Classification Mining System Model based on RBF neural network (17)

Fuzzy logic was used in web mining because fuzzy logic is an ideal tool to handle approximate or vague notions that are inherent in many information retrieval (IR) tasks (23, 29, 30, 47, 71, 81, 96, 97, 115, 126). Most of the search engines search for data in their databases by using the exact words in the user query. Due to the fact that more users cannot articulate the search with the intended keywords, search engines fail to return the desired results from time to time. It is found that the user usually skims only through the first page of the search results; hence, it becomes crucial to output the best possible result to the user through their individual perspective. Fuzzy and Neural Network aided search engine can provide more relevant result to the users' query.(3, 18, 20, 36, 45, 54, 62, 66, 77, 106, 119, 129). It is especially true

when the semantics is taken into design consideration. This is a natural consequence as more relevant information is being extracted added to this process through the generalization feature of fuzzy logic and neural network. Fuzzy logic uses fuzzy rules to tracks the users and makes the decision about their interests. Neural network, once trained, can be used in making an optimal search result. The objective is to retrieve documents that satisfy a given query subject to a specific topic.

Figure 3 represents a search engine architecture utilizing fuzzy logic in interpreting the semantic of the search keywords. Here this search engine enhances the search with fuzzy linguistic search (FLS) or the Fuzzy Numeric Semantics (FNS) search modules. The Fuzzy linguistic search would extend the search to semantically related words based on the keywords entered in the user query. The FNS search technique searches for data that are contain keywords semantically related through the fuzzy linguistic-to-numeric mapping in the chosen application domain. Take for example, the search for high vitamin A foods is translated into a search on food that has over certain International Units of Vitamin A. This increases the efficiency of the search engine by as much as 50% in many cases.

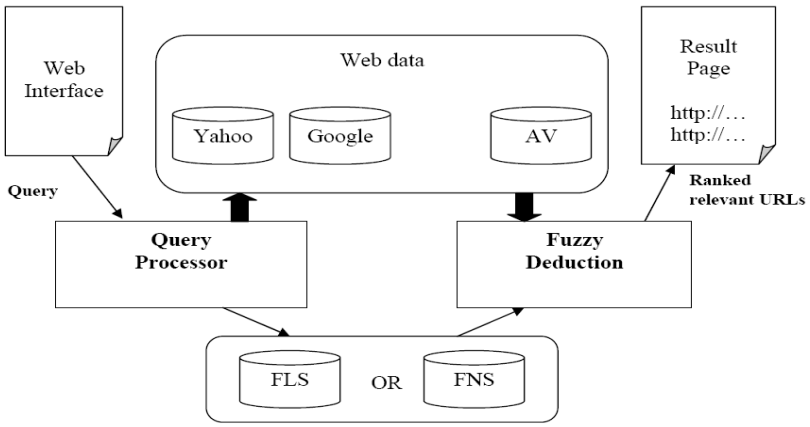

Figure 3 Perception-based search engine with fuzzy semantic (20)

Although fuzzy logic and neural network have been used extensively in various web applications, numerous areas remain open for researchers to bring these soft computing methodologies to solve other matching problems. This list includes:

a) using fuzzy logic to provide frequency mapping and an explanation in search engines.
b) enhancing search engines with fuzzy logic to reliably engage in searches for ideas or concepts which extend beyond mere word or word combination matches.
c) improving existing search engine performance with fuzzy logic.
d) using neural networks to resolve the failure of linear-sequential logic. systems to determine if the information being asked for does NOT exist in the databases which are available.
e) using fuzzy logic to facilitate a more useful and efficient tagging system.
f) applying fuzzy logic to current indexing schemes to enable search engine functions to operate semantically, particularly with respect to the various kinds of learning objects commonly archived in meta-databases, such as those extensively used in distance learning applications.

With the linguistic reasoning and the potential capability to deduce similarity among objects, it is expected that fuzzy logic will be able to offer promising solution to most, if not all, of the above open issues in the near future.

3.2. *eCommerce*

In banking and financial industry management of accounts and information involves heavy reliance on the use of networked computerized data systems. In AEC (Architecture, Engineering and Construction) projects, a large number of members have to work together on design and production of complex products. These team members may be geographically dispersed. Hence computer supported

collaborative work is important in the design process. IT tools are needed that enable collaboration among the team members. Risk assessment is an important area in such complex projects. It is often carried out individually by the various disciplines involved in the project. It is important to have tools available which will enable risk assessment to be undertaken collaboratively. Neural network and fuzzy logic can be used to help assess the risks and correlate information from a variety of technological and database sources to identify suspicious account activity (2, 32, 48, 55, 99, 123, 124).

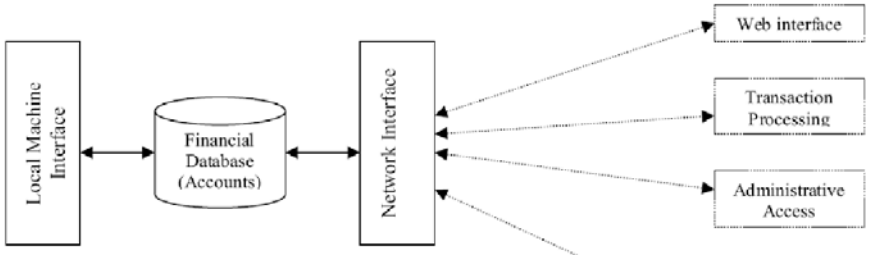

Figure 4: Access Mechanisms to Account (2)

In a typical finance process, the system needs quickly recognize underlying complex patterns in data and use them to assign risk levels to particular sets of transactions and activities observed in the environment of a financial institution. The scheme like that illustrated in Figure 4 proposes an activity monitoring and analysis tool based on the ability of neural networks. These systems are major sources of information that can be used in the identification and prevention of financial fraud like illegal/unauthorized transfer of funds by external and internal entities.

Finding a matching product among large product space and satisfying buyer's preferences is one of the essential activities in e-commerce. In online market, a customer specifies his/her product specifications while purchasing a product. At the same time, the customer wants to have the information about the popularity of the product. Neural network and fuzzy logic can be used to compare and rank the products based on customer's own preferences and on the information from the internet about the products.(7, 14, 19, 25, 26, 34, 49, 51, 56, 61, 63, 68, 75, 78, 87, 100, 101, 102, 110, 122, 134).

Many consumers purchase multi-functional products according to their individual preferences. Consumers are normally aware of their basic needs, but often have little or no idea of product types, functions, usage and terminology with important information. Figure 5 presents a method to translate customer needs into applicable alternative combinations for the products of customers' desire. The theory of the analytic hierarchy process is utilized to evaluate the importance of customer needs, which are generally rated and described by qualitative expressions. When customers make a purchase for a multi-functional product, customers are normally aware of their basic needs but often have little idea of types, function, usage and terminology of the desired product. A fuzzy inference model is employed to establish the relationship between customer needs and alternatives for a multi-functional product. This product customization evaluation model is established for a product consisting of multi-features and their corresponding alternatives. By means of fuzzy inference rules, consumer needs can be translated into ideal combination of alternatives. Furthermore, fuzzy numeric variables are used here to quantify linguistic variables as well as the intensity of consumer's needs. Also, the weight of customer needs can be obtained using the analytic hierarchy process (AHP) with the help of fuzzy membership functions.

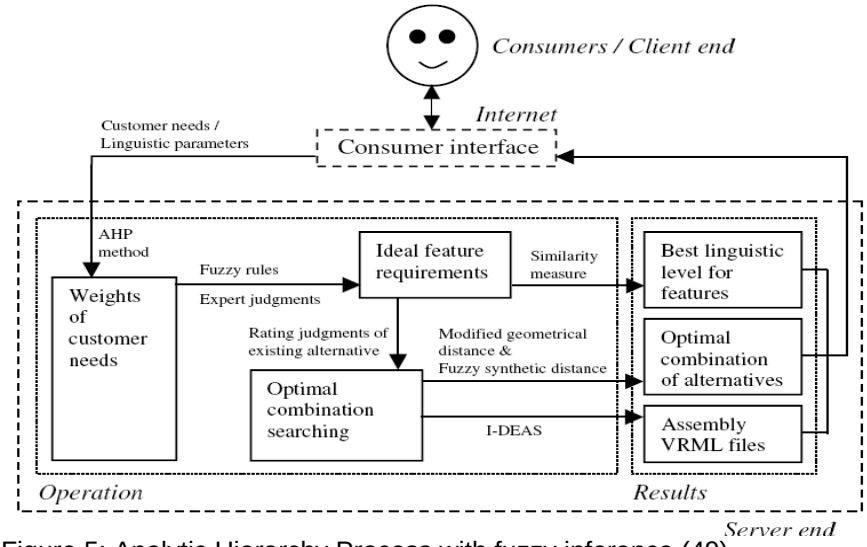

Figure 5: Analytic Hierarchy Process with fuzzy inference (49)

4. Classification of web data and users

4.1. *Internet user classification*

Internet traffic engineering and network management can greatly benefit from a reliable classification of internet users. The potential of different artificial Neural Network and fuzzy logic models for classifying Internet users based on their hourly traffic profile can be advantageous in various traffic engineering tasks and help in the selection of suitable trafficking plans (12, 83, 84, 88, 105, 109).
Figure 6 shows that logs from the web server can provide clues about the users of the website and that these logs could be used to gather information about the behavior of the users. These behavior attributes could be used to classify the different users and tailor the website based on these classifications. Although other methods succeed in grouping users according to their diverse Web interests, they lack the ability to adapt to changes in those interests over time. Adaptive resonance theory (ART1) offers an unsupervised clustering approach that adapts to change in users' access patterns over time without losing earlier information.

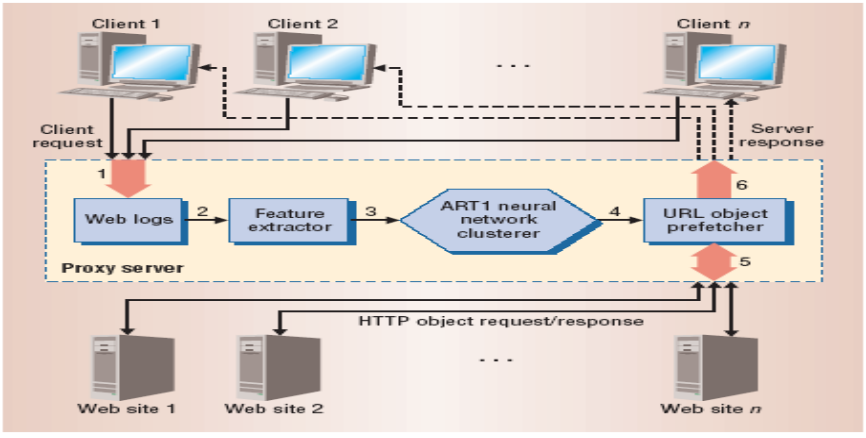

Figure 6: ART1-based clustering and prefetching architecture (105)

4.2. *Webpage classification and recommendation*

Web documents that are either partially or completely duplicated in content are easily found on the Internet these days. These documents not only create redundant information on the Web, which take

longer to filter unique information and cause additional storage space, but also degrade the efficiency of Web information retrieval. Neural network and fuzzy logic can be used to detect similar HTML documents on the internet (93, 113, 127).

Figure 7 shows how blocks of texts in the HTML document is parsed and broken down into hierarchical contents based on the location of the blocks in the document. By using predefined fuzzy clusters, feature vectors of similar documents are used to find the similarity.

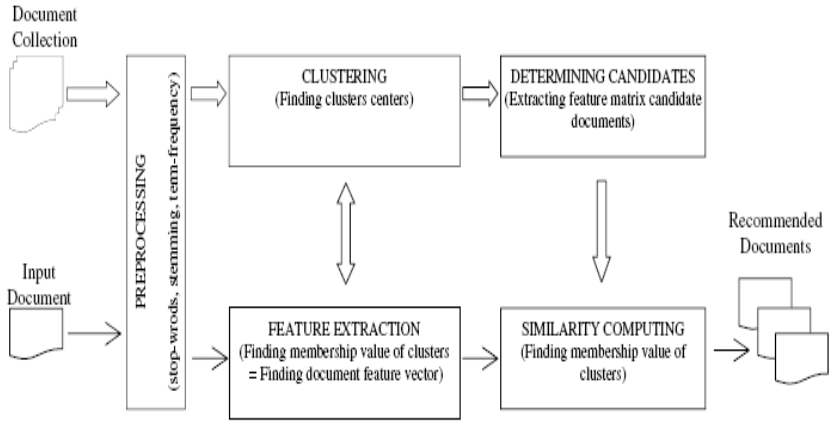

Figure 7 Webpage classification system architecture (93)

The Google's page rank algorithm and most of the other page ranking algorithms are designed to serve general purpose search engines. A ranking system that uses neural network and fuzzy logic to design a page ranking system is capable of doing a customized ranking. This customized ranking system intends to adapt neural network model to make it particularly suited for page ranking problem. The system allows automatic customization based on training examples or particular needs of the user (11, 33, 37, 38, 39). Figure 8 shows Graph Neural Networks (GNN) model that is capable of processing different types of graphs. Here, the Web is considered as a graph with each nodes denote pages and arcs denote hyperlinks. Web page ranking algorithm is fundamental algorithm for search engines. This helps to provide web page rank. This rank helps to sort out web pages returned in response to user queries. The main underlying idea of this approach is that the concept of "page importance" is not absolute but depends on the particular needs of a search engine or a user.

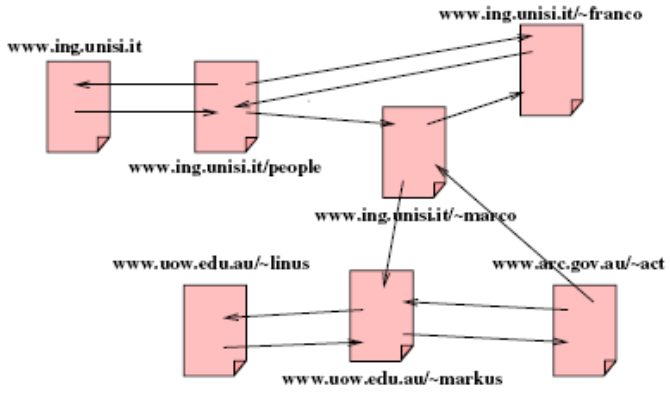

Figure 8 Graph Neural Networks (GNN) model. (39)

The Web information age has brought about a dramatic increase in the sheer amount of information. Hence, not surprisingly, there may be overwhelming information when searching and browsing the WWW. One of the most promising and potent remedy against this is personalization. Personalization aims to customize the interactions on a website depending on the user's explicit and/or implicit interests and desires. Web personalization has become more of a necessity than an option. One of the most successful examples of personalization comes in the form of web recommendation systems using neural network and fuzzy logic (23, 82, 86).

Website classification is popular in the information processing areas. The World Wide Web (WWW) is an information resource, whose full potential may not be realized unless its content is adequately organized and described. This applies not only to the vast network of web pages, but also users' personal repositories of web page bookmarks. However, due to the natures of immense size and dynamic content of the web, manual categorization is not a practical solution to this problem. There is a clear need for automated classification of web content. However it is difficult to increase the accuracy of website classification due to the diversity in the web pages' content. Neural network and fuzzy logic can be used to filtering the data on the web for classification (6, 5, 9, 21, 31, 40, 44, 46, 53, 57, 60, 64, 72, 91, 92, 103, 104, 107, 121, 125).

Figure 9 show the process of classifying a news web page using the web page classification method (WPCM) consists of web news retrieval process, stemming and stopping processes, feature reduction process using web classification process using error back-propagation neural networks. The average results of classifications base on WPCM are 87.82%. Although the WPCM approach provides an improvement of the classification results, the time taken to classify the web news page is significantly longer than other approaches.

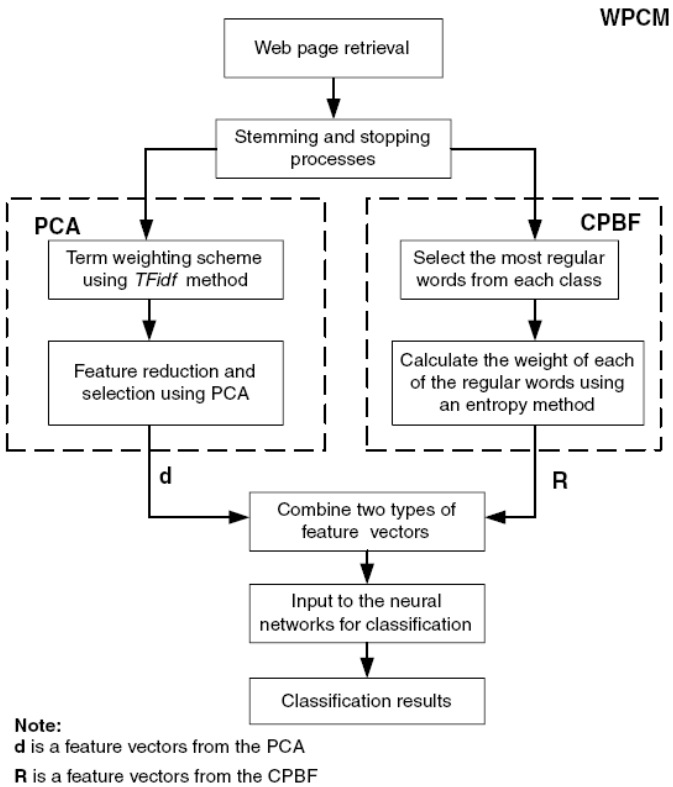

Figure 9 Web page classification using WPCM (107)

5. Other applications

5.1. *Video Game*

The market of video games is getting bigger and bigger throughout the recent years and it has become a facet of many people's lives. This market continues to expand as of now. In addition to its big player base, video games carry perhaps the least risk to human life of any real-world applications. They make an excellent test bed for techniques in artificial intelligence and machine learning. Machine learning is one of the most compelling and yet least exploited technology in the video game industry. This technology using neural network and fuzzy logic can greatly enhance video games, make video games more interesting and realistic, and to build entirely new genres (22, 58, 70, 73, 114). Figure 10 describes a novel game built around a real-time enhancement of the NeuroEvolution of Augmenting Topologies method (NEAT). Real-time NEAT (rtNEAT) is able to complexity neural networks as the game is played, making it possible for agents to evolve increasingly sophisticated behaviors in real time. Robot game agents (represented as small circles) are depicted playing a game in the large box. Every few ticks, two high-fitness robots are selected to produce an offspring that replaces another of lower fitness. This cycle of replacement operates continually throughout the game, creating a constant turnover of new behaviors.

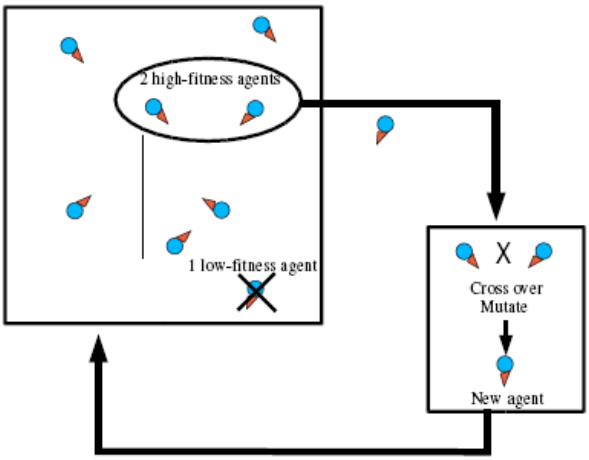

Figure 10 The main replacement cycle in rtNEAT (58)

5.2. *Internet traffic Identification*

Internet traffic identification is an important tool for network management. It allows operators to better predict future traffic matrices and demands, security personnel to detect anomalous behavior, and researchers to develop more realistic traffic models. A sophisticated Bayesian trained neural network is able to classify flows, based on header-derived statistics and no port or host (IP address) information, with up to 99% accuracy for data trained and tested on the same day, and 95% accuracy for data trained and tested eight months apart(10). Further, the neural network produces a probability distribution over the classes for a given flow. By providing high accuracies without access to packet payloads or sophisticated traffic processing this technique offers good results as a low-overhead method with potential for real-time implementation (4, 10, 13, 24, 35, 59, 67, 85, 108, 116, 130).

5.3. *Miscellaneous*

Ontology is the conceptualization of a domain into a human understandable, machine-readable format consisting of entities, attributes, relationships, axioms. It is used as a standard knowledge representation for the semantic web. However, the conceptual formalism supported by typical ontology may not be sufficient to represent uncertainty information commonly found in many application domains due to the

lack of clear-cut boundaries between concepts of the domains. To tackle this type of problems, one possible solution is to incorporate Fuzzy Logic into ontology to handle uncertainty data. Traditionally, fuzzy ontology is generated and used in text retrieval and search engines. However, the manual generation of fuzzy ontology from a predefined concept is difficult and tedious task that often requires expert interpretation. So, automatic generation of concept hierarchy and fuzzy ontology from uncertainty data of a domain is highly desirable. Fuzzy ontology can be incorporated to ontology to represent the uncertainty of the information. In order to tackle this problem fuzzy logic researchers propose a solution for that is known as the Fuzzy ontology generation framework which is basically used for automatic generation of Fuzzy Ontology of uncertainty information (15, 117, 118, 133).

The volume of e-mail that we get is constantly growing. We are spending more and more time filtering e-mails and organizing them into folders in order to facilitate retrieval when necessary. The rate of unsolicited (spam) e-mail is also rapidly increasing. It may vary significantly in content, from get-rich and selling items, to offensive e-mails and pornographic sites. Most modern e-mail software packages provide some form of programmable filtering, typically in the form of rules that organize mail into folders or dispose of spam mail based on keywords detected in the header or body. However, most users avoid the customizing software. In addition, manually constructing robust rules is difficult as users are constantly creating, deleting and reorganizing their folders. Even if the folders remain the same, the nature of the e-mails within the folder may well drift over time. The characteristics of the spam e-mail also change over time. Hence, the rules must be constantly tuned by the user. That is not only time consuming but also error-prone. A system that can automatically learn how to classify e-mails into a set of folders and filter spam e-mails is highly desirable. Neural network and fuzzy logic can be successfully used for automated e-mail filing into mailboxes and spam mail filtering (27, 90, 135). In (135) the success of filtering rates of neural network is 96.2% which is much better than the Bayesian method at 91.72%.

Rapid development of Internet technologies, remotely accessing and operating medical applications, ubiquitously, is becoming increasingly possible. So the virtual medical advice may be planned for the future, using an internet link and a fuzzy logic algorithm to replace the “doctor-patient” direct relations. But in this type of application, uncertainty can arise at various levels, and that can be solved using fuzzy logic algorithm. So we address the representation of uncertainty and the decision process through the use of fuzzy algorithms, in order to replace a medical consultation (1, 28, 52, 69).

Facial expressions contribute fifty five percent towards the meaning of a human interaction. Understanding facial expressions is an important requirement in the development of human computer interaction systems. Facial expressions are qualitative and cannot be expressed in terms of a mathematical model. A system framework that uses fuzzy logic to recognize facial expressions in video sequences can be useful for this purpose. Given a video as input, the system uses image processing techniques to determine MPEG4 Facial Animation Parameters (FAPs). A fuzzy rule base interprets a set of FAPs to constitute a particular facial expression (74, 76, 80, 136).

6. Conclusion

We see a growing interest in using fuzzy logic and neural network for solving internet applications in the past 5 years. The inherent capability of neuro-fuzzy techniques in handling vague, large-scale, and unstructured data is an ideal match for internet related problems. Earlier research tends to focus on how to extract needed information from unstructured internet data. Lately, we have seen the use of neuro-fuzzy methodologies in building a structure web. Semantic web is one example of such. The notion of a structure web can be made more realistic when the concept of fuzzy logic is employed since web data tend to be fuzzy in nature. We expect to see an integration of soft computing techniques in Semantic web methodologies in the near future. Genetic algorithm for internet application should also become more popular as internet applications get larger in scale.

References

1. A. Taleb-Ahmed, A. Bigand, V. Lethuc, P.M. Allioux, “Visual acuity of vision tested by fuzzy logic: An application in ophthalmology as a step towards a telemedicine project**,** ” *Information Fusion*, Volume 5, Issue 3, September 2004, pages 217-230.
2. A. Vikram, S. Chennuru, H.R. Rao, S. Upadhyaya, “A solution architecture for financial institutions to handle illegal activities: a neural networks approach”, *Proceedings of the 37th Annual Hawaii International Conference, System Sciences*, Jan 2004, pages 181-190.

3. Agarwal, S.; Agarwal, P, “A Fuzzy Logic Approach to Search Results’ Personalization by Tracking User’s Web Navigation Pattern and Psychology”, *Tools with Artificial Intelligence, 2005*, 14-16 Nov. 2005 pages 318 – 325.

4. Alandjani, G.; Johnson, E.E., “Fuzzy routing in ad hoc networks” *Performance, Computing, and Communications Conference, 2003*, 9-11 April 2003, Pages 525 – 530.

5. Ali Selamat and Sigeru Omatu,”Neural Networks for Web Page Classification Based on Augmented PCA”, *Proceedings of the International Joint Conference on Neural Networks, 2003*, Volume 3, pages 1792 - 1797.

6. Anagnostopoulos, I. Et al., “Classifying Web pages Employing a Probabilistic Neural Network”, *Proceedings: Software*, v151, n3, June 2004, page 139-150.

7. Ananta Charan Ojha, Sateesh Kumar radhan, “Fuzzy Linguistic Approach to Matchmaking in E-Commerce”, *9th International Conference on Information Technology (ICIT'06)*, December 2006, pages 217-220.

8. Andrew H. Sung, Srinivas Mukkamala, “Identifying Important Features for Intrusion Detection Using Support Vector Machines and Neural Networks” *Proceedings of the 2003 Symposium on Applications and the Internet (SAINT’03)*

9. Ariel Gómez, Jorge Ropero and Carlos León, “A fuzzy logic system for classifying the contents of a database and searching consultations in natural language”, *Electrotechnical Conference*, May 2006, pages 721- 724.

10. Auld, T.; Moore, A. W.; Gull, S. F, “Bayesian Neural Networks for Internet Traffic Classification,” *Neural Networks*, IEEE Transactions, Jan 2007, pages 223 – 239.

11. B. L. Narayan and Sankar K. Pal, “Fuzzy Web Server Model”, *Proceedings of the 2005 IEEE/WIC/ACM International Conference on Web Intelligence (WI’05)*, 2005, pages 1-4.

12. Baoyao Ahou, Siu Cheung Hui, Alvis C. M. Fong, “Discovering ad Visualizing Temporal-Based Web Access Behavior”, *The 2005 IEEE/WIC/ACM International Conference on Web Intelligence(WI' 05)*, September 2005, pages 297-300.

13. Bin Zhou; Mouftah, H.T., “Adaptive Shortest Path Routing in GMPLS-based Optical Network Using Fuzzy Link Costs”, *Electrical and Computer Engineering, 2004*. Canadian Conference on Volume 3, Issue 2-5 May 2004, Pages 1653 - 1657 Vol.3

14. B. K. Mohanty, K. Passi, “Web based information for product ranking in e-business: a fuzzy approach”, *Proceedings of the 8th international conference on Electronic commerce: The new e-commerce: innovations for conquering current barriers, obstacles and limitations to conducting successful business on the internet ICEC '06,* ACM Press, August 2006.

15. Chang-Shing Lee, Zhi-Wei Jian and Lin-Kai Huang, “A Fuzzy Ontology and its application to news summarization”, *Systems, Man and Cybernetics*, Oct 2005, pages 859-880.

16. Chen, Chih-Ming, “Incremental Personalized Web Page Mining Utilizing Self-Organizing HCMAC neural network”, *Web Intelligence and Agent Systems*, v2, n1, 2004, pages 21-38.

17. Chen Junjie, and Huang Rongbing, “Research of Web classification mining based on RBF neural network,” *Control, Automation, Robotics and Vision Conference, 2004*. ICARCV 2004 8th Vol. 2 December 2004 pages1365-1367.

18. Cheng-Zhong Xu Tamer I. Ibrahim, “A Keyword-Based Semantic Prefetching Approach in Internet News Services” *Transactions on Knowledge and Data Engineering*, Volume 16 , Issue 5 (May 2004) Pages 601 – 611.

19. Chenn-Jung Huang, Ming-Chou Liu, San-Shine Chu, Chin-Lun Cheng, “Application of Machine Learning Techniques to Web-Based Intelligent Learning Diagnosis System,” *Fourth Internation Conference on Hybrid Intelligent Systems (HIS '04)*, December 2004, pages 242-247.

20. Chris Tseng, Toan Vu,” A perception-based web search with fuzzy semantic”, CS department, San Jose State University, One Washington Square, San Jose, CA 95192, USA.

21. Christian Bauer, Arno Scharl, “Quantitive evaluation of Web site content and structure”, *Internet Research*, Mar 2000, Volume 10, Issue 1, pages 31 – 44.

22. Christina Christakou and Andreas Stafylopatis, “A Hybrid Movie Recommender System Based on Neural Networks”, *Proceedings of the 2005 5th International Conference on Intelligent Systems Design and Applications (ISDA’05)*

23. Christopher Petenes, Olfa Nasraoui. “Combining Web Usage Mining and Fuzzy Inference for Website Personalization.” WebKDD (2003), pages 37-46.

24. Chrysostomou, C.; Pitsillides, A.; Hadjipollas, G.; Sekercioglu, A.; Polycarpou, M., “Fuzzy logic congestion control in TCP-IP differentiated services networks for quality of service provisioning”, *Information and Communication Technologies: From Theory to Applications, 2004*, Issue 19-23 April 2004, pages 373 – 374.

25. Chun-Lung Huang; Chao, K.-M.; Chi-Chun Lo, “A moderated fuzzy matchmaking for Web services,” *Computer and Information Technology*, Sept 2005, pages1116–1122.

26. Chunyan Miao, Qiang Yang, Haijing Fang, Angela Goh, "Fuzzy Cognitive Agents for Personalized Recommendation", *Proceedings of the 3rd International Conference on Web Information Systems Engineering*, 2002, pages 362 – 372.

27. Clark J, Korpinska I, Poon J, “A neural network based approach to automated e-mail classification*”, IEEE/WIC International Conference on Web Intelligence, 2003. WI 2003, Proceedings*, Oct 2003, Pages 702 – 705.

28. David Parry, “A fuzzy ontology for medical document retrieval”, *Proceedings of the second workshop on Australasian information security, Data Mining and Web Intelligence, and Software Internationalization - Volume 32 ACSW Frontiers '04,* Australian Computer Society, Inc., January 2004.

29. David E. Losada, Félix Díaz-Hermida, Alberto Bugarín, Senén Barro, “Information access and retrieval (IAR): Experiments on using fuzzy quantified sentences in adhoc retrieval ” , *Proceedings of the 2004 ACM symposium on Applied computing SAC '04,* ACM Press, March 2004.

30. Didier Dubois, Henri Prade, Florence Sèdes, “Some uses of Fuzzy logic in multimedia databases querying”, *Fuzzy Systems Conference Proceedings, 1999*, Volume 2, Pages 586 – 591.

31. E. Herrera-Viedma, F. Herrera, L. Martinez, J.C. Herrera, A.G. Lopez, “Incorporating filtering techniques in a fuzzy linguistic multi-agent model for information gathering on the web,” *Fuzzy Sets and Systems*, 2004, pages 61–83.

32. E. W. T. Ngai and F. K. T. Wat, "Fuzzy decision support system for risk analysis in e-commerce development," *Decision Support Systems*, March 2004, Vol. 40, pages 235-255.

33. Elie Sanchez and Jean-AndrC Santini, “Fuzzy Logic and the Internet: a Fuzzy Web Site Evaluator”, *Fuzzy Information Processing Society*, 2002, Annual Meeting of the North American 2002, pages 344 – 347.

34. F.Y. Liu, H.L.Geng, and Y.-Q. Zhang, “Interactive Fuzzy Interval Reasoning for Smart Web Shopping,” *Applied Soft Computing*, vol. 5, July 2005, pages 433-439.

35. Federica Mandreoli, Riccardo Martoglia, Simona Sassatelli, “SRI: Exploiting semantic information for effective query routing in a PDMS.” 2004.

36. Filippo Menczer. “Complementing search engines with online web mining agents.” *Decision Support Systems* 35.2 (2003), pages 195-212.

37. FILIPPO MENCZER, GAUTAM PANT and PADMINI SRINIVASAN, " Topical Web Crawlers: Evaluating Adaptive Algorithms,"*ACM Transactions on Internet Technology; VOL 156*, 2004, pages 378-419.

38. Franco Scarselli, Sweah Liang Yong, Markus Hagenbuchner, Ah Chung Tsoi, **“**Adaptive page ranking with neural networks”, *Special interest tracks and posters of the 14th international conference on World Wide Web*, May 2005, pages 936-937.

39. Franco Scarselli, Sweah Liang Yong, Marco Gori, Markus Hagenbuchner, Ah Chung Tsoi and Marco Maggini, “Graph Neural Networks for Ranking Web Pages”, *Proceedings of the 2005 IEEE/WIC/ACM International Conference on Web Intelligence*, September 2005, pages 666- 672.

40. Friedman, M.; Kandel, A.; Schneider, M.; Last, M.; Shapira, B.; Elovici, Y.; Zaafrany, O, “A fuzzy-based algorithm for Web document clustering**”,** *Fuzzy Information*, 2004. Processing NAFIPS’04, Annual Meeting of the, June 2004, pages 524 - 527 Vol.2

41. Gilson Fernando Laforga, RoseliFranceh Romero, "A Services-Oriented Architecture Applied To Artificial Neural Network," *Neural Information Processing 2003*, Nov 2003, pages 2650-2654.

42. Giorgos Stoilos, Giorgos Stamou, Vassilis Tzouvaras, “Fuzzy owl: Uncertainty and the semantic web.”, *Workshop on OWL: Experience and Directions* (OWL-ED2005).

43. Giorgos Stoilos; Simou, N.; Stamou, G.; Kollias, S.; “Uncertainty and the Semantic Web”, *Intelligent Systems*, IEEE Volume 21, Issue 5, Sept.-Oct. 2006, pages 84 – 87.

44. Giovanni Pilato, Salvatore Vitabile, Giorgio Vassallo, “Web directories as a knowledge base to build a multi-agent system for information sharing.” *Web Intelligence and Agent Systems: An international journal 2*, 2004, pages 265–277.

45. Giovanni Pilato, Salvatore Vitabile, Giorgia Vassallo, Vincenzo Conti, Filippo Sorbello, “ A Neural Multi-Agent Based System for Smart Html Pages Retrieval,” *International Conference on Intelligent Agent Technology (IAT'03)*, October 2003, pages 233.

46. H. O. Nyongesa, Shicheng Tian, Maleki-Dizaji, S. Huang, S.-T. Siddiqi, J. “Adaptive Web Interface Using Fuzzy Logic,” *Web Intelligence*, IEEE/WIC,13-17 Oct. 2003, pages 671- 674.

47. Harshana Liyanage and G.E.M.D.C.Bandara, “Macro-clustering: Improved information retrieval using fuzzy logic”, *Proceedings of the 2004 IEEE International Symposium on Intelligent Control*, September 2004, pages 413-418.

48. Huiping Shang, Chimay J. Anumba and Dino M. Bouchlaghem,"An Intelligent Risk Assessment System for AEC", *Proceedings of the 10th International Conference on Computer Supported Cooperative Work in Design.*

49. Hung-Cheng Tsai, Shi-Wen Hsiao, “Evaluation of alternatives for product customization using fuzzy logic.” *Information Sciences* 158 , 2004, pages 233–262.

50. J.Z. Lei and A. Ghorbani, ”Network intrusion detection using an improved competitive learning neural network”, *Proceedings. Second Annual Conference, Communication Networks and Services Research*, May 2004, pages 190-197.

51. James Liu, Jane You**, “**Smart shopper: an agent-based web-mining approach to Internet shopping**”**, IEEE *Transactions on Fuzzy Systems*, Apr 2003, pages 226 – 237.

52. Javier Herrero, Fatima Al-Shahrour, Ramon Diaz-Uriarte, Alvaro Mateos, Juan M. Vaquerizas, Javier Santoyo and Joaquin Dopazo, “GEPAS: a web-based resource for microarray gene expression data analysis”, *Oxford Journals*, Nucleic Acids Research 2003 Vol. 31, No 13.

53. Jiu-zhen Liang, “ Chinese Web page classification based on self organizing mapping neural networks,” *Computational Intelligence and Multimedia Applications*, ICCIMA, Sep 2003, pages 96-101.

54. Jesus Ibanez Martinez, Antonio F. Gomez Skarmeta and Josep Blat Gimeno, “Fuzzy Approach to the Intelligent Management of Virtual Spaces”, IEEE *Conference Proceedings on Systems, Man, and Cybernetics*, June 2006.

55. Jorge Casillas, Luciano Sanchez, “Knowledge extraction from fuzzy data for estimating consumer Behavior methods.” 2006 IEEE *International Conference on Fuzzy Systems*.

56. K. K. Yuen, H. C. Lau, “A Distributed Fuzzy Qualitative Evaluation System”, *Proceedings of the IEEE/WIC/ACM International Conference on Intelligent Agent Technology*, IAT’06, pages1-4.

57. Kartik Menon and Cihan H. Dagli, "Web Personalization using Neuro-Fuzzy Clustering Algorithms," *NAFIPS 2003 22nd International Conference of the North American*, IEEE, July 2003, pages 525-529.

58. Kenneth O. Stanley, Bobby D. Bryant, and Risto Miikkulainen (2005). “Evolving Neural Network Agents in the NERO Video Game”, *Proceedings of the IEEE 2005 Symposium on Computational Intelligence and Games (CIG'05)*. Piscataway, NJ: IEEE, 2005.

59. Khotanzad, A.; Sadek, N., “Multi-scale high-speed network traffic prediction using combination of neural networks” *Neural Networks, 2003*. Proceedings of the International Joint Conference on Volume 2, Issue , 20-24 July 2003 Page(s): 1071 - 1075 vol. 2.

60. Ko-Kang Chu,Maiga Chang and Yen-Teh Hsia,” A Hybrid Training Mechanism for Applying Neural Networks to Web-based Applications”, *International Conference on Systems, Man and Cybernetics*, 2004, pages 3543-3547.

61. Kuo-Ming Chao, M. Younas, Chi-Chun Lo, Tao-Hsin Tan, “Fuzzy matchmaking for Web services”, *Proceedings of the 19th international conference on Advanced Information Networking and Applications, 2005*. AINA March 2005, pages 721 - 726 vol. 2.

62. Kyung-Joong Kim, Sung-Bae Cho, "A personalized Web search engine using fuzzy concept network with link structure", *IFSA World Congress and 20th NAFIPS International Conference, 2001*, Volume 1, Issue , 25-28 July 2001 pages 81 - 86 vol. 1.

63. L. Gu and Y. Q. Zhang, “Web Shopping Expert Using New Interval Type-2 Fuzzy Reasoning”, *Soft Computing*, v11, 2007, p741-751.

64. Lee, P.Y.; Hui, S.C.; Fong, "Neural Networks for Web Content Filtering", *Intelligent Systems*, IEEE Volume 17, Issue 5, Sep/Oct 2002, pages 48 – 57.

65. Lei Xu, Baowen Xu, Jixiang Jiang. “Testing Web Applications Focusing on Their Specialties.” *ACM SIGSOFT Software Engineering Notes* 30.1, 2005, page 10.

66. Lei Zhang, Yong Yu, Jian Zhou, ChenXi Lin and Yin Yang, “Semantic search: An enhanced model for searching in semantic portals”, *Proceedings of the 14th international conference on World Wide Web WWW '05,* ACM Press, May 2005.

67. Li Hongyan; Wang Hong; Gui Chao, “Internet Time-delay Prediction Based on Autoregressive and Neural Network Model,” *Communications, Circuits and Systems Proceedings*, June 2006, pages1758 – 1761.

68. Lip Wang, Jagath C. Rajapakse, Kunihiko Fukushima,Soo-Young Lee, and Xin Yao, ”A Service Oriented Architecture Applied To Neural Networks”, *Proceedings of the 9th International Conference on Neural Information Processing (ICONIP'OZ)* , Vol. 5, pages 2650-2654.

69. Lixin Dong, Dengming Xiao, Yilu Liu, “The clustering rule based data mining fault diagnosis in internet based Virtual Hospital for power equipment”, *Proceedings of the 7th International Conference on Properties and Applications of Dielectric Materials, 2003*, June 2003, pages 356 - 359 vol.1.

70. Lotfallah, O.A.; Panchanathan, S. “Adaptive Multiple Description Coding for Internet Video”, *Acoustics, Speech, and Signal Processing, 2003. Proceedings*. (ICASSP’03). 2003 International Conference on Volume 5, Issue , 6-10 April 2003 pages 732-5 vol. 5.

71. M. J. Martin-Bautisa, D. H. Kraft, M. A. Vila, J. Chen, J. Cruz, “User profile and fuzzy logic for web retrieval issues” *Soft Computing - A Fusion of Foundations, Methodologies and Applications*, Volume 6, Number 5, February 19, 2004, 285-286.

72. Ma. Heng "Fast Blocking of Undesirable Web pages on Client PC by discriminating URL using Neural Networks," *Expert Systems With Applications, 2007*.

73. Marcin Detyniecki, Claude Seyrat, Ronald Yager, “Interacting with Web Video Objects”, *Fuzzy Information Processing Society, 1999*. NAFIPS. *18th International Conference of the North American*, NY, July 1999, pages 914-917.

74. Masun, H, “A hybrid neural network for Arabic Internet navigator commands recognition,” *Information and Communication Technologies*, April 2004, pages 607 – 608.

75. Menglei Tang, Yan-Quig Zhang, Gang Zhang, “Type-2 Fuzzy Web Shopping Agents,” *IEEE/WIC/ACM International Conference on Web Intelligence (WI'04)*, September 2004, pages 499-503.

76. Mia O Kang,Dominic Palmer-Brown, "An Adaptive Neural Network for Phrase Recognition", 2005, pages 593-597.

77. Michael Chau, Hsinchun Chen. “Comparison of three vertical search spiders.” *Computer*, 2003, pages 56-62.

78. Minnghua He, Nicholas R. Jennings, Adam Prugel-Bennett, “A heuristic bidding strategy for buying multiple goods in multiple english auctions”, *ACM Transactions on Internet Technology (TOIT)*, Vol 6 Issue 4, ACM press, November 2006, pages 465-496.

79. Mourad Atlas and Yan-Qing Zhang, “Fuzzy Neural Agents for Online NBA Scouting”, *Proceedings of the IEEE/WIC/ACM International Conference on Web Intelligence (WI’04)*.

80. Muid Mufti and Assia Khanam, “Fuzzy Rule Based Facial Expression Recognition”, *International Conference on Computational Intelligence for Modelling Control and Automation,and International Conference on Intelligent Agents,Web Technologies and Internet Commerce (CIMCA-IAWTIC'06*), 2006.

81. Murat Koyuncu and Adnan Yazici, “A Fuzzy Knowledge Based System for Intelligent Retrieval”, *Conference proceedings on Fuzzy system, June 2005.*

82. Nasraoui, O.; Petenes, C. (2003), “An Intelligent Web Recommendation Engine Based on Fuzzy Approximate Reasoning**”**, *International Conference on Fuzzy Systems*.

83. Nogueira, A.; Rosario de Oliveira, M.; Salvador, P.; Valadas, R.; Pacheco, A., "Using neural networks to classify Internet users," *Telecommunications, July 2005*, pages 183- 188.

84. Nogueira, A.; de Oliveira, M.R.; Salvador, P.; Valadas, R.; Pacheco, A, “Classification of Internet users using discriminant analysis and neural networks,” *Next Generation Internet Networks*, April 2005, pages 341 – 348.

85. Norashidah M. Din, Norsheila Fisal, “Fuzzy Logic Token Bucket Bandwidth Predictor for Assured Forwarding Traffic in a DiffServ - Aware MPLS Internet”, *Proceedings of the First Asia International Conference on Modeling & Simulation*, AMS 2007.

86. Olfa Nasraoui, Mrudula Pavuluri, “Accurate web recommendations based on profile-specific url-predictor neural networks”, *Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters WWW Alt. '04*, May 2004, pages 300-301.

87. Olfa Nasraoui and Mrudula Pavuluri,"Eager Learning in Two-Stages for Precise and Complete Web Personalization," *International Conference on Fuzzy Systems*, Feb 2005, pages 1026-1031.
88. Pawan Lingras, Chad West. “Interval Set Clustering of Web Users with Rough K-Means.” *Journal of Intelligent Information Systems*, 2004, pages 5-16.

89. Qinghua Hu, Daren Yu and Zongxia Xie. “Information-preserving hybrid data reduction based on fuzzy-rough techniques.” *Pattern Recognition Letters*, 2006, pages 414-423.

90. Ravi, J.; Weisong Shi; Cheng-Zhong Xu, “Personalized email management at network edges”, *Internet Computing***,** Volume 9, Issue 2, March-April 2005, pages 54 – 60.

91. Richard T. Freeman*,* and Hujun Yi, “Web Content Management by Self-Organization”, *Transactions on neural networks*, Vol. 16, No. 5, September 2005, pages 1256- 1268.

92. Richard Jensen, Qiang Shen. “Fuzzy-rough attribute reduction with application to web categorization.” *Fuzzy Sets and Systems*, 2004, pages 469-485.

93. Rıdvan Sarac¸og˘lu *, Kemal Tu¨tu¨ncu¨ and Novruz Allahverdi,"A fuzzy clustering approach for finding similar documents using a novel similarity measure", *Expert Systems with Applications*, 2007, pages 600–605.

94. Rodrigo F. Cadiz, "Fuzzy logic in the arts: applications in audiovisual composition and sound synthesis", 2005, IEEE, pages 551-556.

95. Rojanavasu, P. Pinngern, O. "Extended Rough Fuzzy Sets for Web Search Agent," *Information Technology Interfaces*, 16-19 June 2003, pages 403- 407.

96. Rowena Chau and Chung-Hsing Yeh, "Fuzzy Conceptual Indexing for Concept-Based Cross-Lingual Text Retrieval", *Internet Computing*, October 2004, pages 14-21.

97. Rui Wu; Wansheng Tang; Ruiqing Zhao,"An efficient algorithm for fuzzy Web-mining," *Information Reuse and Integration*, Nov 2004, pages 576 – 581.

98. S. Purwar, I.N. Kar, A.N. Jha, "On-line system identification of complex systems using Chebyshev neural networks", *Applied Soft Computing*, Jan 2007, pages 364-372.

99. Shuxiang Xu, Ming Zhang, "Data mining - an adaptive neural network model for financial analysis", Information *Technology and Applications, 2005, ICITA 2005. Third International Conference on Volume 1*, July 2005, pages 336 - 340 vol. 1.

100. S. Kouremenos,S. Vrettos and A. Stafylopatis,"An Intelligent Agent-Mediated Web Trading Environment,", *Proceedings IEEE International Conference on Web Intelligence*, Issue 13, Oct. 2003, pages 436 - 441.

101. S. M. Bae, S. C. Park, S. H. Ha, "Fuzzy Web ad selector based on Web usage mining", *Intelligent Systems IEEE*, Nov 2003, pages 62 – 69.

102. S. Song, K. Hwang, R. Zhou, K. wok, "Trusted P2P transactions with fuzzy reputation aggregation", *Internet Computing*, Volume 9, Issue 6, Nov.-Dec. 2005 pages 24 – 34.

103. S. Vrettos, A. Stafylopatis, "A Fuzzy Framework for Web Page Filtering," *6th Seminar on Neural Network Applications in Electrical Engineering*, September 26-28, pages 47-51.

104. Sadaaki Miyamoto, "Information clustering based on fuzzy multisets, Information Processing & Management", Volume 39, Issue 2, March 2003, Pages 195-213.

105. Santosh K.Rangarajan,Vir V.Phoha,Kiran S.Balagani,Rastko R.Selmic," Adaptive Neural Network Clustering of Web Users", *Transactions on computer*, Apr 2004,pages 34-40.

106. Seda Özmutlu, Fatih Çavdur. "Neural network applications for automatic new topic identification." *Online Information Review*, 2005, pages 34-53.

107. Selamat A., & Omatu S. (2003). "Web Page Feature Selection and Classification Using Neural Networks", *Information Sciences*.

108. Shuping Yao, Changzhen Hu, Mingqian Sun, "Prediction of Web Traffic Based on Wavelet and Neural Network," *Proceedings of the World Congress on Intelligent Control and Automation*, June 2006, pages 4026-4028.

109. Siriporn Chimphlee, Naomie Salim, Mohd Salihin Bin Ngadiman, "Independent component analysis and rough fuzzy based approach to web usage mining." February 13-16, 2006, Innsbruck, Austria.

110. Soe-Tsyr Yuan. “A personalized and integrative comparison-shopping engine and its applications.” *Decision Support Systems*, 2003, pages 139-156.

111. Sofia Hadjileontiadou, Georgia Nikolaidou, Leontios Hadjileontiadis, George Balafoutas, "A Fuzzy Evaluation System to support Web-based Collaboration Using Collaborative and Metacognitive Data", *International Conference on Advanced Learning Technologies*, 2003.

112. Steve Engels,Vivek Lakshmanan and Michelle Craig,” Plagiarism Detection Using Feature-Based Neural Networks”, *Artificial intelligence* , Vol 39 , Issue 1 ,March 2007, pages 34 - 38.

113. Surajit Chaudhuri, Kris Ganjam, Venkatesh Ganti, Rajeev Motwani, “Similarity queries I: Robust and efficient fuzzy match for online data cleaning”, *Proceedings of the 2003 ACM SIGMOD international conference on Management of data SIGMOD '03,* ACM Press, June 2003.

114. Sushil. K. Prasad, Raj Sunderraman, Yanqing Zhang, Atul Parvatiyar, “A Web-Based Game-Oriented College Selection System Employing Fuzzy Rule Trees”, *Proceedings of the 37th Annual Hawaii International Conference on System Sciences(HICSS'04)*, January 2004, pages 30075.

115. Swain, M.; Anderson, J.A.; Swain, N.; Korrapati, R. “Study of information retrieval using fuzzy queries”, *Southeast Conference*, 2005, Proceedings, 8-10 April 2005 pages 527 – 533.

116. Symington, K.J.; Waddie, A.J.; Taghizadeh, M.R.; Snowdon, J.F. “A Neural-Network Packet Switch Controller: Scalability, Performance, and Network Optimization” *Neural Networks*, Transactions on Volume 14, Issue 1, Jan 2003, pages 28 – 34.

117. Thanh Tho Quan, Siu Cheung Hui, A. C. M. Fong, “Automatic Fuzzy Ontology Generation for Semantic Help-Desk Support”, *Transactions on industrial informatics*, VOL. 2, NO. 3, August 2006, pages 1551-3203.

118. Tho, Q.T.; Hui, S.C.; Fong, A.C.M.; Tru Hoang Cao; "Automatic Fuzzy Ontology Generation For Semantic Web", *Knowledge and Data Engineering*, Volume 18, Issue 6, June 2006, pages 842 – 856.

119. Valasquez, J. D., Weber, R., Yasuda, H., & Aoki, T., “A Methodology to Find Web Site Keywords”, *e-Technology, e-Commerce and e-Service*, 2004, *International Conference*, March 2004, pages 285- 292.

120. Vishwas R Puttige, Sreenatha G Anavatti, “Real-time Neural Network Based Online Identification Technique for a UAV Platform”, *International Conference on Computational Intelligence for Modelling Control and Automation,and International Conference on Intelligent Agents,Web Technologies and Internet Commerce (CIMCA-IAWTIC'06)*, 2006.

121. Vlajic, N.; Card, H.C., "An Adaptive Neural Network Approach to Hypertext Clustering", *Neural Networks*, 1999. IJCNN'99. International Joint Conference, Volume 6, Jul 1999 pages 3722-3726.

122. Wanita Sherchan, Seng W. Loke, Shonalji Krishnaswamy “A fuzzy model for reasoning about reputation in web services”, *Symposium on Applied Computing, Proceedings of the 2006 ACM symposium on Applied computing*, Dijon, France, pages 1886 – 1892.

123. Wen-der Yu, Chien-ching Lai, “WICE: A Web-base Intelligent Cost Estimator for Real-time Decision Support,” *Proceedings of the IEEE/WIC International Conference on Web Intelligence, 2003*, pages 1–4.

124. Xin Wang, Xiaojun Shen, and N.D Georganas, “A Fuzzy Logic Based Intelligent Negotiation Agent (FINA) In E-Commerce,” *Electrical and Computer Engineering, Canadian Conference*, May 2006, pages 276-279.

125. Xing Zhu, Shen Huang, Yong Yu, “Web technologies and applications: Recognizing the relations between Web pages using artificial neural network”, *Proceedings of the 2003 ACM symposium on Applied computing SAC '03*, ACM Press, 2003, pages1217-1221.

126. Yan-Qing Zhang Shteynberg, M. Prasad, S.K. Sunderraman, R. “Granular Fuzzy Web Intelligence Techniques for Profitable Data Mining,” *Fuzzy Systems*, IEEE, 25-28 May 2003, pages 1462-1464 vol. 2.

127. Yerra, R., Ng, Y. (2005). “Detecting Similar HTML Documents Using a Fuzzy Set Information Retrieval Approach**”**, *Granular Computing*, 2005 IEEE International Conference, 25-27 July 2005, Volume: 2, page(s): 693- 699./

128. Yi-Hong Dong, “A novel competitive neural network for Web mining,” *Machine Learning and Cybernetics, 2004*. Proceedings of 2004 International Conference, Volume 6, August 2004, pages 3417 – 3422.

129. Ying Xie, Dheerendranath Mundluru, Vijay V. Raghavan,”Incorporating Agent Based Neural Network Model for Adaptive Meta-Search”, *Proceedings of the 43rd annual Southeast regional conference*, Volume 1, Mar 2005, pages 53-58.

130. You-Wei Yuan Qing-Ping Guo Yue-Ming Liu Jian-Biao Xiao” Neural Networks Method for Fast Web Page Allocation in Mesh Generation”, *Machine Learning and Cybernetics*, 2006 International Conference on Publication Date: Aug. 2006, pages 4516-4520.

131. Yong S. Choi, Suk I. Yoo, “Multi-agent learning approach to WWW information retrieval using neural network”, *Proceedings of the 4th international conference on Intelligent user interfaces IUI '99*, December 1998.

132. Yuan-chao Li, Xiao-dong Wu , De-gan Zhang, Guang-ping Zeng, “Fuzzy-Neural Theory Applied to Web-based Proactive Service”, *Proceedings of the 2005 IEEE/WIC/ACM International Conference on Web Intelligence (WI’05),* 2005, pages 1-4.

133. Yunfeng Li, Qingsheng Zhu, Yukun Cao, “Automatic metadata generation based on neural network”, *Proceedings of the 3rd international conference on Information security InfoSecu '04,* ACM Press, November 2004, pages 192-197.

134. Z. Maamar, I. Younas, D. Benslimane, C. Ghedira, and H. Yahyaoui, “On Self-Coordinating Web Services Using Similarity and Neural Networks”, *e-Technology, e-Commerce and e-Service, 2005. EEE’05*, April 2005, pages 171 – 176.

135. Zhan Chuan, Lu Xianliang, Hou Mengshu, Zhou Xu, “A LVQ-based neural network anti-spam email approach”, *Operating Systems Review*, Volume 39 Issue 1, January 2005.

136. Zhao Yaqin,Ren Guanghui,Wang Xuexia,Wu Zhilu,Gu Xuemai, “Automatic Digital Modulation Recognition Using Artificial Neural Networks”, 2003, pages 257-260.

137. World Wide Web definition, http://en.wikipedia.org/wiki/World_Wide_Web#Publishing_Web_pages.

138. A.Gulli and A.Signorini, “The indexable web is more than 11.5 billion pages”, Pages: 902 – 903, International World Wide Web Conference, 2005.