DEVELOPMENT OF AUGMENTED REALITY TECHNOLOGY TO VISUALIZE APK & E LAB WORK GUIDANCE BOOK

THESIS

Submitted to International Program
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By

Name : Arnes Faradilla
Student Number : 07 522 007

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DEPARTMENT OF INDUSTRIAL ENGINEERING
FACULTY OF INDUSTRIAL TECHNOLOGY
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THESIS APPROVAL OF SUPERVISOR

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THESIS

By

Name : Arnes Faradilla

Student Number : 07 522 007

Yogyakarta, July 2011

Supervisor

M. Ridwan AP., ST., M.Sc., Ph.D

THESIS APPROVAL OF EXAMINATION COMMITTEE

DEVELOPMENT OF AUGMENTED REALITY TECHNOLOGY TO VISUALIZE APK & E LAB WORK GUIDANCE BOOK

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By

Name : Arnes Faradilla

Student Number : 07 522 007

Was defended in front of Examination Committee in Partial Fulfillment of the Requirements for the degree of Sarjana Teknik Industri

Fakultas Teknologi Industri Universitas Islam Indonesia

Yogyakarta, July 27th 2011

Examination Committee

M. Ridwan Andi Purnomo., ST., M.Sc., Ph.D
Examination Committee Chair

Agus Mansur, ST., M. Eng. Sc
Member I

Drs. Imam Djati Widodo, M.Eng.Sc
Member II

Accepted by,
Program Coordinator
International Program Industrial Engineering
Universitas Islam Indonesia

Winda Nur Cahyo ST., M.Sc

UNIVERSITAS ISLAM INDONESIA
FAKULTAS TEKNOLOGI INDUSTRI
JURUSAN : TEKNIK INDUSTRI, TEKNIK KIMIA, TEKNIK INFORMATIKA, TEKNIK ELEKTRO, DAN TEKNIK MESIN
Kampus : Jalan Kaliurang Km. 14,4 Telp. (0274) 895287, 895007 Facs. (0274) 895007 Ext. 148; Kotak Pos 75 Sleman 55501 Yogyakarta
http://www.uii.ac.id atau http://www.fti-uii.org e-mail : fti@uii.ac.id

Nomor : 77/Kalab APK & E/70/Lab. APK & E/VI/2011 3 Juni 2011
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Hal : **Keterangan Ijin Penelitian**

Assalamu'alaikum Wr.Wb.

Kami yang bertanda tangan di bawah ini Kalab APK & Ergonomi, Program Studi Teknik Industri Universitas Islam Indonesia, dengan ini kami: menyatakan bahwa

1. Nama : Arnes Faradila
   No. Mhs : 07522007

Telah melaksanakan penelitian TA di Laboratorium APK&E sejak tanggal 02-31 Mei 2011. Demikian surat keterangan ini dibuat untuk dipergunakan sebagaimana mestinya

Wassalamu'alaikum Wr.Wb.

Mengetahui,
Kalab APK dan Ergonomi

Muhammad Ragil S., ST.

DECLARATION LETTER

Demi Allah, I declare this research was conducted by myself except the citation. If someday this declaration letter to be proved the plagiarims, Universitas Islam Indonesia had right to revoke to its confession.

Yogyakarta, August 10th 2011



Arnes Faradilla

DEDICATION PAGE

I dedicate this final project to my dad, my mom and my brothers. Your unflinching courage and conviction will always inspire me…

MOTTO

"Nothing in life is to be feared, it is only to be understood.
Now is the time to understand more, so that we may fear less."
(Marie Curie)

يُؤْتِى ٱلْحِكْمَةَ مَن يَشَآءُ ۚ وَمَن يُؤْتَ ٱلْحِكْمَةَ فَقَدْ أُوتِىَ خَيْرًا كَثِيرًا ۗ وَمَا
يَذَّكَّرُ إِلَّآ أُو۟لُوا۟ ٱلْأَلْبَـٰبِ ﴿٢٦٩﴾

“He gives wisdom to anyone He wishes, and anyone He gives wisdom to, receives an abundant boon. Yet only prudent persons will reflect on it.”
(QS: Al – Baqarah 269)

\

Money can’t buy happines, but neither can proverty
(Leo Rosten)

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6. For all my friends in IP FIT students for unforgettable memories

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Yogyakarta, July 2011

Author

Abstract

Engineering education contains two aspects; theory and practice. Practice activity supports the students to implement the theory obtained in the class. Therefore, it will be better if the theory has visualization in order to support and make easier the student and lecturer in teaching activity. Analisis Perancangan Kerja dan Ergonomi (APK & E) is one of the laboratories in Industrial Engineering requires the web as a tool to communicate to the students. Currently, the existing website still show the standard display by conventional way. Based on the previous research, it showed the student still facing difficulties to understand the material especially for Micromotion Study. The AR system combines the real and virtual environment in displaying information in the real time, in a way that enhances the individual abilities to operate the system in the real world. AR requires the marker as the uniqe identification to differentiate every object. In this research, the AR technology is proposed to visualize the Micromotion Study module in order to increase the student understanding. The proposed AR system is developed using FLARToolKit. Based on the visual testing, the proposed AR system ables to display the Micromotion Study module in more attractive way. In this research, marker detection accuracy measurement of the used toolkit has been conducted and it showed 85% of accuracy level.

Keywords : augmented reality, micromotion study, engineering education, FLARToolKit

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CHAPTER I

INTRODUCTION

1.1 Background

Engineering education contains two aspects; theory and practice. Nowadays, theory is not enough anymore if there is no practice inside. Therefore, the theory is needed to visualized in order to support and make easier the student and lecturer in teaching activity. The APK & E is one of the laboratories in Industrial Engineering which concern in analysis of work design and ergonomics. APK & E Laboratory uses website as a tool to communicate to the students. Currently, the APK & E lab work contains of 6 subjects; Anthropometrics, Micromotion study, Biomechanics, Physical Work Environment, Physiology and Work Sampling. The APK & E Laboratory provides lab work subject in the website and updated every week continuously. In fact, the website just show standard display and conventional. The modules that provided are still standard and not attractive. The preliminary study showed that the students have bored and doesn't have interest to visit the website.

There is one subject of lab work, which is Micromotion study, which requires a video to show an example of the activity conducted in the lab work to increase the student understanding. Micromotion study learns about the basic elements or motions based on video camera and analyze the required motions in assembly activity. Currently, the students just downloaded the module without understand the content leads to inefficient study time in the class. The assistant must explain all over again the subject because the students have not understood the material.

Based on the problem, the idea of combining between two different media which are Augmented Reality (AR) and website is come up. AR combines the real and virtual that

interactive in the real time and registered in 3D (Azuma, 1997). AR combines the real and virtual environment in displaying information in real time, in a way which enhances the individual abilities of people operating in the real world (Cowper, 2004). Actually, AR is not a new technology in the world. It was founded 40 years ago after Virtual Reality (VR) launched for the first time. VR is a technology that applies the computer-simulated environment which is able to simulate the physical of the real world or just in imaginary world. Therefore, the aim of this research is to develop and combine the AR system with website to improve the display of APK & E module become more attractive and interractive.

In this research, FLARToolKit will be utilized to develop the AR system. The first step is identifying the object to be visualized in the AR system. Based on the previous research, the objects to be visualized are video on the electrical "T" plug assembly process, measurement activity, initial video and suggestion video. The next step is designing the marker. The function of marker is to trigger the object in virtual environment. Therefore, it is needed to measure the accuracy level of the used toolkit which develops the AR system. Thus, the marker can be varied if marker value higher than its noise.

1.2 Problem Formulation

Based on the background above, the problems are formulated as follows:

a. What is the AR system which able to visualize Micromotion Study module?

b. What is the accuracy level of toolkit to develop the AR system?

1.3 Problem Limitation

To focus the research in achieving the objective, the research needs to be limited in certain aspects. Those problem limitations can be defined as follows:

a. The problem is only in subject module of Micromotion Study and not all of the objects will be visualized.

b. Assembly activity shown is just based on the cases in the Micromotion Study lab work.

c. Accuracy measurement is just for the used toolkit.

1.4 Purpose of Research

The purposes of this research are:

a. To develop the AR system that able to visualize and also able to embeded on the website.

b. To determine the marker detection accuracy of the used AR toolkit.

1.5 Research Benefits

The benefits of this research are:

a. For the Author:

Increase the knowledge about the application of AR technology in real world and to know the marker detection accuracy of the used AR toolkit.

b. For the Institution:

As evaluation of APK & E Laboratory module especially in Micromotion Study module in order to increase the student understanding

c. For the Another Research:

This research can be reference to increase the knowledge related with AR technology.

1.5 Outline of Thesis

The rest of the research outline will be arranged as follows:

CHAPTER II LITERATURE REVIEW

This chapter gives brief information about previous researches done by other researchers. This chapter also describes theoretical background and any related concept supporting the research.

CHAPTER III RESEARCH METHODOLOGY

This chapter provides information about the research object, model development, and the workflow of the research itself. A flowchart will be provided to show the steps which have to be through by the researcher in order to solve the research problem.

CHAPTER IV DATA COLLECTION AND PROCESSING

This chapter contains the data collected that will be used to solve the problem. This chapter also describes how the problem solving will be done.

CHAPTER V DISCUSSION

This chapter discusses about the result of data processing done in previous chapter. Analysis toward the result will be done to measure how far the research has solved the problem that has been formulated in problem formulation.

CHAPTER VI CONCLUSION AND RECOMMENDATION

This chapter provides the final result of the research, answering the problem formulation. Several possibility of next improvement will also be recommended as the base of next research.

REFFERENCES

APPENDICES

CHAPTER II

LITERATURE REVIEW

This chapter explains about the literature review and the previous research that related with this research. All sub chapters will be explained as follows:

2.1 Theoretical Review

2.1.1 Micromotion Study

Micromotion Study was developed by Frank B. Gilbreth. He divided motion into 17 motions or elements that called by Therbligh. The study learns about work analysis for job improvement. It analyzes the motion element using camera and determine the standard time as the requirement in assembly activity. In Micromotion Study also analyzes the assembly technique in order to decrease the standard time. This method is categorized by indirect work. Generally, Therbligh motion can define as follows:

a. Search (Sh)

   This motion starts from searching the object and ends when the object is found. Search motion is including of the effective motion since the operator is wasting time for searching the object.

b. Select (St)

   Select motion is choosing one object from the several objects that have different types. It starts from when the eyes or hand choosing one object and ends when the eyes or hand find the object in certain location.

c. Grasp (G)

It begins from taking hold the object, closing the finger to the object and ends when the fingers are gripping the object.

d. Transport Empty (TE)

Transport empty begins when the hand moves without a load and ends when the hand is stopping the movement.

e. Transport Loaded (TL)

Transport loaded is the opposites with transport empty. It begins from when the hands moves with a load and ends when the hand is stopping the movement.

f. Hold

It begins when the hand is stopping the movement and ends when the hand is doing next motion.

g. Release Load (RL)

Release load means that the object is separated by the hands or it is categorized by the last motion.

h. Position (P)

It means that prepare for positioning of fitting the object in order to get proper location. It begins when the hand is preparing for position the object and ends when the object finding the proper location.

i. Pre-Position (PP)

In pre-position, the object in the exact location. It is included in effective motion.

j. Inspect (I)

Testing and examining the object or product for the specific standard.

k. Assembly (A)

Assemble and placing the object become integrated product. It begins when the object is placing or assemble to another objects and ended when the object has completed the assembly.

l. Disassembly (DA)

Dissambly makes the product is separated into some parts. It begins when the hand is separating into some parts and ended when the object has completely separated.

m. Use (U)

It begins when the hand is holding the object and ended when the object is functioning.

n. Unavoidable Delay (UD)

It is a delay beyond the control of the operator. It begins when the hand stops the activity and ended when the activity is resumed.

o. Avoidable Delay (AD)

Avoidable delay is a delay of the operator.

p. Plan (P)

It means that Preparing of next motion.

q. Rest to Overcome Fatigue

This motion is a delay factor or allowance provided to permit the worker to recover from the fatigue incurred by work.

2.1.2 Augmented Reality

An augmented reality system generates a composite view for the user which is the combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The virtual scene generated by the computer is designed to enhance the user's sensory perception of the virtual world they

are seeing or interacting with. The goal of Augmented Reality is to create a system in which the user cannot tell the difference between the real world and the virtual augmentation of it.

Another definition of AR is a technology that combines the real and the virtual world. In virtual objects, AR is combined by the real environment and the human's eyes. It means that there is facilitator between eyes and the real surroundings. AR technology is not a new technology since AR was developed in the 1990's as a technology improvement of Virtual Reality (VR). The example of AR is projecting the computer screen or a miniature PC through data glasses. The AR technology combines the real and virtual display that showing the information in real time, in a way that enhances the individual abilities of people to operating in the real world. There are two basic principles of AR; Video-See-Through (VST) and Optical-See-Through (OST). In VST, the human see the real world video using camera. In other hand, the OST see the real world video or object using optical or glass. The basic principle of AR is shown in Figure 2.1.

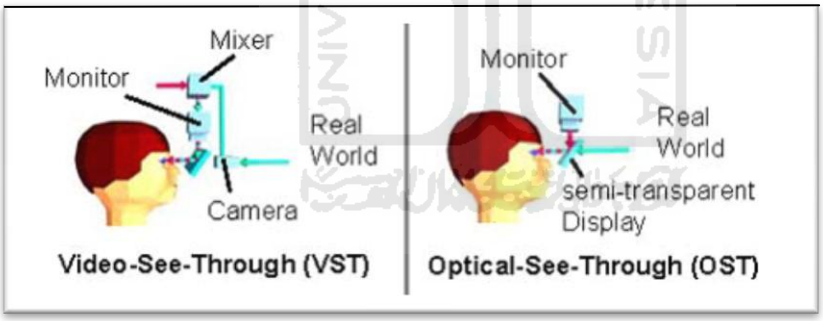


Figure 2.1 Basic Principle of AR

Another goal of AR technology is to create the virtual object which can present in the real world. AR technology can develop in assembly product and manufacturing system. The assembly worker is guided by AR technology. It can increasing the efficiency of the assembly output. AR can be as an instruction to assembly worker. It means that AR technology be able to show the assembly tools, components and steps of assembly process. One of the AR application is Helmet Mounted Display (HMD) and Head-up Display (HUD).

In this two system, the user can see the image or object using monitor that placed in front of the eyes. After that, monitor display would be updated and searching for the new head location to see the real and virtual image. The display even flow of AR system is shown in Figure 2.2.

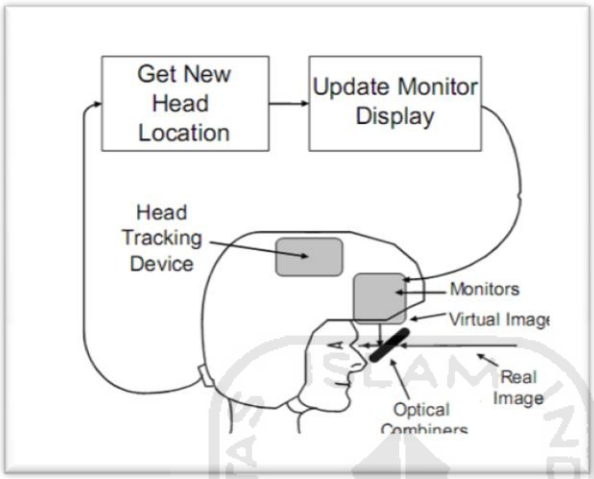


Figure 2.2 Display Even Flow of AR System

The AR technology is applicable. It used to assembly work, manufacturing system, product design even to increase the understanding of student in school. There are 2 types of the AR systems as follows:

a. The Optical Augmentation

   The application of Optical Augmented is HUD (Head-up Display) and HMD (Helmet Mounted Display). HUD technology is used in military jet fighters. HUD system has a semi transparent semi-reflective glasses that called by a combiner that placed above the monitor. Moreover, in HMD, the combiner and monitor are placed at the same position in the helmet. It placed in front of the viewer's eyes.

b. The Video Augmentation

   In video Augmentation, the user sees the object indirectly since the virtual object and the real are separated.

AR can be used in many fields such as in assembly activity, manufacturing, healthy, etc. According to the AR definition, there are two benefits of AR:

a. An AR-based design environment is semi immersive design environment in which the users can see the real world. AR provides more realism feeling to the users and makes the users feel safer and more comfortable while working on the product design.
b. An AR-based environment is easy to require but expensive to setting up since this technology is rarely used by people.

2.1.3 Marker

Marker is a unique identification to trigger the video objects. Marker in FLARToolKit is image which contains the black frame and an image in the middle. The marker's size is shown in Figure 2.3.

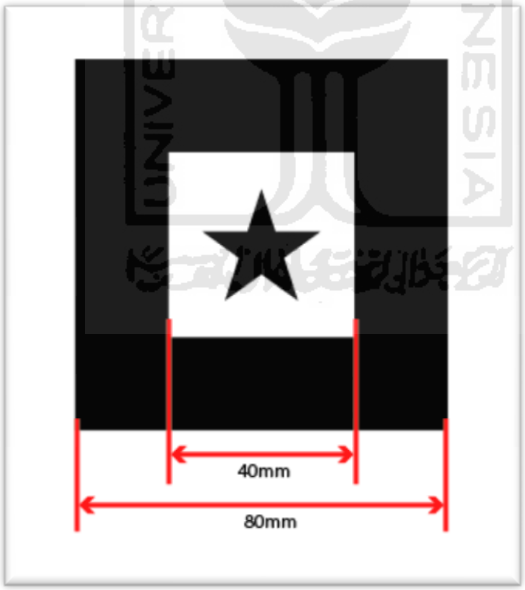


Figure 2.3 Marker

2.1.4 Multimedia

Multimedia is media and content which uses a combination of different content forms. The term can be used as a noun (a medium with multiple content forms) or as an adjective

describing a medium as having multiple content forms. The term is used in contrast to media which only use traditional forms of printed or hand-produced material. Multimedia includes a combination of text, audio, still images, animation, video, and interactivity content forms.

Multimedia is usually recorded and played, displayed or accessed by information content processing devices, such as computerized and electronic devices, but can also be part of a live performance. Multimedia (as an adjective) also describes electronic media devices used to store and experience multimedia content. Multimedia is distinguished from mixed media in fine art; by including audio, for example, it has a broader scope. The term "rich media" is synonymous for interactive multimedia. Hypermedia can be considered one particular multimedia application.

2.1.5 Noise

Image noise is a disturbance of brightness in the image (Zhang, 2000). Noise arises as a result of the process disturbance in the production and capture of the real signal. The characteristics of noise depend on its source. Generally, noise can be grouped as two; independent noise and noise which is dependent on the image data. The independent noise is addictive noise model. In this event, the image contains of the low frequency information. Hence, noise will be dominant. The second group is noise–dependent data, it means noise will arise when monochromatic radiation is scattered from a surface that causing the roughness of the order of a wavelength. These models are mathematically more complicated; hence, if possible, the noise is assumed to be data independent.

2.2 Related Research

The previous researches that related with this research are:

Reinhart & Patron (2003) is integrating Augmented Reality into assembly domain. AR is a new technology of human-machine interaction based on computers that show the

information of the real world. AR can increase the worker understanding in virtual object based on the real condition. The functions of AR in assembly domain are guiding the assembly worker and as visual assembly instruction.

Susperregui & Linaza (2005) is developing the system visualization using AR technology and integrating into tourism application. The researcher combines the tourism concepts and AR system to helping the application. Therefore, the visitor can understand and interest about the information since it more attractive. Thereby, it is the good way to increase the exchange gain.

Fernandes & Sanchez (2008) research the influence of Augmented Reality in Computer Aided Design (CAD) at Catalonia University. Even though the results shown that AR is not influence the CAD, but the students feel that AR helps them in material understanding.

S.L Wong et al (2010) use Augmented Reality in English vocabulary study. This system is contains of two components; the magic book and the card system. It uses heuristic evaluation and scale of the usability system (SUS). The heuristic and SUS are used to make the questionnaire for the lecturer. The result of this research is AR technology in English vocabulary study has positive function especially for the students' score.

Tang et al (2003) research the effectiveness of AR in assembly product. This research explains about the AR technology that combines the virtual object or environment. It can decrease the error level in assembly product. The obtained value is 82 % especially in error cumulative.

Bachtiar (2011) researches the AR system to games animation using camera in PC. It explains the way to build AR system in games animation with car as an object. The researcher explains about pose estimation in three different markers and also detecting the

lighting influence. The result of this research is marker can detect the object with lighting range around 50 Cd-140Cd with the distance 40 cm.

Dangelmaier et al (2004) research the vrtual and AR Support for Discrete Manufacturing System Simulation. The background of this research because the dynamics of innovation is increase and the product life cycle become shorter. Therefore, they use virtual factory in the production method to reduce time and cost.

Tateno et al (2005) explain about nested for AR. They use camera calibration in developing marker. After design the marker, then develop the AR system to demonstrate the ability of nested marker. It uses ARToolKit framework as software. The purposes of this research are visualization the marker design and experiments evaluation using the artificially rendered marker images.

Kustiawan (2005) researches about Tsunami Augmented Reality: Interaction of Marker as a Pointer. The research focused on identifying tsunami using Augmented Reality. The methodology is taking 10 samples (5 females and 5 males) randomly. After taking the samples, the research was started with designing the marker then installed to the AR technology and testing until the object can be appeared.

Zhang (2000) researches the Noise Reduction in Image Based on Threshold Neural Network. It presents the new type of threshold neural network (TNN), which combines the linear filtering and threshold method. The result of this paper is a new method gives a good performance for the peak-signal-to-noise-ratio (PSNR) and visual effect.

Pang, Yan et al (2006) research the assembly feature design in an AR environment. The purpose of this research is to apply AR technology to assembly design in the early design stage. Aproof-of-concept with AR interface is developed. Through AR interface, designers can design the assembly on the real assembly platform. The system helps users to design the assembly features to provide proper part-part constraints in the early design stage. The virtual

assembly features are rendered on the real assembly platform using AR registration techniques. The new evaluated assembly parts can be generated in the AR interface and assembled to assembly platform through assembly features. The model-based collision detection technique is implemented for assembly constraint evaluation. More interaction tools need to be developed to support the complex assembly design efficiently. The presented system encourages designers to consider the assembly issues in the early design stage. The primitive 3D models of assembly parts with proper part-part constraints are generated using the system before doing detailed geometry design. A new marker less registration approach for AR system is presented. This generic approach can be also used for other AR applications.

Kato & Billingurst (1999) have described marker tracking and HMD calibration for a video based Augmented Reality conferencing system. They described an augmented reality conferencing system which requires the overlay of virtual images on the real world. Remote collaborators are represented on Virtual Monitors which can be freely positioned about a user in space. Users can collaboratively view and interact with virtual objects using a shared virtual whiteboard. This is possible through precise virtual image registration using fast and accurate computer vision techniques and HMD calibration. The propose a method for tracking fiducially markers and a calibration method for optical see-through HMD based on the marker tracking.

In the last ten years, some virtual assembly systems have been reported. The VADE system (Jayaram et al., 1999) used constrained CAD models within a VR environment that represents the assembly area, and an assembly planner can manipulate virtual parts and the assembly tools using both hands and dexterous finger tip-based manipulations to perform realistic assembly operations.

Sellen (1992) have been developing an AR conferencing system that allows virtual images (Virtual Monitors) of remote collaborators to be overlaid on the users real environment. The AR conferencing system tries to overcome some of the limitations of current desktop video conferencing, including the lack of spatial cues, the difficulty of interacting with shared 3D data, and the need to be physically present at a desktop machine to conference. While using this system, users can easily change the arrangement of Virtual Monitors, placing the virtual images of remote participants about them in the real world and they can collaboratively interact with 2D and 3D information using a Virtual Shared Whiteboard. The virtual images are shown in a lightweight head mounted display, so with a wearable computer our system could be made portable enabling collaboration anywhere in the workplace.

Kothe (1998) research the primary image segmentation. This paper introduces the notion of primary image segmentation which serves as a well defined link between low- and high-level image analysis. A general algorithmic framework based on priority queues is proposed that allows for the integration of a variety of different segmentation algorithms. A seeded region growing approach, along with a number of improved seed selection methods and foveation of critical areas, is chosen to realize this framework. Experimental evaluation shows very good performance of these algorithms on a relatively large number of outdoor photographs without the need to adjust parameters.

Otsu (1979) has described a threshold selection method from grey-level histogram. A nonparametric and unsupervised method of automatic threshold selection for picture segmentation is presented. An optimal threshold is selected by the discriminated criterion, namely, so as to maximize the separability of the resultant classes in gray levels. The procedure is very simple, utilizing only the zero- and the first-order cumulative moments of the gray-level histogram. It is straightforward to extend the method to multithreshold

problems. Several experimental results are also presented to support the validity of the method.

2.3 Chapter Conclusion

Based on the previous researches, the researches of AR in lab work material and marker detection does not study yet. In this research, the lab work material to be visualized using AR technology to increase the student understanding. After that, measure the marker detection accuracy level of the used toolkit in order to know the accuracy level of the AR system. Based on the research, marker can be varied if marker value higher than noise level. Therefore, it can be claimed as the novelties of this research.

CHAPTER III

RESEARCH METHODOLOGY

This chapter discusses about the research object and explains the required data. The steps of this research will be illustrated in the research flowchart as shown in Figure 3.1. All sub chapters will be explained in the following sub sections.

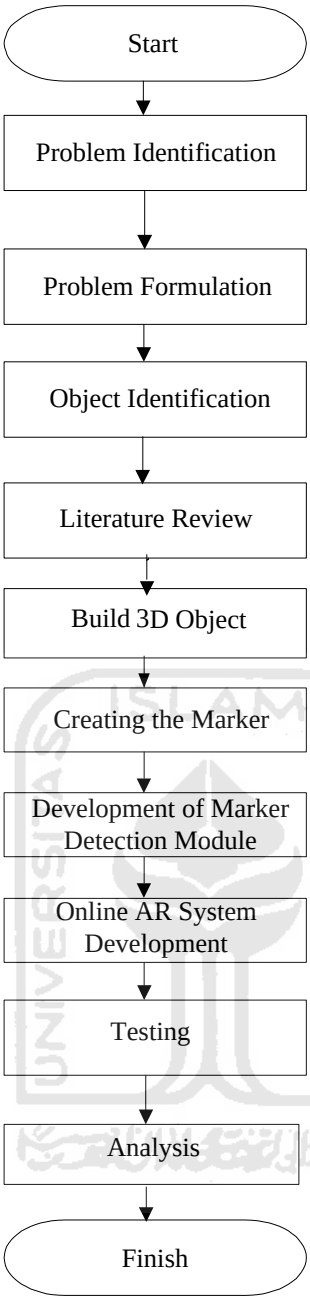


Figure 3.1 Research Flowchart

3.1 Problem Identification

The first step of this research is identifying the problem of APK & E Laboratory. It was obtained from the preliminary study related to the students understanding.

3.2 Problem Formulation

The selected critical problem to be formulated and solved using AR technology.

3.3 Object Identification

Based on the preliminary study, the selected object as an object assembly is T-shape electrical plug. At this point, the object identification was determined by spreading the questionnaire. There are 3 object assemblies; T-shape e;lectrical plug, electrical plug and terminal plug. The object selected is the required object of this research.

4 Literature Review

Literature review was carried out in order to find any related topics to support this research. The research is focused on AR system development in APK & E lab work module. In this research, the required data to solve the problem are:

a. Primary Data.

Primary data is the data taken directly from the observation in the location which are:

1. Video Assembly Activity

This video was taken directly by APK & E Laboratoriy's operator using web cam. The video assembly activity to be visualized are measurement activity, initial layout of assembly work station and suggested layout of assembly work station.

2. Video on T-shape Electrical Plug Assembly Process

   This video was designed the T-shape electrical plug assembly process using *3D Studio Max 9*. After that, it will be converted into video file which is in "*.avi*" format.

b. Secondary Data

   Secondary data is obtained from literature or another document that related to the research object and Standard Operating Procedure (SOP) of the assembly activity at APK & E Laboratory.

5 Build 3D Object

This step is build 3 dimensions (3D) object of T-shape electrical plug assembly process. The first step is carried out by build 3D object for each component; upper body, lower body, T-shape and nut.

6 Creating the Marker

The function of marker is to trigger the video object in the virtual environment. There are 4 designed marker with picture in the middle represents the video object to be displayed in the virtual environment.

7 Development of Marker Detection Module

This step is developing the marker detection module. There are three steps in marker detection module; finding potential marker, marker pattern identification and matching found marker with database of marker.

8 Online AR System Development

The required software to develop the AR system is *FLARToolKit 2.5.1*. The output of AR system will be deployed directly to the internet.

9 Testing

Testing to be used to test the system whether is able to show the video perfectly. This step also to be used to test the printed marker which is one marker can show one video.

10 Analysis

This step is determining the marker detection accuracy of the used toolkit. The aim of this step is to know the system maximum capability to detect the marker which has the noise.

CHAPTER IV

DATA COLLECTION AND PROCESSING

This chapter explains the process of an online AR system development. The online AR system is needed since the AR system will be deployed to the internet as a web page. There are several steps in the online AR system development and will be explained in detail in the following sub chapter.

4.1 Data Collection

In this step, the required data is tried to be collected through some sources. The data to be collected are the software to be used to develop an online AR system effectively, to model 3 dimensions (3D) objects, animation and video, and to edit a video. Another required data is the technique to create proper unique marker for the online AR system.

Based on the data collected mainly from the internet source, it can be known that the software to be used effectively to develop an online AR system is *FLARToolKit* 2.5.1. This toolkit is developed based on *Adobe Flash* software which its output can be deployed directly to the internet. The software to be used to model 3D objects is *3D Studio Max*. This software is able to be used not only to model 3D objects but also to create animation and video file. The software to be used to edit a video is *Adobe After Effect*. The main editing of the video is to remove the video's background in order to get floating-look video in the virtual environment. The software to be used to design a proper marker for the online AR system is *Adobe Photoshop*. The software will be used to design a rectangle marker with 2 cm width black frame and an image in the middle. Example of a proper marker is shown in Figure 4.1.

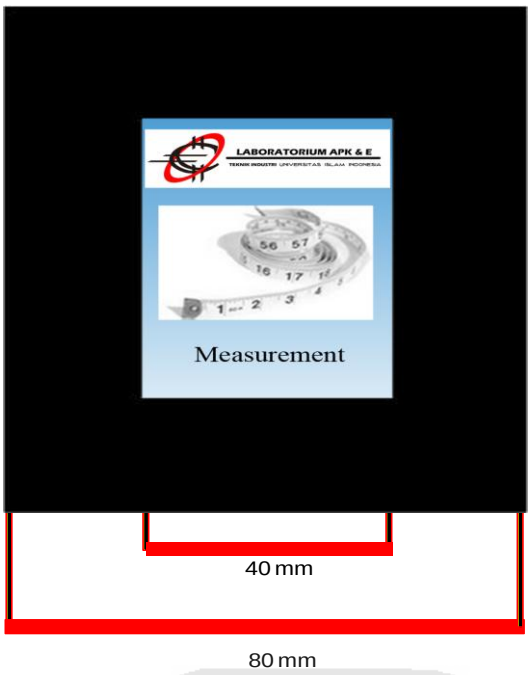


Figure 4.1 Marker as Unique Identification

4.2 Data Processing and System Development

Technically, the aim of developing an online AR system is to augment the video objects in a web-based virtual environment using unique markers. Basically, when the user accesses the web page, the AR system will be downloaded automatically to the user computer as *activeX* object. The *activeX* object will access webcam installed in the user computer to get real time picture of the user. The user needs to show a printed marker to the webcam in order to see the virtual object in the virtual environment. High level architecture of the online AR system to be developed is shown in Figure 4.2.

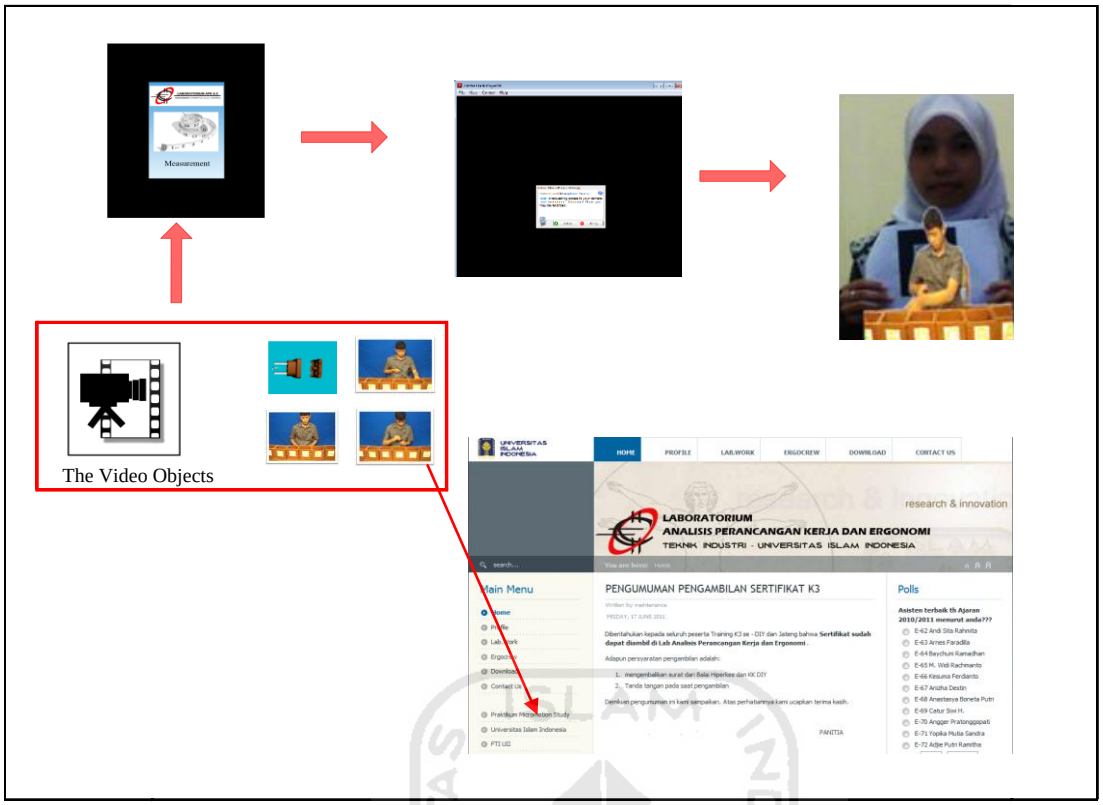


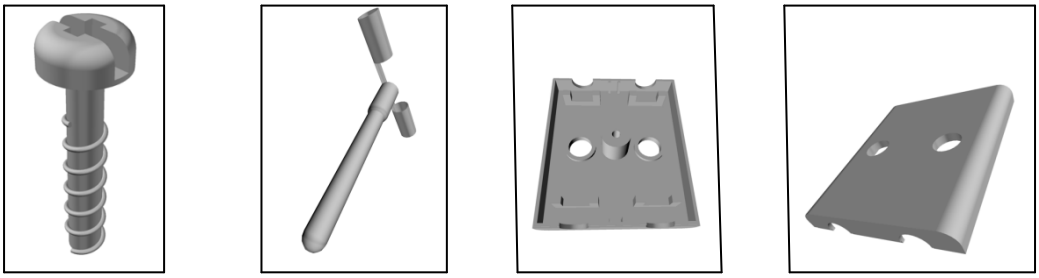
Figure 4.2 High Level Architecture

4.2.1 Creating the Video Objects

The video objects to be visualized are the video on T-shape electrical plug assembly process, measurement activity, initial layout of assembly work station and suggested layout of assembly work station. The detail step of creating each video objects will be explained in the following sub sections.

4.2.2 Creating Video on T-Shape Electrical Plug Assembly Process

The first step in creating the video on T-shape electrical plug assembly process is identifying components of the T-shape electrical plug. This step is carried out by disassembling a T-shape electrical plug and then drawing each component in 3D. The components of T-shape electrical plug is shown in Figure 4.3.



(a) (b) (c) (d)

Figure 4.3 (a). Nut
(b). T-Connector
(c). Lower Body
(d). Upper Body

The second step is build 3D object for each component. In this step, the well known 3D graphic design software called 3D Studio Max 9 is utilized. The reason of using the 3D Studio Max software is because the software can also be used to create an animation of the assembly process of T-shape electrical plug based on the built 3D objects. The definition of the assembly process of the T-shape electrical plug is carried out through the disassembly process of the T-shape electrical plug itself in reverse order. The result of this step is shown in Figure 4.4.



Figure 4.4 Disassembly Process of T-shape electrical plug

The next step is creating an animation of the assembly process of T-shape electrical plug. In order to give a clear explanation on the T-shape electrical plug assembly process, the animation duration is set to 20 seconds. The created animation will then be converted into video file which is in "*.avi*" format. The screenshot of the created video is shown in Figure 4.5.

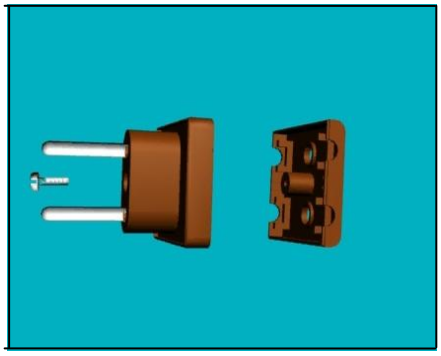
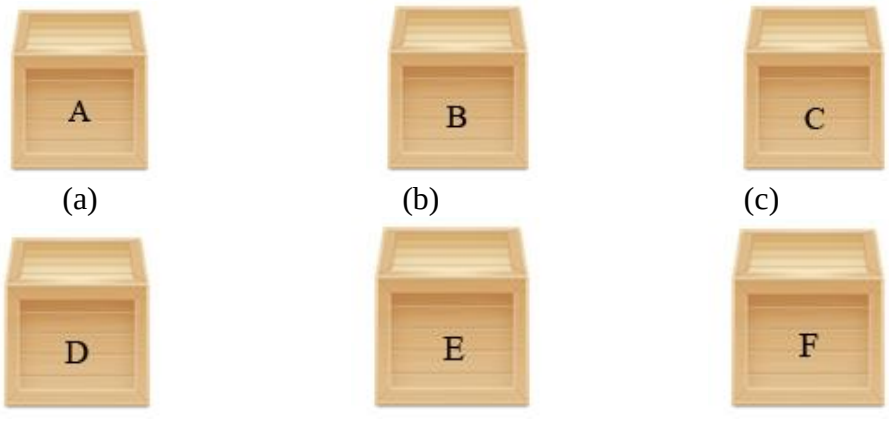


Figure 4.5 Screenshot of Video on T-Shape Electrical Plug Assembly Process

4.2.3 Creating Video on Measurement Activity

Basically, video on measurement activity concerns about the standard time measurement influenced by assembly activity and the distance of the operator to the boxes contained T-shape electrical plug components. The distance range will be used to calculate the standard time using Method Time Measurement (MTM). The aim of calculating the standard time is to measure the required time in assembling the T-shape electrical plug. The longer distance will produce more time for the operator to take assembly part. The activities of creating video on measurement activity can be explained in two steps:

a. First step is putting the T-shape electrical plug's component in the separated boxes. The aim of putting the component in the separated box is to easier the operator in selecting the T-shape electrical plug's component. The boxes' component of T-shape electrical plug is shown in Figure 4.6.



(a) (b) (c)

(d) (e) (f)

Figure 4.6 (a). Upper Body
(b). T-Connector
(c). Lower Body
(d). Nut
(e). Screw Driver
(f). T-Shape Electrical Plug

b. Second step is measuring the distance range from operator's center to each box and this activity will be recorded directly using webcam.

The video duration is set to 21 seconds. The screenshot of video on measurement activity is shown in Figure 4.7.



Figure 4.7 Screenshot of Video on Measurement Activity

4.2.4 Creating Video on Initial Layout of Assembly Work Station

Video on initial layout of assembly work station operator concerns about the assembly activities on T-shape electrical plug. The assembly activity of operator is carried out by following the assembly chart which is shown in Figure 4.8.

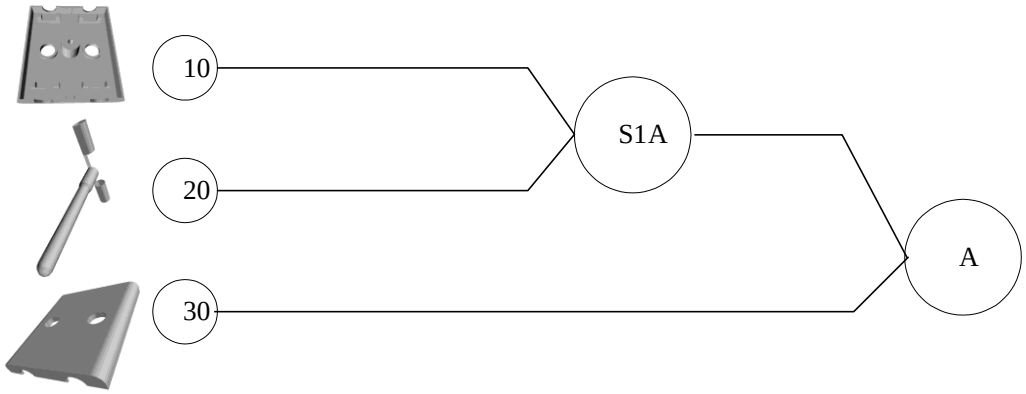


Figure 4.8 Assembly Chart of T-shape Electrical Plug

The video duration on initial layout of assembly work station is set to 23 seconds. The screenshot of video on initial layout of assembly work station is shown in Figure 4.9.



Figure 4.9 Screenshot of Video on Initial Layout of Assembly Work Station

4.2.5 Creating Video on Suggested Layout of Assembly Work Station

Basically, the concept of creating video on suggested layout and initial layout is similar. In the proposed layout, the distance between the boxes and the operator is closer than in the initial layout. The video duration on suggested layout of assembly work station is set to 26 seconds. The screenshot of video on suggested layout of assembly work station is shown in Figure 4.10.



Figure 4.10 Screenshot of Video on Suggestion Layout of Assembly Work Station

4.2.6 Removing the Video's Background

Based on the preliminary research, backgrounded video will block the camera view leads to virtual environment blockage. Therefore, the background of the video will be removed in order to get floating-look video in the virtual environment.

The software to be used to edit a video is *Adobe After Effect*. The step in removing the video's background is importing the video objects file. The tool in *Adobe After Effect* to be used to remove the video's background is *Kelight 1.2*. This tool is able to detect the color around the selected color with 1.2 minimum intensity differences. The comparison between backgrounded video and backgroundless video is shown in Figure 4.11.



(a) (b)

Figure 4.11 (a). Backgrounded Video
(b). Backgroundless Video

From Figure 4.11, backgroundless video floats in virtual environment looks more realistic than backgrounded video which blocked virtual environment.

4.2.7 Creating the Marker

The function of marker is to trigger related video appearance in virtual environment. The software to be used to design a marker is *Adobe Photoshop*. The aim of using *Adobe Photoshop* is because the software can be used to create the proper marker and also to determine the pixel size in each marker. The first step in creating the marker is designing a rectangle marker with 2 cm width black frame. The second step is creating an image with 4 cm in the middle of marker. In this research, there are 4 designed marker with picture in the middle represents the video object to be displayed in the virtual environment. The various marker is shown in Figure 4.12:



(a) (b) (c) (d)

Figure 4.12 (a). Measurement Activity Marker
(b). Object Assembly Marker
(c). Suggested Video Marker
(d). Initial Video Marker

4.2.8 Development of Marker Detection Module

The steps in the development of marker detection module are finding potential marker, marker pattern identification and matching found marker with database of marker. The detail step in the development of marker detection module will be explained in the following sub sections.

4.2.9 Finding the Potential Marker

The first step in finding the potential marker is doing the grayscaling of the original image. There is a quite contrast object; a black bordered on white paper. Thus, most probably a good direction is to search for black image frame surrounded by white areas and do their analysis. The second step is to try doing thresholding and then blob analysis for finding the black image frame. One of method to be used to threshold the black image frame is Otsu method. The comparison between original image and Otsu method is shown in Figure 4.13.



(a) (b)

Figure 4.13 (a). Original Image
(b). Image Using Otsu Method

4.2.10 Marker Pattern Identification

The first step of marker pattern identification is the image marker divided into cells. The image cells is shown in Figure 4.14.

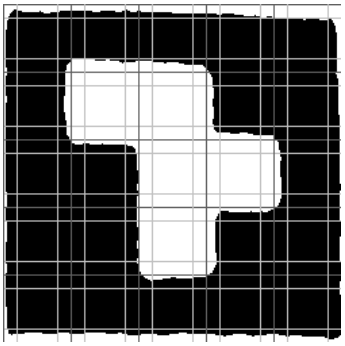


Figure 4.14 Image Cells

The Figure 4.14 shows the marker image is divided by dark gray lines into 5x5 grid of cells having same width and height. The second step is counting the number of white pixels in each cell. If the number is greater than cell's area then assumed that the cell is filled by white color which corresponds to "1". And if the number is less than half of the cell's area then the black cell will correspond to "0". The confidence level for each cell is if the entire cell is filled with white or black pixels, then confident value of cell's color is 100%. However, if a cell has 60% of white pixels and 40% of black pixels, then recognition confidence drops to 60%. If a cell is half filled with white and half filled with black color, then confidence equals to 50%.

4.2.11 Matching Found Marker with Data Base of Marker

The finding a matching marker's database needs to do compares of extracted marker data with every object in the database - compare the possible rotations of extracted object data with the database. The required FLARToolKit is saved in *".dat"* file.

4.2.12 Pseudocode

The language to be used to explain the process of developing program based on natural language is pseudocode. The pseudocode of this system is shown in Figure 4.15.

```
startprogram()

function startprogram()
{
import pattern file
set video to play
if (grabAndDisplayCamera() === pattern file)
                {
                papervision(video to play)
                }
                else
                {
                return false
                }
}

function grabAndDisplayCamera()
{
set width of cam picture
set height of cam picture
get camera source(camera index)
add camera signal to cam picture
add cam picture to scene
return bitmap per frame
}

function papervision(videoOBJ)
{
set width of videoOBJ
set height of videoOBJ
set position of videoOBJ
create new 3d scene
render videoOBJ
create papervision object
}
```

Figure 4.15 Pseudocode

Based on the pseudocode above, the first step is starting to initialize the program with importing pattern file and set the video to be played. After that, set the dimension of bitmap file to be captured from camera and get source the camera to grab the scene per frame and add to display. The output from this step will be an image file to be compared with pattern file. If it is similar (Boolean value return true), then it will go to create paper vision object. The first step was to set the dimension of the video that mentioned in previous, and then set the position video object. The last step was created the 3d scene and renders the object.

4.2.13 Testing the AR System

Basically, the video's position can be controlled using marker. The aim of controlling the video objects using marker is in order to show the video objects in various angles. The screenshot video in normal position is shown in Figure 4.16.



Figure 4.16 Video in Normal Position

When the marker turned 45° with Y axis as center, thus video will rotate 45°. The screenshot of rotated video in AR system is shown in Figure 4.17.



(a) (b)

Figure 4.17 (a). Rotated Video in Y axis as far as +45°
(b). Rotated Video in Y axis as far as - 45°

When the marker turned 45° with Z axis as center, thus video will rotate 45°. The screenshot of rotated video in AR system is shown in Figure 4.18



(a) (b)

Figure 4.18 (a). Rotated Video in Z axis as far as + 45°
(b). Rotated Video in Z axis as far as - 45°

CHAPTER V

DISCUSSION

This capter discusses the marker detection accuracy of the used toolkit. The marker detection accuracy is needed since marker has function to trigger the related video in virtual environment. There are steps in measure the marker detection accuracy of the used toolkit and will be explained in the following sub chapter.

5.1 Noising the Marker

In this step, the required data is collecting the marker which is able to show the video in the online AR system. Noise is a disturbance of brightness in the image. The marker to be given the noise in various sizes. The aim of giving the noise in the marker is to measure the ability of marker contained noise in detecting the object. The formula to calculate the noise in the marker is shown in Equation 5.1.

$$A = W \times H \quad (5.1)$$

Where :

A = Area of marker/noise ($pixel^2$)

W = Width of marker/noise (pixel)

H = Height of marker/noise (pixel)

Based on the formula above, the whole marker and its calculation is shown in Figure 5.1.

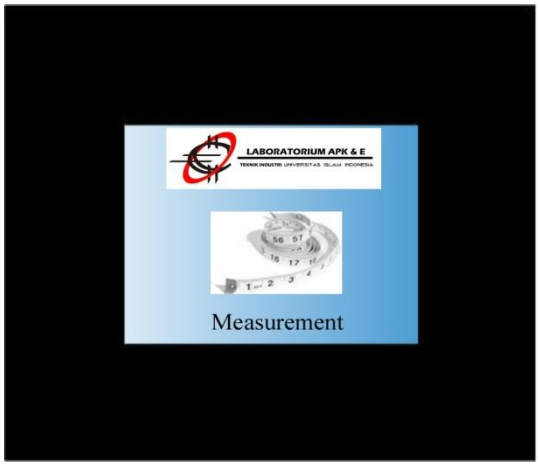


Figure 5.1 Whole marker

The size of whole marker with 800 pixels width and 1000 pixels height, and then the marker 1 area is:

$$A = W \times H$$

$$= 800 \text{ pixels} \times 1000 \text{ pixels}$$

$$= 2{,}500{,}000 \text{ pixels}^2$$

In this research, there are 5 treatments in noising the marker. The 5 treatments as follows:

1. **Treatment 1 :**

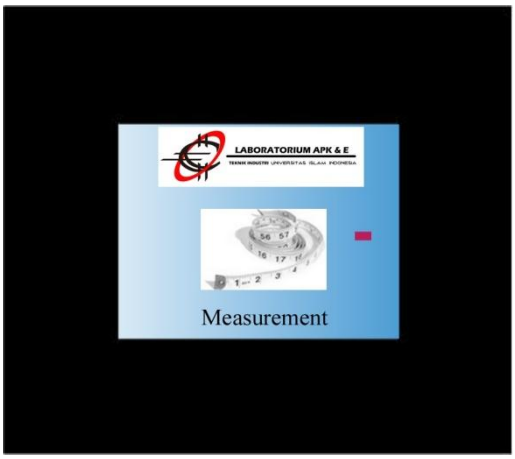


Figure 5.2 Treatment 1

In this treatment, the noise size with 100 pixels width and 190 pixels height. Based one the result, camera still read the marker and show the video. The calculation as follows:

$$A_1 = W \times H$$

$$= 100 \text{ pixels} \times 190 \text{ pixels}$$

$$= 19{,}000 \text{ pixels}^2$$

2. Treatment 2 :

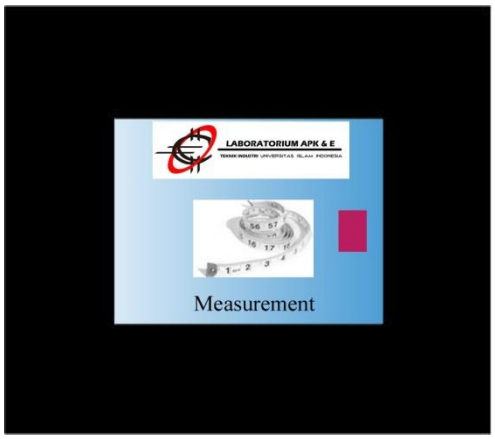


Figure 5.3 Treatment 2

In this treatment, the noise size with 200 pixels width and 340 pixels height. Based on the result, camera still read the marker and show the video. The calculation as follows:

A_2 = W x H

= 200 pixels x 340 pixels

= 68,000 $pixels^2$

3. Treatment 3 :



Figure 5.4 Treatment 3

In this treatment, the noise size with 340 pixels width and 400 pixels height. Based on the result, camera still read the marker and show the video but in weak detection. The calculation as follows:

$$A_3 = W \times H$$

$$= 340 \text{ pixels} \times 400 \text{ pixels}$$

$$= 136{,}000 \text{ pixels}^2$$

4. Treatment 4:



Figure 5.5 Treatment 4

In this treatment, the noise size with 500 pixels width and 420 pixels height. Based on the result, camera still read the marker and show the video but also in weak detection. The calculation as follows:

$$A_4 = W \times H$$

$$= 500 \text{ pixels} \times 420 \text{ pixels}$$

$$= 210{,}000 \text{ pixels}^2$$

5. **Treatment 5 :**



Figure 5.6 Treatment 5

In this treatment, the noise size with 750 pixels width and 500 pixels height. Based on the result, camera cannot read the marker and the video at all. The calculation as follows:

$$A_5 = W \times H$$

$$= 750 \text{ pixels} \times 500 \text{ pixels}$$

$$= 385{,}000 \text{ pixels}^2$$

5.2 The Accuracy Level of the Used Toolkit

The accuracy level of the used toolkit can be determined by calculating the noise detection in the marker. The formula to measure the accuracy level of the used toolkit is shown in Equation 5.2.

$$ND = \frac{AN}{AM} x100\% \quad \text{.....(5.2)}$$

Where :

ND = Noise Detection (Percentage)

AN = Area of Noise (Pixel)

AM = Area of Marker (Pixel)

Based on the equation above, there are several steps to measure the accuracy level of the used toolkit and will be explained in detail as follows:

1. **Noise 1 :**

$$\mathrm{ND} = \frac{\mathrm{AN}}{\mathrm{AM}} \mathrm{x}\,100\%$$

$$\mathrm{ND} = \frac{19{,}000\,\mathrm{pixels}}{2{,}500{,}000\,\mathrm{pixels}} \mathrm{x}\,100\% = 0.76\%$$

2. **Noise 2 :**

$$\mathrm{ND} = \frac{\mathrm{AN}}{\mathrm{AM}} \mathrm{x}\,100\%$$

$$\mathrm{ND} = \frac{68{,}000\,\mathrm{pixels}}{2{,}500{,}000\,\mathrm{pixels}} \mathrm{x}\,100\% = 3\%$$

3. **Noise 3 :**

$$\mathrm{ND} = \frac{\mathrm{AN}}{\mathrm{AM}} \mathrm{x}\,100\%$$

$$\mathrm{ND} = \frac{136{,}000\,\mathrm{pixels}}{2{,}500{,}000\,\mathrm{pixels}} \mathrm{x}\,100\% = 5\%$$

4. **Noise 4 :**

$$\mathrm{ND} = \frac{\mathrm{AN}}{\mathrm{AM}} \mathrm{x}\,100\%$$

$$\mathrm{ND} = \frac{210{,}000\,\mathrm{pixels}}{2{,}500{,}000\,\mathrm{pixels}} \mathrm{x}\,100\% = 8\%$$

5. **Noise 5 :**

$$\mathrm{ND} = \frac{\mathrm{AN}}{\mathrm{AM}} \mathrm{x}\,100\%$$

$$\mathrm{ND} = \frac{385{,}000\,\mathrm{pixels}}{2{,}500{,}000\,\mathrm{pixels}} \mathrm{x}\,100\% = 15\%$$

Based on the result above, the accuracy level of the used toolkit has 85 %. It means that the webcam still able to show the video which has marker contained noise less than 15 %. Thus, the marker can be varied if marker value higher than 15 %.

CHAPTER VI

CONCLUSION AND SUGGESTION

This chapter presents the conclusion and suggestion of this research. All sub chapters will be explained as follows:

6.1 Conclusion

The result of the research can be concluded as follows:

1. The developed AR system is able to visualize Micromotion Study module.
2. The accuracy level of marker is 85%. It means that system can read the marker with noise less than 15 %.

6.2 Suggestion

1. For the next research can use dynamic threshold to decrease the noise level because it can reduce the noise.
2. Develop further research for another APK & E subjects using AR technology in order to make understand better of the students.

References

Dangelmaier et al. 2004. Virtual and augmented reality support for discrete manufacturing system simulation. *Computers in Industry* **56***: 371–383*.

Lu, SC-Y., Shpitalni, M. & Gadh, R. 1999. Virtual and augmented reality technologies for product realization. *Annals of the CIRP* **48(2)**: 471–495. USA.

Yuan. M. L et al. 2000. Assembly guidance of augmented reality environments using a virtual interactive tool. *National University of Singapore*. Singapore.

Tateno, K., Kitahara, I. & Ohta, Y. 2005. A nested marker of augmented reality. *Proceedings of the 2nd International Workshop on Augmented Reality*. Japan.

Reinhart, G. & Patron, C. 2003. Integrating augmented reality in the assembly domain – fundamentals, benefits and applications. *Proceeding of TU Munchen, Garching.* Germany.

Ong, W. 2011. Augmented assembly technologies based on 3D bare-hand interaction. *National University of Singapore* 11757. Singapore.

Dorfmuller, K. 2011. Robust tracking for augmented reality using retroreflective markers. *ZGDV Computer Graphics Center, Visual Computing Department, Rundeturmstr* 6D-64283. Germany.

Domingues et al. 2010. Virtual laboratories in (bio)chemical engineering education. *IBB–Institute for Biotechnology and Bioengineering, Centre of Biological Engineering, Universidade do Minho, Campus de Gualtar*. Portugal.

Khapre & Chandramohan. 2011. Personalized web service selection. *Department of Computer Science, Pondicherry University, Pondicherry*. India.

Kato & Billinghurst. 1999. Marker tracking and HMD calibration for a video-based augmented reality confrencing system. *Proceedings of the 2nd IEEE and ACM International Workshop on Augmented Reality 85-94.* San Francisco.

Hlavac, V. 2008. Image segmentation. Czech Technical University, Faculty of Electrical Engineering, Department of Cybernetics. (online) : http://cmp.felk.cvut.cz (May 5th 2011).

Burke, D.W. et al. 1991. Micromotion of cemented and uncemented femoral components. *British Editorial Society of Bone and Joint Surgery*. USA.

Siegl, H. et al. 2007. An augmented reality human–computer interface for object localization in a cognitive vision system. *Image and Vision Computing* **25**: 1895–1903.

Shen, Y., Ong, S.K. & Nee, A.Y.C. 2010. Augmented Reality for collaborative product design and development. *Design Studies* **31**: 118-145.

Kustiawan, I. 2005. Tsunami augmented reality: interaction of marker as a pointer. *Proceedings of the ACM Symposium on Interactive 3D Graphics* 35-38.

Saqoosha. 2010. How to use FLARToolKit. (online): http://saqoosha.net (March 2th 2011).

Reinhart, G. & Patron, C. 2003. Integrating augmented reality into assembly domain. *Proceedings of ClRP Design Seminar on New Tools and Product Development* 131-143.

Azuma, R.T. 1997. A survey of augmented reality. *Teleoperators and Virtual Environments* **6***:* 355-385.

Fernandez, B.C.A. & Sanchez, J.F. 2008. Acceptance of an augmented reality system as a visualization tool for computer-aided design classes. *Interactive Educational Multimedia An on time journal published.* Barcelona.

Hsieh, M.C. & Lin, H.C.K. 2010. Interaction design based on augmented reality technologies for english vocabulary learning. *Proceeding of the 18th International Conference on Computers in Education*.

Tang, A et al. 2003. Comparative effectiveness of augmented reality in object assembly. *New Techniques for Presenting Instructions and Transcripts* **5**: 1.

Fritz, F., Susperregui, A. & Linaza. M.T. 2005. Enhancing cultural tourism experiences with augmented reality technologies. *Asociación VICOMTech, San Sebastian.* Spain.

Pang, Yan et al. 2006. Assembly feature design in an augmented reality environment. *Assembly Automation* **26(1)**: 34-43. USA.

Jayaram et al. 1999. VADE : A virtual design environment. *IEEE Computer Graphics and Application* **19(6)**: 44-50.

Kothe, U. 1998. Primary image segmentation. *Fraunhofer-Institut für Graphische Datenverarbeitung*. Germany.

Otsu, N. 1979. A threshold selection method from grey-level histogram. *IEEE Transactions on System, Man, and Cybernetics* **9:** 1.

APPENDICES

1. Main File

1.1 Webcam

```
import org.papervision3d.objects.primitives.Sphere;

import org.papervision3d.lights.PointLight3D;
import org.papervision3d.materials.WireframeMaterial;
import org.papervision3d.materials.shadematerials.FlatShadeMaterial;
import org.papervision3d.materials.VideoStreamMaterial;
import org.papervision3d.materials.utils.MaterialsList;
import org.papervision3d.objects.primitives.Cube;
import org.papervision3d.objects.primitives.Plane;
import org.papervision3d.objects.parsers.Collada;


[SWF(width=700,height=700,frameRate=30,backgroundColor=0x0)]

public class SimpleVideo extends PV3DARApp {

    private static const PATTERN_FILE:String = "resources/measurement.pat";
    private static const CAMERA_FILE:String = "resources/camera_para.dat";

    protected var plane:Plane;
    protected var objectsContainer:DisplayObject3D;
    protected var quality:uint = 16;
    protected var netConnection:NetConnection;
    protected var video:Video;
    protected var netStream:NetStream;
```

1.2 Marker Detection

```
[SWF(width=700,height=700,frameRate=30,backgroundColor=0x0)]

public class SimpleVideo extends PV3DARApp {

    private static const PATTERN_FILE:String = "resources/measurement.pat";
    private static const CAMERA_FILE:String = "resources/camera_para.dat";

    protected var plane:Plane;
    protected var objectsContainer:DisplayObject3D;
    protected var quality:uint = 16;
    protected var netConnection:NetConnection;
    protected var video:Video;
    protected var netStream:NetStream;

    protected var cube:Cube;
    protected var imageMat:BitmapFileMaterial;
    protected var video_cube:Cube;
    protected var vni_logo_cube:Collada;
    protected var videoMat:VideoStreamMaterial;
    protected var fmat:FlatShadeMaterial;
    protected var wmat:WireframeMaterial;

    public function SimpleVideo()
    {
        addEventListener(Event.INIT, onInit);
```

1.3 Video

```
private function onInit(e:Event):void
{
    removeEventListener(Event.INIT, onInit);

    //Create light source for shade material
    var light:PointLight3D = new PointLight3D();
    light.x = 1000;
    light.y = 1000;
    light.z = 1000;

    // create client for netStream object
    var customClient:Object = new Object();
    customClient.onMetaData = metaDataHandler;

    netConnection = new NetConnection();
    netConnection.connect(null);

    netStream = new NetStream(netConnection);
    netStream.client = customClient;
    netStream.play("resources/Mengukur.flv");
    // add listener for net status to control video looping
    netStream.addEventListener(NetStatusEvent.NET_STATUS, statusHandler);
```

```
video = new Video();
video.width = 500;
video.height = 500;
video.smoothing = true;
//video.deblocking = 5;
video.attachNetStream(netStream);

//Create Materials
videoMat = new VideoStreamMaterial(video, netStream, true, true);
fmat = new FlatShadeMaterial(light, 0x214fa1, 0x18347b);
wmat = new WireframeMaterial(0xff0000);
wmat.doubleSided = true;

//Create objects
objectsContainer = new DisplayObject3D();
plane = new Plane(wmat, 100, 100,1,1);
video_cube = new Cube(new MaterialsList( { front: videoMat } ), 250, 1, 250, quality, quality, qu
//vni_logo_cube = new Collada("resources/vni_logo.dae", new MaterialsList( {all : fmat } ), .1,
```

```
}

override protected function _onEnterFrame(e:Event = null):void
{
    super._onEnterFrame(e);
}

private function metaDataHandler(infoObject:Object):void
{
    trace('metaDataHandler= ',infoObject);
}

private function statusHandler(eventObject:Object):void
{
    if(eventObject.info.code == "NetStream.Play.Stop")
    {
        // loop video
        netStream.seek(0);
    }
```

2. Video File

```
private function onStreamStatus ( event:NetStatusEvent ):void
{
    switch ( event.info.code )
    {
        case "NetStream.Play.Start":
            animated = true;
            break;
        case "NetStream.Unpause.Notify":
            animated = true;
            break;
        case "NetStream.Play.Failed":
            animated = false;
            break;
        case "NetStream.Play.Stop":
            animated = false;
            break;
        case "NetStream.Play.StreamNotFound":
            animated = false;
            break;
        case "NetStream.Pause.Notify":
            animated = false;
            break;
        case "NetStream.Seek.Notify":
            animated = true;
        break;
```

3. Papervision

```
package org.papervision3d
{
    import org.papervision3d.core.log.PaperLogger;


    /**
    * The Papervision3D class contains global properties and settings.
    */
    public class Papervision3D
    {
        // ____________________________________________________ SETTINGS


        /**
        * Indicates if the angles are expressed in degrees (true) or radians (false). The default
        */
        public static var useDEGREES  :Boolean = true;

        /**
        * Indicates if the scales are expressed in percent (true) or from zero to one (false). Th
        */
        public static var usePERCENT  :Boolean = false;
```

4. Camera 3D

```
public override function orbit(pitch:Number, yaw:Number, useDegrees:Boolean=true, target:DisplayObject3D=null
{
    target = target || _target;
    target = target || DisplayObject3D.ZERO;

    if(useDegrees)
    {
        pitch *= (Math.PI/180);
        yaw *= (Math.PI/180);
    }

    // Number3D.sub
    var dx          :Number = target.world.n14 - this.x;
    var dy          :Number = target.world.n24 - this.y;
    var dz          :Number = target.world.n34 - this.z;

    // Number3D.modulo
    var distance    :Number = Math.sqrt(dx*dx+dy*dy+dz*dz);

    // Rotations
    var rx :Number = Math.cos(yaw) * Math.sin(pitch);
    var rz :Number = Math.sin(yaw) * Math.sin(pitch);
    var ry :Number = Math.cos(pitch);
```

5. Bitmap

```
public class BitmapViewport3D extends Viewport3D implements IViewport3D
{

    public var bitmapData       :BitmapData;

    public var _containerBitmap :Bitmap;
    protected var _fillBeforeRender:Boolean = true;
    protected var bgColor           :int;
    protected var bitmapTransparent:Boolean;

    public function BitmapViewport3D(viewportWidth:Number=640, viewportHeight:Number=480, autoScaleToStage
    {
        super(viewportWidth, viewportHeight, autoScaleToStage, interactive, true, autoCulling);
        this.bgColor = bgColor;
        _containerBitmap = new Bitmap();

        bitmapData = _containerBitmap.bitmapData = new BitmapData(Math.round(viewportWidth), Math.round(vi
        scrollRect = null;
        addChild(_containerBitmap);
        removeChild(_containerSprite);
    }

    override public function updateAfterRender(renderSessionData:RenderSessionData):void
    {
        super.updateAfterRender(renderSessionData);
```