The Correlation of Lux and Distance to Markerless Augmented Reality Detection Technique for Digital Therapy Application

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Abstract: Considering the huge number of autistic children in Indonesia, it appears that many parents of autistic children do not have a good understanding of how to specifically treat autistic children. A consultation with a psychologist for therapy cannot be undertaken at any time or place, according to a treatment perspective. Digital therapy applications are reportedly being considered as a solution to these problems in the current digital era. Markerless augmented reality has the potential to be one of the innovative technologies with interactive features that can create a visual world that resembles the real world. There are several important aspects associated with measuring the accuracy of the tracking surface and object appearance. The purpose of this paper is to determine the connection between lux and distance to build markerless augmented reality capable of detecting long distances with minimal lux. The proposed method was tested at different locations, lux, and distances in the range 2 to 200 cm. The result, it can connect the design between distance and lux to show therapy objects in both indoor and outdoor areas using a markerless augmented reality method.

1 INTRODUCTION

Noticeably, there is a persistent rising number of autistic children per year. The World Health Organization (WHO) stated that autistic children's rate experiences a remarkable rise year after year. The prevalence range with regards to the number of autistic children in the local context is 1.14 per 1000 or 1 in 87 children (Alshaban et al., 2019), while the prevalence range in the United States is 16.8 per 1000 children. This statistical number could undergo a rise if there is an attempt to screen every child across the country. Autism is a sort of developmental disorder in a child whose symptoms have already appeared before the child reaches the age of three years. It occurs due to a severe neurobiological disorder that affects brain function hence the child is incapable to interact and communicate effectively with the outside world. Associate with this issue, parents are demanded to have such a good understanding regarding certain things around autism and be capable to organize therapy exercises for their children. Autistic children undergo such difficulties in terms of recognizing and expressing emotions as well. Most educators and psychologists are in the same agreement that their emotions can affect their ability to focus on a task. In addition to having several characters such as hyperactive or unable to remain silent, most autistic children perform repetition tasks due to the boredom and lack of attractiveness while encountering certain objects. This occur sowing to the presence of a disorder in the child's brain function called Attention Deficit Hyperactivity Disorder (ADHD). As a consequence, autistic children frequently spend a huge time resting and undergo such difficulties in terms of retaining their focus (Escobedo et al., 2014).

Accordingly, innovation is highly needed by utilizing digital technology to provide therapeutic treatment for autistic children. Some technologies that previously have been applied as therapeutic media comprise digital libraries in the form of

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pocket pc consisting of image-based communication media and user data storage (Leroy et al., 2005), emotion-based video games with artificial intelligence (Irani et al., 2018), speech therapy for autism monitoring mobile application (Santiputri et al., n.d.), and audio recording-based therapy applications to advance the quality of data records. Nevertheless, some of these applications remain able to obtain such development again with more interactive technology to complete the existing systems.

One of the alternative technologies that can be exploited is the augmented reality. Augmented reality is a current technology that enables the introduction of elements both objects and computer-generated locations based on the real world view. There are two methods used by augmented reality, namely marker detection and markerless detection. The marker detection method has been applied to find out the short length of a marker that can be detected to execute on an embedded system with low computing requirements. This research conducted on indoor and outdoor environmental conditions has three scenarios to research the number of markers detected by the system. The augmented reality also has the advantage of a quick, straightforward, and robust process under changing lux and distance conditions. On top of that, the level of accuracy and throughput in terms of detecting markers and acquiring results in different environments possess a fairly high level (Díaz et al., 2018). The usage of augmented reality in the form of applications has also been administered to health care, sports, military, security systems (Díaz et al., 2018), and virtual laboratory applications (Abhishek et al., 2019).

Nevertheless, back to the major target issue of this paper discussed is those who are autistic children with the hyperactive character or unable to be silent, and a more precise method to use is markerless augmented reality. Markerless augmented reality possesses the ability to detect a certain point in a quick time by using one of the algorithms in ARCore namely environmental understanding. With this algorithm, ARCore will explore clusters of feature points that appear to take place on general horizontal or vertical surfaces, such as tables, walls, and other textured surfaces. In other research (Singh et al., 2018), it is also demonstrated that augmented reality can be utilized for accurate measurements based on focal distance, age, and brightness within the distance limit of 33.3 to 50 cm. So that both marker detection and markerless detection seem to demand a deeper paper to detect objects based on the parameters of lux and distance to the environment. The limitation of this paper is that it can only detect objects from a distance of 50 cm. The proposed markerless augmented reality method in this paper has a distance more than 50 cm. Besides that, this method has the advantage of being able to detect movement, which is relevant for autistic children who have trouble focusing. In other papers, determining the correlation value is also necessary to understand the connection between the two parameters, namely the distance value and the lux value (Astuti, 2017).

This paper proposed the correlation of distance and lux to demonstrate objects video tutorials as a therapeutic media for autistic children using markerless augmented reality. The calculations presented in the test section include the average value, median, standard deviation, and covariance for estimating the size of the data center. Ultimately, this paper aims to measure the accuracy of the system known through the results of its correlation value. Furthermore, the influence for autistic children themselves while using this application can be noticed in an interaction between the application and the location of scanning objects thus as to train the sensory and motor skills of autistic children in which the success of therapy also depends on the severity of the symptoms while being reviewed from the age factor of starting therapy and parental support (Asrizal, 2016). The result, this technique can be used to support digital therapy for autistic children.

2 SYSTEM OVERVIEW

This section explores designing a system for applying lux values and distance values in searching markerless augmented reality-based correlation values. Figure 1 demonstrates a diagram block of the proposed research method. From the diagram block, the discussion will be consisting of several points ranging from markerless augmented reality design, MAXST AR framework implementation, system implementation, retrieval of lux value and distance value data, and the size of the data centralization. The system design is conducted from android applications made using Unity software with C# programming language as a method for designing digital therapy applications for autistic children.

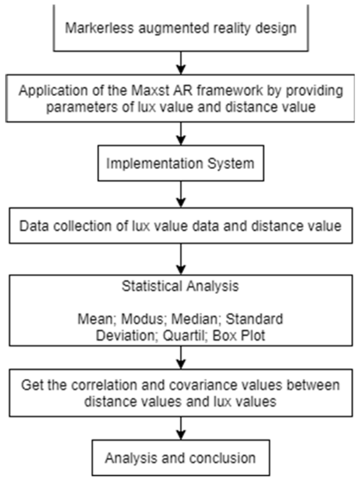

Figure 1: Research Diagram Block.

2.1 Markerless Augmented Reality Design

The design of markerless augmented reality is typically conducted in some stages. The first stage is to invent scene tracking through Unity software using Maxst AR. This paper will apply Instant Tracker which is a technology to fine-tune the issued object based on the field found in the camera image.

After the MAXST AR SDK is attached to Unity, a single special scene is created for tracking in which there is one canvas and button to start and complete the tracking process. As a parameter of the appearance of markerless objects, parameters are given based on the Distance Sensor and Lux Sensor that will simultaneously appear when the location point tracking process begins. The scene tracking picture is as shown in the Figure 2.

Figure 2: Object Tracking Implementation View of Markerless Augmented Reality.

It can be noticed from the picture that there are several elements in the object tracking scene comprising the button for start and stop tracking, the back button, and two sensors to measure the values of both lux and distance programmed using the language C#. With the relevant lux value and distance value, markerless AR objects in the therapy video for autistic children will be displayed. The therapy video will display after tracking starts and the video will still be at the first point of tracking. When the camera is moved in another direction beside the first tracking point, the camera will present a real-world view and when it returns to the first tracking point, the user can review the therapy video as an object of markerless augmented reality. Figure 3 presents the flowchart of the course of the system in this research.

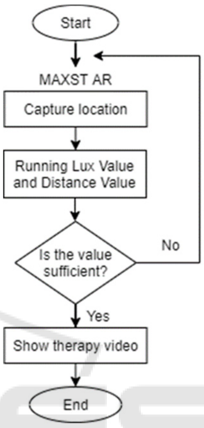

Figure 3: Proposed System Workflow.

2.2 Data Retrieval Process

Noticeably, there is a scenario in the process of retrieving data in testing the markerless augmented reality design. The data retrieval scenario owns two parameters there are lux value and distance value. The scenario aims to know the value of lux and the value of optimal distance for tracking objects. Moreover, it can also identify whether or not an augmented reality markerless object appears at that point. The process of data retrieval scenarios is demonstrated as shown in Figure 4.

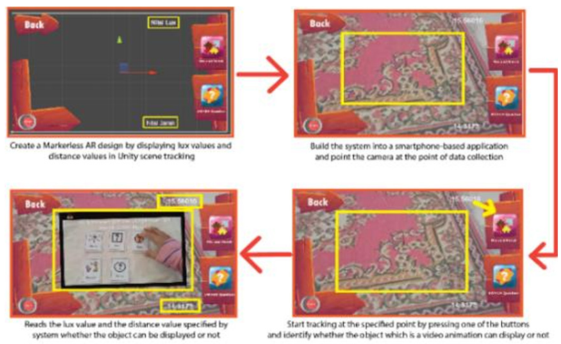

Figure 4: Data Retrieval Scenarios.

Data retrieval steps for markerless augmented reality testing are as shown clearly from the diagram block. The first step is the devise of markerless design with Unity in which there is a design to load scene tracking through Unity software using the MAXST AR framework. Once the application is successfully created in the smartphone, the tracking point markerless augmented reality is then determined. On this occasion, 10 points will be tested in two-area conditions, namely in the indoor and the outdoor area. Once the tracking point is set up, the user can open this application through their smartphone and do tracking at the specified location. Once the application is open, the user can identify and read both the lux and distance value at that point. Furthermore, the user can start tracking by pressing the start button according to the therapy video to display. Moreover, the user can identify the appearance of objects ranging from a distance of 2 cm to 200 cm with multiples of 2 cm. This is conducted 10 times at the specified points and read the lux value and write it down in the data retrieval table.

Testing is managed under two environmental conditions. In collecting data in the indoor area, it is conducted at 07.00 – 10.30 (Western Indonesian Time) in several indoor areas such as Kitchen, Living Room, and Room Corners. This tracking is undertaken in 10 points such as on prayer mats, cardboard, tables, and rooms. Similar to data collection in the indoor area, data collection in the outdoor area is managed from06.00 –09.30(Western Indonesian Time). A total of 280 data are taken with a range of multiples of 2 ranging from 2 - 200 cm. In this condition, there are also 10 tracking points such as Courtyard, Terrace Plants, and several different alleys.

2.3 Statistical Analytics

When conducting data testing using the results of data collection in both indoor and outdoor areas, statistical analytical calculations such as calculating the average, median, and covariance values are performed. The statistical data is calculated immediately following the data collection process. In this paper, two parameters are used: the distance value and the lux value. The goal of this research technique is to find the correlation value between the distance value and the lux value. The analysis of the obtained correlation values demonstrates the system's accuracy. From the results of the data collection process, the distribution of plot data in both indoor and outdoor areas is shown in Figures 5 and 6.

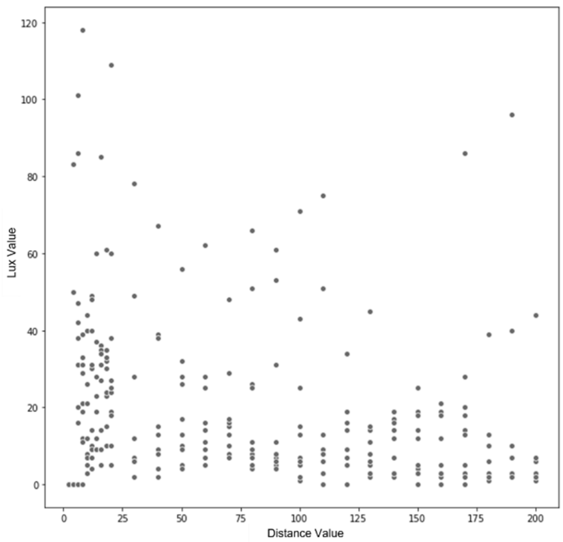

Figure 5: Lux Data Distribution and Distance in Indoor Area.

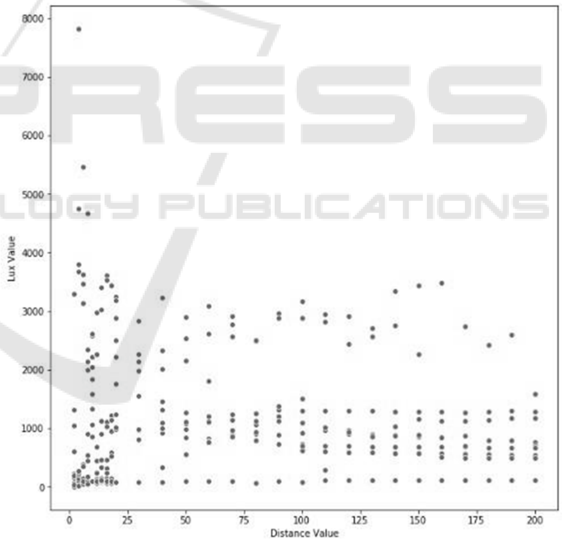

Figure 6: Lux Data Distribution and Distance in Outdoor Area.

From Figure 5, it can be noticed that testing in indoor area leads to the results stating that the average appearance of Lux value at a distance of 2-200 cm frequently occurs when lux is 0-30 lux so that the approximate average value of lux is in the range of 1-30 lux. Meanwhile, for outdoor testing in Figure 6, it is demonstrated that the average appearance of Lux value at a distance of 2-200 cm frequently occurs when lux is 0-1500 lux. Therefore, the approximate average value of lux is in the range of 0-1500 lux.

From the data of the acquisition of both distance and lux value, it is later on processed to set up statistical data. The first calculation is to find out the average value of the lux through in (1)

$$Mean = \frac{\sum_{i=1}^{k} fi.xi}{\sum_{i=1}^{k} fi} \quad (1)$$

By using the equation, it can be noticed that fi is the frequency of the "i data group" and xi is the middle value of the i-group of data thus the average value of lux in indoor area obtained a value of 18.72 lux and the average lux in the outdoor area obtained a value of 1240.4 lux, and then continued by looking for the median value of lux by use in (2)

$$Median = T + \left(\frac{\frac{1}{2}n - f_{kum}}{f_m}\right) l \quad (2)$$

The equation indicates that the variable T is the bottom edge of the median class, f_{um} is the cumulative frequency, and f is the frequency of the median class. After the calculation, the median value of lux in indoor area obtained a value of 18.16 lux and the median value of lux in the outdoor area obtained a value of 1199.5 lux. After that, calculations the standard deviation value in group data and to find out this value can be obtained by use in (3)

$$Standard\ deviation = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(xi - x)^2} \quad (3)$$

On the equation, x is the mean value and N is the amount of data. By using (3), the standard deviation value in the indoor area obtained a value of 8.67271 while the standard value of deviation in the outdoor area obtained a value of 334,839. After gaining the value of data centering size, it is supposed to look for a summary of its measurements encompassing covariance and correlation to look for a so-called covariance value that is a measure of the combined variability of two random variables. Afterward, it is then supposed to perform calculation operations like a (4)

$$Cov\ (X,Y) = \frac{\sum(x-\mu x)(y-\mu y)}{n} \quad (4)$$

From the calculations taken, it is obtained that the value of covariance for the indoor area is -7999.71 and for the outdoor area is -307165.82. After obtaining the covariance value, the calculation to determine the correlation value is then conducted to know the tightness of the connection of two variables in this case namely the lux value and distance value. Regarding finding out the correlation value, it is demanded first to know the value of distance and its average and the value of lux and its average. Once the required value is acquired, the calculation can be continued use in (5)

$$Corr_{,y} = \frac{E\,(XY) - E(X)E(Y)}{\sqrt{Ex^2 - E^2(x)}\sqrt{Ey^2 - E^2(y)}} \quad (5)$$

Based on the equation, calculations are then carried out and the correlation value in the indoor area reaches out -0.52value while the outdoor area reaches out -0.51 value. Due to having a negative value, the connection between the two variables has opposite characters in which the increase in distance value will be accompanied by a decrease in the value of the lux value.

3 EXPERIMENT AND EVALUATION

The tests conducted in this paper are carried out in the indoor area and the outdoor area ranging from a distance of 2 cm to 200 cm with a range of multiples of2.Thus,it is known that there are 280data obtained from the results of data collection this time. In this section, the results of the research will be displayed to find out the best correlation value between the distance value and the lux value. Previously, to determine the actual average value of lux, it is necessary to know each average value of lux per centimeter (cm) as shown in both Figure 7 and Figure 8 it can demonstrated that has two parameters are lux value and distance value.

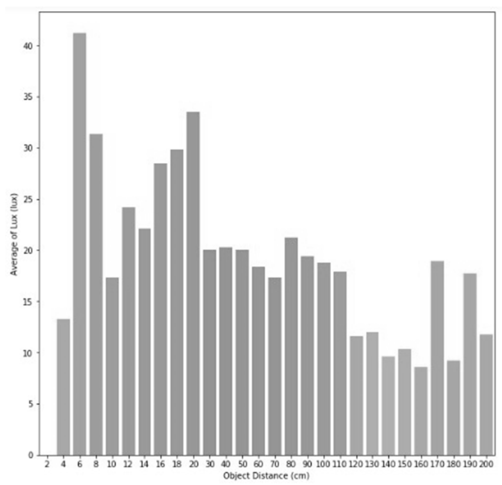

Figure 7: The Graph of Average Lux in Indoor Area.

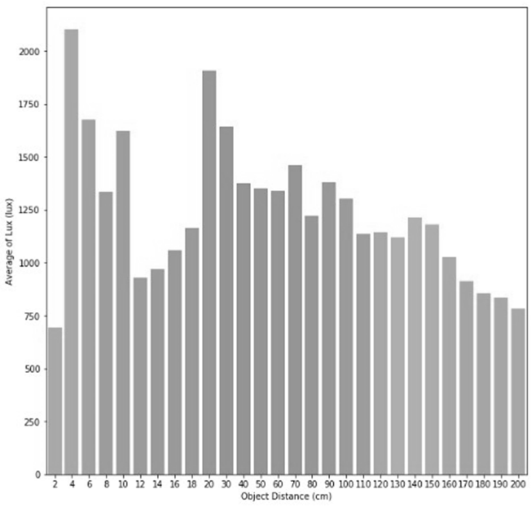

Figure 8: The Graph of Average Lux in Outdoor Area.

According to Figure 7, the minimum distance for data collection in the Indoor Room is 2 cm. However, because all tracking objects at 10 points cannot be displayed at a distance of 2 cm, the value is set to 0. As a result, the graph demonstrates the connection between the average lux value and the distance value for the appearance of markerless augmented reality objects. The figure demonstrates that at a distance of 4-200 cm, the average lux that covers each distance is in the 10-30 lux range.

Meanwhile, Figure 8 means the data was collected at a distance of 2-200 cm, with the average lux obtained covering each distance, namely in the range of 0-1500 lux. It has a higher value at a distance of 6 cm in the indoor space and 4 cm in the outdoor space. This is due to the environmental conditions, as data was collected at 07.00 WIB with the camera facing direct sunlight, resulting in comparatively high lux values.

As shown in Table 1, equation (5) is used to calculate the correlation value. When the correlation value obtained both indoor and outdoor is negative. The number of data points, standard deviation, and covariance as a reference parameter for the correlation value were also included in the table.

Table 1: Table of Correlation Value Testing Results in Indoor and Outdoor Area.

Location	Amount of Data	Standart Deviation	Covariant	Correlation Value
Indoor Area	280	8,67271	-7999,71	-0,52
Outdoor Area	280	334,839	-307165,82	-0.51

In the table, a negative value indicates that the correlation between the two variables is inverse. When the distance between two points increases, the value of lux decreases. This is coherent with the graph, which shows that at distanceslessthan100cm, the lux value obtained is relatively high. Meanwhile, if the distance is slightly higher than 100 cm, the lux value obtained is relatively low. To display video as an object of digital therapy for autistic children, application users should be in an area with proper lighting and at a reasonable distance. To display video as an object of digital therapy for autistic children, application users should be in an area with adequate lighting and at a reasonable distance. The calculation of the correlation between lux values and distance values in this paper is useful for determining the recommended value for displaying therapeutic video objects in the design of digital therapy applications that children with autism can use.

4 CONCLUSIONS

Based on the research, it is completely obvious that this research utilizes augmented reality technology, which enables the integration of elements, both objects and computer-generated locations based on real-world views. This technology is appropriate to use to increase interest in digital therapy for children with autism by using one of the methods, namely markerless, because augmented reality also has the advantage of a fast, straightforward, and strong process in different lux and distance conditions.

This paper also includes calculations for determining the correlation value between the lux value and the distance value. Both obtain negative results, namely -0.52 in the indoor area and -0.51 in the outdoor area. The correlation value with the markerless method can have an effect on the object's appearance. When the markerless design detects objects at a close distance, the lux value will be high. The result, when using this application, users should be in a well-lit area and at a reasonable distance from the object tracking surface. According to the results of tests with a minimum data collection distance of 2 cm, video objects can only be displayed in outdoor area. This happens because the lux value, which is 60 lux, is sufficient. Furthermore, the markerless design used has a maximum distance of 200 cm. In other situations, if the distance is greater than 200 cm, the video object displayed as a therapy media will appear small and difficult to see. For the future research, this application can be added to a database that aims to store data from the value of lux and distance in indoor and outdoor area.

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