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Factor Analysis of Cybersickness in Driving Simulation Using Virtual Reality Technology

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ABSTRACT
Virtual reality (VR) is a technology that makes presentations of real-world situations or environments simulated in 3D by computers. Cybersickness is defined as motion sickness-like symptoms caused by the virtual environment. Symptoms that appear are nausea, dizziness, disorientation and discomfort that can last during or after using virtual reality. The purpose of this study is to determine the independent variables that affect the Number of Errors. knowing the cybersickness caused in several driving simulation scenarios and knowing the type of scenario that is optimal for driving and minimal accident rates. This research uses the Multi-Variate ANOVA method. The result of this study is that the significance value of experience on accumulation error is 0.000. For other variables such as weather, time of day, traffic conditions, and gender do not have an impact on accumulation error. The highest cybersickness score is caused by scenario three which is rainy, night, and crowded with a score of 13015.65, this can be due to the graphics and visualizations displayed that are very disturbing to human vision. So that cybersickness symptoms appear in humans. Symptoms with the highest quantity appearing in humans are dizziness symptoms with a percentage of 87% and the optimal scenario is intended with the smallest number of errors when compared to other scenarios and the minimum number of accidents. The optimal scenario is scenario four, namely night, rain and quiet with a total number of errors of 286.
Keywords: *virtual reality, cybersickness, Multi-Variate ANOVA*

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I. INTRODUCTION

Virtual reality is a technology that allows users to interact with virtual world environments, so that users feel like they are in that environment. The main advantage of virtual reality is the experience that makes users feel the sensation of the real world in the virtual world. With virtual reality we are taken to another dimension where the depiction of the situation resembles the original form of the object, even though in reality we are still in the same place (Musril et al., 2020). Cybersickness is a set of unpleasant symptoms caused by exposure to a virtual environment and can last from a few minutes to several days. Symptoms include eye fatigue, headache, nausea or even vomiting. It is estimated that about 20% to 80% of the total population experiences cybersickness to some extent. As virtual reality devices have become increasingly popular, reports of cybersickness have increased as well, although the condition has been recognized and studied for a long time (Prawita & Yoga Wahyu Yuwono, 2021). Factors that affect cybersickness are gender, age, experience, posture, length of use, time of use and congenital diseases (Hasibuan et al., 2023).

City car driving is an application used to perform realistic driving simulations for both beginners and expert drivers. The application, which has been released since 2007 and was developed by Forward Development, Ltd. is one of the most complex and detailed driving simulators because small things are included in the simulator. Such as using a seatbelt, turning on music, and refueling are found in the application. In this application, it uses a first person camera so that the player feels the first person view as a car driver (Franssugar & Sarvia, 2023).

Driving skills are divided into 2 parts, namely, Technical Skills are some things that humans must have in order to drive a car under normal circumstances. The more often humans drive a car, the better the technical skills will be (Panuntun et al., 2022) and Non-Technical Skills in driving are needed to support technical skills. The better the driver's non-technical skills, the more it will ensure safety and comfort for both the driver and other road users (Burkhardt et al., 2016).

Safety Driving is the basis of further driving training that pays more attention to safety for drivers and passengers. Safety Driving is influenced by several factors including human factors such as age, education, length

of work, knowledge, vehicle factors such as passenger load capacity, environmental factors in this case road conditions and weather (Puteri & Nisa, 2020). Multi-Variate ANOVA is a statistical test method used to determine an independent variable that has a category of influence or not on the dependent variable which is quantitative data. This method is also commonly called MANOVA, the meaning of the word multi is because there are more than two dependent variables and this is a requirement for the use of MANOVA (Hasanah et al., 2022).

II. METHODS

2.1 Multi-Variate ANOVA

Multi-Variate ANOVA is a statistical test method used to determine an independent variable that has a category of influence or not on the dependent variable which is quantitative data (Hasanah et al., 2022). This method is also commonly called MANOVA, the meaning of the word multi is because there are more than two dependent variables and this is a requirement for the use of MANOVA. One of the applications for using MANOVA is SPSS 23. There are several assumptions that are met to use the MANOVA method, which are as follows:

a. The dependent variable data is normally distributed.
b. There is a similarity of covariance matrix between groups on the dependent variable.
c. Outlier data needs to be removed because the MANOVA method is quite sensitive to outlier data.

2.2 Cybersickness

Kennedy in 1993 announced that he created a simulator sickness questionnaire (SSQ) that is used in various jobs. The SSQ is divided into three categories namely slight, moderate, and severe. Each category can be filled with a value between 0 to 3 which is then calculated. The method can be used to evaluate and reduce simulator sickness in order to find out about more potential causal effects such as age, gender and others.

Formula Cybersickness = {([Amount Slight] X 7.58) + ([Amount Moderate] X 9.54) + ([Amount Severe] X 13.92)} X 3.74

III. FINDINGS AND DISCUSSION

3.1. Findings

This research was conducted at the APK & Ergonomics Laboratory of the Industrial Engineering Study Program, Faculty of Industrial Technology, Muslim University of Indonesia, Makassar, South Sulawesi, Indonesia.

The required data are:

- Quantitative data, namely the number of errors and accumulation errors and qualitative data on the questionnaire which includes non-technical factors and cybersickness.
- Primary data taken directly from the object of research, namely, data taken when conducting virtual reality technology trials and from questionnaires.

The number of errors data is obtained from calculating the total number of errors made by participants in each scenario. In the simulation, there are four scenarios with independent variables (weather, time, and traffic conditions) combined with several types of participants (male and female, expert and amateur). As for the questionnaire data, it is obtained from filling out questionnaires by participants after completing each scenario subjectively.

3.2. Discussion

1. Quantitative Data

The number of errors data is obtained from calculating the total number of errors made by participants in each scenario.

The following is data related to the number of errors from all participants and scenarios.

Table 1. Recapitulation of Number of Error Data

Participant	*Gender*	Experience	Age	*Number of Error* Skenario1
P-1	P	E	24	9
P-2	P	A	22	9(k)
P-3	P	E	21	3
P-4	P	E	21	2
P-5	W	E	20	12(k)
P-6	W	A	20	7
P-7	P	E	26	2
P-8	P	A	22	2(k)
P-9	W	E	19	9
P-10	P	E	19	13(k)
P-11	P	E	28	4

P-12	W	A	23	9
P-13	W	A	23	2
P-14	W	E	22	5
P-15	W	A	27	11
P-16	P	E	27	10
P-17	W	E	21	8
P-18	W	E	21	1
P-19	P	A	27	12
P-20	P	E	20	9
P-21	W	E	24	6
P-22	P	A	23	8
P-23	W	A	21	12(k)
P-24	P	E	26	9
P-25	P	A	22	6
P-26	P	A	21	3
P-27	P	A	26	10(k)
P-28	W	E	23	3
P-29	W	A	21	11(k)
P-30	W	E	26	12
P-31	W	A	26	10(k)
P-32	P	A	21	12
P-33	P	A	21	10
P-34	W	A	26	1
P-35	P	A	20	10
P-36	W	E	26	11
P-37	W	E	26	9
P-38	P	A	26	2
P-39	P	E	23	4(k)
P-40	P	E	23	5
P-41	W	E	26	13(k)
P-42	W	A	21	4
P-43	P	E	24	1
P-44	W	A	26	2
P-45	W	E	23	6(k)
P-46	W	A	24	9
P-47	P	A	27	5
P-48	W	A	22	9
Total: 342 Error				342
Note: Columns in red indicate that an accident occurred in that scenario. k= Terjadi kecelakaan				
P= Male; W=Female; E=Expert; A=Amateur 1= Day-Sunny-Crowded				

2. Qualitative Data

The following will show qualitative data, namely related to the total value of filling out the questionnaire by participants in each scenario. The questionnaire covers two things, namely non-technical factors and cybersickness.

Table 2. Recapitulation of Non-Technical Factor Questionnaire Data

No	Question (Objective)	*Likert Scale*					Kind
		1	2	3	4	5	
1	VR applications are easy to understand (Collect and understand information)	0	14	44	65	69	Kognitif
2	I can handle decision making while playing (Problem description and choosing options (technical during simulation))	1	11	73	63	44	
3	I did not feel any difficulty during the simulation (Reviewing the results (understanding of the application))	0	27	62	55	48	
4	This application helps me to practice driving (Execution and understanding of safety driving)	2	3	24	63	100	
5	I don't often ask and seek help from observers/writers (Receiving information and communication)	0	20	61	64	47	Inter-personal
6	I felt comfortable during the simulation (Managing stress)	14	34	82	36	26	Intra-personal
7	I don't feel tired when doing simulations (Identify stress symptoms)	27	47	76	29	13	
Deskripsi							
1 = Strongly Disagree	2 = Don't agree	3= Neutral	4 = Agree	5 = Strongly Agree			

Note: Columns with red numbers indicate the highest values.

Table 2 is the recapitulation result with a total of 192 questionnaires related to non-technical factors from the participants subjectively. The numbers in the table show the number of participants choosing from the five available scales.

Table 3. List of Number of Cybersickness in each Scenario

Skenario		*Slight*	*Moderate*	*Severe*
1	Day – Bright – Crowded	182	166	22
2	Day – Bright – Silent	203	144	21
3	Night – Rain – Crowded	225	151	24
4	Night – Rain – Silence	206	149	32
Total		816	610	99

Table 3 shows the number of symptoms experienced by participants in each scenario and categorized into three levels of symptom impact.

IV. CONCLUSION AND SUGGESTION

4.1 Conclusion

From the previous chapter, namely data processing and data analysis, a conclusion can be determined. Here are some conclusions on the research:

1. With the multi-variate ANOVA method, it is found that the significance value of experience on accumulation error is 0.000. Experience is measured by how much human flight hours to drive a car, when the human is included in the expert group, then in technical matters as measured by the number of errors and accumulation errors are smaller when compared to amateurs where driving hours are less when compared to the expert group. For other variables such as weather, time of day, traffic conditions, and gender do not have an impact on accumulation error.
2. The symptoms of cybersickness that appear occur in humans when using VR. In the experiments conducted, the highest cybersickness score was caused by scenario three, namely rain, night, and crowded with a score of 13015.65, this can be due to the graphics and visualizations displayed that greatly disturb human vision. So that cybersickness symptoms appear in humans. Symptoms with the highest quantity appearing in humans are dizziness symptoms with a percentage of 87%.
3. The optimal scenario is intended with the smallest number of errors when compared to other scenarios and the minimum number of accidents. The optimal scenario is scenario four, namely night, rain and quiet with a total number of errors of 286. While the scenario with the largest total number of errors is the first scenario, namely day, sunny and crowded with a total number of errors of 342.

4.2 Suggestion

Some suggestions are determined to provide a better development in further research. The following are suggestions on research:

1. In driving simulations using VR, development is needed in terms of applications such as improving the quality of graphics in order to produce immersive and higher levels of satisfaction.
2. Further review of scenario design that is tailored to several regions in Indonesia. So that the simulation can really be used for training containers and adjust to the desired location, such as the type of area or road used, both narrow roads, toll roads, to highways. These scenarios can make the types of scenarios more diverse.
3. The use of sophisticated technology can also be applied to produce greater immersion. Such as the use of a 9D simulator chair, the chair can sway according to the conditions in the VR game.

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