

Consumer Agents Based on Cultural Model

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ABSTRACT

In recent years, many researchers have worked on agent-based modeling of consumer behavior. This field of research involves many fields such as computer science, management, sociology and purchasing psychology. There are many efforts in this area which most of them are based on linear modeling. In this research we focus on agent-based cultural fuzzy modeling of consumer behavior. The model includes two fuzzy sub-systems. The first sub-system updates the desired state of consumer agent and the second one specify that when consumer agent should make decision to purchase a product to satisfy its internal needs. The model also includes a few non-fuzzy sub-systems for perception, and choosing the best product to purchase. Moreover, a state vector is considered to store internal state of consumer agent. The model has been implemented with Repast Symphony which is a java based environment for developing multi-agent systems. Our experimental results suitably show that how consumer agents make decision to purchase a product.

KEYWORDS: Agents, Culture, Fuzzy Logic, Consumer behavior.

1. INTRODUCTION

Consumer behavior involves five stages including need recognition, information search, evaluation, purchase and post-purchase [Engel, J.F, et al, 1990; A.J.Della Bitta, 1993; Kotler, Ph., 1995]. Need recognition is one of the most important stages in consumer purchasing behavior [Solomon 2006; Engel 1990; Roozmand 2011]. There are two kinds of needs. These are functional and psychological needs. The functional needs refer to the physiological needs such as need to eat, to clothing, to drink, and need for housing [Maslow 1970]. On the other hand, psychological needs indicate the needs related to spirit and morality which include social status, novelty, power, affiliation and social responsibility. In general, when a certain need arises, it should be satisfied or compensated with the purchase of special goods.

There are many important factors influencing consumer behavior such as culture at macro-level, and personality at micro-level which known as psychological factors [Solomon 2006]. Also, some demographic factors such as age, sex, education, income, and material status affect the purchasing behavior [Engel 1990]. Culture is one of the most important factors influencing purchasing behavior which inherently holds fuzzy value. There are many efforts in mathematical modeling of consumer behavior; however, fuzzy modeling of culture is missed. In this paper we aim to model the culture based on fuzzy logic in multi-agent systems. The agents are new analytical entities which can be applied in social complex systems [Gilbert 2008]. Agent-based models have been applied in many fields of area [Shamshirband 2010, Vaezi 2009] as well as consumer behaviors modeling [Zhang&Zhang 2007; Jager 2000].

This paper is organized as follows. Section 2 contains the literature review and related works. Section 3 explains the proposed model. Experimental results are represented in section 4 and finally section 5 concludes the paper and proposes the future works.

2. LITERATURE REVIEW AND RELATED WORKS

In this section, the literature and previous works related to this research are presented. Subsection 2.1 describes consumer decision making process. Subsection 2.2 describes Hofstede's cultural model. Agent based models are explained in subsections 2.3.

2.1. Consumer Behavior

Consumer decision making is thoroughly discussed in marketing and management fields of research [Solomon 2006]. Five important stages are included in consumer decision making process: need recognition, information search, evaluation, purchase, and post-purchase. The most important stage is need recognition. When consumer feels an unsatisfied need, he (or she, hereafter he) makes

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decision to satisfy the need by purchasing a suitable product. Unsatisfied need refers to a big discrepancy between its actual and desired state, where consumer tries to reduce the discrepancy. Actual state indicates the current status of the consumer, and desired state refers to the state that consumer likes to be in that situation. How desired state of a consumer is changed as well as recognizing the need arousal is modeled based on fuzzy logic.

2.2. Hofstede's Cultural Model

Culture is referred to the unwritten rules but accepted by a group of people in a society [Hofstede 1980]. Culture influences consumer behavior [De Mooij 2003] alongside many other influential factors. Hofstede's model is one of the well-received cultural models in the world and benefits of many advantages for modeling such as defining culture in different numeric dimensions [Roozmand 2011]. Hofstede [1980] proposes four dimensions for culture which are described below.

Power Distance: It is referred to the societies in which inequality is accepted by the people. Many of people are powerful while others are known as less powerful. There is a defined relationship between bosses and subordinates [Hofstede 1980]. The need for such societies is social status [De Mooij 2003].

Individualism: The difference between 'I' and 'We' is defined by this dimension. Individualism countries pay attention to 'I' preferences instead of group tendencies. In contrast, collectivism cultures respect the group preferences. The main need for individualism countries is called novelty need which leads them to be different to satisfy "I" preferences [Hofstede 1980].

Masculinity: The difference between 'She' and 'He' is described by this dimension. Masculine culture emphasizes on gender role, in which males are more assertive and looking for material success; while females are supposed to be more modest. In contrast, in feminine societies both males and females take the similar role and are supposed to be modest [Hofstede 1980]. The need for masculine culture is related to material success for showing off [De Mooij 2003].

Uncertainty Avoidance: This dimension is strongly connected to dealing with ambiguity. High uncertainty avoidance cultures avoid encountering the situation with ambiguity; however, the lower ones tend to try new things. Therefore, the need related to low uncertainty avoidance dimension could be called as novelty need.

2.3. Agent-Based Models

Agent based modeling is well-received for modeling of social science complex systems such as consumer behavior modeling [Gilbert 2008]. There are many efforts in this area which the most important ones are reviewed here. Jager [1990; 2000] focuses on modeling need in consumer decision making process. The paper models four cognitive modules including deliberation, social comparison, repetition, and comparison. The model suffers from the lack of culture and personality. Zhang & zhang [2007] proposes a model based on sensitivity to price, quality, and advertisement. The model considers these sensitivities as a personality factors. Roozmand *et. al.* [2011] emphasizes on modeling culture and personality in consumer decision making process. Power distance as one important cultural dimension is modeled in [Roozmand 2011a] and uncertainty avoidance is modeled in [Roozmand 2011b]. Both works take related personality traits alongside mentioned cultural dimension. Although, fuzzy modeling of personality is applied in negotiation [Nassiri 2009]; however, to the best of our knowledge, no model take fuzzy logic as a key mathematical feature in consumer behavior modeling. Therefore, next section, proposes our fuzzy model for consumer decision making process. The general conceptual model is somehow borrowed from Roozmand [2011a] but, we have added two important fuzzy modules to it.

3. Proposed Model

In this section, the proposed model is elaborated.

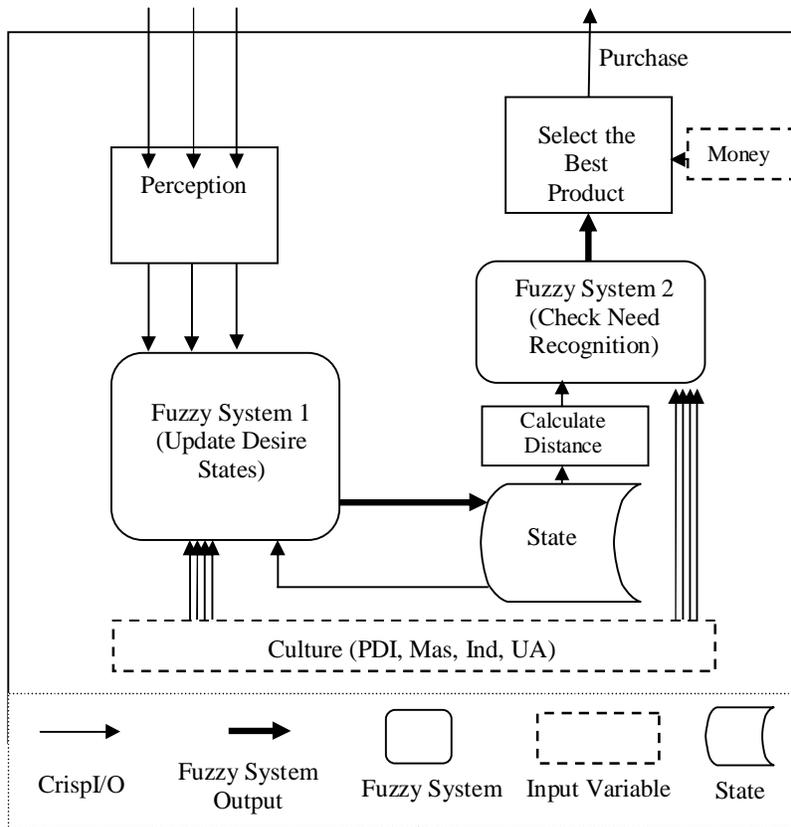


Figure 1. Conceptual model for consumer agent

Figure 1 shows the conceptual model for consumer agent. Here, different attributes and modules of the proposed model are described.

Culture: It includes four dimensions of Hofstede’s cultural model. Power distance, masculinity, individualism, and uncertainty avoidance are these four dimensions which are abbreviated as PDI, Mas, Ind, and UA, respectively. The fuzzy set for each cultural value is shown in figure 2.

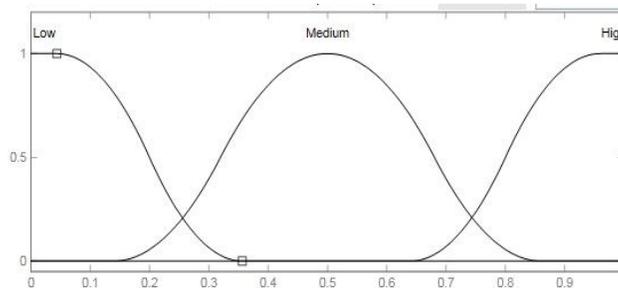


Figure 2. Fuzzy set for each cultural dimension

Perception Module: Consumer agent perceives the products and other consumer agents’ possession in its neighborhood based on Roozmand (2011).

State: This vector includes the actual state and desired state of the consumer agent on different needs. Actual state (AS_{need}) refers to the current state of the consumer agent by its belongings and is calculated based on function $1-\exp(-x)$ [Jager 2000] like $AS_{Need_i} = 1-\exp(-PR_{Need_i})$. Desired state (DS_{need}) indicates what state the consumer agent like to be in and is calculated based on fuzzy system 1 which is described later. The discrepancy of these two states is the key stimulus for consumer arousal.

Fuzzy System 1 (Update Desired States): There are three important states for consumer agent based on cultural backgrounds including desire toward social status, status (power), and novelty which are abbreviated as DS_{ss} , DS_{st} , and DS_{nov} , respectively. The proposed fuzzy system module utilizes of many fuzzy rules to update these desired states. Table 1 shows the rules about only two dimensions of culture, power distance and masculinity.

Table1 . Some fuzzy rules for updating desired states

No	IF	THEN	No	IF	THEN
1	PDI is HIGH SS is HIGH PR _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is MED	2	PDI is HIGH SS is HIGH PR _{ss} is HIGH DS _{ss} is MED	DS _{ss} is HIGH
3	PDI is HIGH SS is HIGH PR _{ss} is HIGH DS _{ss} is HIGH	DS _{ss} is HIGH	4	PDI is HIGH SS is HIGH CA_PR _{ss} is HIGH CA _{ss} is HIGH DS _{ss} is HIGH	DS _{ss} is HIGH
5	PDI is HIGH SS is HIGH CA_PR _{ss} is HIGH CA _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is MED	6	PDI is HIGH SS is HIGH CA_PR _{ss} is HIGH CA _{ss} is HIGH DS _{ss} is MED	DS _{ss} is HIGH
7	PDI is HIGH SS is HIGH PR _{ss} is LOW DS _{ss} is LOW	DS _{ss} is LOW	8	PDI is HIGH SS is HIGH PR _{ss} is MED DS _{ss} is LOW	DS _{ss} is MED
9	PDI is LOW SS is HIGH PR _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is LOW	10	PDI is MED SS is HIGH PR _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is LOW
11	PDI is HIGH SS is LOW PR _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is LOW	12	PDI is HIGH SS is MED PR _{ss} is HIGH DS _{ss} is LOW	DS _{ss} is MED
13	PDI is HIGH SS is LOW PR _{ss} is LOW DS _{ss} is LOW	DS _{ss} is LOW	14	PDI is HIGH SS is LOW PR _{ss} is MED DS _{ss} is LOW	DS _{ss} is LOW
15	PDI is HIGH SS is HIGH CA_PR _{ss} is MED CA _{ss} is HIGH DS _{ss} is MED	DS _{ss} is MED	16	PDI is HIGH SS is HIGH CA_PR _{ss} is LOW CA _{ss} is HIGH DS _{ss} is MED	DS _{ss} is MED
17	PDI is HIGH SS is HIGH CA_PR _{ss} is MED CA _{ss} is MED DS _{ss} is HIGH	DS _{ss} is HIGH	18	PDI is HIGH SS is HIGH CA_PR _{ss} is LOW CA _{ss} is LOW DS _{ss} is MED	DS _{ss} is MED
19	PDI is HIGH SS is HIGH CA_PR _{ss} is MED CA _{ss} is MED DS _{ss} is MED	DS _{ss} is MED	20	PDI is HIGH SS is LOW CA_PR _{ss} is MED CA _{ss} is HIGH DS _{ss} is MED	DS _{ss} is MED
21	PDI is HIGH SS is MED CA_PR _{ss} is MED CA _{ss} is MED DS _{ss} is LOW	DS _{ss} is MED	22	PDI is MED SS is LOW CA_PR _{ss} is MED CA _{ss} is LOW DS _{ss} is LOW	DS _{ss} is LOW
23	MAS is HIGH CA_PR _{st} is HIGH DS _{st} is HIGH	DS _{st} is HIGH	24	MAS is HIGH CA_PR _{st} is HIGH DS _{st} is MED	DS _{st} is HIGH
25	MAS is HIGH CA_PR _{st} is HIGH DS _{st} is LOW	DS _{st} is MED	26	MAS is LOW CA_PR _{st} is HIGH DS _{st} is LOW	DS _{st} is LOW
27	MAS is MED CA_PR _{st} is HIGH DS _{st} is LOW	DS _{st} is MED	28	MAS is MED CA_PR _{st} is LOW DS _{st} is LOW	DS _{st} is LOW
29	MAS is LOW CA_PR _{st} is MED DS _{st} is LOW	DS _{st} is LOW	30	MAS is MED CA_PR _{st} is MED DS _{st} is MED	DS _{st} is MED

In which, SS represents the social status (position) of the consumer, CA_PR_{ss} indicates the social status value of the product (PR) possessed by consumer CA which is perceived by the consumer,

and CA_{ss} refers to the social status of perceived consumer agent. We eliminate the rules based on individualism and uncertainty avoidance for the lack of papers. The rules update the desired states of consumer agent on different needs.

Calculate Distance: The discrepancy between desired and actual states is calculated as follows:

$$Discrepanc_{y_{need_i}} = DS_{need_i} - AS_{need_i}$$

Fuzzy System 2 (Check Need Recognition): This fuzzy system uses the calculated discrepancy in previous function as well as some other cultural features, and determines the arousal of consumer agent on each need. Table 2 represents the necessary rules for power distance and masculinity, and the representation of the rules for individualism and uncertainty avoidance is ignored for the lack of paper.

Table2 . Some fuzzy rules for recognizing need arousal

No	IF	THEN	No	IF	THEN
1	D _{ss} is HIGH PDI is HIGH SS is HIGH	Arousal _{ss} is HIGH	2	D _{ss} is HIGH PDI is MED SS is HIGH	Arousal _{ss} is HIGH
3	D _{ss} is HIGH PDI is HIGH SS is MED	Arousal _{ss} is HIGH	4	D _{ss} is HIGH PDI is MED SS is MED	Arousal _{ss} is LOW
5	D _{ss} is HIGH PDI is LOW SS is LOW	Arousal _{ss} is LOW	6	D _{ss} is MED PDI is HIGH SS is HIGH	Arousal _{ss} is HIGH
7	D _{ss} is LOW	Arousal _{ss} is LOW	8	D _{ss} is HIGH PDI is LOW SS is LOW	Arousal _{ss} is LOW
9	D _{st} is HIGH MAS is HIGH	Arousal _{st} is HIGH	10	D _{st} is HIGH MAS is MED	Arousal _{st} is HIGH
11	MAS is LOW	Arousal _{st} is LOW	12	D _{st} is MED MAS is HIGH	Arousal _{st} is HIGH
13	D _{st} is LOW	Arousal _{st} is LOW	14	D _{st} is MED MAS is MED	Arousal _{st} is LOW

In which, D_{ss} determines the discrepancy between actual and desired state of need social status. The arousal takes only two fuzzy value LOW and HIGH and is shown as follows.

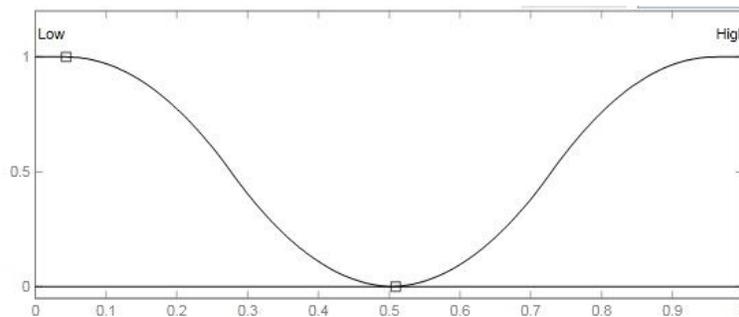


Figure 3. Fuzzy set for fuzzy variable Arousal

Select The Best Product: The output of the fuzzy system 2 is a crisp value in the interval [0, 1]. The value higher than 0.5 means that arousal happens in consumer agent. The pseudo code below shows that if agent should make decision to purchase.

```

If(Arousalneed_i <= 0.5){
    Do Nothing...
}else{
    Select_The_Best_Product().
}

```

If the agent makes decision to purchase, then the following formula comes to help the agent to estimate value of each alternative and finally select the best one. It is inspired from Roozmand (2011b).

$$U_{PR} = \sqrt{PDI * SS * PR_{ss}} + MAS * PR_{st} + \sqrt{IND * (1 - UA) * PR_{Novelty}}$$

This utility function indicates that power distance and social status of the consumer agent influence the importance of 'social status' value of the products. Masculinity has a great influence on 'material status' attributes of the product and novelty is high of importance for individualist and low uncertainty avoidance people.

4. EXPERIMENTAL RESULTS

The model has been implemented by Repast and FuzzyJ. Repast is a java-based environment for developing multi-agent systems and FuzzyJ is a component which includes necessary fuzzy functions and is based on java. To test the model, we have designed a scenario in which different agents with different cultural values and money are created. Also, different products which include miscellaneous attributes are generated. Table 3 represents the generated data about consumer agents.

Table 3. Data for consumer agents

No. of agents	PDI	MAS	Ind	UA	Money
5000	ND (n=5000, m=0.5, SD= 0.1)				

The table shows that 5000 agents are created for the test. ND refers to the normal distribution with mean (m= 0.5) and standard deviation (SD=0.1). First parameter (n=5000) indicates that 5000 numbers are generated and each one is assigned to one agent. The total number of 5000 is enough to cover all possible inputs for the agents. We have tested the model for 100 times with batch run. Table 4 shows the products generated for this test.

Table 4. Products data

No. of Products	A1= "Social Status" Attributes	A2= "Status Material" attributes	A3= "Novelty" attributes	Price
1000	UD (n= 1000, min=0.0, max = 1)	UD (n= 1000, min=0.0, max = 1)	UD (n= 1000, min=0.0, max = 1)	(A1+A2+A3)/3

According to table 4, 1000 products with different attributes are generated in this test. UD means uniform distribution, n shows number of data produced by the distribution, and min and max represent the minimum and maximum range for the data, respectively. Table 5 represents our results. It includes the correlation between each cultural dimensions and tendency toward each attribute of product. The correlation is the result of average of 100 times run.

Table 5. Correlations between each cultural dimensions and product attributes

	A1= "Social Status" Attributes	A2= "Status Material" attributes	A3= "Novelty" attributes
PDI	0.623*	NA	NA
MAS	NA	0.571**	NA
Ind	NA	NA	0.45*
UA	NA	NA	-0.52*

The results shown in table 5 confirm the theory behind the model. However, we expect to gather some good data about the influence of culture on consumer behavior. Then we will be able to test the model with real data, however, for the time being, the results suitably reflects the theory behind the model.

5. Conclusion and Future Work

In this paper, we proposed a fuzzy model for consumer agents. Agents utilize two important fuzzy modules which help the agent to make realistic decisions. What makes the model different is applying fuzzy logic in agent decision making. However, the model suffers from the lack of modeling of personality in agent decision making. Also the model is not evaluated against real data. Therefore, to enrich the model and make it more realistic, we need to model the personality in consumer agent, and take some more influential parameters.

REFERENCES

1. J.F. Engel, R.D. Blackwell, P.W. Miniard, Consumer Behavior, Dryden, Hinsdale (Ill); D.L. Loudon, 1990.
2. A.J. Della Bitta, Consumer Behavior, McGraw-Hill, New York, 1993.
3. P. Kotler, Marketing Management, Prentice Hall, Englewood Cliffs, NJ, 1995.
4. M. Solomon, G. Bamossy, S. Askegaard, K.H. Margaret, Consumer Behavior a European Perspective, Third ed., Prentice Hall, 2006.
5. O. Roozmand, M.A. Nematbakhsh, A. Baraani, An electronic marketplace based reputation and learning, *Journal of Theoretical and Applied Electronic Commerce Research* 2 (2007) 1–17.
6. O. Roozmand; N. Ghasem-Aghaee, G. J. Hofstede; MA Nematbakhsh; A. Baraani, T. Verwaart. (2011a) Agent-Based Modeling of Consumer Decision making Process Based on Power Distance and Personality. *Knowledge Based Systems* 24 (7). - p. 1075 - 1095.
7. O. Roozmand; N. Ghasem-Aghaee, MA Nematbakhsh; A. Baraani; Hofstede, G.J. (2011b) Computational Modeling of Uncertainty Avoidance in Consumer International Journal of Research and Reviews in Computer Science (Special Issue). - p. 18 - 26.
8. A.H. Maslow, Motivation and Personality, 2nd ed., Harper & Row, New York, 1970.
9. N. Gilbert, Agent-Based Models, Sage publication, 2008
10. S. Shamshirband, S. Kalantari and Z. Bakhshandeh. Designing a smart multi-agent system based on fuzzy logic to improve the gas consumption pattern. *Scientific Research and Essays* Vol. 5(6), pp. 592–605, 18 March, 2010. ISSN 1992- 2248 © 2010 Academic Journals .
11. S. K. Vaezi. Role of intelligent agents in knowledge management (case of electronic public services). *Scientific Research and Essays* Vol. 4 (5), pp. 392–397, May 2009. ISSN 1992-2248 © 2009 Academic Journals
12. T. Zhang, D. Zhang, Agent-based simulation of consumer purchase decision-making and the decoy effect, *Journal of Business Research* (2007) 912–922.
13. M. Janssen, W. Jager, An integrated approach to simulating behavioural processes: a case study of the lock-in of consumption patterns, *Journal of Artificial Societies and Social Simulation*(JASSS) 2 (1999).
14. G. Hofstede, Culture's consequences: international differences in work-related values, Sage Publications, Beverly Hills, CA, 1980.
15. M. De Mooij, Consumer Behavior and Culture: Consequences for Global Marketing and Advertising, India, Sage publications, 2003
16. F. Nassiri-Mofakham, M.A. Nematbakhsh, N. Ghasem-Aghaee, A. Baraani, A heuristic personality-based bilateral multi-issue bargaining model in electronic commerce, *Journal of Human-Computer Studies* 67 (2009) 1–35.