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Simulation Modeling Of Consumer Behavior Within The Concept Of Smart Consumption

Lyubov Krestyanpol*

Lesya Ukrainka Volyn National University, ave. Voli 13, Lutsk 43005, Ukraine

Abstract

The article is devoted to the study of consumer behavior. The developed system allows to prevent food losses at all stages of its life cycle. The system contains software hardware and information components that ensure its operation. The information component is created by generating databases that are related to the software, as well as obtained from consumers, filling out web forms or through a mobile app. The social aspect of the system is taken into account in the region, because without it cannot be considered a full-fledged system. In turn, the decision of the consumer to participate in this system depends on the type of consumer behavior. For a deeper understanding of the social component of the developed system, the author explored the concept of "consumer behavior" and considered the possibility of its adjustment. The paper describes the formation of consumer behavior in terms of psychology and economics. The possibility of correcting consumer behavior to encourage participation in the system of collecting information using social engineering methods is considered. The phases of consumer choice in which it is possible to adjust consumer behavior are described. The author interviewed 1,000 respondents to study their consumer behavior. Based on the data obtained from the survey, the author developed a simulation model that reproduces the process of moving customers in the trading hall of the store. The main points of influence on the consumer in the trading hall are determined with the help of the simulation model. The author has developed and recommended the use of strategies for the correction of consumer behavior within the developed concept of smart packaging.

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* Corresponding Author. *Email Address:* Krist_88@i.ua

1. Introduction

Consumer behavior is a set of actions and reactions of the social subject in the field of consumption, which includes economic interest and social interaction. The economic component of such behavior involves: choosing the most profitable alternatives; the rationality of the acting subject, the presence of thinking about the results of behavior in his actions in terms of its effectiveness; conditionality of economic motives to maximize material benefits; awareness of possible ways to meet their needs. But, on the other hand, it is important to consider consumer behavior in the context of social relations, as described by the model of “homo economicus”, which main characteristics are: the conditionality of behavior by socio-cultural conditions; the impossibility of developing a rational scheme of human behavior: individual human actions may be spontaneous and unpredictable [1]. Based on this, consumer behavior can be divided into rational and irrational. But is it possible to influence and change consumer behavior? This article considers the possibility of using social engineering methods to change the rational and irrational behavior of consumers.

Today society is required to adhere to the rational consumption of both resources and raw materials and food. The problem of food waste growth is becoming global. Every year, tons of ready-made food and semi-finished products are transported from the refrigerator to the landfill. The situation with food losses during production is not better as well. If the production process is controlled by the manufacturer, then this process during the sale and consumption is almost uncontrollable. In the points of sale and shops, the appearance of food waste is monitored directly by employees, who may not always be able to find expired goods in time. Such goods are usually disposed of in food waste, or consumers can purchase such goods through their negligence. In turn, consumers at the stage of consumption of goods also generate a significant percentage of food waste. This is due to a number of reasons. One of them is the long shelf life of products. Too long shelf life often seems suspicious to consumers, so they try to get rid of a product at least a few days before it expires.

Another reason for food waste is the inability to calculate consumption. Experiments [2] show that people do not know how to determine correctly how much food they can eat over a period of time. Buying junk food, or so-called “gastronomic shopaholism” is a problem that exists in real life. Quite often consumers buy food that they do not like or consider not very useful because of curiosity or other non-obvious motives. Another reason for the appearance of food waste is a violation of storage rules. Very often food becomes unfit for consumption due to improper storage. Violation of the rules of commodity neighborhood, re-freezing, failure of the temperature regime, all leads to the inevitable loss of useful properties. Irrational attitude to food leads to unpleasant and even dangerous consequences. Improper approach to eating and storing food leads to unplanned financial costs. You have to buy food more often. Too many resources are spent on food production, so throwing them into landfills is also a significant impact on the environment.

The result of the study of this topic is the author's concept of smart consumption, which is described in detail in [3]. These studies present an analysis of a new information collection system aimed at improving the concept of “smart” packaging. The authors propose an innovative approach to understanding the concept of “smart” packaging as an integral part of modern technical solutions and social responsibility. The articles highlight the possibility of using RFID data transmission technology to maintain the performance of the information collection system. Procedures for encoding RFID tags and obtaining the information are clearly defined and illustrated by experimental data. The main advantage of the proposed model is the ability to use time ID-tags to monitor product expiration limits in real-time.

One of the components of this system is the consumer, who has his/her own consumer behavior and the information in this system depends on their actions. It is the consumers at the level of information in the system who have the opportunity to enter the required information about the product, namely about defects, damage or expired date of the food. Therefore, the next study of the author, which he considers in this article is the analysis of consumer behavior and the possibility of influencing it in ways of social engineering

2. Literature review

The fundamental bases for the interpretation of the essence of consumer needs are formed in the works of A. Maslow, R. Blackwell, W. James, Their efforts created a solid theoretical and methodological foundation for the

study of this issue, solved many of its methodological and applied aspects. Prerequisites for the theory of rational choice arose in the middle of the XVIII - early XIX centuries in the doctrines of the morality of the Scottish school of morality, whose representatives first proposed an individualistic concept of rational human behavior and drew attention to its fruitfulness to explain other social phenomena. A significant contribution to the development of the evolutionary theory of individual behavior was made by R. Nelson and S. Winter [4]. Among the researches on the theory of consumer behavior, the work of Saeed [5] and Michael S. Miller attracts our attention [6].

The theory of rational consumption, the foundations of which were laid by R., Stark [7], Amartya Sen [8], J., Meyer, [9] and others in the development of “rational consumer budget” considers the possibility of determining targets for consumption. Physiological needs, functional household processes, social requirements can act as such. Rationality in economic theory is realized primarily in the model of “economic man”. “Economic man” is meaningfully defined as a set of relations of human exchange with the natural and social environment because this exchange provides him with the means to meet material needs [10]. In her work O. Aleinikova [1] highlights the following features of an “Economic Man”:

- Actions are subject to one motive - selfish pursuit of self-interest, which is expressed in maximized utility;
- Identified needs that are limited only by the availability of resources;
- Rationality of decisions made;
- Autonomy in decision-making.

Neoclassicists divide consumer behavior into rational and irrational.

The rational one includes:

- Target function (purposefulness of activity - a person seeks to best meet their needs, which means material needs, those that are met by external sources);
- External information available for selection and decision-making;
- Human intellectual capabilities: memory, which stores information about the hierarchy of needs, the degree of their satisfaction, and the mind, which enables to calculate the results of their possible actions, weigh their importance and choose the best option.

Irrational consumer behavior is based on logically unmotivated actions. The consumer performs certain actions unconsciously or under the influence of certain emotions. Modern marketing and advertising have sophisticated methods of persuasion in their arsenal, which use the latest advances in psychology, sociology and other sciences that study human behavior. Studying and taking into account irrational forms of decision-making is the gold mine of modern marketing, especially advertising. Marketing technologies use the whole possible arsenal of means to influence the consumer, based on the mechanisms of imitation, infection and suggestion (hypnosis, suggestion). Incentives for unconscious action are often hidden behind outwardly invulnerable forms of marketing influence, which the consumer can rationally analyze as may seem at first glance.

If we describe these two types of behavior in one word, then for the rational one the corresponding word is thought, and for the irrational one, it is feeling. An interesting example of the formation of consumer behavior is given in the works [11], where the author considers the formation of attitudes and intentions based on thoughts and feelings in Fig.1.

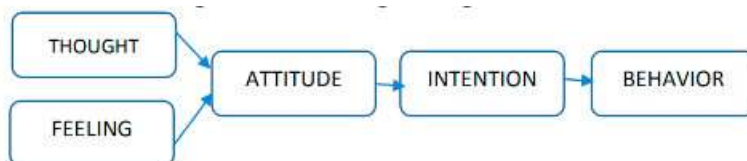


Fig. 1. Formation of consumer behavior Source: researchers' elaboration based on research data.

All components of consumer behavior shown in Fig. 1 are important elements that can be considered as a vector of attack in shaping the strategy of social engineering. The author considers the possibility of using social engineering methods to change consumer behavior. The term “social engineering” is most often used in the context of fraud, cybercrime and manipulation. Today, there are many methods of using social engineering based on the manipulation of human fears, interests or trust. In his work, R. Moseley [12] considers various psychological models and the psychology of manipulating an individual or a group of people. However, social engineering can be used for

the benefit of society to solve certain problems. In particular, the use of certain behavior modeling strategies can encourage consumers to change their consumer choices.

Developed B. Lipsten's [13] mathematical model is presented of consumer behavior in the marketplace under advertising stimulation. The model relates advertising effort to attitude changes and consumer purchases, using a nonstationary Markov process. Researching methods of social engineering, the author found similarities with advertising stimulation. Digital marketing techniques are often used to shape consumer behavior [14, 15].

An interesting approach to simulation modeling of consumer behavior is described G. Çagil [16]. The design of an intelligent simulation model of online consumer behavior (ISMOCB) that incorporates a knowledge base using some form of the Artificial Intelligence methods such as Naïve Bayes Classifier and Artificial Neural Networks.

The research results presented at the Winter Simulation Conference (WSC) by specialists from India Meghendra [17], Mayuri, [18] are of interest. The report Meghendra [17] raises the issue of taking into account various aspects of behavior (in particular, personality, affect, stress, etc.) during the construction of simulation models. The developers provide a set of guidelines that should be included in the basis of the development of behavioral simulation models. The paper claims that detailed behavior models can be used to study the dynamics of any complex dimensions in some situation to be investigated.

3. Material and methods

The simulation modeling of the process of consumer behavior formation is carried out in the work. As a software environment, the author used the simulation environment AnyLogic.

Since a full-scale experiment took a lot of time and required a large number of participants, the author proposed to develop a simulation model that would reproduce the process of moving consumers in the sales hall of a store. Agent modeling was best suited for the implementation of the task. Agent modeling is a branch of simulation modeling that allows you to study systems whose functioning is determined by the behavior of individual subjects (agents) and their interaction, rather than by general rules. Agents can be individual enterprises, organizations, computer programs that act according to a certain set of rules and can change independently. Each agent must be able to solve problems in a specific environment. In this case, two types of agents are highlighted. Separation of agents by gender (men and women), which in turn are divided by age category (18-35, 36-55, 55+). All agents are characterized by a certain state. The main types of states for agents are active and passive. An agent that participates in the system and will fill out the web form is an agent with an active status. An agent with a passive state does not participate in the system. Agents can change their state depending on conditions. The purpose of the simulation model is to identify the levers of influence and their locations in the trading room in order to change the state of the agent from passive to active.

In the process diagram for female and male agents, the event diagrams are separate. The «select_type» block sets the initial type of consumer behavior (participates in filling out the web form "yes" or does not accept "no") Fig. 2. The probability of accepting participation in filling out the web form was calculated on the basis of the data obtained from the survey of respondents and the answer to question №.4. on Fig.3. Out of 1000 respondents, 350 men and 550 women agreed. Thus, in the «select_type» block, the probability for a female agent is 0,55 and for a male agent is 0,35.

The next block «select» simulates the selection of the trajectory of movement on the trading floor. We have proposed five trajectories of movement between zones and racks by which active agents move and one for passive agents.

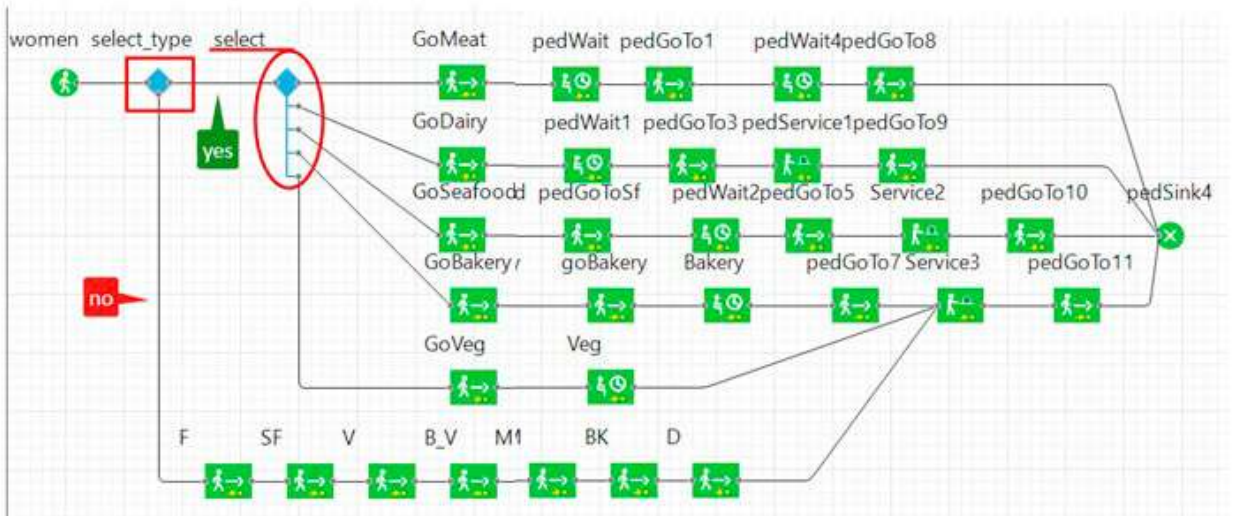


Fig. 2. The part of the process diagram of moving consumers through the trading floor

The main properties of agents are:

- the ability to process information coming from other agents and transmit it;
- the ability to make decisions based on this information;
- ability to set own goals and take actions to fulfill them;
- the ability to cooperate with other agents and consider their capabilities;
- the ability to change one's own behavior patterns.

Agent modeling is a bottom-up approach, that is, attention is focused on the behavior of individual agents. The basis of modeling is abstraction and simplification, which depends on the task at hand. Using an agent modeling allows you to solve problems of a high level of complexity.

4. Results

For two decades, humanity has been actively discussing and solving the problem of packaging disposal. As a result, there are new technologies for packaging processing, new environmentally friendly packaging materials and packaging methods. However, there is another problem now that is more global and less studied. This problem is the rational use of natural resources. According to research by international organizations (UN, FAO and UNEP), the main source of environmental pollution in the world today is food waste. Every year the planet produces 4 billion tons of food, a third of which goes to waste (1.3 tons of waste) [19]. In turn, the UN has developed a program "Save Food" which has a truly global goal, which is to find effective ways to reduce food waste and food losses, conservation and rational use of natural resources owned by humans, reducing human impact on the environment, and combating malnutrition and hunger worldwide. According to the Food and Agriculture Organization of the United Nations, the largest losses occur in four groups of consumer goods. Namely: meat and meat products, fish and seafood, vegetables and fruits, and dairy products. There are also significant losses at the points of sale and storage of food.

Within the framework of this initiative, the author proposed the creation of a concept of smart packaging [20], which would ensure proper storage of food and prevent food waste.

One of the steps in implementing the concept of smart packaging is to develop a system for collecting and processing information. The system is implemented through hardware, software and includes social aspects of information relations. If the issue of technical support is clear, then the issue of information support, through the prism of a certain society, requires detailed research. One of the elements of this system's functioning is the consumer. He/she is a source of information for the system and helps trade hall administrators prevent food waste.

To identify and report illiquid goods, the consumer shall fill out a web form. The link to the web form is contained in the price tag in the form of a QR code. By selecting the necessary items, the consumer informs the system about the availability of illiquid goods in a particular shopping area.

Each consumer can be characterized by a certain consumer behavior. Depending on the type of behavior, the consumer will take an active part in the system or not. In order to determine the level of consumer interest in participating in the system, a survey of potential participants was conducted. The author interviewed more than 1,000 potential consumers, who were asked questions regarding the principles of creating a system to monitor product quality indicators.

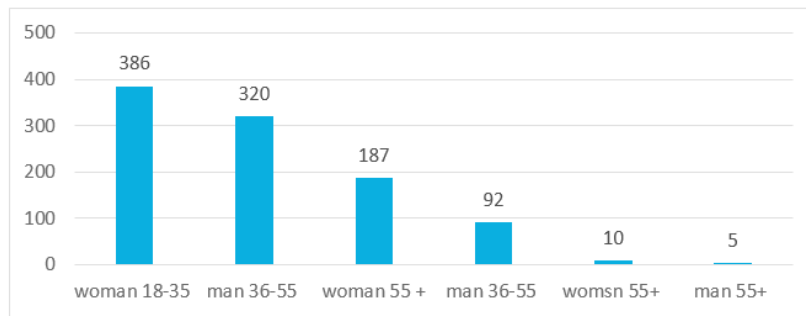
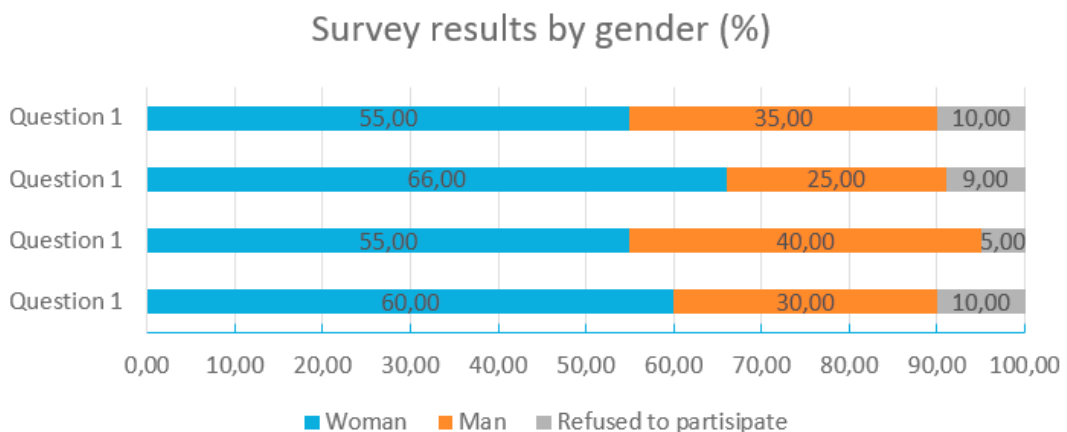


Fig. 3. The number of survey participants is divided by gender and age

In particular, the main questions aimed at determining the consumer's motivation:

- Question 1. Are you concerned about environmental pollution with food waste?
- Question 2. Would you like to rationally allocate financial expenses for food?
- Question 3. When buying food in a store, are you interested in the shelf life of products?
- Question 4. In the sales hall of the store, there is an opportunity for the consumer to identify and indicate product defects. Will you identify and point out defects?

The results of the survey are shown in diagram.



Summary of survey results by age group (%)

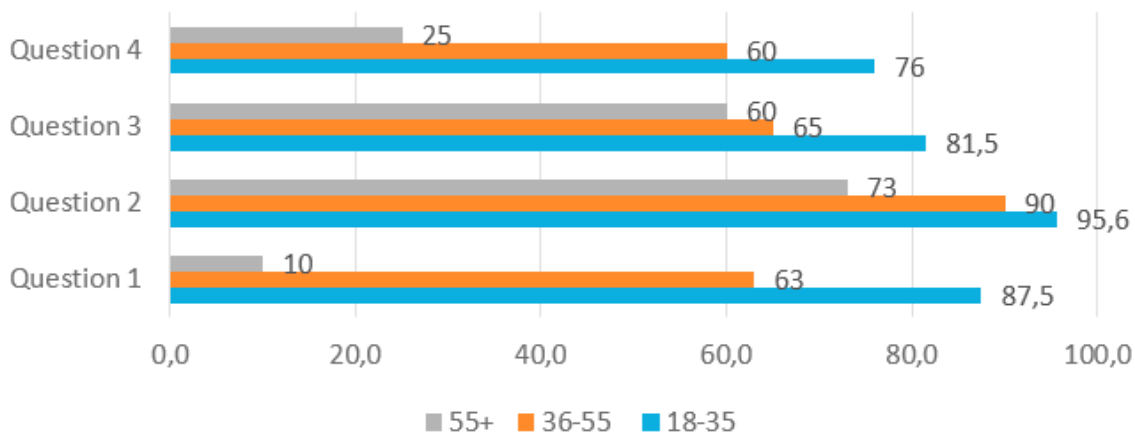


Fig. 4. The results of a survey of groups on participation in the system of monitoring the quality of food products

The results of the survey were processed and certain focus groups were identified. For the convenience of processing the results of the respondents were divided by gender (women and men), and by age category (18-35 years, 36-55 years, 56+ years). It should be noted that women and men aged 18-35 took a more active part in the survey.

Analyzing the data obtained, it can be stated that the majority of respondents would like to participate in the system of monitoring the quality of goods. However, a large percentage of respondents indicate additional privileges (discount or bonus points). This is due to a certain type of consumer behavior. Therefore, in order to better understand how to encourage consumers to participate in the system best, it is necessary to consider the formation of consumer behavior and its types.

Returning to Fig. 1, the formation of consumer behavior begins with thought for the rational one and with the feeling for the irrational one. If to analyze the rational behavior, the consumer wants to get the most benefits for the least resources. In the developed system of monitoring the quality of goods, the good has no material form and is an act of consumer action. In this case, it is filling out a web form. The action is voluntary and depends entirely on the desire or intention of the consumer. The resource is the personal time of the consumer that he spends on this action. Accordingly, in rational behavior, the consumer will seek a balance between the action and the time spent on it.

In this case, a certain motivational lever may be an additional benefit, as a reward for resources spent. Such benefits can be discounts on certain groups of goods, discount cards, bonuses, which can later be exchanged for goods; or privileges in service.

For irrational behavior, the vector of attack is to evoke a certain feeling in the consumer, which will form an intention in the future.

To reproduce the process of collecting information and filling out a web form, the author created a simulation model that simulates the movement of consumers in the trading hall of the store. Model agents are divided by gender and type of consumer behavior. The model takes into account irrational and rational behavior and performs six scenarios of consumer movement. The scheme of the 2D model is shown in Figure 5.

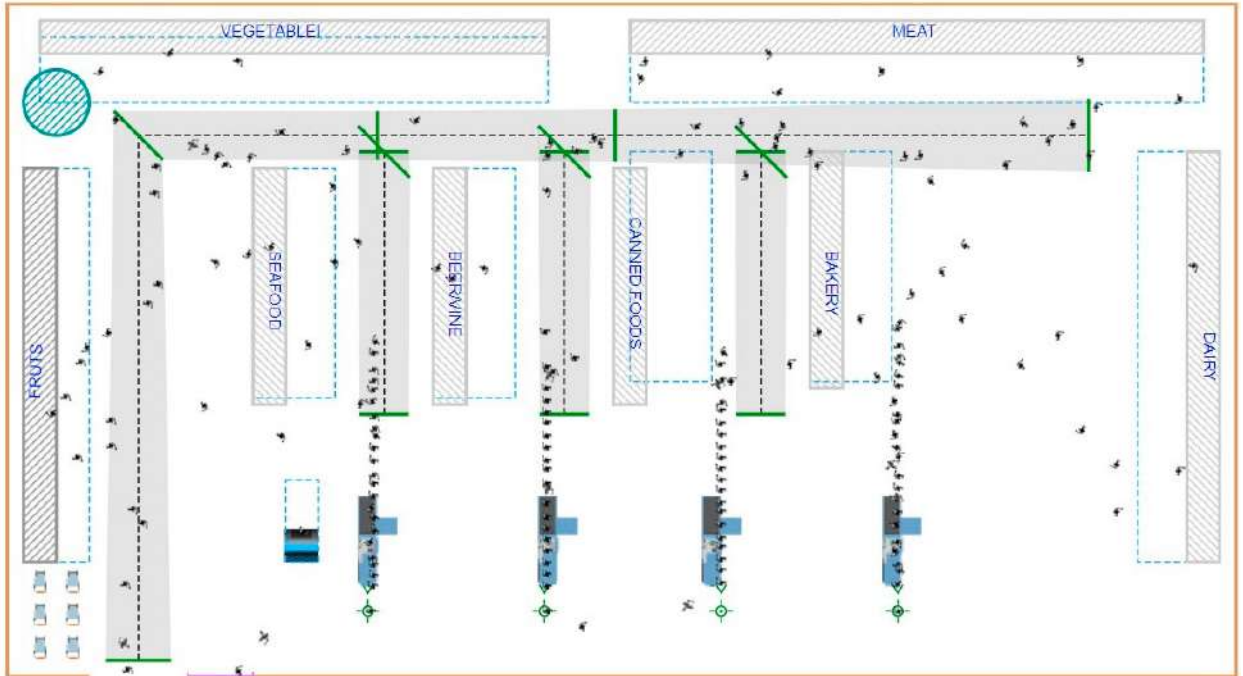


Fig. 5. 2D scheme of simulation model

As a result of the simulation model, it was possible to establish the zones with the largest concentration of consumers. The largest congestion occurs in the end areas of the racks and at the ticket offices. In Figure 6, they are marked with red markers.

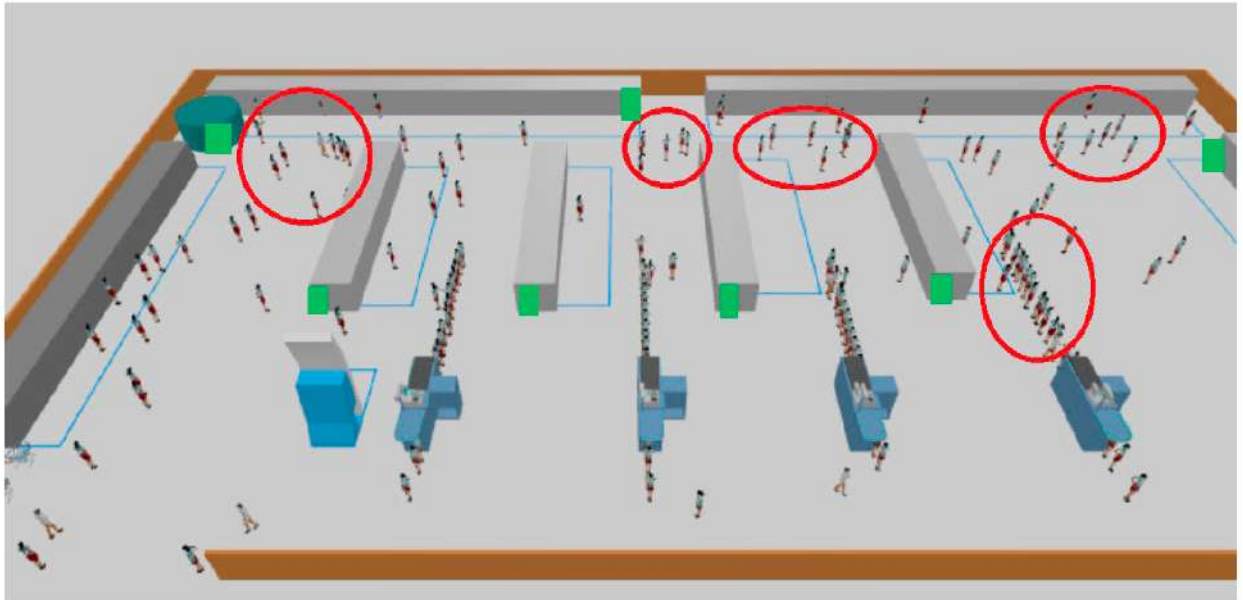


Fig. 6. 3D scheme of simulation model

It can be argued that in these areas it would be appropriate to place messages or signals that will encourage consumers to take certain actions. In this case, it is an incentive to fill out a web form. The signal placement areas are marked in green in Fig.6.

Given the impact of consumer behavior, the author has developed strategies to encourage consumers to fill out web forms. The strategy for rational consumer behavior is based on the creation of messages (stimuli) that will describe the additional or bonus opportunities, which the consumer will receive by performing a certain action.

The strategy for irrational consumer behavior is based on the formation of certain feelings in the consumer that will motivate him to take action.

In irrational behavior, it is possible to evoke the following feelings of consumers:

- “Participation and significance in a great cause”. The consumer understands that his actions can help the environment and reduce food waste.
- “I’m one of them”. The consumer joins the community with famous people, politicians who support this initiative.

5. Conclusions

Social and economic research in the concept of smart packaging is a necessity. Without the participation of consumers, this concept cannot be considered complete. The system operates on the flows of information from the technical support and the social sphere. The combination of technical and social security provides a more complete and in-depth understanding of the information collection and processing system within the concept of smart packaging.

Analyzing the results of the experiment, we can conclude that the application of strategies increases significantly the active participation of consumers in the system of monitoring the quality of goods. Undoubtedly, there are participants in the experiment who did not take part despite the applied strategies. This is due to lack of time, lack of mobile phone at the time of the experiment or lack of interest in the problem. Conducting the experiment in three different stages precluded informing respondents about the final bonuses and benefits, which provided an opportunity to recreate the real environment of buyers.

As a result of the experiment, new problematic issues in the study were revealed, namely the optimization of the web form interface and the consumer information system. A well-designed user-friendly interface will encourage the customer to inform the store administrators about these problems. We shall also consider the communication strategies used in the web framework interface:

- global strategy (i.e., be polite, be positive, be honest);
- local strategy (i.e., greetings, request for personal information, detailed description, gratitude for the client's help).

Of course, communication with the consumer is mandatory and transparent. It shall be noted that the client must have complete information about the procedure in which he participates. He must understand the importance of his feedback and must be motivated to provide as much information as possible to minimize food loss. At the same time, the process of gathering information shall not take too long, otherwise, the client will simply give up or reject the idea in the middle of gathering information while filling out the web form.

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