A Cascaded Fuzzy Inference System for Dynamic Online Portals Customization

Erika Martinez Ramirez and Rene V. Mayorga

Abstract—In our modern world, more physical transactions are being substituted by electronic transactions (i.e. banking, shopping, and payments), many businesses and companies are performing most of their operations through the internet. Instead of having a physical commerce, internet visitors are now adapting to electronic commerce (e-Commerce). The ability of web users to reach products worldwide can be greatly benefited by creating friendly and personalized online business portals. Internet visitors will return to a particular website when they can find the information they need or want easily. Dealing with this human conceptualization brings the incorporation of Artificial/Computational Intelligence techniques in the creation of customized portals. From these techniques, Fuzzy-Set technologies can make many useful contributions to the development of such a human-centered endeavor as e-Commerce. The main objective of this paper is the implementation of a Paradigm for the Intelligent Design and Operation of Human-Computer interfaces. In particular, the paradigm is quite appropriate for the intelligent design and operation of software modules that display information (such Web Pages, graphic user interfaces GUIs, Multimedia modules) on a computer screen. The human conceptualization of the user personal information is analyzed throughout a Cascaded Fuzzy Inference (decision-making) System to generate the User Ascribe Qualities, which identify the user and that can be used to customize portals with proper Web links.

Keywords—Fuzzy Logic, Internet, Electronic Commerce, Intelligent Portals, Electronic Shopping.

I. INTRODUCTION

THE internet is greatly influencing the purchasing trends among consumers. While creating physical retail stores, companies make significant investments into promoting to provoke a positive experience and an attractive environment for customers. An increasing number of businesses are migrating to the internet, assisting them to perform all or almost all their trading through electronic transactions using an online portal [1]. Statistic Canada [9], 'The Daily' important news, reports a significant increase in online sales;

the combined private and public sector online sales in 2004 was $28.3 billion (49.7%) in comparison to $5.6 billion in 2000. In 2004, the percentage of retail trade enterprises that used the Internet to by good or services was 42.6, while in 2002 was 29.3. By using e-Commerce, the costs involved in creating and managing a physical retail store and the correspondent requirements are significantly reduced, and in some cases eliminated. Internet-oriented companies can sell their products and reach customers worldwide through the internet, making available electronic portals for marketing, selling, banking (i.e. eBay). Online customers purchase products based on their perception of the product/portal, easiness of navigation, level of trust, shopping experience, and services provided. These aspects must be given great consideration when designing a website. The creation of useful websites and their ability to be customized to user interests will enormously influence on customer's revisits for purchasing.

To assist buyers in searching and browsing for specific information on the Internet, many current Web portals such as Yahoo!, in organized information in the form of Web documents, into some predefined categories such as *Arts & Humanities, Computers & Internet,* and *Entertainment.* Identifying, organizing, and classifying web documents to consumer interests require human conceptualization, yielding to ambiguity and subjectivity. Consequently, the unlimited and constantly increasing amounts of web documents added to the internet make available huge quantities of data making it no simple task for the classification process with conventional techniques.

A more advanced technique is the application of a decision-making Fuzzy Inference System (FIS) that can be applied as an information filtering tool and can also be used to improve the retrieval results from a query process [7]. Our work focuses on an application of Fuzzy Logic for e-Commerce. Here, we consider a Paradigm for Intelligent Decision and Control [5][6], and an Intelligent Design and Operation of Human-Computer interfaces [3], implemented by non-conventional (Artificial Intelligence, Computational Intelligence, Soft Computing) techniques. Our work is based on a Cascaded FIS (unlike using a single FIS presented in [7]) to generate a personal profile (User Ascribe Qualities UAQ) required for the dynamic generation of an online portal. The portal contains the links of Web pages that better suit the customer. In this paper, we refer to the *customer* also as a potential *purchaser.*

An Artificial Intelligent (AI) concept greatly used in Information technology is the term agent. Agents usually have different roles and can work on different tasks. An important role of agents is their ability to solve complex problems. Complex problems can be separated into uncomplicated components.[8] Several AI techniques can be used to identify customer profiles. The techniques can be applied individually or in hybrid technology between two or more techniques, such as Computational Web Intelligence, Fuzzy Web Intelligence, Neural Web Intelligence, Rough Web Intelligence and Fuzzy-Rough Web Intelligence among others [2]. Considering the ability of the agents (decompose into components) and the available techniques, identifying a personal profile can be separated into components and be solved using FIS in their components (agents). It is worth to mention that our Cascaded FIS consists of several interacting agents to provide an online portal with the most appropriate links, dynamically. Also, this work is based on a Cascaded Fuzzy Inference System, unlike the work presented in [7] that uses a single Fuzzy Inference System. To certain extent can be placed in the Fuzzy Web Intelligence that consists in fuzzy logic and web technology. Berkan and Trubatch indicated in [2] the main goal of Fuzzy Web Intelligence as to "*design intelligent fuzzy e-agents which can deal with fuzziness of data, information and knowledge, and also make satisfactory decisions like the human brain for e-Business application effectively*". However, this paper presents a novel Cascaded Fuzzy Inference System to generate online portals displaying information using Web pages corresponding to a particular user profile.

II. Fuzzy Logic

Fuzzy logic, introduced by Zadeh in 1965 [5][10], has the ability to interpret and represent the human concepts and terms that do not have precise definitions into fuzzy membership functions (MF). A fuzzy set is a set without a crisp boundary, in contrast to a classical set. This is the smooth transition from "belong to a set" to "not belong to a set", which can be represented through MFs. With the MFs defined, fuzzy logic systems are based on simple IF-THEN rules. Fuzzy logic reasoning is applied in many decision-making and expert systems, and is used in a wide variety of applications.

From the types of Fuzzy systems, the most used are: **Mamdani**-*type inference* which uses an aggregation operator to combine consequents of each rule and a defuzzification method to defuzzified the resulting fuzzy set to obtain the output of the system; and **Sugeno**-*type inference* which uses a weighted linear combination of the inputs for the consequent of each rule to obtain the output.

Another important stage in a FIS is the **Defuzzification**, the process of transforming a fuzzy output into a crisp output. Jang et al [4] explains different defuzzification strategies, such as: centroid of area method (CENTROID), bisector of area method (BISECTOR); mean of maximum method (MOM), smallest of maximum method (SOM), and largest of maximum method (LOM).

III. Methodology

In order to analyze and organize the personal information from the customer, a Cascaded FIS with specific characteristics is proposed. The Cascaded FIS contains a fuzzy agent that classifies the customers and a second fuzzy agent identifies their interests. The main characteristic of these agents is that they are connected in a cascade, in which the second fuzzy agent receives data from the first. Specifically, an input and an output of the first agent are part of the inputs for the second agent. Fig. 1 illustrates the components of the Cascaded FIS.
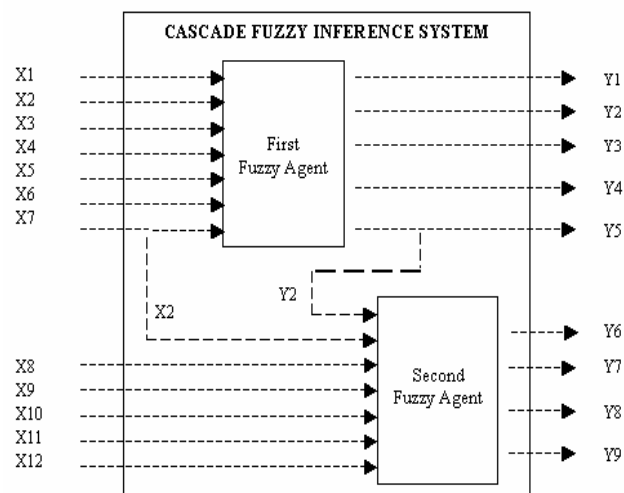

Fig. 1 Diagram for the Cascaded Fuzzy Inference System.

An essential advantage of the fuzzy system is that it can be used to dynamically solve a decision-making problem. Thus, our fuzzy agent generates a profile for a particular user to access proper web links, by interpreting the user's answers to a brief questionnaire about his/her characteristics and areas of interest. These agents are connected and generate a main user profile (UAQ).

A. Characteristics of the Cascaded FIS

Our Cascaded FIS is implemented using Mamdani-type inference and to defuzzify the resulting fuzzy set, the Mean of the Maximum (MOM) defuzzification method is selected. The first agent, named "Main", identifies customers and the second, named "Preference Link", identifies their interests of preferences.

B. Overall Inference System

The "Main" agent yields the following outputs: *purchaser capacity*, *purchaser link*, *purchaser free time*, occupation *experience* and *occupation*; after applying the fuzzy reasoning to the inputs *gender*, *age*, *marital status*, education (*studies*), *years working*, *children age* and *occupation*. The "Preference Link" agent obtains the *preferences*, *news*, *health* and '*other links*' after fuzzy reasoning of the inputs: *purchaser capacity*,

age, *news, health, entertainment, shopping* and *travel*. The diagram representation for the Cascaded FIS is illustrated in Fig. 2.

As previously mentioned, these agents are in cascaded; therefore the *age* input that receives "Preference Link" agent is an input from the first fuzzy agent and the *purchaser capacity* input is an output from the "Main" fuzzy agent. The characteristics of our Cascaded FIS are included in Table I.
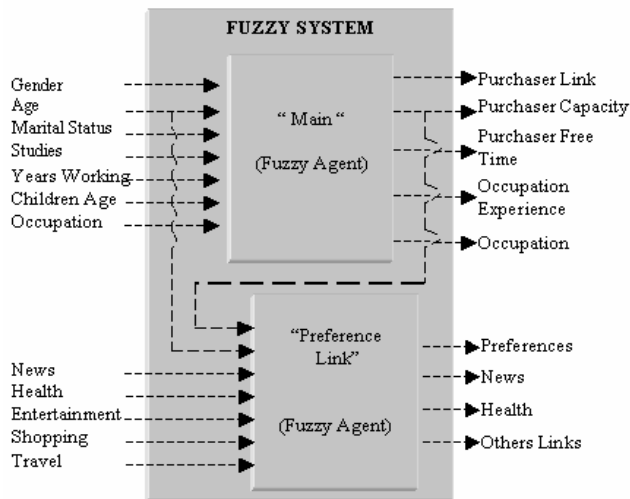

Fig. 2 Fuzzy System General Diagram

TABLE I
CHARACTERISTICS OF EACH OF THE CASCADED FIS AGENTS

	Main.fis (Identify customers Fuzzy Agent)	PreferencesLinks.fis (Identify customer preferences Fuzzy Agent)
Type	Mamdani	Mamdani
Number of Inputs	7	7
Number of Outputs	5	4
Number of Rules	56	34
Defuzzification Method	Mom	Mom

The relationship between inputs and outputs for the fuzzy IF-THEN rules are illustrated in Fig. 3 and Fig. 4. Indicated the set of inputs considered to obtain the resulting output. This relationship is explained in more detail in the implementation section. Fig. 3 illustrates the input/output relation for the "Main" fuzzy agent.
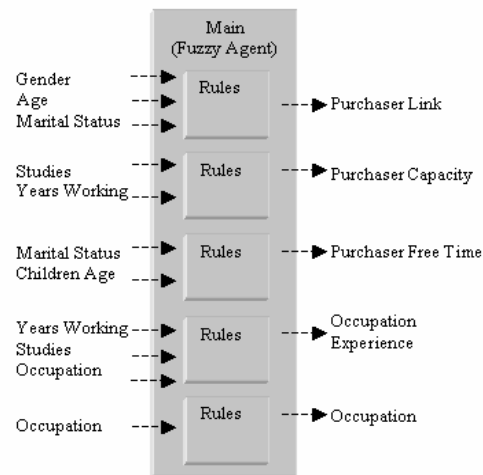

Fig. 3 Inputs/Outputs relationship "Main" Fuzzy Agent

The second "Preference Link" fuzzy agent relation for the fuzzy rules is illustrated in the Fig. 4.
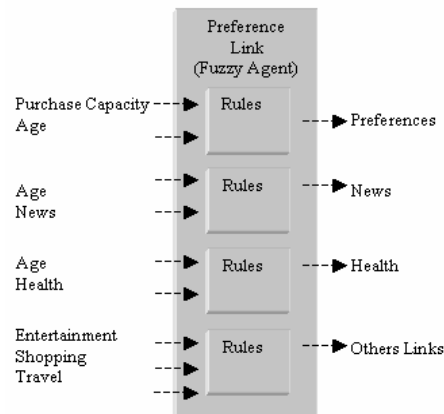

Fig. 4 Inputs/Outputs relationship "Preference Link" Fuzzy Agent

IV. IMPLEMENTATION

For proof of principle purposes, our system can be represented using the Fuzzy Logic (Maltab) toolbox. Fig. 5 shows the Matlab representation for our Cascaded FIS.
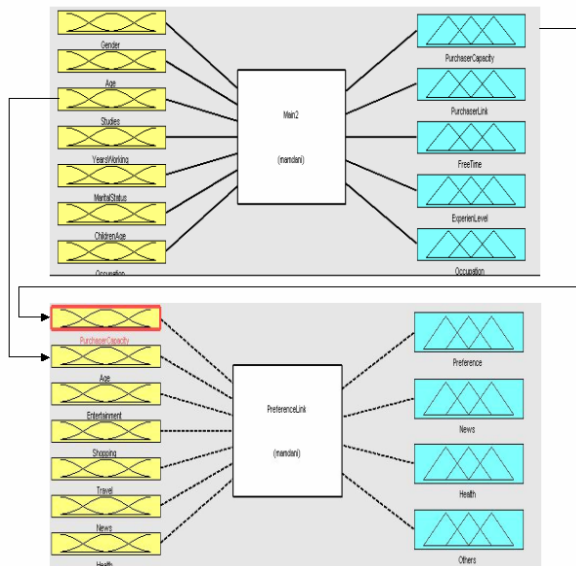
Fig. 5 Fuzzy System Diagram using Fuzzy Toolbox

"Main" fuzzy agent is described in detail below. In Table II and Table 3 are presented the names of the membership functions (MF) for each of the inputs and outputs of this agent.

TABLE II
"MAIN" INPUT VARIABLES

Gender	Age	Studies	Years Working	Marital Status	Occupational Area	Children Age
Male Female	Very young Young Middle age Old	None Primary-High-Tech School University Graduate Studies	None Few Some Several	Single Married	Engineering Business Arts Sciences	Low Medium High

TABLE III
"MAIN" OUTPUT VARIABLES

Purchaser Capacity	Purchaser Links	Free Time	Occupational Experience	Occupation
Very poor Poor Moderate Good Very good	Kids Teenager SingleWomen Women SingleMen Men SingleMature Mature	None A little Medium A lot	Beginners Moderate Experts	Technical-Engineering Business-Administration-Marketing Art-Music-Ballet Medical-Computer-Biology

A description for each "Main" input is presented below, beginning with the "Gender" Input Variable. The information included is range, number of MFs (NumMFs), and each of the MFs' names (MF1='Male'; which means the Membership Function 1 has the semantic variable 'Male'). It also indicates the type of MFs, such as: trapezoidal MF (trapmf), triangular MF (trimf), and Gaussian type 2 MF (gauss2mf). The MF parameters are located between bracket "[..]". A trapezoidal MF requires 4 parameters, a triangular 3 and a Gaussian 2 as explained in Jang et al [4].

Name   : 'Gender'
Range   : [0 1]
NumMFs   : 2
MF1='Male'   : trapmf',[-0.1307   -0.112   0.264   0.5065]
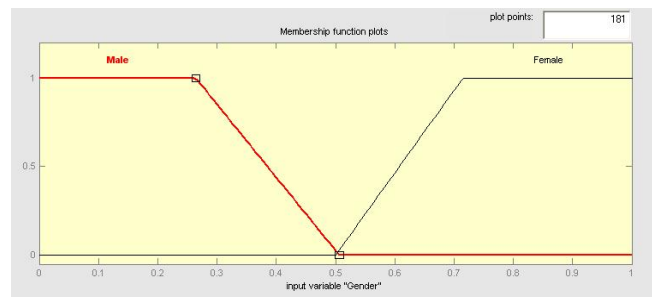MF2='Female' : 'trapmf',[0.5 0.715 1.09 1.13]

Fig. 6 Input Variable "Gender" from Main Fuzzy Agent

Following the previous definitions, the rest of the inputs indicating their MFs for the "Main" fuzzy agent are also presented.

A. "MAIN" Fuzzy agent

Input Variable: *Age*

Name   : 'Age'
Range   : [0 70]
NumMFs   : 4
MF1   : 'gauss2mf',[8.12 -1.6 2.18 4.77]
   ='VeryYoung'
MF2='Young'   : 'gauss2mf',[3.09 14.4 3.07 18.6]
MF3='MiddleAge'   : 'gauss2mf',[3.18 28.2 2.55 47]
MF4='Old'   : 'gauss2mf',[1.74 52.5 7.93 74.9]
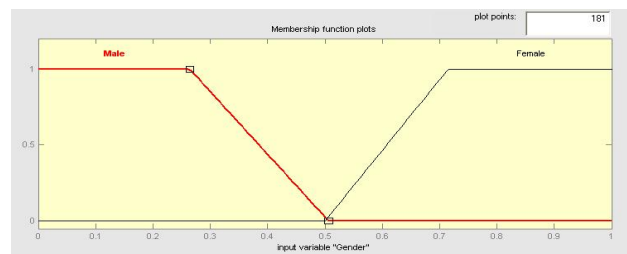

Fig. 7 Input Variable "Age" from Main Fuzzy Agent

Input Variable: *Studies* (Education)

Name   : 'Studies'
Range   : [0 4]
NumMFs   : 4
MF1='Primary-   : 'gauss2mf',[0.162 1.34 0.135 1.73]
High-Tech-School'
MF2='University'   : 'gauss2mf',[0.171 2.36 0.14 2.72]
MF3='Graduates-   : 'gauss2mf',[0.155 3.37 0.156 4.54]
Studies'
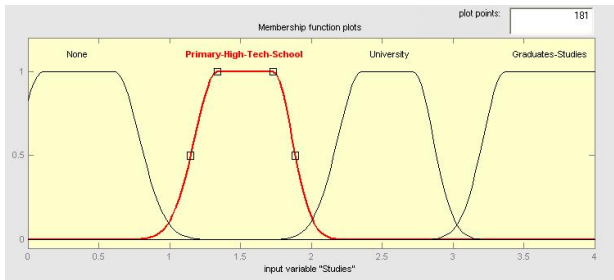MF4='None'   : 'gauss2mf',[0.179   0.11   0.179   0.608]

Fig. 8 Input Variable "Studies" from Main Fuzzy Agent

Input Variable: *Years Working*

Name	:	'YearsWorking'
Range	:	[0 40]
NumMFs	:	4
MF1='None'	:	'trimf',[-5 0 0]
MF2='Several'	:	'gaussmf',[3.78 35.5]
MF3='Few'	:	'gaussmf',[2.123 5]
MF4='Some'	:	'gaussmf',[4.247 20]
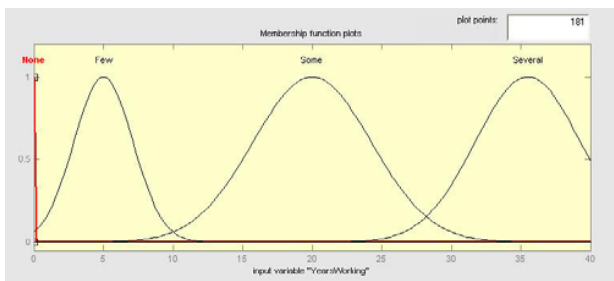
Fig. 9 Input Variable "Years Working" from Main Fuzzy Agent

Input Variable: *Marital Status*

Name	:	'MaritalStatus'
Range	:	[0 1]
NumMFs	:	2
MF1='Single'	:	'gauss2mf',[0.2 0.186 0.0361 0.457]
MF2='Married'	:	'gauss2mf',[0.0422 0.56 0.117 0.878]
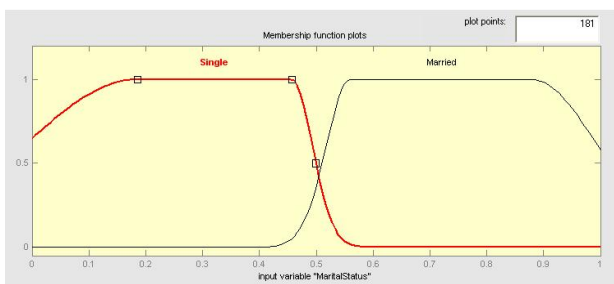
Fig. 10 Input Variable "Marital Status" from Main Fuzzy Agent

Input Variable: *Children Age*

Name	:	'ChildrenAge'
Range	:	[0 18]
NumMFs	:	4
MF1='Babies'	:	'gauss2mf',[0.411 1.51 0.45 3.2]

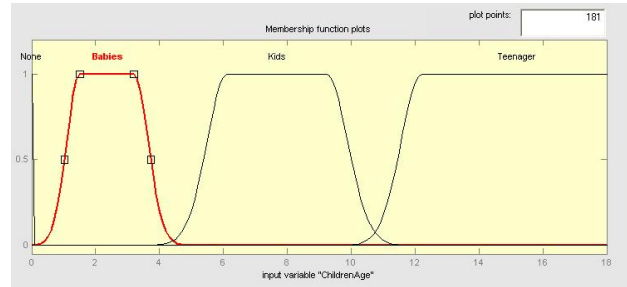|		
MF2='Kids'	:	'gauss2mf',[0.6319 6.124 0.6727 9.218]
MF3='Teenager'	:	'gauss2mf',[0.6455 12.21 2.446 19.02]
MF4='None'	:	'trapmf', [-0.5 -0.4 0 0]

Fig. 11 Input Variable "Children Age" from Main Fuzzy Agent

Input Variable: *Occupation*

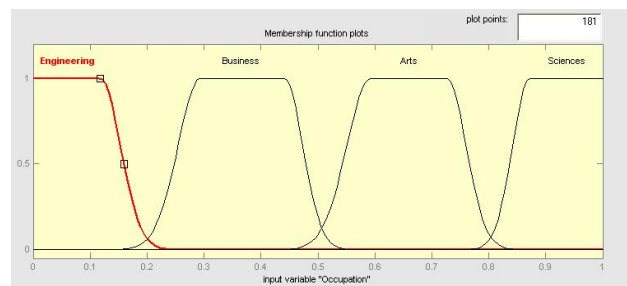|		
Name	:	'Occupation'
Range	:	[0 1]
NumMFs	:	4
MF1='Engineering'	:	'gauss2mf',[0.113 -0.0333 0.0352 0.118]
MF2='Business'	:	'gauss2mf',[0.0397 0.294 0.0323 0.441]
MF3='Arts'	:	'gauss2mf',[0.0422 0.593 0.0341 0.726]
MF4='Sciences'	:	'gauss2mf',[0.03 0.872 0.113 1]

Fig. 12 Input Variable "Occupation" from Main Fuzzy Agent

Once the inputs variables have been presented, we describe in the following graphs and data the outputs variables and their MFs, for the "Main" fuzzy agent.

Output Variable: *Purchaser Capacity*

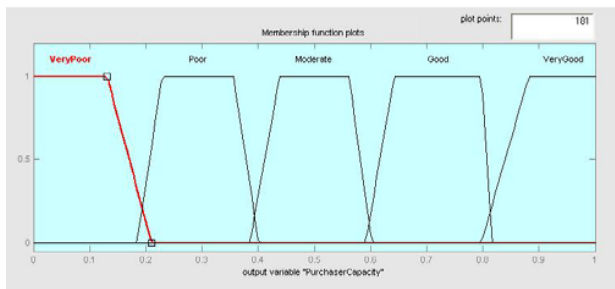|		
Name	:	'PurchaserCapacity'
Range	:	[0 1]
NumMFs	:	5
MF1='VeryPoor'	:	'trapmf',[-0.225 -0.025 0.131 0.21]
MF2='Poor'	:	'trapmf',[0.184 0.229 0.356 0.401]
MF3='Moderate'	:	'trapmf',[0.385 0.438 0.562 0.602]
MF4='Good'	:	'trapmf',[0.591 0.642 0.798

0.816]

MF5='VeryGood   'trapmf',[0.797 0.882 1.03 1.24]
'

Fig. 13 Output Variable "Purchaser Capacity" from Main Fuzzy
Agent

Output Variable: *Purchaser Links*

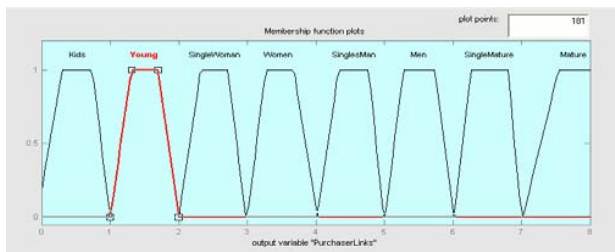| Name	:	'PurchaserLinks'
Range	:	[0 8]
NumMFs	:	8
MF1='Kids'	:	'trapmf',[-0.0645 0.296 0.739 1]
MF2='Teens'	:	'trapmf',[1.001 1.31 1.7 2]
MF3='SingleWoman'	:	'trapmf',[2 2.32 2.71 2.98]
MF4='Women'	:	'trapmf',[3 3.27 3.68 4.02]
MF5='SinglesMan'	:	'trapmf',[4.02 4.33 4.77 4.99]
MF6='Man'	:	'trapmf',[5.01 5.28 5.74 6.01]
MF7='Mature'	:	'trapmf',[7.02 7.54 9.92 9.92]
MF8='SingleMature'	:	'trapmf',[6.02 6.26 6.8 7]

Fig. 14 Output Variable "Purchaser Link" from Main Fuzzy Agent

Output Variable: *Purchaser Free Time*

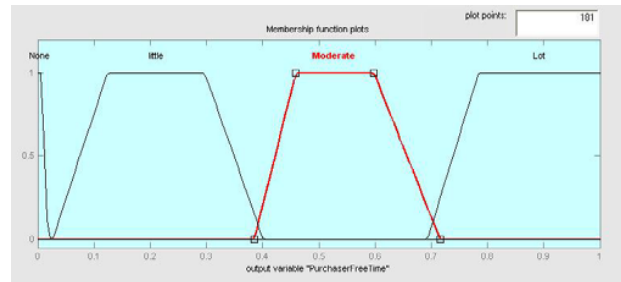| Name	:	'PurchaserFreeTime'
Range	:	[0 1]
NumMFs	:	4
MF1='Moderate'	:	'trapmf',[0.385 0.459 0.598 0.716]
MF2='little'	:	'trapmf',[0.0262 0.124 0.297 0.401]
MF3='Lot'	:	'trapmf',[0.693 0.784 1.04 1.36]
MF4='None'	:	'trapmf',[-0.0368 -0.034 0.0065 0.0181]

Fig. 15 Output Variable "Purchaser Free Time" from Main Fuzzy
Agent

Output Variable: *Experience Level*

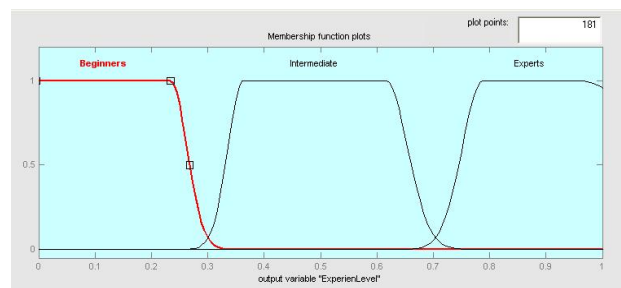| Name	:	'ExperienLevel'
Range	:	[0 1]
NumMFs	:	3
MF1='Beginners'	:	'gauss2mf',[0.143 -0.00321 0.0288 0.234]
MF2='Intermediate'	:	'gauss2mf',[0.027 0.363 0.0383 0.616]
MF3='Experts'	:	'gauss2mf',[0.0365 0.788 0.136 0.959]

Fig. 16 Output Variable "Occupation Experience Level" from Main
Fuzzy Agent

Output Variable: *Occupation*

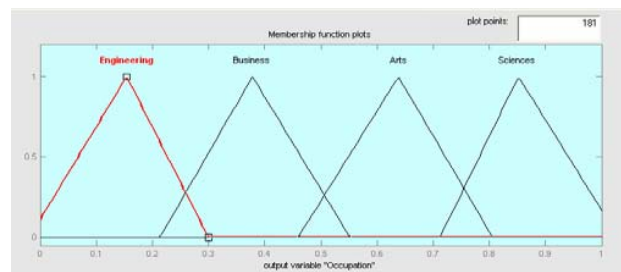| Name	:	'Occupation'
Range	:	[0 1]
NumMFs	:	4
MF1='Engineering'	:	'trimf', [-0.0198 0.154 0.3]
MF2='Business'	:	'trimf', [0.213 0.378 0.552]
MF3='Arts'	:	'trimf', [0.459 0.638 0.806]
MF4='Sciences'	:	'trimf', [0.712 0.852 1.03]

Fig. 17 Output Variable "Occupation" from Main Fuzzy Agent

The rules relationship of our system is interpreted below.

To identify the customer or "Purchaser Link", it is required of the inputs: "Gender", "Age", and "Marital Status". This relation is shown as follow:

TABLE IV

PURCHASER LINK RELATION (AGE & GENDER → PURCHASER LINK)

	Man/Single	Female / Single	M–F/ Married
Very Young	Kids	Kids	--
Young	Kids	Teen	--
Middle age	Single Man	Single Woman	Men-Women
Old	Single Mature	Single Mature	Mature

To generate the level of capacity of the customer to purchase, our system uses the output "Purchaser Capacity", which is based on the "Studies" and "Years Working" inputs.

TABLE V

PURCHASER CAPACITY RELATION (YEARS WORKING & LEVEL OF EDUCATION → PURCHASER CAPACITY)

	None	Elementary High school Tech School	University	Graduate Studies
None	Very Poor	Very Poor	Very Poor	Very Poor
Few	Poor	Moderate	Good	Good
Some	Poor	Good	Good	Very Good
Several	Moderate	Good	Mature	Very Good

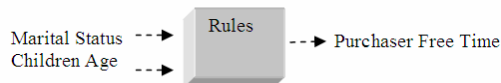To obtain the available free time of the purchaser, "Marital Status" and "Children age" inputs are used.

TABLE VI

PURCHASER FREE TIME RELATION (GENDER & CHILDREN AGE → USER FREE TIME)

	None	Babies	Kids	Teenagers
Single	A lot	None	A little	Moderate
Married	Moderate	A little	Moderate	A lot

The level of experience for the purchaser is generated using the inputs: "Year Working", "Studies" and "Occupation".

TABLE VII

OCCUPATION EXPERIENCE RELATION (OCCUPATION & LEVEL OF EDUCATION → OCCUPATION EXPERIENCE)

	None	Elementary High school Tech School	University	Graduate Studies
Engineering	Beginners	Beginners	Experts	Experts
Business	Intermediate	Intermediate	Experts	Experts
Arts	Beginners	Beginners	Intermediate	Experts
Sciences	Beginners	Intermediate	Intermediate	Experts

Defining the above rules relationships facilitates the creation of the fuzzy IF-THEN rules for the "Main" fuzzy agent. The fuzzy rules created are:

1. If (MaritalStatus is Single) and (ChildrenAge is Babies) then (PurchaserFreeTime is None) (1)

2. If (MaritalStatus is Single) and (ChildrenAge is Kids) then (PurchaserFreeTime is little) (1)

3. If (MaritalStatus is Single) and (ChildrenAge is Teenager) then (PurchaserFreeTime is Moderate) (1)

4. If (MaritalStatus is Married) and (ChildrenAge is Babies) then (PurchaserFreeTime is little) (1)

5. If (MaritalStatus is Married) and (ChildrenAge is Kids) then (PurchaserFreeTime is Moderate) (1)

6. If (MaritalStatus is Married) and (ChildrenAge is Teenager) then (PurchaserFreeTime is Lot) (1)

7. If (Studies is None) and (YearsWorking is None) then (PurchaserCapacity is VeryPoor) (1)

8. If (Studies is None) and (YearsWorking is Few) then (PurchaserCapacity is Poor) (1)

9. If (Studies is None) and (YearsWorking is Some) then (PurchaserCapacity is Moderate) (1)

10. If (Studies is None) and (YearsWorking is Several) then (PurchaserCapacity is Moderate) (1)

11. If (Studies is Primary-High-Tech-School) and (YearsWorking is None) then (PurchaserCapacity is VeryPoor) (1)

12. If (Studies is Primary-High-Tech-School) and (YearsWorking is Few) then (PurchaserCapacity is Poor) (1)

13. If (Studies is Primary-High-Tech-School) and (YearsWorking is Some) then (PurchaserCapacity is Moderate) (1)

14. If (Studies is Primary-High-Tech-School) and (YearsWorking is Several) then (PurchaserCapacity is Good) (1)

15. If (Studies is University) and (YearsWorking is None) then (PurchaserCapacity is VeryPoor) (1)

16. If (Studies is University) and (YearsWorking is Few) then (PurchaserCapacity is Moderate) (1)

17. If (Studies is University) and (YearsWorking is Some) then (PurchaserCapacity is Good) (1)

18. If (Studies is University) and (YearsWorking is Several) then (PurchaserCapacity is VeryGood) (1)

19. If (Studies is Graduates-Studies) and (YearsWorking is None) then (PurchaserCapacity is VeryPoor) (1)

20. If (Studies is Graduates-Studies) and (YearsWorking is Few) then (PurchaserCapacity is Good) (1)

21. If (Studies is Graduates-Studies) and (YearsWorking is Some) then (PurchaserCapacity is VeryGood) (1)

22. If (Studies is Graduates-Studies) and (YearsWorking is

Several) then (PurchaserCapacity is VeryGood) (1)

23. If (MaritalStatus is Single) and (ChildrenAge is None) then (PurchaserFreeTime is Lot) (1)

24. If (MaritalStatus is Married) and (ChildrenAge is None) then (PurchaserFreeTime is Moderate) (1)

25. If (Studies is None) and (YearsWorking is None) then (ExperienLevel is Beginners) (1)

26. If (Studies is None) and (YearsWorking is Few) then (ExperienLevel is Beginners) (1)

27. If (Studies is None) and (YearsWorking is Some) then (ExperienLevel is Intermediate) (1)

28. If (Studies is None) and (YearsWorking is Several) then (ExperienLevel is Intermediate) (1)

29. If (Studies is Primary-High-Tech-School) and (YearsWorking is None) then (ExperienLevel is Beginners) (1)

30. If (Studies is Primary-High-Tech-School) and (YearsWorking is Few) then (ExperienLevel is Beginners) (1)

31. If (Studies is Primary-High-Tech-School) and (YearsWorking is Some) then (ExperienLevel is Intermediate) (1)

32. If (Studies is Primary-High-Tech-School) and (YearsWorking is Several) then (ExperienLevel is Intermediate) (1)

33. If (Studies is University) and (YearsWorking is None) then (ExperienLevel is Beginners) (1)

34. If (Studies is University) and (YearsWorking is Few) then (ExperienLevel is Intermediate) (1)

35. If (Studies is University) and (YearsWorking is Some) then (ExperienLevel is Experts) (1)

36. If (Studies is University) and (YearsWorking is Several) then (ExperienLevel is Experts) (1)

37. If (Studies is Graduates-Studies) and (YearsWorking is None) then (ExperienLevel is Intermediate) (1)

38. If (Studies is Graduates-Studies) and (YearsWorking is Few) then (ExperienLevel is Intermediate) (1)

39. If (Studies is Graduates-Studies) and (YearsWorking is Some) then (ExperienLevel is Experts) (1)

40. If (Studies is Graduates-Studies) and (YearsWorking is Several) then (ExperienLevel is Experts) (1)

41. If (Gender is Male) and (Age is VeryYoung) then (PurchaserLinks is Kids) (1)

42. If (Gender is Female) and (Age is VeryYoung) then (PurchaserLinks is Kids) (1)

43. If (Gender is Male) and (Age is Young) then (PurchaserLinks is Young) (1)

44. If (Gender is Female) and (Age is Young) then (PurchaserLinks is Young) (1)

45. If (Gender is Female) and (Age is MiddleAge) and (MaritalStatus is Single) then (PurchaserLinks is SingleWoman) (1)

46. If (Gender is Female) and (Age is MiddleAge) and (MaritalStatus is Married) then (PurchaserLinks is Women) (1)

47. If (Gender is Male) and (Age is MiddleAge) and (MaritalStatus is Single) then (PurchaserLinks is SinglesMan) (1)

48. If (Gender is Male) and (Age is MiddleAge) and (MaritalStatus is Married) then (PurchaserLinks is Man) (1)

49. If (Gender is Male) and (Age is Old) and (MaritalStatus is Single) then (PurchaserLinks is SingleMature) (1)

50. If (Gender is Male) and (Age is Old) and (MaritalStatus is Married) then (PurchaserLinks is Mature) (1)

51. If (Gender is Female) and (Age is Old) and (MaritalStatus is Single) then (PurchaserLinks is SingleMature) (1)

52. If (Gender is Female) and (Age is Old) and (MaritalStatus is Married) then (PurchaserLinks is Mature) (1)

53. If (Occupation is Engineering) then (Occupation is Engineering) (1)

54. If (Occupation is Business) then (Occupation is Business) (1)

55. If (Occupation is Arts) then (Occupation is Arts) (1)

56. If (Occupation is Sciences) then (Occupation is Sciences) (1)

B. "PREFERENCE LINKS" Fuzzy agent

Now, we present the inputs and output variables data and graphics for the second fuzzy agent "Preference link", as well as its rules relationships and fuzzy IF-THEN rules.

Input Variable: *Purchaser Capacity*

Name	:	'PurchaserCapacity'		
Range	:	[0 1]		
NumMFs	:	5		
MF1='VeryGood'	:	'trapmf',[0.797 0.882 1.03 1.24]		
MF2='Moderate'	:	'trapmf',[0.385	0.438	0.562 0.602]
MF3='Good'	:	'trapmf',[0.591	0.642	0.798 0.816]
MF4='Poor'	:	'trapmf',[0.184	0.229	0.356 0.401]
MF5='VeryPoor'	:	'trapmf',[-0.225	-0.025	0.131 0.21]
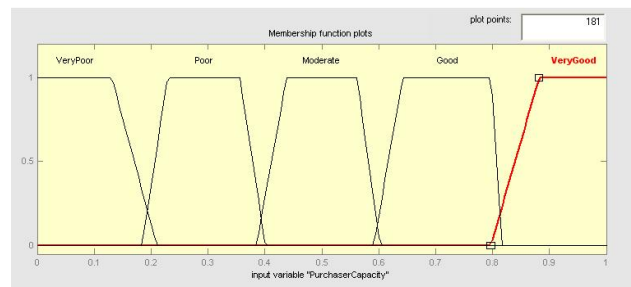
Fig. 18 Input Variable "Purchaser Capacity" from PreferenceLinks Fuzzy Agent

Input Variable: *Age*

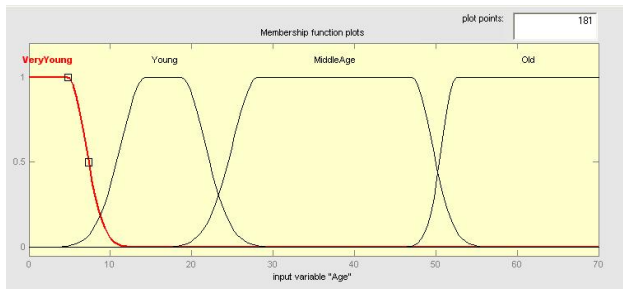| Name	:	'Age'		
Range	:	[0 70]		
NumMFs	:	4		
MF1='VeryYoung'	:	'gauss2mf',[8.12 -1.6 2.18 4.77]		
MF2='Young'	:	'gauss2mf',[3.09	14.4	3.07 18.6]
MF3='MiddleAge'	:	'gauss2mf',[3.18 28.2 2.55 47]		
MF4='Old'	:	'gauss2mf',[1.74	52.5	7.93 74.9]

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Fig. 19 Input Variable "Age" from PreferenceLinks Fuzzy Agent

Input Variable: *Entertainment*

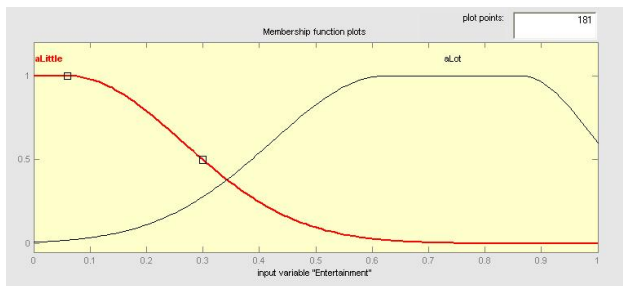| Name	:	'Entertainment'
Range	:	[0 1]
NumMFs	:	2
MF1='aLittle'	:	'gauss2mf',[0.1359 -0.04 0.2038 0.06]
MF2='aLot'	:	'gauss2mf',[0.204 0.626 0.136 0.862]

Fig. 20 Input Variable "Entertainment" from PreferenceLinks Fuzzy Agent

Input Variable: *Shopping*

Name	:	'Shopping'
Range	:	[0 1]
NumMFs	:	2
MF1='Alittle'	:	'gauss2mf',[0.1359 -0.04 0.2038 0.06]
MF2='Alot'	:	'gauss2mf',[0.204 0.625 0.136 0.91]
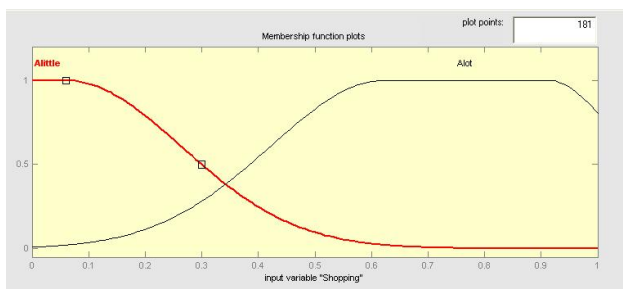
Fig. 21 Input Variable "Shopping" from PreferenceLinks Fuzzy Agent

Input Variable: *Travel*

Name	:	'Travel'
Range	:	[0 1]
NumMFs	:	2
MF1='aLittle'	:	'gauss2mf',[0.1359 -0.04 0.2038 0.06]
MF2='aLot'	:	'gauss2mf',[0.204 0.583 0.136 0.854]
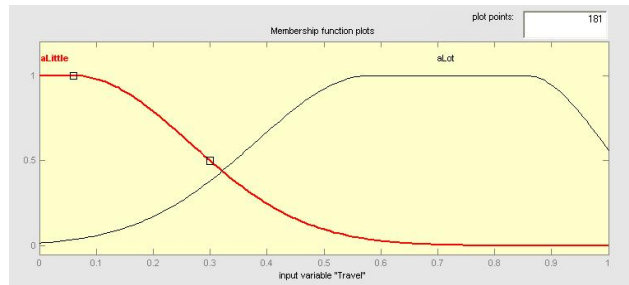
Fig. 22 Input Variable "Travel" from PreferenceLinks Fuzzy Agent

Input Variable: *News*

Name	:	'News'
Range	:	[0 1]
NumMFs	:	2
MF1='aLittle'	:	'gauss2mf',[0.1359 -0.04 0.2038 0.06]
MF2='aLot'	:	'gauss2mf',[0.204 0.541 0.136 0.824]
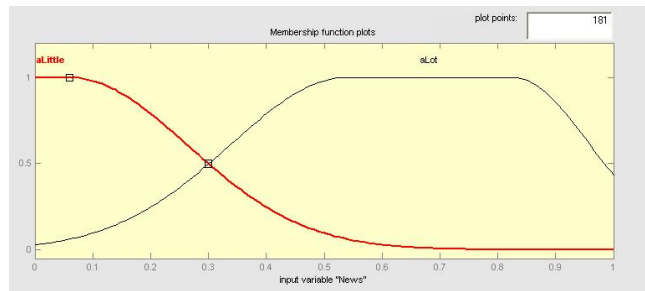
Fig. 23 Input Variable "News" from PreferenceLinks Fuzzy Agent

Input Variable: *Health*

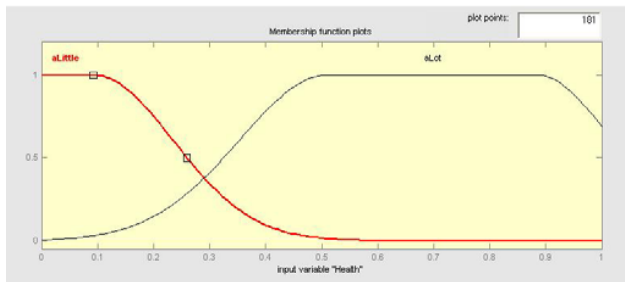| Name	:	'Health'
Range	:	[0 1]
NumMFs	:	2
MF1='aLittle'	:	'gauss2mf',[0.136 -0.0848 0.142 0.0924]
MF2='aLot'	:	'gauss2mf',[0.159 0.512 0.136 0.882]

Fig. 24 Input Variable "Health" from PreferenceLinks Fuzzy Agent

The outputs variables for the "Preference Link" agent are now described in detail.

Output Variable: *Preferences*

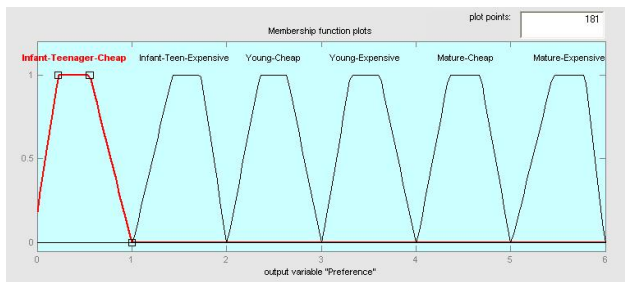| Name	:	'Preference'
Range	:	[0 6]
NumMFs	:	6
MF1='Infant-Teenager-Cheap'	:	'trapmf',[-0.04838 0.222 0.5543 1]
MF2='Infant-Teen-Expensive'	:	'trapmf',[1.01 1.43 1.73 2]
MF3='Young-Expensive'	:	'trapmf',[3.01 3.31 3.62 4]
MF4='Mature-Expensive'	:	'trapmf',[5.01 5.45 5.79 5.99]
MF5='Young-Cheap'	:	'trapmf',[2.01 2.35 2.64 3]
MF6='Mature-Cheap'	:	'trapmf',[4.01 4.35 4.68 5]

Fig. 25 Output Variable "Preference" from PreferenceLinks Fuzzy Agent

Output Variable: *News*

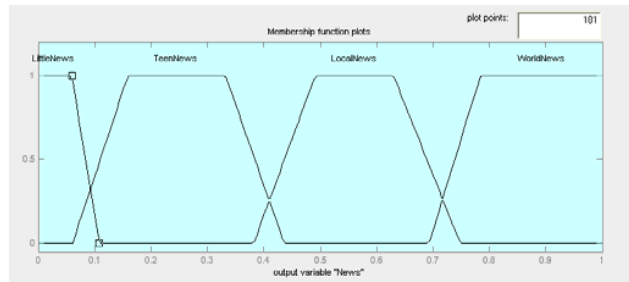| Name	:	'News'
Range	:	[0 1]
NumMFs	:	4
MF1='LittleNews'	:	'trapmf', [-0.0947 -0.0354 0.0596 0.108]
MF2='LocalNews'	:	'trapmf', [0.0609 0.159 0.332 0.436]
MF3='TeenNews'	:	'trapmf', [0.382 0.491 0.63 0.748]
MF4='WorldNews'	:	'trapmf', [0.693 0.784 1.04 1.36]

Fig. 26 Output Variable "News" from PreferenceLinks Fuzzy Agent

Output Variable: *Health*

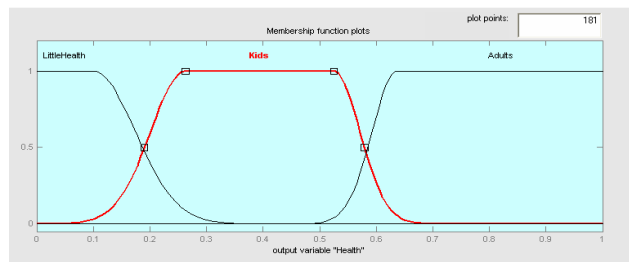| Name	:	'Health'
Range	:	[0 1]
NumMFs	:	3
MF1='LittleHealth'	:	'gauss2mf', [0.0765 -0.077 0.074 0.1]
MF2='Kids'	:	'gauss2mf', [0.0615 0.263 0.0463 0.525]
MF3='Adults'	:	'gauss2mf', [0.044 0.637 0.0383 1.2]

Fig. 27 Output Variable "Health" from PreferenceLinks Fuzzy Agent

Output Variable: *Others Links*

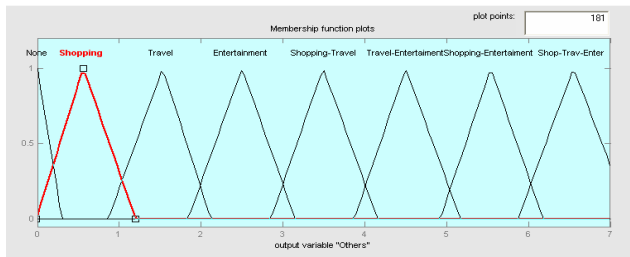| Name	:	'Others'
Range	:	[0 6]
NumMFs	:	8
MF1='None'	:	'trapmf', [-3.34 -0.532 3.76e-005 0.299]
MF2='Shopping'	:	'trimf', [-0.015 0.561 1.2]
MF3='Travel'	:	'trimf', [0.863 1.53 2.12]
MF4='Entertainment'	:	'trimf', [1.84 2.5 3.15]
MF5='Shopping-Travel'	:	'trimf', [2.85 3.49 4.16]
MF6='Shopping-Entertainment'	:	'trimf', [3.87 4.5 5.17]
MF7='Travel-Entertaiment'	:	'trimf', [4.92 5.54 6.18]
MF8='Shop-Trav-Enter'	:	'trimf', [5.87 6.55 7.25]

Fig. 28 Output Variable "Others" from PreferenceLinks Fuzzy Agent

The rules relationship for the "Preference Links" fuzzy agent follows the representation presented for the "Main" fuzzy. The following fuzzy IF-THEN rules created are:

1. If (PurchaserCapacity is VeryPoor) and (Age is VeryYoung) then (Preference is Infant-Teenager-Cheap) (1)

2. If (PurchaserCapacity is Poor) and (Age is VeryYoung) then (Preference is Infant-Teenager-Cheap) (1)

3. If (PurchaserCapacity is Good) and (Age is VeryYoung) then (Preference is Infant-Teen-Expensive) (1)

4. If (PurchaserCapacity is Moderate) and (Age is VeryYoung) then (Preference is Infant-Teen-Expensive) (1)

5. If (PurchaserCapacity is VeryGood) and (Age is VeryYoung) then (Preference is Infant-Teen-Expensive) (1)

6. If (PurchaserCapacity is VeryPoor) and (Age is Young) then (Preference is Infant-Teenager-Cheap) (1)

7. If (PurchaserCapacity is Good) and (Age is Young) then (Preference is Infant-Teenager-Cheap) (1)

8. If (PurchaserCapacity is Moderate) and (Age is Young) then (Preference is Infant-Teen-Expensive) (1)

9. If (PurchaserCapacity is VeryGood) and (Age is Young) then (Preference is Infant-Teen-Expensive) (1)

10. If (PurchaserCapacity is VeryPoor) and (Age is MiddleAge) then (Preference is Young-Cheap) (1)

11. If (PurchaserCapacity is Poor) and (Age is MiddleAge) then (Preference is Young-Cheap) (1)

12. If (PurchaserCapacity is Good) and (Age is MiddleAge) then (Preference is Young-Expensive) (1)

13. If (PurchaserCapacity is Moderate) and (Age is MiddleAge) then (Preference is Young-Expensive) (1)

14. If (PurchaserCapacity is VeryGood) and (Age is MiddleAge) then (Preference is Young-Expensive) (1)

15. If (PurchaserCapacity is VeryPoor) and (Age is Old) then (Preference is Mature-Cheap) (1)

16. If (PurchaserCapacity is Poor) and (Age is Old) then (Preference is Mature-Cheap) (1)

17. If (PurchaserCapacity is Moderate) and (Age is Old) then (Preference is Mature-Cheap) (1)

18. If (PurchaserCapacity is Good) and (Age is Old) then (Preference is Mature-Expensive) (1)

19. If (PurchaserCapacity is VeryGood) and (Age is Old) then (Preference is Mature-Expensive) (1)

20. If (Age is VeryYoung) and (News is aLot) then (News is TeenNews) (1)

21. If (Age is Young) and (News is aLot) then (News is LocalNews) (1)

22. If (Age is MiddleAge) and (News is aLot) then (News is WorldNews) (1)

23. If (Age is Old) and (News is aLot) then (News is WorldNews) (1)

24. If (Age is VeryYoung) and (Health is aLot) then (Health is Kids) (1)

25. If (Age is Young) and (Health is aLot) then (Health is Adults) (1)

26. If (Age is MiddleAge) and (Health is aLot) then (Health is Adults) (1)

27. If (Age is Old) and (Health is aLot) then (Health is Adults) (1)

28. If (Entertainment is aLot) and (Shopping is Alittle) and (Travel is aLittle) then (Others is Entertainment) (1)

29. If (Entertainment is aLittle) and (Shopping is Alot) and (Travel is aLittle) then (Others is Shopping) (1)

30. If (Entertainment is aLittle) and (Shopping is Alittle) and (Travel is aLot) then (Others is Travel) (1)

31. If (Entertainment is aLittle) and (Shopping is Alot) and (Travel is aLot) then (Others is Shopping-Travel) (1)

32. If (Entertainment is aLot) and (Shopping is Alittle) and (Travel is aLot) then (Others is Travel-Entertainment) (1)

33. If (Entertainment is aLot) and (Shopping is Alot) and (Travel is aLittle) then (Others is Shopping-Entertainment) (1)

34. If (Entertainment is aLittle) and (Shopping is Alittle) and (Travel is aLittle) then (Others is None) (1)

35. If (Age is VeryYoung) and (News is aLittle) then (News is LittleNews) (1)

36. If (Age is Young) and (News is aLittle) then (News is LittleNews) (1)

37. If (Age is MiddleAge) and (News is aLittle) then (News is LittleNews) (1)

38. If (Age is Old) and (News is aLittle) then (News is LittleNews) (1)

39. If (Age is VeryYoung) and (Health is aLittle) then (Health is LittleHealth) (1)

40. If (Age is Young) and (Health is aLittle) then (Health is LittleHealth) (1)

41. If (Age is MiddleAge) and (Health is aLittle) then (Health is LittleHealth) (1)

42. If (Age is Old) and (Health is aLittle) then (Health is LittleHealth) (1)

43. If (Entertainment is aLot) and (Shopping is Alot) and (Travel is aLot) then (Others is Shop-Trav-Enter) (1)

V. GRAPHIC INTERFACE AND EXAMPLES

The above fuzzy agents are combined to build the overall Cascaded Fuzzy Inference System. For proof of principle purposes, a Matlab graphic interface is used to implement our Fuzzy Inference System. Such interface is shown next (and in http://uregina.ca/~mayorgar/PPTs/Erika.ppt); in particular to exemplify several diverse user profile inputs.

Here, it is convenient to make a few observations regarding the Purchaser Link and refer to Table IV.

When the user is *Very young*, independently if the user is *Male* or *Female*; the **Purchaser Link** is **Kids.** The same is valid for *Young* users, so that the **Purchaser Link** is **Teen.**

For *Middle age* and *Mature* users the **Purchaser Link** changes:

If the user is a *Man* and his *Marital Status* is *Single;* the **Purchaser Link** is **Single Man.** And if his *Marital Status* is *Married,* the **Purchaser Link** is just **Men**. Similarly, if the user is a *Woman* and her *Marital Status* is *Single,* the **Purchaser Link** is **Single Woman.** Otherwise, If her *Marital*

Status is *Married,* the **Purchaser Link** is just **Women**. In the cases of *Mature* users, we just consider his/her *Marital Status.* If the user is single, the **Purchaser Link** is **Single Mature;** otherwise if he or she is *married*, **Purchaser Link** is just **Mature.**

Fig. 29 Interface example 1.

In this (extreme) case we have a very young (kid) single male, with no studies, with no working experience, and with some interest sections. It can be observed that the output of our Cascaded Fuzzy Inference System yields as

Purchase capacity: **Very poor**;

Purchase link: **Kids**;

Free Time: **A lot**;

Occupational Experience: **Beginners**

Other sections links: **Shopping-Entertainment**, None or little interest in **News** and **Kids Health**.

Fig. 30 Interface example 2.

In this case we have a young single female, with University studies, with some working experience in business; and with a great interest in entertainment and shopping activities, with little interest to travel, with interest on world events, and a huge interest in her physical condition. It can be observed that

the output of our Cascaded Fuzzy Inference System yields as

Purchase capacity: **Very good**;

Purchase link: **Single Woman**;

Free Time: **A lot**, (taking into consideration that she is single and she does not have children);

Occupational Experience: **Experts**

Other sections links: **Shopping, Entertainment, World News, Adult Health.**

Then, this output can be easily directed to the following links:

Fig. 31 Dynamic online portal example 1

The following example is considering a mature purchaser with different profile, illustrated in Fig. 32.

Fig. 32 Interface example 3.

In this case we have a mature married male without children, with University studies, with many years of working experience in engineering; and with a great interest in entertainment activities and also in traveling, with little interest in shopping and on world events, and interested in his physical condition. It can be observed that the output of our Cascaded Fuzzy Inference System yields as

Purchase capacity: **Very good**;

Purchase link: **Mature**;

Free Time: **Moderate**, (considering that he is married);

Occupational Experience: **Experts**

Other sections links: **Travel, Entertainment, Adult Health**.

Then, this output can be easily directed to the following links:

Fig. 33 Dynamic online portal example 2

The third example is based on the characteristics specified for a married male purchaser. Fig. 34 shows the profile for this purchaser.

Fig. 34 Interface example 4.

In this case we have a young married male with children (babies), with graduates' studies, with several years of working experience in Sciences; and with a interest in entertainment, shopping and traveling, with a huge interest on world events, and interested in his physical condition. It can be observed that the output of our Cascaded Fuzzy Inference System yields as

Purchase capacity: **Very good**;

Purchase link: **Men**;

Free Time: **A little**, (taking into consideration that he is married and he has children);

Occupational Experience: **Experts**

Other sections links: **Shopping, Entertainment, Travel, World News, Adult Health.**

Then, this output can be easily directed to the following links:

Fig. 35 Dynamic online portal example 3

VI. Conclusions

Electronic commerce (e-Commerce) has changed the way that people shop and conduct business. The use of the e-Commerce market is increasing at a remarkable rate. For companies to maintain or increase this rate, they must be able to create usable e-Commerce sites based on their targeted market. More than websites, personalized E-Commerce portals should reflect the same value-to-price trade-off that the company has built its business on and at the same time to reach the appropriated potential customers.

This Paper presented a novel Cascaded Fuzzy Inference System for portal customization based on personal user profiles. The results obtained reflect that our system can be used to improve the efficiency of Web-based advertising. Furthermore, it can also be a valuable approach for advertising in other media. The overall flexibility of the proposed framework will also allow rapid prototyping of novel applications.

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Erika Martinez Ramirez, obtained her B.Sc. in Computer Systems from University of Celaya, Mexico; and her M.Sc. in Instrumentation and Automatic Control from the Autonomous University of Queretaro, Mexico. She is currently working as a graduate student in the Wise & Intelligent Systems & Entities Lab in the Department of Industrial Systems Engineering at the University of Regina, where she is completing her Ph.D. program. She has worked in projects involving Neural Networks, Fuzzy Systems and Rough Sets Theory. Her research interests include Soft Computing, Human-Computer Interaction, Human-Computer-Automated Systems, Web Intelligence and application of AI to Engineering problems.

Dr. Rene V. Mayorga, is the head of the *W.I.S.E* (Wise & Intelligent Systems & Entities) Lab at the University of Regina. He is interested in the development of Artificial / *Computational Sapience [Wisdom]* (as an extension of Artificial / Computational Intelligence and Soft Computing) and *MetaBotics* (as a generalization of Robotics) as new disciplines. He is involved in the development of Paradigms for Intelligent and *Sapient [Wise]* Systems, *Sapient* Decision & Control, and *MetaBots*; and their application to Robotics (Robot and Multi-Robot Systems Motion Planning and Design), Automation, Manufacturing (Decision Making, Optimization), Human-Computer Interaction/Interface, and Software Engineering. Dr. Mayorga is the Editor of the journal of *Applied Bionics and Biomechanics*, and Associate Editor of the *Journal Intelligent Service Robotics*. Previously, (January 2002 - May 2006), he was Associate Editor of the journal of *Control and Intelligent Systems*. He has been in several recent occasions the General Chair of the *ANIROB International Symposium of Robotics and Automation* and Editor of the corresponding Proceedings.