Int. J. Nonlinear Anal. Appl. 15 (2024) 6, 339–348
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2022.27777.3705

Character processing for intelligent agents in the electronic market using fuzzy logic

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(Communicated by Farshid Khojasteh)

Abstract

This paper presents the design of fuzzy electronic markets based on several agents. The character of the buyer and seller agents influences their behavior in the market. Various factors play an important role in the precise, real, flexible and attractive design of a market. This research aims to model the market and the character of intelligent agents based on fuzzy logic. In the market, sellers are known with different titles or credits. Results confirmed that sellers with high levels of personality would gain more credit than other sellers, consequently, they earn more sales and profit. In this model, when a seller does not tell the truth about his product, the customer might also suspect the honesty of the seller about the quality of other products. In fact, the seller is recognized as a non-reputable person who possibly conceals the truth regarding the quality of his products. Therefore, the costumer will focus on sellers with high reputation for the future purchases. If the costumer finds no reputable seller, he will buy from those sellers whose credibility has not yet been evaluated (disreputable seller). He only purchases again from the non-reputable sellers if he could find neither the reputable seller nor the disreputable seller. Salesmen can offer promotions for attracting customers which is the most important goal of sellers. One of the promotions is giving discounts to buyers who have made more purchases from specific sellers or have brought more profit for the seller. In the proposed model, the discount was an important factor in attracting customers, which was achieved by sellers with high personalities. This feature was not included in previous models, and we have implemented this model with Aglet, and MATLAB. Results indicated that fuzzy agents modelling buy/sell based on their personality are more satisfied than sell/buy agents using only fixed bids.

Keywords: personality, fuzzy logic, reliability, electronic market, intelligent agent
2020 MSC: 03B52, 60K10, 91B74

1 Introduction

Using the Internet and electronic commerce (e-commerce) in the late 1990s led to the disappearance of intermediaries between sellers and customers. A seller/producer can sell his products and services directly to the buyer without an intermediary. With the development of e-commerce technologies, new types of intermediaries were created. New intermediaries attract new buyers and sellers with new services while supporting the ongoing business process [4].

Previous studies confirm the association between personality and the consumer purchasing decision process [16, 5, 6, 10]. Consumers have different characteristics in their lives that affect their buying behavior. Social factors

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Received: March 2022 *Accepted:* July 2022

(like family, groups, roles, and status) and personal factors (like age, career, lifestyle, personality, and self-concept) characterize the buyer's behavior in the final decision.

The major point about agent-based e-markets is the decision-making ability of seller and buyer agents [15]. The decision of buyer and seller agents in the virtual world should be the same as real markets, which are influenced by various factors such as their personality, culture, and sense of the moment. A lot of research has been investigated to increase the decision-making ability of the agents and consequently to improve the performance of agent-based e-markets [3, 1, 13]. Since seller and buyer agents in this field are utilized to be replaced by humans in doing business, the agents should be modelled based on real human factors.

In this study, we have considered the fuzzy personality factor in modelling buyer and seller agents to improve the decision-making ability of the agents and to make the market and the agent's behaviors more realistic. The design of a fuzzy multi-factor e-market was thoroughly examined and the proposed system was performed by simulation. Afterwards, the results were compared with the previous research.

By increasing the use of agents in e-commerce, researchers have tried to automate buying and selling without the presence of an individual [7, 8, 12]. In transactions related to e-commerce, all the activities will be performed by actual intelligent agents; in other words, agents can completely replace humans. Agents behaving like a human can not only be practical for e-commerce, but they can also be beneficial in all other areas of agent application [9, 14, 11]. Therefore, agents considering individuality in decision-making can play a substantial role in the future world of agents.

2 Background

In psychology, intensive studies have been conducted on personality introducing various models such as OCEAN [16] and the Cattel 16 personality factor [5]. The OCEAN model includes five basic factors: open/closed, compatible/incompatible, conscientious/unconscionable and irresponsible, extroverted/introverted, and emotional/logical. An agent is a piece of software code that acts in the Internet virtual world and the other computer networks as a representative of a particular activity or the activities of a specific user [15]. An e-market is an Internet-based environment that provides the condition of doing business for the buyers and sellers [3].

Various studies have been held on credibility and reliability modeling [1], but no modeling has been designed for showing the effect of personality on the validation model. Individuals with high personality factors are more flexible about the frauds in the market, and they might continue buying from those cheater sellers. Thus, validation modeling can be influenced by personality, which is considered in this study. The importance of agent-based validation modeling in the e-market is that the agents can prefer or focus on reputable agents. The first article on the fuzzy field, entitled 'Fuzzy Test' by Professor Lotfi Zadeh [17], was like a spark changing the world of mathematics. Despite having strong opponents of fuzzy theory in the 1970s and early 1980s, no one can deny the value of fuzzy logic and fuzzy controls.

3 E-market based on agent

In this section, the definitions and symbols used in this model are presented.

3.1 Market components

Buyer and seller agents are recognized as the major elements of an agent-based e-market [2].

A Buyer is an agent present in the market for buying a specific product (s) that is sufficient to satisfy its user. A seller is an agent in the market selling a particular product (s) with the maximum profit.

3.2 Decision-making capability

Generally, decision-making is a mental process that all people deal with throughout their lives. The decision–making process takes place in the light of culture, perceptions, beliefs and values, attitudes, personality, knowledge, and insights of an individual, and all these parameters interact with each other. In modern management, decision-making is defined as the process of solving a problem; thus, decision-making is often referred to as problem-solving. In other words, all the activities and actions that are performed by human in all fields. Decision-making as an integral part of management is evident in every management task including determining the goals of an organization, formulating the goals, designing the organization, selecting, and evaluating.

3.2.1 Fuzzy set

Fuzzy set is a theory for acting in the conditions of uncertainty [17]. This theory can formulate many concepts, variables, and inaccurate and ambiguous systems. Also, it provides the basis of reasoning, inference, control, and decision-making in uncertain conditions.

4 Definitions

In this section, the definitions and symbols in this model are defined. The above index in the symbols indicates the desired feature is determined by the buyer or seller. The symbols in the parentheses indicates the reference of that feature.

4.1 Definition 1

If the personality and weight vectors are respectively denoted by $\Psi = (\psi_1, \psi_2, \psi_3, \psi_4, \psi_5)$ and $W = (w_1, w_2, w_3, w_4, w_5)$; then the personality score based on the OCEAN model is calculated as follows:

$$\Psi_w = \sum_{i=1}^{5} w_i \psi_i \tag{4.1}$$

where $\psi_i \in [0,1]$, $\sum_{i=1}^{5} w_i = 1$, $w_i \in [0,1]$, ψ_3, ψ_2, ψ_1, and ψ_4 are respectively the scores of the openness, conscientiousness, extroversion, and agreeableness in the OCEAN model. But the emotional stability factor score (ψ_5) in the model is the inverse of the neuroticism agent. Ψ_w is the inner product of W and Ψ vectors which is the weighted average of the five factors in the OCEAN model.

4.2 Definition 2

If S is a set of sellers and B is a set of buyers, the profit function based on a personality of a seller ($s \in S$) would be:

$$k_{\Psi}^{s}(b) = \left(1 - \Psi_{w}^{s}\right).k \tag{4.2}$$

where $k \in (0,1)$ is the maximum percentage of logical profit based on market custom. Obviously, $k_{\Psi}^{s}(b)$ is a real number less than k. Therefore, sellers with a high degree of personality consider lower profit percentage. For convenience, this function is shown by k_{Ψ}^{s} symbol.

4.3 Definition 3

If S is a set of sellers and B is a set of buyers, a seller will be considered reputable by buyer b whenever $r^b \geq \Theta_{\Psi}^{b}$. The parameter $\Theta_{\Psi}^{b} \in (0,1)$ is the credit threshold based on buyer personality:

$$\Theta_{\Psi}^{b} = \Psi_{w}^{b}.\Theta_{q}^{b} + \left(1 - \Psi_{w}^{b}\right).\Theta_{p}^{b} \tag{4.3}$$

A seller will be identified invalid by the buyer b, if $r^b \leq \theta_{\Psi}^{b}$, where $\theta_{\Psi}^{b} \in (-1,0)$ is the invalidity threshold based on the buyer's personality, as shown below:

$$\theta_{\Psi}^{b} = \Psi_{w}^{b}.\theta_{q}^{b} + \left(1 - \Psi_{w}^{b}\right).\theta_{p}^{b} \tag{4.4}$$

In the conditions of $\theta_{\Psi}^{b} < r^{b} < \Theta_{\Psi}^{b}$, a seller will be considered non-reputable by buyer b; then the credit of seller S is unknown to buyer b.

5 Market operation mechanism

In the simulated market in Aglet MATLAB, the seller and buyer agents are able to be present and do their business transactions. The proposed environment is computer-based which the seller and buyer agents transact. Also, there is a market contributor who has the responsibility to record the seller and buyer agents' data and to assist the buyer agent in finding the proxy address of those seller agents that have the product. The agents of seller and buyer will make various transactions (purchasing or selling) in the market as following:

1) After operation, the buyer and seller agents provide their personal information to the market contributor in order to register in the market. This information includes agent number (it will be assigned when the user executes), the agent proxy address (it will be considered automatically by performing Aglet), goods available to the seller, and personality questionnaire.

2) The market contributor calculates the personality scores for the buyer and seller agents and he will store them in the intended data structure with the information received from the buyer and seller agents. This data structure is an array of objects that contains fields related to buyer and seller agent information. Ac separate database is provided for the seller and buyer agents.

3) The market contributor retrieves the list of related sellers from the seller agents' database and delivers it to the buyer agent requested the data.

4) The buyer agent has received all the offers and evaluates them based on his personality as well as his level of trust in different sellers (this level is obtained in different transactions). For example, a buyer agent with high personality score tries to choose high quality goods, while a seller agent with low personality score prefer a product with lower price.

5) The winning seller agent delivers the goods to the buyer in the form of a message (for simulating the model and algorithms of the buyer and seller agent) and based on his own personality will credit the buyer agent.

6) After receiving the goods, the buyer agent calculates its true value and based on his personality will credit the selected seller agent.

7) Other agents who was not successful in selling their products, will reconsider the quality and price of their offers based on their personality.

5.1 Market assumptions

To make the market more realistic, the following assumptions were considered in the model:

1) The user might consider any character for the seller and buyer agent which indicates the presence of agents with different characteristics in the market.

2) The seller agents consider the discount for the reputable buyer agent based on their personality.

3) There are unreliable seller agents who lie about the quality of the products. This characteristic of the market is related to the existence of these agents who are unfair.

4) Each buyer evaluates the offered product based on their personality.

5) The buyer can test the quality of the product only after receiving it.

6 Algorithms

Various algorithms are used in this study, including:

6.1 Seller agent algorithm

Based on definition one, the sellers' (S) personality score will be as follows:

$$\Psi_w^s = \sum_{i=1}^{5} w_i^s \psi_i^s, \tag{6.1}$$

where $\Psi^s = (\psi_1^s, \psi_2^s, \psi_3^s, \psi_4^s, \psi_5^s)$ and $W^s = (w_1^s, w_2^s, w_3^s, w_4^s, w_5^s)$ are respectively the vectors of personality and weight of the seller S.

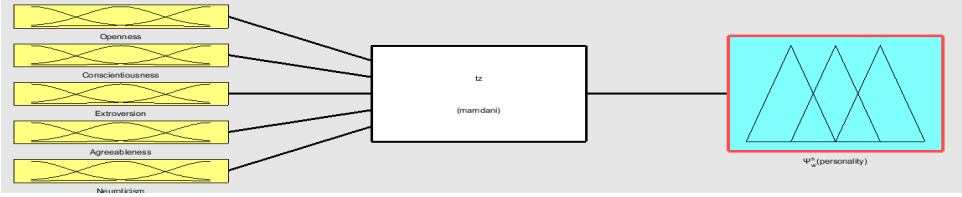

Figure 1: Fuzzy system inputs based on the OCEAN model.

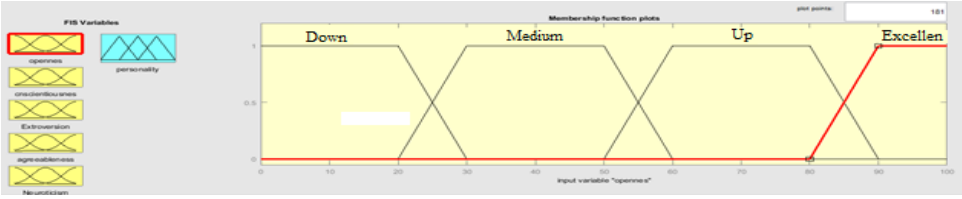

Figure 2: The inputs of Openness variable.

For each dimensions, components and linguistic indicators of personality, the fuzzy membership function (low, medium, high, excellent) was defined with the trapezoidal membership function and accordingly the fuzzy sets of inputs was defined. Personality motor inputs include five main features of the OCEAN model: openness, conscientiousness, extroversion, agreeableness and neuroticism and the output of the personality function (Figure 1).

A fuzzy system was used to model the openness input regarding qualitative features, input and output parameters and rules. The input of character engine consists of the five mentioned functions, all of which have qualitative values (low, normal, good, and excellent). The fuzzy inference engine in the proposed architecture is Mamdani model with the centroid fuzzy system.

In Figure 2, the inputs of openness variable is indicated as an example. The parameter has qualitative values (low, medium, high, and excellent), and a membership function (range from 0 to 100) with a trapezoidal diagram (Figure 2). The range of recovery threshold values was estimated from the actual results of the tests on human. For completing the fuzzy inference system, it is required to define the rules of the logic fuzzy, which are the heart of the fuzzy system. These rules will convert the input data of the fuzzy inference system to the output data. According to the inputs, 30 rules were defined and then they were amended by experts. Some of the rules used in this study, are as follows:

Rule 1) if all the personality factors (openness, conscientiousness, extroversion, agreeableness, and neuroticism) of an individual were low, his personality score would be low.

Rule 2) if the openness and neuroticism factors were low and the conscientiousness, extroversion, and agreeableness factors were normal, the personality score would be normal.

Rule 3) if the openness and agreeableness factors were normal and the conscientiousness, extroversion and neuroticism factors were good, the personality factor would be good.

Rule 4) if all the personality factors (openness, conscientiousness, extroversion, agreeableness, and neuroticism) of an individual were high, his personality score would be excellent.

6.2 Buyer agent algorithm

The buyer agents are equipped with the reinforcement learning algorithms and will accredit the seller agents in terms of quality and the price of the offered products. The buyer can identify those sellers who offer high quality products and who offer a right price. Also, the buyer agent can determine the honesty of different sellers about the quality of the offered product before delivery.

Assume that a buyer (B) is looking for a product (g) with a quality (40) in the market. The seller (S) will offer their product mentioning its quality as equal to 50. After purchasing and receiving the product, the buyer evaluates its quality as 45. Since seller (S) offered the quality of his product 5 units higher, the buyer (b) has evaluated a possible error (0.08) in the quality of the offered product and will consider it in the subsequent purchases. This error estimation will be updated in the future purchases of buyer B from seller S, based on reinforcement learning algorithm. Thus, there is a difference between the sellers' honesty and the credibility of their products. In the previous example, seller S has a negative score in terms of honesty in presenting its product. He can still build up a positive reputation

from buyer B if he delivers a product with higher quality than buyer B expected.

The following reinforcement algorithms for the buyer agents is provided to estimate the sellers' honesty and the credibility of their products. Credit modeling and estimation function are two main parts of the buyer algorithm. Based on definition 3, buyer B can estimate the value of the whole offers by each seller using the following function:

$$E^b = \frac{q^s_{bid}}{q_{\max}}.\Psi^b_w - \frac{p^s_{bid}}{p_{\max}}.\left(1-\Psi^b_w\right) \tag{6.2}$$

Suppose that buyer B evaluates the actual quality of the product (g) equal to $\widehat{q}$ after receiving it from seller S^*. Then, the buyer will update the credibility of seller S^* regarding the quality:

$$r^b_q\left(s^*\right) \leftarrow r^b_q\left(s^*\right) + \lambda^b_q.\left(1-r^b_q\left(s^*\right)\right), \tag{6.3}$$

where λ^b_q is the credibility impact factor of quality based on personality and is calculated as:

$$\lambda^b_q = \begin{cases} \Psi^b_w.RD_q & , \quad RD_q \geq 0 \\ \left(1-\Psi^b_w\right).RD_q & , \quad RD_q < 0 \end{cases} \tag{6.4}$$

The parameter RD_q is the relative deviation of quality:

$$RD_q = \begin{cases} \frac{\widehat{q}-q^b_{dem}}{q_{\max}-q^b_{dem}} & , \quad \widehat{q} \geq q^b_{dem} \\ \\ \frac{\widehat{q}-q^b_{dem}}{q^b_{dem}-q_{\min}} & , \quad \widehat{q} < q^b_{dem} \end{cases} \tag{6.5}$$

The parameter q^b_{dem} is the demanded quality of product g by buyer B and $q_{\min}$ is the minimum quality of product g that existed in the market. If $RD_q \geq 0$, seller S^* has delivered product g with a quality higher than or equal to buyer b expectation. The higher the personality score of buyer, the higher λ^b_q; thus, the buyer will add more validity to the sellers' previous credit (and vice versa). If $RD_q < 0$, seller S^* has delivered product g with a quality lower than the buyer expectation. The lower the personality score of the buyer, the lower λ^b_q and the buyer will greatly reduce the sellers' previous credit (and vice versa).

7 Unified Modelling Language (UML)

In complex systems, it is hard to understand the whole system simultaneously. Therefore, visualization and modeling are essential before building or reconstructing such systems. UML – apart from specific programming languages and development processes – is based on a standard modeling language using a meta-model and markup symbols. UML is the key to designing e-commerce systems that are developed in object-oriented and component-based environments and must be compatible with applications in different companies, different environments, and different languages.

7.1 Use-case diagrams

Use-case diagrams are used to show the users' needs and expectations from system (Figure 3). Users are those who interact with the system. To identify system actors, the following questions must be answered: Who uses this function? Who gets the information? Who can change the information? Does the other systems interact with this system?

7.2 Sequence diagrams in factor-based e-markets

Sequence diagrams, as the important UML diagrams, are used to express dynamic system behaviors. Each buyer and seller agent needs to register in the market for using market conditions and interacting with other agents. The sequence diagram used to register the buyer agent in the market is shown in Figure 4.

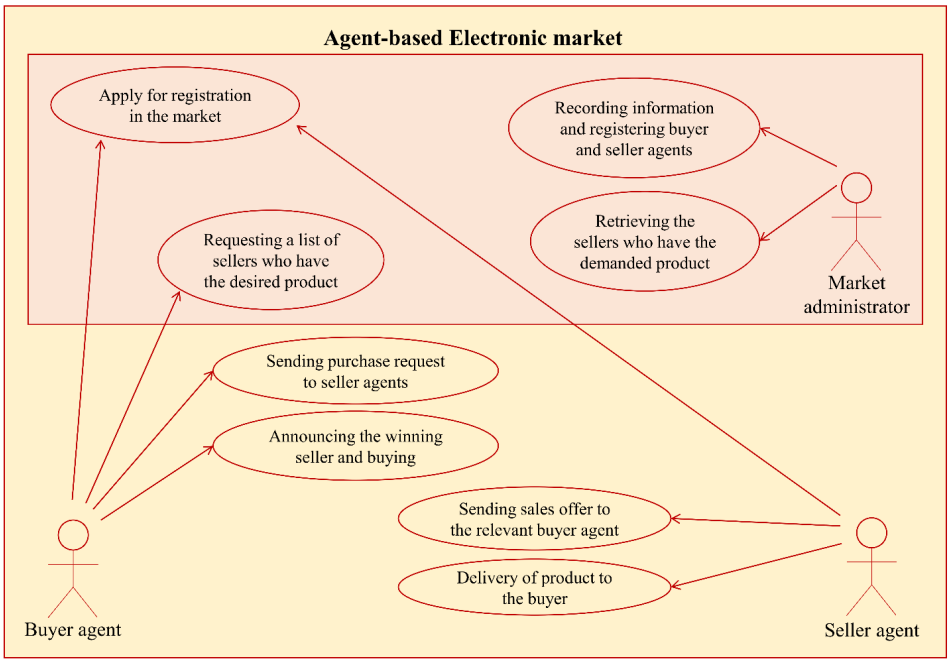

Figure 3: UML use-case diagram for agent-based e-market.

7.3 Activity diagrams in factor-based e-markets

Activity diagrams indicate the control flow from one activity to another during a specific operation. Activities are shown with round edge rectangles (Figure 5). By ending one activity, the operation goes to the next stage. Decision points can be used and parallel activities can be presented by concurrency bars concept. Vertical lines represent the boundaries of actors within the system.

8 Experiment

This study examined an experiment with 25 seller agents and 40 buyer agents in a proposed environment performing 2800 business operations. The sellers are divided into five categories:

Group 0) five sellers $(s_1, s_2, ..., s_5)$ with weak personality:

$Group\ 0 = \{s_i \in S | \Psi_w^{s_i} \leq 0.20,\ i = 1, 2, \ldots, 5\}$.

Group 1) five sellers $(s_6, s_7, ..., s_{10})$ with moderate personality score:

$Group\ 1 = \{s_i \in S | 0.20 < \Psi_w^{s_i} \leq 0.50,\ i = 6, 7, \ldots, 10\}$.

Group 2) those sellers $(s_{11}, s_{12}, ..., s_{15})$ who do not act based on the defined characteristic model and offer the product with a constant price and quality (quality 40 and price 45).

Group 3) sellers $(s_{16}, s_{17}, ..., s_{20})$ with good personality score:

$Group\ 3 = \{s_i \in S | 0.50 < \Psi_w^{s_i} \leq 0.75,\ i = 16, 17, \ldots, 20\}$.

Group 4) sellers $(s_{21}, s_{22}, ..., s_{25})$ with excellent personality score:

$Group\ 4 = \{s_i \in S | \Psi_w^{s_i} > 0.75,\ i = 21, 22, \ldots, 25\}$.

All the 40 buyer agents $b_1, b_2, ..., b_{40}$ followed the proposed algorithms. The other assumptions of experiment are:

- The quality of the product is considered equal to its production cost; on the other hand, the higher the quality of the product, the higher the cost of production.
- Generally, a seller can obtain the maximum normal market profit equal to 20% of the production cost. For instance, a seller can offer a price of 48 for a product that has been produced at a cost of 40. Then he reduces the price for attracting customers.

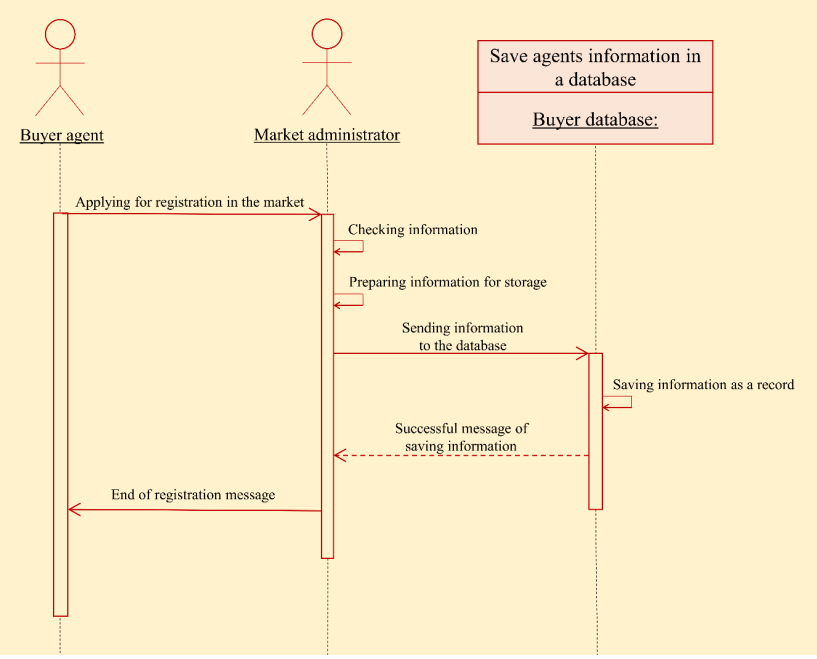

Figure 4: Sequence diagram for registration of buyer agents in the market.

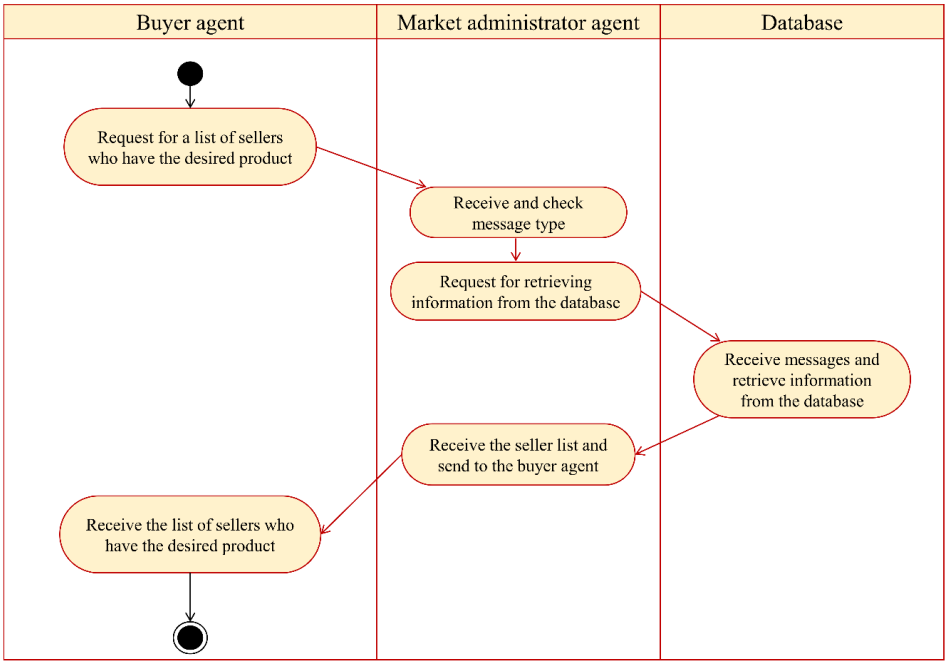

Figure 5: Sellers list request based on activity diagram.

Table 1: Total number of sales and average sales for different groups of sellers.

sellers' group	Total sales	Average sales
group 0	200	40
group 1	236	47.2
group 2	78	15.6
group 3	604	120.8
group 4	1682	336.4

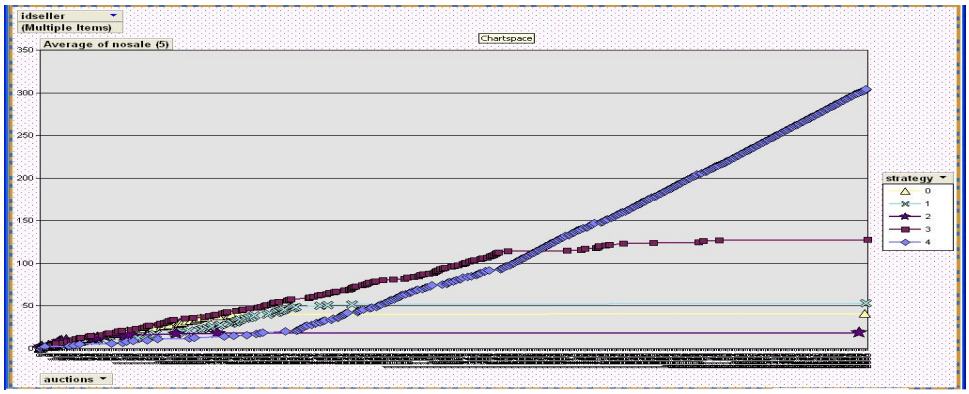

Figure 6: Number of sales versus time for sellers 1, 6, 11, 16, and 21 as a representative of groups 0,1,2,3, and 4, respectively.

- The minimum and maximum prices of product g in the market are respectively 40 and 60 ($P_{\min} = 40$, *and* $P_{\max} = 60$).
- The lowest and highest qualities of product g in the market are 30 and 50, respectively ($q_{\min} = 30$, *and* $q_{\max} = 50$). Also, $\theta_q^b = -0.15$, $\theta_p^b = -0.7$, *and* $\Theta_q^b = \Theta_p^b = 0.5$ are considered.

Results showed that sellers in group 0 (with lower personality scores) could only deceive buyers in their first purchase, and the buyer will not select them for the next shopping. All the 40 buyers in the market inevitably are deceived by this group once a time. Consequently, each seller in group 0 has a maximum of 40 sales due to losing their credibility (Table 1). Group 1 (with moderate personality scores) is expected to have an average trade in the market. Considering the competitive market, group 2 cannot get a better result due to offering constant quality and price. In fact, the competition in the market is between group 3 and group 4. Obviously, groups 3 and 4 have much more sales compared to the other groups (Table 1).

Figure 6 indicates the average number of sales for different groups of sellers. Group 4 has the highest selling rate. With increasing time and purchase of buyers, most of the sales are made by seller 20 from group 4 (purple points). Seller 1 from group 0 has good sales at first. After a short time, buyer agents learn not to buy from this group of sellers; as a result, seller 1 no longer has sales in the market.

9 Conclusion

Various factors in the market play a significant role in the accurate, factual, flexible, and attractive modeling and design of the market. In a real market, sellers are known with different titles and credits. In previous models, the personality of seller and buyer agents have not been modeled. This study aimed to use fuzzy personality factors in market modeling. Seller with high level of personality usually gain more credit than the others and consequently will gain more sale and profit. While those sellers who have low level of personality, give less discount to the buyers and therefore they do not earn a decent profit. Moreover, when a seller conceals the truth about the quality of a product, the buyer intrinsically guesses that the seller might deceive about the quality of other products. This seller is known as non-reputable, and the buyer only focuses on reputable sellers for the future purchases. If there were no reputable seller, the buyer would switch to those sellers whose credibility has not yet been evaluated. Attracting customers is the primary goal of sellers in the market. Sellers can offer promotions to their customers like giving discount to the buyers who make more purchases or bring more profit. This study observed that giving discount is a vital factor in

inviting customers which is achieved by high personality sellers. This feature was not included in any of the previous models.

10 Recommendation

The seller agents start the sales offer for each buyer from an initial default amount. Usually sellers can offer a product based on the similarity of a buyer with previous buyers. The next step is to use the buyers' personal information and preferences and to apply the nearest neighbor learning algorithm for adjusting the sales offer to new buyers.

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