Jurnal Penelitian dan Aplikasi Sistem & Teknik Industri (PASTI)
Vol. XIV, No. 2, Agustus 2020, pp.105-112
p-ISSN 2085-5869/ e-ISSN 2598-4853

Usability Testing Vision Sensor Based Work Time Measurement Technology

Euis Nina Saparina Yuliani[1], Ajeng Yeni Setianingrum[2], Muhammad Kholil[3]
[1,3)] Industrial Engineering Program, Mercu Buana University
[2)] Industrial Engineering Program, Gajah Tunggal Polytechnic
Jl. Meruya Selatan, Kembangan, Jakarta Barat 11650
Email: nina.yuliani@mercubuana.ac.id, ajeng-yeni@poltek-gt.ac.id, m.kholil@mercubuana.ac.id

Abstract

A product or technology is perceived easily in case it has a high level of usability. This means users have no difficulties or encounter problems while using. The purpose of this study is to conduct usability testing of vision sensor-based working time measurement technology. It is meant to determine the ability of the technology to conduct work time measurement functions with the same results as the conventional process using a stopwatch. The study involves an experimental method with two factors. Based on the results of the ANOVA Two-Way Analysis (within-subject design), the first and second levels in apparatus factor shows there is no difference in the average value of the cycle time between work measurements with and without the vision sensor technology ($F_{obtained}(4,1) < F_{critical}(5,12)$). Therefore, the technology designed is capable of measuring the same work as manual measurement.

Keywords: *Cycle time, Vision sensor technology, Usability testing.*

INTRODUCTION

Time is a variable widely used as a measurable parameter (tangible) and directly represents the duration a work cycle is carried out. Cycle time referred to the period needed from beginning to the end of a task and is related to the completion of a work function. Subsequently, is often processed to produce a standard measure, which is the output of direct time study. To facilitate the measurement of cycle time, Yuliani, Setianingrum, Kholil, and Wardoyo (2019), researched the development of a tool to measure work duration with technology-based methods. The tool was a vision sensor-based working time measurement technology. It was capable of measuring work time automatically and process it in real-time and precision. This technology consists of hardware integration components from Pixy CMUcam5 components with Arduino Uno Rev 3 with AT Mega 328P and Logitech C930E series webcams. The programming language used to support hardware is the Visual Studio 2015 programming language.

A product or technology is considered easy in case it has a high level of usability. This means users have no difficulties using it. Usability guarantees that a designer is capable of making a product design that suits the users. Usability, according to ISO 9241-11 in Hertzum (2016), is how a system, product, or service can be utilized by certain users to achieve the goals specified effectively, efficiently, and satisfactorily.

Several goals and objectives need to be achieved in designing usability. According to Rubin (1994) in Yogasara and Muliawan (2006), these objectives include (1) Usefulness, (2) Effectiveness (ease to use), (3) Learnability, and (4) Likeability.

Holt, Lane, and Street (2013) researched a system of arm rehabilitation for children with upper-limb hemiplegia due to cerebral palsy. The research team designed a two-player, interactive (competitive or collaborative) computer play therapy system that provided powered assistance to children while they played specially designed games promoting arm exercises. A system suitable for use in schools was designed. However, due to the overriding need for schools to focus on academic activities, children could not use the system maximally and gain the therapeutic benefit.

Chan, Yang, and Song (2017) evaluated the usability of a hybrid cooling vest associated with the success of its application in industrial settings. The result showed a structural equation model estimated by analysis of moment structures. It was constructed to evaluate the usability of the vest as influenced by cooling effect and ergonomic design. The cooling effect (path coefficient = 0,69, $p < 0{,}001$) and ergonomic design (path coefficient = 0,55, $p < 0{,}001$) significantly affect the usability of the cooling vest.

The purpose of this research is to conduct usability testing of vision sensor technology with the experimental method. It aims to determine whether the technology developed is capable of performing work time measurement functions with the same results as conventional processes using a stopwatch.

METHODS

The usability testing of equipment designed to measure a work process with experimental methods was tested. This experiment was carried out in the form of a simulated work of moving eggs into the provided space.

The technology testing involves comparing the output produced through the equipment designed for conventional measurement using a stopwatch. At this stage, variation in the work time measurements needs to be analyzed using the designed equipment. For the success of the comparison process, the technology is integrated with a webcam camera which takes pictures in the observed work process. Afterward, the conventional work time measurements were taken using a stopwatch.

Participants

The participants involved in the experiment include 10 people who participated in this experiment 6 men and 4 women. The age ranged between 20 years to 25 years with all participants is not having significant problems related to eye health conditions.

Stages of Experiments

In this experiment, participants conduct simulation experiments, each with 10 work cycles. The description of the experimental steps of the two simulations is as follows:

First Simulation (A1)

This involves six steps, including

a) Participants sat on the experiment bench,
b) After getting the "START" command, the movements begin,
c) In the first movement, each participant took an empty egg rack,
d) In the second movement, participants move the empty egg rack to the specified front position and open it,
e) In the third movement, participants fill the rack with the prepared eggs, until they are finished,
f) During the fourth movement, participants close the filled egg rack and move them to the designated position.

Second Simulation (A2)

The second simulation involved eight steps, including

a) Participants sat on the experiment bench,
b) After getting the "START" command, they begin their movements,
c) In the first movement, the participants took an empty egg rack,
d) During the second movement, they move the empty egg rack to the specified front position and open them,
e) In the third movement, the participants filled the rack with the prepared eggs,
f) In the fourth movement, the participant's hand comes out of the recording area,
g) During the fifth movement, the participants continue the process of filling eggs until they are finished,
h) In the final movement, they close the filled egg rack and move to the designated position.

Figure 1. Vision Sensor Technology

Figure 2. Integrated Vision Sensor Technology with laptop

Figure 3. Example of simulated experiments

RESULTS AND DISCUSSIONS
Experiment Output
Cycle Time Data

The cycle time data successfully collected were categorized into two factors, the class of simulation type (treatment factor (A)) and data collection with/without vision sensor technology (apparatus factor (B)). There were a total of 10 data groups from each participant (see in Table 1).

Furthermore, the cycle time data from 10 participants were calculated to obtain the average value for each level and further processed in the ANOVA Two-Way Analysis (within-subject design) using SPSS version 20.

Table 1. The Collected Data (cycle time in seconds)

		Apparatus Factor (B)	
		Vision Sensor Technology (B1)	Stopwatch (B2)
Treatment Factor (A)	First Simulation (A1)	12,8	14,3
		13,3	12,1
		10,8	13,6
		10,5	11,1
		10,2	11,5
		10,2	12,1
		10,6	11,6
		12,5	12,4
		12,7	13,6
		11,3	11,6
	Second Simulation (A2)	13,5	13,8
		16,6	15,6
		11,2	12,9
		10,5	11,1
		9,8	11,5
		11,2	11,5
		9,3	11,4
		12,8	12
		15,2	15,1
		13,8	13,1

Table 2. Mean and Standard Deviation of Data (in seconds)

	A1B1	A1B2	A2B1	A2B2
Mean	11,49	12,39	12,39	12,80
Standard Deviation	1,2	2,4	1,1	1,6

The ANOVA Two-Way Analysis (Within Subject Design)

The ANOVA Two-Way Analysis (within-subject design) in the processing of experimental data uses a significant level of 5% with the following hypothesis:
H_o: There is no difference in the mean of cycle time between work measurements in the first simulation and second simulation
H_1: There is a difference in the mean of cycle time between work measurements in the first simulation and second simulation

H_o: There is no difference in the mean of cycle time between work measurements with and without vision sensor technology
H_1: There is a difference in the mean of cycle time between work measurements with and without vision sensor technology

H_o: There is no interaction between the treatment factor (A) and apparatus factor (B)
H_1: There is an interaction between the treatment factor (A) and apparatus factor (B)

Therefore, it was conducted with the following criteria:
if $F_{obtained} < F_{critical}$, H_o is accepted
if $F_{obtained} \geq F_{critical}$, H_o is rejected
The results of data processing using SPSS version 20 are as follows.

Table 3. The Result of ANOVA Two-Way Analysis (Within Subject Design)

Source	SS	df	MS	F	Sig.
Treatment	4,29	1	4,29	2,421	0,154
Error (Treatment)	15,947	9	1,772		
Apparatus	4,29	1	4,29	4,1	0,074
Error (Apparatus)	9,417	9	1,046		
Treatment x Apparatus	0,6	1	0,6	3,221	0,106
Error (Treatment x Apparatus)	1,677	9	0,186		

Two parameter values are used to analyze the results of an experiment, such as the mean-standard deviation score and the F ratio.

The Mean-Standard Deviation Score Analysis

1. The test results show that the mean cycle time for the first simulation using vision sensor technology is 11,49 seconds (standard deviation is 1,2), while a stopwatch recorded 12,39 seconds (standard deviation is 2,4). This shows that measurements with vision sensor technology have smaller mean cycle time compared to the first simulation with a stopwatch. From the results of these data, it can be seen that there is a difference in the value of 0,9 seconds. Based on the standard deviation, measurements using vision sensor technology also have a smaller standard deviation. This means that the variation of cycle time in measurements using vision sensor technology is also smaller than using a stopwatch. Therefore, data is more stable with smaller variation (close to the mean).
2. The test results show that the mean of cycle time for the second simulation using vision sensor technology is 12,39 seconds (standard deviation is 1,1), while the score for a second simulation with a stopwatch is 12,80 seconds (standard deviation is 1,6). This indicates that measurements with vision sensor technology have a mean of cycle time smaller than performed with a stopwatch, a difference of 0,41 seconds. Based on the standard deviation, the same thing also happens in the second simulation, namely the variation of the cycle time in measurements using vision sensor technology is smaller

than using a stopwatch. Therefore, data is more stable with smaller variation (close to the mean).

The F Ratio Analysis

Treatment Factor (A)

3. The second parameter is the F Ratio. The test results show that the F ratio is 2,421 ($F_{obtained}$) which is smaller than 5,12 ($_{Critical}$), meaning H_o is accepted (for treatment factor). The conclusion is there is no difference in the mean of cycle time between work measurements in the first simulation and second simulation.

Apparatus Factor (B)

4. The next result is the F Ratio for apparatus factor. The test results show that the F ratio is 4,1 ($F_{obtained}$) which is smaller than 5,12 ($_{Critical}$), meaning H_o is accepted (for apparatus factor). The conclusion is there is no difference in the mean of cycle time between work measurements with and without vision sensor technology. The vision sensor technology takes measurements the same way as the manual or with a stopwatch. In other words, the performance of vision sensor technology is the same as when the work measurement is conducted manually by workers. Therefore, vision sensor technology can take measurements the same as a stopwatch or manually by workers.

Interaction Between Treatment and Apparatus (A x B)

5. The last result is the F Ratio for interaction between treatment factor and apparatus factor. The test results show that the F ratio is 3,221 ($F_{obtained}$) which is smaller than 5,12 ($_{Critical}$), meaning H_o is accepted. The conclusion is there is no interaction between the treatment factor and the apparatus factor.

Advanced Analysis

From the mean cycle time, there is a difference in the value between the mean cycle time measured using a vision sensor technology and using a stopwatch. The results show that measurements with vision sensor technology have smaller mean cycle time than using stopwatch measurements for both the first and the second simulation. This difference is attributed to the ability of the observer's eye to capture the starting and ending points of measurement based on the motion of the image in the recorded video. Generally, stopwatch measurement relies heavily on the ability of the observer's eye to capture the signal to start and end the measurements. The level of the observer's focus on the movement affects the measured value of the cycle time. In contrast, in the measurements made using vision sensor technology, the equipment immediately starts calculating the cycle time when the colored paper is in the "START" coordinate position and stop counting once the color paper is in the "STOP" coordinate position. The "START" and "STOP" coordinates make measurements using vision sensor technology more consistent in starting and ending cycle time measurements. Therefore, variation cycle time caused by differences in starting and ending measurements can be potentially be minimized or eliminated.

The results of data processing using The ANOVA Two-Way Analysis (within-subject design) both in the first and the second simulation show there is no difference in the mean of cycle time between work measurements with and without vision sensor technology. Therefore, the equipment designed takes measurements the same as manual work with a stopwatch. The equipment can do almost similar work measurements manually, and therefore it assists the observer in measuring time.

Although the test results showed that the vision sensor technology has a performance almost similar to manual measurement, some things need to be considered as summarized in Table 4.

Table 4. Notation the Use of Vision Sensor Technology

No	Component	Description
1	Workers observed	Make sure workers know and understand the START and STOP positions before beginning and stopping work. This is important to take measurements according to the functional equipment.
2	Color paper (as a marker to be censored by equipment)	Make sure the colored paper as a marker is properly installed in the hands of workers, has pretty good color, and does not have a smooth and glossy surface. This is because the equipment is quite sensitive to light.
3	Sensor reading area	Define the sensor reading area well. Ensure the area of movement of the worker to be measured is the same as the sensor reading part. This is because in case the colored paper is outside the sensor reading area, the equipment "pause" at the time measurement and restart when it is back in the sensor reading area.
4	START-STOP coordinate point	Ensure that the START and the STOP coordinates are quite distinct and do not overlap.
5	Time measurement in seconds	Measuring time in seconds unit, therefore if the users are going to use another unit, it is necessary to convert the values manually. Additionally, measurements per 100 seconds cannot be recorded.

CONCLUSION

Based on the results of data processing using The ANOVA Two-Way Analysis (within-subject design) in both the first and second simulations, there is no difference in the mean of the cycle time between work measurements with and without vision sensor technology. Therefore, the equipment designed take the same measurements as manually (with a stopwatch), and might assist the observer in recording work time.

Recommendations

Based on the results of this usability testing, the recommendation for future research is to test the usability of vision sensor technology where the test is an industry where participants are operators.

ACKNOWLEDGMENT

The authors are grateful to the Ministry of Research, Technology and Higher Education, Rector of Mercu Buana University, Director of Research and Technology, Publications and Domestic Cooperation, Head of Research Center, Dean of the Faculty of Engineering, Chair of the Industrial Engineering Study Program, CV. Marcom, and all those that helped in this research. This research was funded by the Ministry of Research, Technology, and Higher Education Grant.

REFERENCES

Ani, N. U. R., Noprisson, H., & Ali, N. M. (2019). Measuring Usability and purchase Intention for Online Travel Booking : A Case Study. *International Review of Applied Sciences and Engineering*, *10*(2), 165–171. https://doi.org/10.1556/1848.2019.0020

Chan, A. P., Yang, Y., & Song, W. (2017). Evaluating the usability of a commercial cooling vest in the Hong Kong industries Title page. *International Journal of Occupational Safety and Ergonomics*, *0*(0), 1–21. https://doi.org/10.1080/10803548.2017.1282237

Hertzum, M. (2016). Usability Testing : Too Early ? Too Much Talking ? Too Many Problems ? *Journal of Usability Studies*, *11*(3), 83–88.

Holt, R., Lane, W., & Street, C. (2013). A System in the Wild : Deploying a Two-Player Arm Rehabilitation System for Children With Cerebral Palsy in a School Environment. *Journal of Usability Studies*, *8*(4), 111–126.

Swatriani, R. (2018). Analisis Hubungan System Usability Scale dengan Deskiling Pengguna. *NARADA, Jurnal Desain & Seni, FDSK-UMB*, *5*(1), 80–92.

Yogasara, T., & Muliawan, S. (2006). Analisis Ergonomi dan Usulan Perancangan Fasilitas Permainan Untuk Anak-anak (Studi Kasus di Taman Kanak-kanak Paulus , Bandung). In *Prosiding Seminar Nasional Ergonomi dan K3* (pp. 1–10).

Yuliani, E. N. S., Setianingrum, A. Y., Kholil, M., & Wardoyo, A. S. (2019). Development of Direct Time Study Technology for Advanced Work Measurement. In *the 4th International Conference on Technology, Informatics, Management, Engineering, and Environment* (p. 104).