DESIGN OF AN IOT BASED AUTOMATIC LAWN VACUUM & LEAF BAG USING USABILITY AND WORK POSTURE METHOD

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Abstract. Smart Garden is a system design created to make work in plantations easier. Currently, most Indonesians use sling type lawn mowers because they are cheap but can causing noise and air pollution. It can also cause CTDS in users due to bad posture while using the tool. The researchers innovated an IoT-based automatic cutting machine. Where in the machine application, the machine can be moved using a smartphone connected using bluetooth. Which consists of two options, namely machine and vacuum. The REBA method are used to analyzing ergonomics for all parts of the body and a usability method which will determine the extent to which the product can achieve effectiveness, efficiency and comfort. This data collection was carried out by distributing the SUS questionnaire. The REBA results showed that the average body posture at moderate risk had a score of 7.8 and 9 which required further analysis of the bent posture even though it was still classified as moderate. Meanwhile, the results of the usability approach use a questionnaire as a reference for processing data. From this data, users can accept the presence of the Control Smart System Application and are quite satisfied with the interface used.

Keywords: Lawn Mower, Reba, Usability, and Website

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1 Introduction

Smart Garden is a system design created to facilitate work in plantations [1]. Not only that, smart gardens use control and monitoring system applications for watering/care of plants that utilize smart technology [2]. The benefits of having a smart garden & city park are that it can save a lot of time, improve productivity, and increase comfort. Mowing the lawn is a common outdoor activity that involves trimming and maintaining the grass in one's yard. This task typically requires the use of a lawnmower or grass cutter, which can be manual or powered by electricity or gasoline. It is essential for keeping the lawn tidy and aesthetically pleasing while also promoting the health and growth of the grass. Regular lawn mowing helps prevent weeds, pests, and diseases from taking over and ensures a safe and enjoyable outdoor space for recreational activities. It is considered a routine part of lawn care and landscaping, contributing to the overall curb appeal of a propert [3]. Mowing the lawn with a powered machine carries certain risks that individuals should be aware of to ensure their safety. Common hazards associated with this activity include the potential for accidental cuts or injuries from the sharp blades of the lawnmower, as well as the risk of debris being thrown from the machine, which can cause eye injuries or harm to bystanders. Moreover, the operation of gasoline-powered lawnmowers poses additional dangers such as the risk of fuel spills and potential fire hazards. To minimize these risks, it is crucial to follow safety guidelines provided in the user manual and wear appropriate protective gear such as safety goggles, closed-toe shoes, and hearing protection when operating the equipment [4]. The integration of various tools and the internet has revolutionized the way we work, communicate, and access information. From cloud-based collaboration platforms like Google Workspace and Microsoft 365 to project management tools like Trello and Asana, these integrated systems have streamlined workflows and enhanced productivity for individuals and organizations alike. Furthermore, the Internet of Things (IoT) has enabled the connectivity of everyday objects and devices to the internet, offering unprecedented convenience and automation in areas such as smart homes and industrial processes. This integration of tools and the internet continues to shape the digital landscape, providing innovative solutions and reshaping the way we interact with technology [5].

Work posture is a determining factor in analyzing the effectiveness of a job. When the work posture adopted by the operator is good and ergonomic, it can be ensured that the results obtained by the operator will be good. However, if the operator's work posture is not ergonomic, the operator is likely to experience fatigue. When the operator easily experiences fatigue, the work performed by the operator will also decline and not meet expectations [6]. Work posture is closely related to the science of ergonomics, and both are closely related to human activities. Natural work posture or normal posture is the posture during the work process that conforms to the body's anatomy, preventing shifts or pressure on vital body parts such as organs, nerves, tendons, and bones, thus creating a relaxed state and avoiding musculoskeletal complaints and other bodily system issues. Abnormal body positions during activities can result in disruptions to muscles, ligaments, and joints. This can lead to injuries in specific body segments such as the neck, spine, shoulders, wrists, and more. Non-ergonomic work postures are typically the result of a mismatch between the worker and their capabilities [7].

Rapid Entire Body Assessment (REBA) is a research method that is relatively easy to use because it does not require specific angle measurements; it only involves angle ranges [8]. The REBA method is quickly used to assess the posture of a worker's neck, back, arms, wrists, and legs. The steps to determine REBA scores involve first calculating the scores in Table A, which consists of the neck, trunk, and legs. The second step is to calculate Table B, which includes the upper arm, lower arm, and wrist. After obtaining the final scores for Tables A and B, they are entered into Table C, which then determines the action category [9]. This method is also suitable for studying work postures with dynamic body types and can be used for both stable and unstable body postures.

Usability is a quality attribute that assesses how easily users can use or understand the interface of a website or application. To measure the usability of a website or application, there are standards used, namely ISO, to determine how effectively, efficiently, and satisfactorily a product can be used by users to achieve their goals [10]. A product can be defined as the output obtained from a production process and represents added value from raw materials, sold by a company to consumers. This process becomes positive when there is added value, both in terms of functionality and economically [11]. Using a grass sickle will be effective for small yards, while for the process of mowing large lawns, people prefer to use oil-powered lawn mowers. However, this makes users tired because they use their own power and the sound produced by the machine makes noise. To reduce the use of fuel oil and the noise it causes, manufacturers are starting to produce lawn mowers that use AC electricity which has a smooth sound and does not require fuel oil. However, lawn mowers that use AC electricity are not effective, because they require long cables. Therefore, it is necessary to design and make automatic grass cutting tools so that they can reduce the risks in their use. Automatic lawn mowers are designed to make users more comfortable than using previous tools. This research uses an ergonomic approach using usability and work posture methods. Which aims to make an automatic lawn mower to clean the yard. This tool can be used in Android applications with the help of Bluetooth to connect the device and application. The benefits of the research are reducing the burden of human energy in the grass cutting process and reducing the number of risks to users so as to avoid the risk of accidents. This research uses an ergonomic approach using usability and work posture methods. Which aims to make an automatic lawn mower to clean the yard. This tool can be used in Android applications with the help of Bluetooth to connect the device and application. The benefits of the research are reducing the burden of human energy in the grass cutting process and reducing the number of risks to users so as to avoid the risk of accidents. This research uses an ergonomic approach using usability and work posture methods. Which aims to make an automatic lawn mower to clean the yard. This tool can be used in Android applications with the help of Bluetooth to connect the device and application. The benefits of the research are reducing the burden of human energy in the grass cutting process and reducing the number of risks to users so as to avoid the risk of accidents.

2 Methods

In this study, measurements were carried out using the REBA (Rapid Entire Body Assessment) method with 5 respondents with an average age of over 30 years and usability measurements of 5 respondents with an average of 20 years. This method assesses all parts of the body and is measured in 3 conditions, namely lifting, carrying and putting. The type of work that can be used in this method is dynamic or changing, for example lifting cardboard. This REBA method can be used quickly to assess a worker's posture, besides that it is influenced by coupling factors, as well as external loads supported by the body and the worker's activities [12]. After measuring the respondents, they continued with interviews regarding feedback on the use of manual cutting machines. The aim of collecting this data is so that researchers can adapt lawn mowers to parts of the body that often hurt, reduce the noise from lawn mowers, and can design safer ones for users of these tools.

Next, Usability is a qualitative analysis technique to find out how easy a piece of software is to be used by users. In another sense, usability can be defined as the process of optimizing interactions between users and a system that can be done interactively [13]. The usability aspect is an aspect that determines the success of software and is a sign that users accept the software [14]. 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 [15].

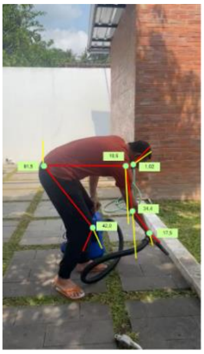
3 Result and Discussion

3.1 REBA and Usability

The following is a table of subject measurement results using the Rapid Entire Body Assessment (REBA) method:

Table. 1. Formed Angle

No	Respondent	Torso	Neck	Foot	Upper arm	Forearm	Wrist
1.		84.1°	32.1°	31.1°	18.1°	26.9°	15.9°
2.		19.5°	29.9°	29.0°	8.7°	107.5°	23.5°

No	Respondent	Torso	Neck	Foot	Upper arm	Forearm	Wrist
3.		91.5°	1.02°	42.0°	10.5°	34.4°	17.5°
4.		14.5°	25.2°	37.1°	8.7°	50.2°	21.9°
5.		53.2°	11.3°	29.4°	18.6°	60.5°	21.1°

Usability testing is used to determine the user's level of ease in using an application and determine how effectively and efficiently the application can help the user achieve their goals. An application called Control Smart System is designed to determine the level of effectiveness, efficiency and ease of use. The following are the results of the tests that have been carried out:

a. Effectiveness (Error)

The effectiveness attribute functions to analyze and measure the effectiveness of the smart system control by seeing how often errors occur when respondents complete tasks.

Table. 2. Effectiveness

Users	***Task Scenarios***		
	Easy	***Normal***	***Hard***
User 1	0	0	0
User 2	1	0	0
User 3	0	0	0
User 4	2	2	9
User 5	0	1	1
Average	**0.6**	**0.6**	**2**

b. Efficiency

Data collection using efficiency attributes is carried out in order to determine the speed level and length of time the user takes to complete the given task.

Table. 3. Efficiency

Users	***Task Scenarios***		
	Easy	***Normal***	***Hard***
User 1	58	55	55
User 2	23	19	20
User 3	16	21	31
User 4	18	23	22
User 5	20	73	50
Average	**119**	**132.6**	**138**

c. Satisfaction

Data collection uses the satisfaction attribute regarding customer satisfaction given by customers from services or products in terms of whether the service or product can meet customer needs and expectations.

Table. 4. Satisfaction

Users	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**Total**	***2.5**
*Users*1	3	2	4	2	3	2	4	3	4	1	28	70
*Users*2	4	3	3	2	4	3	3	4	3	3	22	55
*Users*3	4	3	4	3	2	3	4	3	3	2	23	57.5
*Users*4	3	2	4	1	2	2	4	3	4	4	25	62.5
*Users*5	3	2	4	2	5	4	2	3	2	2	23	57.5
TOTAL											**60.5**	

3.2 Usability Attributes

Based on the data that has been obtained, the following are the details of each indicator:

a. Effectiveness (Error)

Based on the results of data obtained from usability tests regarding effectiveness (error) which consists of three categories, namely easy, normal, hard. From the usability test based on effectiveness (error) which was carried out in the easy category, the average error result was 0.6. In the normal category, the average error result was 0.6. In the hard category, the average error result was 5.

b. Efficiency

Based on data obtained from the usability test regarding efficiency in using the smart system control application, the average value for each category was obtained, namely easy, normal and hard. In the easy category, the average processing time was 119 seconds. In the normal category, the average processing time was 132.6 seconds. In the hard category, the average processing time was 138 seconds.

c. Satisfaction

The following is a recap and attributes of satisfaction on the website:

Table. 5. Recap and Attributes of Satisfaction

No	Question
1.	I will use this application
2.	I consider this application difficult to use
3.	I consider this application easy to use
4.	I assess the functions (features) provided on this site as very good
5.	I feel the features provided are inefficient
6.	I feel that many people will find it easy to use this application
7.	I think this application is too complicated for people who don't understand technology
8	I feel confident when using this application
9.	I need to learn a lot of things before using this app well
10.	I think this site is very complicated to use

Based on the data obtained by conducting a usability test regarding respondent satisfaction in using the smart system control application, the following calculations can be made:

SUS score = ((R1-1)+(5-R2)+(R3-1)+(5-R4)+(R5-1)+(5-R6)+(R7-1)+(5-R8)+ (R9 - 1) + (5 - R10)) *2.5)

Based on the calculation results, the average SUS score was 60.5. These results are included in Grade Scale D with Adjective Rating Good and Acceptability Ranges Marginal Low.

3.3 Innovation Aspect

Currently, the lawn mowers that are often found in the community still use fuel oil (BBM) for their energy consumption. The disadvantage of lawn mowers that use fuel is the air and noise pollution they cause. Based on these things, the researchers designed a lawn mower that uses a battery as a voltage source for the electric lawn mower. So you will get an electric lawn mower that is more sophisticated, effective and environmentally friendly and minimizes the pollution and noise that occurs on lawn mowers that use fuel oil (BBM).

Table. 6. Feature Comparison

Carrying Lawn Mower	Innovation Lawn Mower
Must be worn on the user's back	Just put it on the grass
Makes a noisy sound	Doesn't make a sound
It's heavy, it makes you sick	Does not cause body pain
Using fuel oil	Using battery power
Causes air pollution	Does not cause air pollution
Driven by human power	Driven by remote control

Lawn vacuum & leaf bag lawn mower is a machine that uses one or several rotating blades to cut the surface of the grass so that the height is the same. The height of the grass being cut can be adjusted according to the design of the lawn mower which can be adjusted by the operator. The dimensions of the product are 65x45x60 cm, the width of the cutting area is 45cm. Equipped with 5 precision steel cutting blades, front and rear wheels measuring 10 inches with a weight of 12.7 kg. This lawn mower is equipped with a place to collect grass clippings at the back, so that the garden will not be dirty with remaining grass clippings which means we have to work twice. Equipped with 4 wheels which will make it easier for us to control it. And can be controlled via cellphone with the application provided.

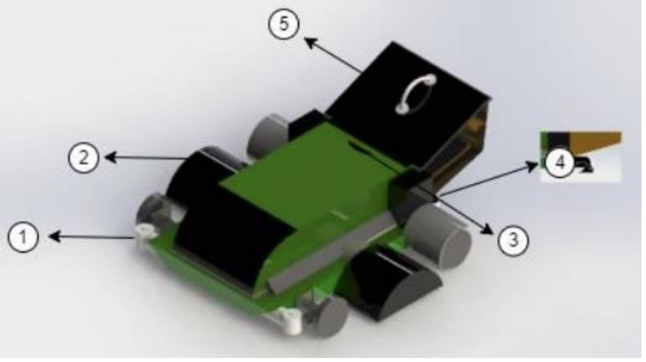


Fig. 1. Lawn Mower Innovation

Information:

1. Ball joint : To turn the wheel to the right and left
2. Knife blade : For cutting grass
3. Handle : To open the hood on the machine
4. Vacuum : To suck up cut grass
5. Grass bag : A container for holding grass cut results

3.4 Conclusion

Based on the research that has been carried out, it can be concluded that the respondent's position requires further investigation into the standing position when cleaning the yard. Standing errors can be resolved by improving the standing position for the better and making the grass cleaning tool according to ergonomics. In order to get a solution for designing a grass cleaning tool that has ergonomic value for respondents, namely by making design improvements and by adding a vacuum to make it easier. Apart from that, several features have been added, such as an application that connects to your cell phone using Bluetooth, which will then be able to control the lawnmower automatically. The feature itself consists of 2 options, namely the machine feature and the vacuum feature which can save the machine's battery.

3.5 Acknowledgmemt

The author would like to thank the Work System Design and Ergonomics Laboratory of the Islamic University of Indonesia, especially all the Ergonomics science lecturers at the UII

Industrial Engineering Study Program who have supported and assisted in providing direction and in collecting data so that they were able to complete this research well.

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