Augmented Reality Application Using 3D Model of TLS (Terrestrial Laser Scanner) (Case Study: Plaosan Lor Temple, Klaten Regency)

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Key words: Augmented Reality, 3D Model, Poisson Surface Reconstruction, TLS

SUMMARY

Technology developments are increasingly expanding along with the rolling of 4.0 industrys resulting on Augmented Reality (AR). AR provides an overview to the user about the merging of the real world with the virtual world seen from the same place. The application of AR in this study is aimed at the education and tourism sector through the development of a 3D model in Plaosan Lor Temple. The 3D model in this study was generated from data recording using TLS. TLS will generate a point cloud that is processed with the Poisson Surface Reconstruction method so that it becomes a 3D model that can provide information on Plaosan Lor Temple through the CloudCompare software. The resulting 3D model then displayed in the AR world using the Unity software. Next, the software and the target image registered in the Vuforia. It will produce AR of Plaosan Temple in .apk form which can be accessed by the public via Android smartphone. The final result of this research shows the number of point clouds generated from TLS data with a points cloud of 7,198,274 points and produces a 3D mesh model of 12,959,390 faces. The AR application test results on the Android system show good application performance on the Android 8 system. As well as the usability test results show good performance for the application so that it can be used as a learning medium and scientific discipline collaboration in the field of Geodesy and Information Technology.

Augmented Reality Application Using 3D Model of TLS (Terrestrial Laser Scanner) (Case Study: Plaosan Lor Temple, Klaten Regency)

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1. INTRODUCTION

Indonesia has a beauty that is an attraction for local and foreign tourists to visit and travel in it. Indonesia has an advantage that is difficult to match in the Asian region through existing resources. The diversity of natural panoramas that are owned such as beaches, mountains, flora, fauna and other natural appearance are the uniqueness of Indonesia. In the world, the competitiveness of natural tourism in Indonesia is ranked 14 (Tirto, 2017). Not only that, historic sites are also an attraction to tread Indonesia's deeper. Because of its potential, until 2019 UNESCO set 9 locations in Indonesia to be a list of World Heritage (UNESCO, 2019).

2020 became a worrying year for the tourism sector because of the existence of the Covid-19 virus outbreak which became a pandemic worldwide. That was felt by Indonesia who occupied the largest death rate in Southeast Asia due to the virus in March 2020. After the enactment of social restrictions by regional autonomy makes tourist attractions must be closed for health purposes. According to the Indonesian Ministry of Tourism and Creative Economy (2020) through all entrances in September 2020 amounted to 153,498 visits or decreased by -88.95% compared to September 2019. This condition has an impact on the Indonesian economy. The contribution to this sector decreased due to hotels, malls, and other retail which also had to close. to make employee layoffs in a number of offices. The changes that occurred due to this Pandemic made President Jokowi convey four directions regarding the new normal order in the tourism sector. One direction is to open a new tourism trend in the middle of Pandemi Covid-19.

Along with the development of technology, the world is now introduced to the field of new communication through the virtual world. One of them is AR. AR has three principles namely interactive (displaying virtual objects into the real world), real time (real time) and can interact with three -dimensional objects (Prita Haryani, 2017). The AR work process is assisted by the media which is a place for binding the model. There are two methods, namely using a marker and or not using a marker. This study uses the based on marker method. AR that uses a marker is a computer vision software system that uses markers to harmonize real

and virtual cameras (Prita Haryani, 2017). The 3D model from Plaosan Temple is produced from TLS rides. TLS is one part of a lidar techogi that is being popular and is widely used for documentation of 3D historic buildings. TLS is a tool that uses laser light to get a three-dimensional shape from the measurement of points in a pattern directly on the surface of the object of a place on the surface of the earth (Reshetyuk, 2009). Laser lighting carried out by TLS will produce a three - dimensional coordinating clouds point for the establishment of the tool. TLS has advantages compared to other conventional measuring devices, namely data collection faster and the quality of measurement results is much more accurate. The geometric accuracy level of TLS is declared higher compared to other tools (Bernard Ray Barus, 2017).

The cloud point obtained from TLS will then be processed into a 3D model with a solid surface (mesh) with the Poisson Surface Reconstruction method. Poisson Surface Reconstruction is a plugin that produces a mesh pole algorithm made by Misha Kazhdan from Johns Hopkins University. The process of building a model using this plug-in must enter the normal value that is certainly clean from noise (Cloudcompare, 2020). Besides being a 3D form, output can also enter density information to get a more valid mesh.

The process of making AR applications using the unity application. Unity is a game maker software. But now widely used as a 3D and 2D maker application. This software can make platform applications not only desktop, but mobile, web, console, and various other platforms. More than 60% of AR / VR content on the market was developed and designed by Unity 3D (Shijie Wang, 2019). Unity is equipped with C# programming language which can be used to set the application button function (Ulfah Mediyanti, 2019). Design of applications in Unity requires vuphoria. Vuphoria is one of the plug-in that supports the making of AR known as Software Development Kit (SDK). Vuphoria provides features to be a target that can be downloaded and estimated locally on the AR application. The features presented can be accessed free of charge for the basic ones, but for more Advanse features can be accessed paid (Ulfah Mediyanti, 2019).

This AR application can be one of the innovations to realize new tourism trends because of its virtual nature makes tourists not need to contact directly with the location so that they can avoid the COVID-19 virus. This study took one of the historic sites, the Plaosan Temple to become a case study by collaborating geodesy through TLS to build AR. This research is expected to produce AR applications that can display 3D models virtually. The system that is not in direct contact with its object directly, is expected to be a way out such as conservation needs, online tourism, distance learning, and other related problems.

2. MATERIALS AND METHODS

The main tool used in this study is TLS. The TLS used is BLK 360 released by Leica Geosystem. BLK 360 is able to capture 360,000PTS every second and can take pictures quickly with less than 3 minutes. Equipped with a 150 MP camera that is circular when taking data. This study uses Point Cloud Candi Plaosan which is a secondary data taken by PT. Reliable creations in harmony on November 14, 2019. After conducting the registration process, the Point Cloud will be made a Mesh model as a material for the 3D AR model. The marker media used to display the 3D model in this research uses a barcode produced from the barcode generator on "www.barcodesinc.com".

The AR application processing method in this study follows the flow and work steps as in Figure 1. Based on the flow diagram, the following explanation of each process:

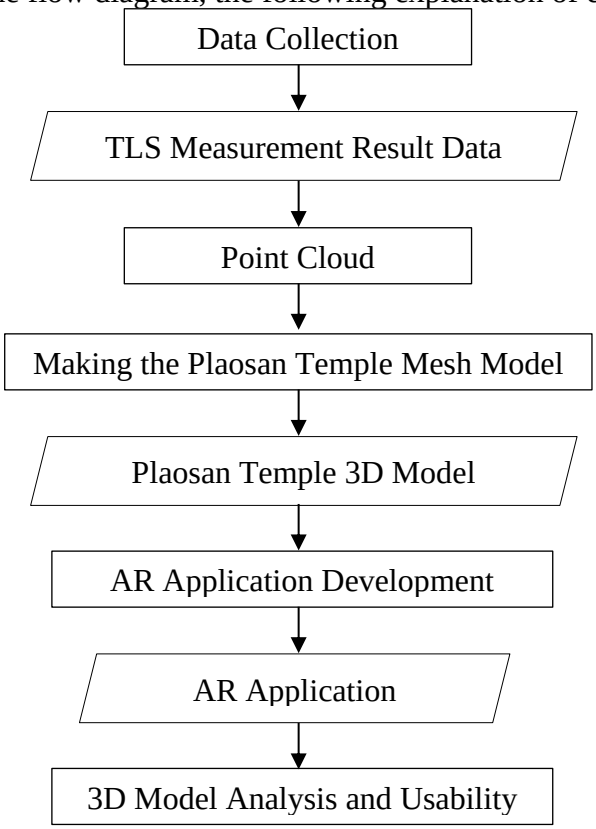


Figure 1. Research Flow Diagram

2.1 Point Cloud Registration

The registration process for the unification of cloud points using the Cloud to Cloud method with the binding of three points using Autodesk Recap Pro. The unification process has three indicators produced, namely Overlap, Balance and Point <6mm. Overlap value represents the percentage of points located in the same region as the points of other scanning and good if it does not exceed 30%. The balance value illustrates how strong the scan is parallel to all 3 coordinates of the axis direction and good if it reaches a

value of more than 20%. The accuracy level is represented by a percentage point that is closer than 6mm to the points in the same region but from other scanning and good value if more than 90%.

2.2 Making Mesh Plaosan Temple

Mesh modeling process in CloudCompare software with the Poisson Surface Reconstruction method. The parameter that must be arranged first is to enter the normal value into the cloud point. In normal settings, first select Quadric on a good local surface for corrugated areas. Second, the octree value of 0.290 is an auto value generated from the scale and density of the Point Cloud. Finally, Orientation uses the Minimum Spanning Tree Use method because this method tries to refer to all point consistently with Narest Neighbors (KNN) costanta of 8.

After the normal process, then the modeling process is carried out with several parameters. The first parameter entered the octree level value. This study uses an octree level of 11 because the relief model can be well represented at that level. Then, choose an interpolate color parameter that functions to produce colors on the model of each cloud point. This color will be used in the final results of storage in the form of .FBX which is the only model that can store RGB colors in the model in CloudCompare software. Finally, choosing Ouput Density as SF to produce a model that has a height density value based on scalar fields.

2.3 Making AR Application

The AR application manufacturing process itself is carried out on Unity by using a marker. In general, making AR applications through several stages as shown in Figure 2.

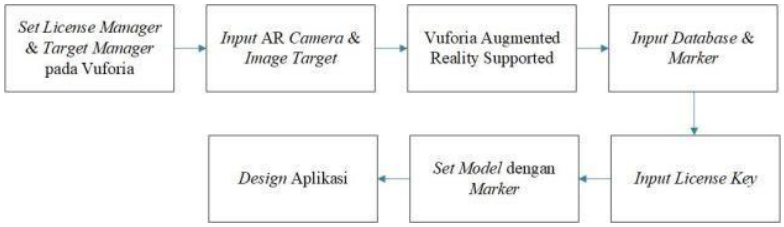


Figure 2. AR Application Flow Diagram

The first thing done in making the AR application is to register a marker that will be used on AR. Accessed with the help of Vuphoria Engine through "developer.vuphoria.com". Work in this Vuphoria Engine aims to create a License Manager and Target Manager that will be used for application development in Unity.

In Unity, starting with entering the research material, the 3D Plaosan Temple and Marker models that are targeted by images. Activate AR Camera and choose an Android system for target image as the final product of the application later. Then, enter the license manager that has been made in the Vuforia Engine to be able to run the process. After that, set the placement of the marker with the model to be displayed as shown in Figure 3.

Displaying 3D models in an application certainly pay attention to the appearance of the application itself. The application design is divided into four screens, namely: Main Screen, Camera AR Menu Screen, Laya Menu Info, and Credit menu screen. Unity uses C# as her programming language. This is useful for making commands on each of the nant menu buttons so that they function and can display the screen you want to run.

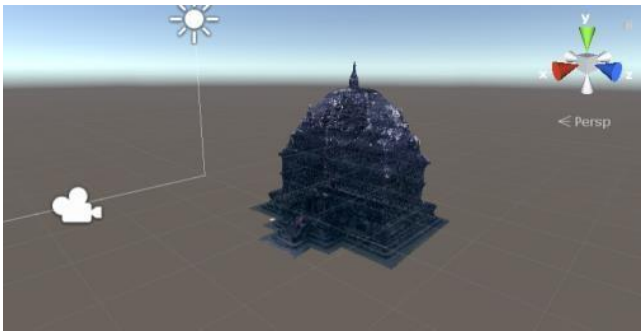


Figure 3. Display markers and models on Unity

To build applications in the form of .apk for the Android platform, first settings are set and SDK. For Unity version 2020.1.2.F2 both can be directly downloaded at the Unity Hub. After the installation is carried out, connect to Unity. SDK uses version 28.0.3 because the unity version asks for a minimum of SDK 25 while JDK using version 1,80_152 is the JDK qualification used in the Unity version used. In this study the API level used for applications can be used is Android 7.1 Nougat (API Level 25). The API level was chosen because the version of the unity used requires a minimum level of API level 25.

2.4 Quality Test and Application Usability

The feasibility of an application created is proven by testing both the application and user who will use the application. Quality validation test is done by testing applications in terms of the Android version. Making applications on Unity provides provisions with a minimum Android 7.1 Nougat (API level 25). Testing using random sampling using 3 devices with different Android versions listed in Table 1. The testing conducted on the application covers operations of devices on applications ranging from installation to run each menu in the application. The tests carried out seen in Table 2.

The second test is the application usability test. Research can be measured through several components, namely ease (learning), efficiency (efficiency), remembered (memorability), security (error), satisfaction (satisfaction). The instrument used for testing this application usability was made in the form of a questionnaire consisting of 11 questions. The scale given for the assessment of each question is a Likert scale. The Likert scale contains the level of variables from 1 to 5. The details of the scale are the value of 1 (strongly agree), 2 (agree), 3 (doubt), 4 (disagree), and 5 (strongly disagree). Table 3 shows the contents of the questionnaire used for testing the AR Temple Plaosan AR application test.

Table 1. Quality Validation Testing Device

No.	Device 1	Device 2	Device 3
1.	Samsung Galaxy A50s	Asus Zenfone 3	OPPO F5
2.	Android 10	Android 8.0	Android 7.1.1
4.	Camera 48MP	Camera 16MP	Camera 16MP
5.	RAM 4GB	RAM 3GB	RAM 3GB

Table 2. Application Quality Validation Testing

No.	Testing
1.	APK installation
2.	AR Camera Menu Planning
3.	Marker detection
4.	INFO MENU PLANN
5.	Credit menu planning
6.	Exit options

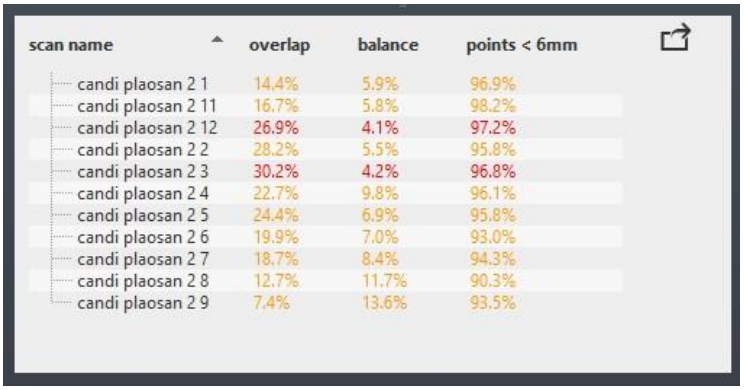
Table 3. Usability Test Questionnaire

No.	Testing
1.	Are you easy to download the Augmented Reality Application Plaosan Temple?
2.	Are you easy to install the Augmented Reality Application Plaosan Temple?
3.	Are you easy to do a 3D temple scanning on the marker provided?
4.	Are you easy to return to the initial menu with exit access?
5.	Are you easy to access the info menu?
6.	Are you easy to access the credit menu?
7.	Do you easily understand the information provided?
8.	Are you easy to recognize the object of the Augmented Reality application Plaosan Temple?
9.	Are you easy to move from one object to another in the application?
10.	Are you easy to recall the appearance of the Augmented Reality Application Plaosan Temple?

3. RESULT AND DISCUSSION

3.1 3D modeling using TLS

The results of the TLS data registration process unites the Point Cloud from 11 stands from the results of data collection. The unification process has three indicators produced, namely Overlap, Balance and Point <6mm as in Figure 4. There are 9 standing points of the tool with the results of the yellow indicator registration. Yellow indicates one or several quality metrics less than the threshold that is prioritized. While 2 points are Plaosan Temple 2 12 12 and Palosan Temple 2 with red indicators. Red shows the results that are on the verge of the limit because some values do not meet the minimum limit. In addition, one indicator also does not meet sufficient requirements so that the index is leading for indications that are not good or weak.



scan name	overlap	balance	points < 6mm
candi plaosan 2 1	14.4%	5.9%	96.9%
candi plaosan 2 11	16.7%	5.8%	98.2%
candi plaosan 2 12	26.9%	4.1%	97.2%
candi plaosan 2 2	28.2%	5.5%	95.8%
candi plaosan 2 3	30.2%	4.2%	96.8%
candi plaosan 2 4	22.7%	9.8%	96.1%
candi plaosan 2 5	24.4%	6.9%	95.8%
candi plaosan 2 6	19.9%	7.0%	93.0%
candi plaosan 2 7	18.7%	8.4%	94.3%
candi plaosan 2 8	12.7%	11.7%	90.3%
candi plaosan 2 9	7.4%	13.6%	93.5%

Figure 4. Point Cloud Tls Registration Results

Indications that cause the registration value are not optimal can be caused by several factors, including:

1. The mode used when scanning Point Cloud uses medium mode. This density scan refers to how solid 3D Point Cloud and is a measure of how many points are captured during one scan. It also affects the quality of 3D mesh. This is what causes the quality of the medium is not so good for open spaces and scanning for detailed buildings such as temples.
2. Balance value will always produce a small value in this case. That is because the value of balance will be bad for scanning in open areas. Then the value that will be produced will only be a maximum of the yellow indicator.

After the registration process is successful, the next process is filtering. The number of points in the Plaosan temple cloud point decreased to 95%, from 129,429,314 points to only 7,198,274 points as shown in Figure 5. Reduction of the number of points was carried out because the study area focused on the main building of Plaosan Temple which became the 3D model material in the AR application.

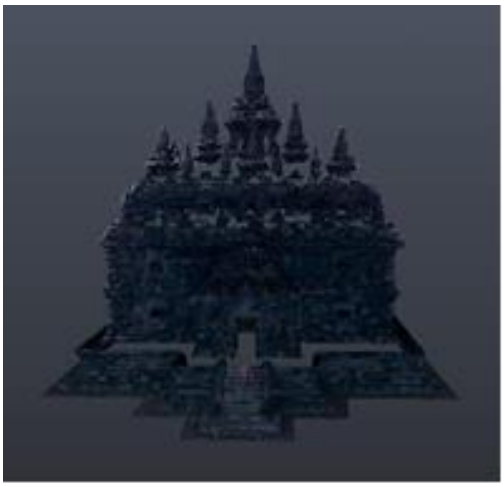


Figure 5. The Results Of The Plaosan Temple Cloud Point

Poisson Surface Reconstruction produces a faces value in the 3D Plaosan temple model of 12,959,390 faces. In Figure 6 at the top of the temple is not properly represented. That is because the number of cloud points that are not fulfilled at the top of the temple so as to produce a leap that is not good during the process. In addition, TLS that cannot take the side vertically also affect the results of this modeling. While horizontally, TLS has the advantage in recording by taking a large number of sample points. This makes the side of the temple which contains relief information can be described properly as in Figure 6 side. At the bottom also the Tin Tin Temple produced from the vertex is said to be successful because between points have the same intensity. The results of the 3D model are stored in .FBX format to be applied to the process of making AR applications in Unity.

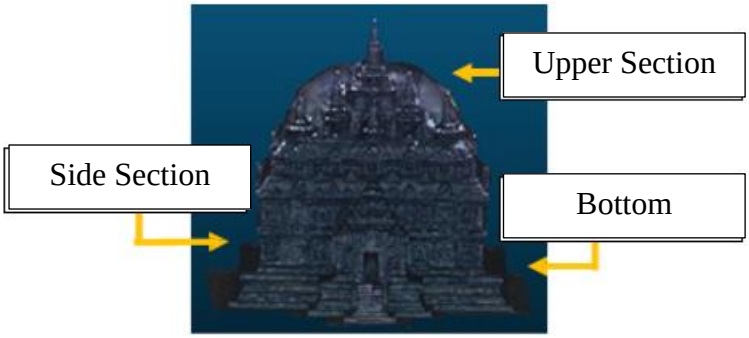


Figure 6. Plaosan Temple 3D Model

3.2 AR Application Performance

AR applications that have been formed through Unity have a very good sensitivity to the targets being scanned. This is based on the power of the barcode displayed on Vuforia which features a five -star which means very sensitive. On the first page of the AR application created (Figure 7) contains several menus in it, namely:

1. Camera AR menu, which will lead the user to the camera as a medium to display the model when scanning the target takes place as shown 8.

2. The info menu, which will lead users to the page that contains the history of Plaosan Temple as Figure 9.
3. Credit menu, which will lead users to pages that contain application makers data such as Figure 10.

In addition, to show the quality of AR for smartphones, testing is carried out on the Android system. This is very important because through this system it can later be seen at the level of Android how many data applications function ideally.

Application testing in three different systems can be seen in Table 4. In general, the indicators produced in application testing display success in each test. But there is an "successful enough" indicator on the AR camera menu and marker detection menu on device 3. The resulting indicator is due to the AR camera is run and starts detecting markers, the application of the crash. When the marker detection takes place, the model can be shown for a few seconds before the application finally closes by itself. Device 3, which in this case is the Oppo Series F5 smartphone, has a version of Android 7.1.1 which is the minimum version that is the provision of using the application by Unity. This condition can be the cause of the lack of successful application of applications on the smartphone. Whereas in Device 2 which has a greater version of Android than Device 3, there are no obstacles in the process number 2 and 3 Table 4. This can be a new suggestion that a good application for running the AR Plaosan AR Temple application must have a Android version of at least 8 because the minimum 7 specified unity shows the poor application.

Table 4. Application Testing

No.	Testing	Device 1	Device 2	Device 3
1.	APK installation	Succeed	Succeed	Succeed
2.	AR Camera Menu Planning	Succeed	Succeed	Successful enough
3.	Marker detection	Succeed	Succeed	Successful enough
4.	INFO MENU PLANN	Succeed	Succeed	Succeed
5.	Credit menu planning	Succeed	Succeed	Succeed
6.	Exit options	Succeed	Succeed	Succeed

Application testing on different Android systems produces the Android 8 system recommendation to operate applications. Furthermore, the test continues to Usability from the AR application. Usability test was carried out to 12 respondents randomly sampling, obtained the results listed in Table 5.

Usability test results can be summarized as follows:

1. Attribute 1 Value "Is you easy to download the Augmented Reality application Plaosan Temple?" amounting to 1,750, attribute value 2 "Is you easy to install the Augmented Reality Application Plaosan Temple?" amounting to 1,917; The value of attribute 3 "Is you easy to do a 3D temple scanning model on the marker provided?" amounting to 1.58. These results indicate that the AR application has a good aspect of learning.
2. Attribute Value 7 "Is you easy to understand the information provided?" Amounting to 1,667; attribute value 8 "Is you easy to recognize the object of the Augmeted Reality application Plaosan Temple?" of 1,750. This result shows that the AR application has a good aspect of efficiency.
3. Attribute Value 10 "Are you easy to recall the display of the Augmented Reality Application Plaosan Temple" of 1,583. These results indicate that the AR application has a good aspect of memorability.
4. Attribute value 4 "Is you easy to return to the initial menu with exit access?" amounting to 1,500; Attribute 5 "Is you easy to access the info menu?" amounting to 1,917; Attribute 6 "Is you easy to access the credit menu?" amounting to 1,667; Attribute value 9 "Is you easy to move from one object to another in the application?" of 1,500. These results indicate that the AR application has a good aspect of error.
5. The whole attribute has an average value of 1.5 on a scale 5. This result shows that the AR application has a good satisfaction aspect.

The results of the usability test showed a good value to all aspects of the use of use. The display of the 3D model from Plaosan Temple in the AR application can be seen in Figure 9.

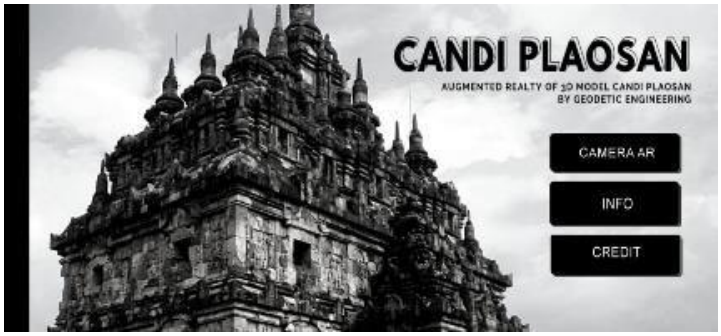


Figure 7. Main menu display

Figure 8. Camera AR menu display

Figure 9. Information menu display

Figure 10. Display Credit Menu

Table 5. Usability Test Results

No.	Testing	Value
1.	Are you easy to download the Augmented Reality Application Plaosan Temple?	1.750
2.	Are you easy to install the Augmented Reality Application Plaosan Temple?	1.917
3.	Are you easy to do a 3D temple scanning model on the marker provided?	1.583
4.	Are you easy to return to the initial menu with exit access?	1.500

No.	Testing	Value
5.	Are you easy to access the info menu?	1.917
6.	Are you easy to access the credit menu?	1.667
7.	Do you easily understand the information provided?	1.667
8.	Are you easy to recognize the object of the Augmented Reality application Plaosan Temple?	1.750
9.	Are you easy to move from one object to another in the application?	1.500
10	Are you easy to recall the appearance of the Augmented Reality Application Plaosan Temple?	1.583

4. CONCLUSION

3D modeling from the Cloud Point produced by TLS in this study is well registered. A total of 7,198,274 points from the results of the cloud point filtration then produce a mesh model with 12,959,390 faces. The performance of the AR application can run well on the Android 8 system from the smartphone to be used. AR application has a very good use of use and can be used as a form of learning media that can be used in various aspects.

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