REDESIGN OF AUTOMATIC VACUUM CLEANER WITH PARTICIPATORY APPROACH

Ade Irawan Said[1], *Ardhini Ramadhani Yusri[2], Tania Sephia Azzahra Damanik[3], Atyanti Dyah Prabaswari[4]**, *and Nurdiyana Sofi[5]*

[1]Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia
[2]Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia
[3]Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia
[4]Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia
[5†]Department of Industrial Engineering, Faculty of Industrial Technology, Islamic University of Indonesia

Abstract. While using automatic vacuum cleaners, users found dissatisfaction namely dust problem, obstacle problem, and narrow space problem. Therefore, the problems in this automatic vacuum cleaner must be fixed so that it can maximize user productivity. The methods that researchers will use to carry out this research include the participatory ergonomic which is a method for translating consumer needs into an optimal and solutive products by gain aspirations from users and stakeholders. The next method is Maynard Operation Sequence Technique which is a predetermined motion time method that aims to determine the standard time for doing work. There are also participatory usability and ergonomics methods that help this research. For the dust problem, researchers have looked for a solution to the problem, namely by adding SLAM and Artificial Intelligence logarithms to the automatic. For the narrow space problem, researchers have designed different nozzles for the automatic to use. For this exact problem, researchers have added a crevice nozzle to the automatic so that the automatic can insert suction in narrow areas such as the back of cupboards. Researchers created this feature so that users no longer need to bother cleaning dust from sofas, tables and other items in the user's room.

Keywords: Artificial Intellignet (AI), High-Ground Cleaning, Participatory Ergonomic, Maynard Operation Sequence Technique (MOST), Vacuum Cleaner

1 Introduction

One of the processes of social change in society is modernization. Modernization cannot be separated from human life, because modernization is one of the social changes that occur in

* Corresponding author: atyanti.dyah@uii.ac.id

society. Society cannot avoid it, because every human society is always changing and always wants to change [1]. Modernization is the process of building change opportunities for progress. This modernization involves a change from a traditional society to a modern society. Modern society is a society that has gone through all kinds of changes. They are able to adapt to any modern situation [2]. The application of technology to people's daily lives is becoming increasingly evident. Nowadays, there are also many conditions where people do not have free time to do household work. Because of this, people think about how to use technology in household activities. One of the technologies created by humans is automatics. Automaticics is now a popular field in the world of education, industry, services and many other fields. Japan is one of the countries that has very large funds for research and development of automatics. In general, a automatic is an electromechanical circuit that can move and has intelligence. However, the definition of a machine or tool that is classified as a automatic is currently still being discussed and standardized [3]. Automatic vacuum cleaners have been on the market for several years now. The popularity of this automatic is growing and has succeeded in attracting human attention. This automatic can help humans in doing household tasks, especially house cleaning work. In the 70s Quasar Industries claimed to have developed a automatic capable of carrying out household tasks, this claim turned out to be false [4]. But now, more than 50 years later, many types of automatic vacuum cleaners can be purchased on the market.

Usability is a fundamental concept in design and technology that focuses on ensuring products, websites, software, and interfaces are user-friendly and intuitive. It revolves around the idea of making it easy for individuals to interact with and understand a system or product, ultimately enhancing their overall user experience. Usability also emphasizes simplicity and efficiency. A usable design should be straightforward, reducing the learning curve for users and allowing them to accomplish their tasks quickly and effectively. This involves clear navigation, intuitive interfaces, and concise instructions. Feedback mechanisms are crucial in usability. Users should receive informative feedback on their actions, such as confirmation messages, error notifications, and progress indicators. This helps users understand the system's response and correct any mistakes they make. Automatic vacuum cleaners have been on the market for several years. Therefore, users have some problems with this vacuum cleaner automatic trigger dissatisfaction. For example, the problem with this vacuum cleaner automatic is the dust problem, the obstacle problem that the automatic has to face, and the narrow space problem, narrow space where the automatic cannot reach the area. With these problems, the performance of this automatic is not optimal. Usability testing is a common method used to assess and improve usability. This involves observing real users as they interact with a prototype or the actual product to identify usability issues, gather feedback, and make necessary refinements. This iterative approach helps refine the design and ensures that it aligns more closely with user needs. User will have satisfaction and comfortable if the product is fulfilling what they need, so developer needs to understand what is user really needs.

So the developer must use some method to gather important information from user or users can be participated on product development project. Ergonomic participatory design is a collaborative approach that places a strong emphasis on the involvement of end-users in the design and development process of products, workspaces, and systems. This approach recognizes that the individuals who will use a particular product or workspace are the experts in their own needs and preferences. Therefore, their active participation in the design process is essential to create solutions that truly cater to their well-being and comfort. One of the significant benefits of ergonomic participatory design is the potential for increased user satisfaction and productivity. When individuals have a direct role in designing their work environment or tools, they are more likely to feel comfortable and supported in their tasks. This, in turn, can lead to reduced stress, improved job satisfaction, and enhanced overall well-

being. With these combinations of knowledges to redesign automatic vacum will solve any trouble before and create smart, multifunction, and smart automatic vacum. Technological features in social service automatics continue to be developed to make life easier. Therefore, the problems with this automatic vacuum cleaner must be fixed so that it can make life easier [5].

2 Methods

The methods that will be use to carry out this research include the participatory ergonomic approach. Being a design element, in this sense means that any problem that customer have will be used to design new products based on consumer feelings and demands. In the field of art and design, participatory ergonomic is an approach to catch optimum product that will be helped by the next method is the MOST (Maynard Operation Sequence Technique) method which can be defined as a way of analyzing operations or sub-operations carried out through several methods, steps and sequences, and so on. In other words, MOST is a motion time method that has been determined which aims to determine the standard time for doing work [6]. The MOST method is very useful because the time value of statistical calculations of the MOST approach can be applied to various jobs [7].

Next is Usability which is a qualitative analysis technique to determine how easy the automatic vacuum cleaner application is to be used by users. The usability aspect is an aspect that determines the success of application and is a sign that users accept the application [8]. One tool for measuring usability is the System Usability Scale (SUS) proposed by J Brooke. This system uses 10 questions with responses in the form of a five-point Likert scale for each question [9]. For the last method is the Participatory Ergonomics method which is defined as the process of solving ergonomic problems in work systems by involving related parties from the planning process to implementation by considering ergonomic aspects [10]. Participatory Ergonomics is a process of solving work system ergonomic problems by involving related parties from the design process to implementation by considering ergonomic aspects [11]. In addition, the participatory ergonomics approach is one where users and other stakeholders are actively involved in improving efficiency from the design process to implementation [12].

3 Equations and mathematics

3.1 Data Processing Using The Most Method

In MOST data processing, standard time calculations will be carried out from the time of use of manual vacuum cleaners and automatic vacuum cleaners. The following is the calculation of the standard time for collecting MOST data:

Table 1. Manual Vacuum Cleaner MOST Data Collection

Working Method					**Assembly Activities**	
No	**Element Work**	**Sequence Models**			**Index**	**Time (second)**
		Obtain	**Move**	**Return**		
1	Take vacuum tool *cleaner*	A1B6G1	M3X3I1	A0	150	5.4

Working Method					Assembly Activities	
No	**Element Work**	**Sequence Models**			**Index**	**Time (second)**
		Obtain	**Move**	**Return**		
2	Turning on vacuum cleaner	A1B0G1	M1X3I1	A0	70	2.52
3	Carry out cleaning using1 vacuum cleaner tool round	A16B3G1	M6X16I1	A16	590	21.24
4	Turning off vacuum tool cleaner	A1B0G1	M1X3I1	A0	70	2.52
5	Put return the vacuum tool cleaner	A1B6G1	M3X3I1	A0	150	5.4
Total					1030	37.08

Table 2. Automatic Vacuum Cleaner MOST Data Collection

Working Method					Assembly Activities	
No	**Element Work**	**Sequence Models**			**Index**	**Time (second)**
		Obtain	**Move**	**Return**		
1	Take vacuum tool *cleaner*	A1B0G0	M1X1I1	A0	40	1.44
2	Turning on vacuum cleaner	A1B0G0	M1X1I1	A0	40	1.44
3	Carry out cleaning using1 vacuum cleaner tool round	A1B0G0	M1X1I1	A16	40	1.44
4	Turning off vacuum tool cleaner	A1B0G0	M1X1I1	A0	40	1.44

Working Method					Assembly Activities	
No	Element Work	Sequence Models			Index	Time (second)
		Obtain	Move	Return		
5	Put return the vacuum tool cleaner	A1B0G0	M1X1I1	A0	40	1.44
Total					200	7.2

Time Saving

$$Standard\ Time\ Saving = \frac{Manual\ Vacuum\ Standard\ Time - Robot\ Vacuum\ Standard\ Time}{Manual\ Vacuum\ Standard\ Time} x100\%$$

$$Standard\ Time\ Saving = \frac{37.08-7.2}{37.08}\ x\ 100\%\ \text{x}$$

$$Standard\ Time\ Saving = 0.8058\%$$

Based on the tables above, it is found that the standard time value for a automatic vacuum cleaner is smaller than for a manual vacuum cleaner. This difference in standard time is because the automatic vacuum cleaner makes more concise movements compared to the manual vacuum cleaner. The standard time calculation results for the manual vacuum cleaner were 37.08 seconds and for the automatic vacuum cleaner it was 7.2 seconds, resulting in a time savings calculation of 0.8058%.

3.2 Data Processing on Usability Method

From the results of the usability tests that have been carried out, we can analyze the results of these tests. The first is analysis of effectiveness results or the number of errors in the product application interface. Due to the number of errors in the application interface there are 2 errors. The cause of this error is because the colors of the features used blend too much with the background, making it difficult for users to read them. We carried out calculations using SPSS to find out whether there was a difference in the average effectiveness value of the application interface. The results we get are that there is no difference in the average value of effectiveness based on the scenario category.

Next is the analysis of efficiency data. Based on the results of calculations and data processing performed with SPSS software, using as much as 5 data it is concluded that there is no difference between the average value of efficiency based on the task. The efficiency value is calculated based on how long it takes each respondent to complete each given task. Because there is no difference between the average efficiency scores based on the task, it can be said that the product application interface can be easily accessed by novice respondents whose appearance is easy to understand. Based on the task given, the efficiency value will increase with each increase in the level of the given task, which consists of easy tasks, normal tasks, and hard tasks. The final analysis is user satisfaction analysis. Based on the results of the SUS questionnaire data processing, the product application interface has a value of 71.5. So it gets a score of B which is included in the range70 – 79. Therefore, the product is acceptable or can be said to have a sufficient level of usability.

Figure 1. Interface of Automatic Vacuum Cleaner Application

3.3 Innovation Aspects

The development of automatic vacuum cleaners from time to time has developed rapidly. Starting from the first automatic vacuum cleaner produced by the Swedish company, Electrolux, 1997. When the Automatic Vacuum Cleaner started, it first found the nearest wall. From there it follows the walls and the contour of the room and whatever objects it senses with its sonar system until it finally returns to its starting point near the wall. However, Electrolux does not explain how this point can be reliably recovered. Once the vacuum cleaner covers the perimeter of the room, it cleans the rest of the room by moving in a random pattern [13]. We can see automatic vacuum cleaners on the market today with interesting features such as Smart AI for detecting objects to avoid. Delegating household tasks we don't want to complete ourselves to a machine will give us more time to focus on activities we find valuable. With their help, we can create the necessary conditions to enjoy private life at home much more easily [14]. Therefore, it is important for researchers to further develop this vacuum cleaner automatic by adding innovations that help humans enjoy their personal lives at home. The following are the innovations that we will develop for the products in this research along with recommended sizes that can be applied to vacuum products:

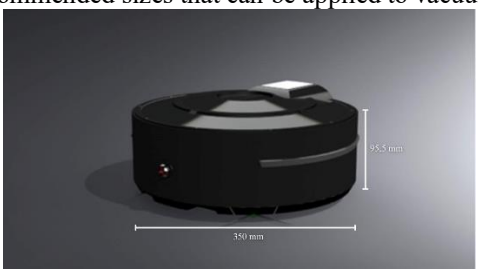

Figure 2. Automatic Vacuum Cleaner Design

Figure 3. Automatic Vacuum Cleaner Design with Charging Pod

Figure 4. Charging Pod Design with Dust Container

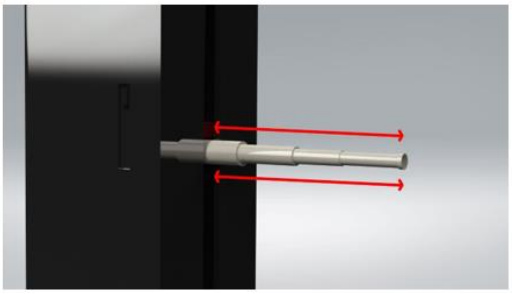

Figure 5. Extended Suction Nozzle Design

Figure 6. Design Crevice Nozzle, Upholstery Nozzle and Brush Nozzle

Figure 7. Design Hight-Ground Cleaning with Automatic Vacuum Cleaner

3.4 Conclusion

From the research that has been carried out, the following conclusions can be drawn that there are many respondents who stated that the automatic vacuum cleaners currently available on the market can help people shorten their working time, especially for those who do not have free time to do cleaning activities. This automatic vacuum cleaner can also save human energy in cleaning activities, which of course using a manual vacuum cleaner can take time and energy, whereas if you use a automatic vacuum cleaner it doesn't use any energy or time at all. Automatic Vacum will have been designed to have innovative features of the automatic vacuum cleaner that we have designed to be as effective as possible and are automated to solve current problems, namely dust problems, obstacle problems and narrow space problems. For the dust problem, we have looked for a solution to the problem, namely by adding SLAM and Artificial Intelligence logarithms to the automatic. For obstacle problems or obstacles such as pets, children's toys, etc. The way to solve this problem is with the help of SLAM logarithms, Ultrasonic sensors, and AI. If the automatic detects that there is a disturbance in its route, such as a children's toy, the automatic will carry out its program, namely circling the object 1 turn or moving the object depending on the size of the toy read by the sensor and AI. However, if there are obstacles such as pet waste, sensors and AI will detect the item and will circle the object. For problems such as narrow space problems, we have designed different nozzles for the automatic to use. For this exact problem, we have added a crevice nozzle to the automatic so that the automatic can insert suction in narrow areas such as the back of cupboards. Not only that, we also added features such as high-ground cleaning which functions to clean parts that are higher than the floor such as sofas, tables, etc. We created this feature so that users no longer need to bother cleaning dust from sofas, tables and other items in the user's room.

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