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Master's Thesis

Academic Year 2014

Layered Information Overlay on Telexistence using Augmented Reality Techniques

Graduate School of Media Design,
Keio University

Chaiwat Meetanatharvorn

A Master's Thesis

submitted to Graduate School of Media Design, Keio University

in partial fulfillment of the requirements for the degree of

MASTER of Media Design

Chaiwat Meetanatharvorn

Thesis Committee:

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Abstract of Master's Thesis of Academic Year 2014

Layered Information Overlay on Telexistence using Augmented Reality Techniques

Category: Science / Engineering

Abstract

Telexistence is fundamentally a concept named for the general technology that enables a human being to have a real-time sensation of being at a place other than where he actually exists, and to interact with the remote environment [1] . We have achieved human-like neck movements to visually interact with a remote object in 3 dimensional spaces through previous versions of TELESAR We introduce TELESAR V which maps a user spinal1, neck, head and arm movements into a dexterous slave robot and allowing the operator to feel the robot body as his own body through visual, auditory, kinesthetic and fingertip tactile sensation. With TELESAR V, operator can perform tele-operations confidently with no prior practice. However, in Telexistence theory, there is an opportunity to provide information by using augmented reality to increase the robot capability and user's satisfaction.

The paper propose layered Information overlay system that can provide information according to distance of robot and object. The information such as object properties, personal information and visual remote controller are necessary for user because user can go anywhere user want and when user goes to some place that user is not familiar with, user need information to help him/her to achieve the goal. However, without layered based information system, user will get too much of detail and information that may disturb his/her vision that can make a trouble in the end.

With this system, user can feel comfortable to look at the object he/she is

interesting and receive the appropriate information at the appropriate distance. User can get closer to the object to learn more. This kind of interaction is a very intuitive way of human behavior. As a result, user have no need to learn how to select information, just only one sentence, user will know how to do the interaction which increase the ease of use and satisfaction in the end.

This kind of interaction can be applied for much kind of robot and also head mounted display. In recent technology, it can be say that the future head mounted display can become a widely use and augmented reality itself will become one of the important technology. At that time, layered based information also can be applied for any kind of information provider and become standard of interaction way in the end.

Keywords:

Telexistence, Vitual Reality, Telepressence, Robot, Augmented Reality

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1. Introduction

1.1 Augmented Reality

Augmented reality is a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data. It is related to a more general concept called mediated reality, in which a view of reality is modified (possibly even diminished rather than augmented), by a computer. As a result, the technology functions by enhancing one's current perception of reality. By contrast, virtual reality replaces the real world with a simulated one. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulate-able. Artificial information about the environment and its objects can be overlaid on the real world. [2]

Nowadays, augmented reality tends to become more and more important to the user in daily life. They use it for see the map, entertainment, getting information; interact with people in the same society and so on. The information is unlimited but the physical space such as field of view, screen size, readable text size are limited, so, this paper concerns how to categorized information in limited space.

So, this paper will describe how to categorize information in augmented reality technology and then trying to integrate to Telexistence technology which call 'Layered Information Overlay on Telexistence using Augmented Reality Techniques'

In the result, this platform it will help user be able to understand the specific object by just look at the object and be able to get more information by get closer to the object. And in the hope that the better information user receives it will be lead user to become more knowledgeable and have a potential to inspire the wisdom in the end. [3]

1.2 First-person view Augmented Reality

Sight [4] concept video shows the future augmented reality in normal social life style by attach the augmented reality into contact lens. Na-no technology tends to be very important factor to realize this concept. Moreover, the ways to choosing information are not so clear but the experience itself is very outstanding and it became one of the most important concepts that inspire this research. This paper is trying to realize object properties, personal information and remote controller which all showed in this concept video. User can check what kind of product was places inside the box, and be able to pick the right object very easily and faster compare to normal behavior which user need to pick each of object at check it one by one to see what is inside and the remaining. So this function is very useful when user want to find an object with limited information scenario.

Figure 1-1: Object properties: Augmented Reality concept in Sight concept video

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Next focused function call 'personal information', it is the function that be able to provide information of opposite side just like seeing Facebook at the same time as talking to opposite side. You will be able to know, what she like or don't like. What is her background, what is her recently news. All of this information is very useful when you interesting in someone as it are

very success in internet world. Someone say that Facebook help you to keep in touch with your high school friend even if they are study aboard or even, life aboard. So, this paper believe that augmented reality system has a very strong social impact if it can be able to provide social community which is become more immersive and intuitive compare to using website as media. Moreover, Sight concept video doesn't focus on only personal information. Sight video also focuses on analyzing opposite site feeling and advice user to response to individual action. For example, when she feel depress, the system will advise user to go and change the place or making a joke. This kind of function will be very useful when you don't know other's language or when the communication is limited. For example, when your girlfriend angry on something but you don't know what it is but it make you feel uneasy. At that time, you trying to talk to her but she won't tell you about it. And you don't know what to do next. AT that time, if you have system that help you to understand what is inside her mind, and what should you do to solve this uneasy atmosphere, it will be very useful and your relationship can be recover faster and easier..

Figure 1-2: Personal information concept in Sight concept video

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Other function concept call 'video controller'. In this function concept, user can choose to order the drink by using virtual controller right

away without waiting for waiter to come and receive the order. Newsday, some chain restaurant use tablet to receive order instead of using waiter which is very useful and reduce time consumption, labor cost and human-error at the same time. Tablet is very strong media and very useful but there is a limitation on using device which is the limitation of space and hand control. To solve those issues, using augmented reality which has no issue on space and no need to pick anything by hand will become easier and more intuitive. Sight concept only show video controller using for ordering the wine but in this paper, it will focus more on how to open the controllable device such as television or others. When Telexistence user be able to control the stuff by using the robot, user may feel as if he/she is super hero and have a special power compare to his/her normal life and it can be a very good experience in the end.

Figure 1-3: Virtual Controller concept in Sight concept video

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1.2.1 Wearable Augmented Reality

Augmented reality tends to be used for many kind of information provider. Here is one of the interesting concepts from Iron Man movie [5]. When Tony Stark wear Iron Man suit, he will get information provided by

computing system. The information such as object properties, human identification, emotion tracking, zoom in and out was proposed from this movie with very rich and beautiful user interface. Iron Man can use all of information to detect who is the terrorist and who are normal people and he will be able to target correctly and shot them with one strike. Moreover, when he was targeted by missile, system also warns him by voice. Most of interactions tend to be focus on military concept but with the same interaction such as human identification, Telexistence robot will have a potential to be utilized as a patrol police robot in the future.

The concept from RoboCop [6] movie is focus more on police activities compare to Iron Man idea. RoboCop movie showed the concept of using augmented reality into high-tech Cyborg. When Cyborg need to identify the terrorist out of crowd, he is just look at them and system will show the result automatically. It is very easy and effective if it can be realize.

Moreover, in RoboCop movie, RoboCop use physical analysis with augmented reality to analysis where to shot and how the bullet reflects from that angle. So, ROBOCOP can shot the gun indirect way but it can reach the target precisely.

1.3 Telexistence

There is Telexistence theory that aims to afford a remote person the opportunity to virtually participate in a gathering or party by using a surrogate robot to communicate with local participants while moving around freely at the party venue. A mutual Telexistence surrogate robot system was designed for achieving this aim. The prototype system was developed and its efficacy was verified through demonstration experiments.

Telexistence theory that aims to afford a remote person the opportunity to virtually participate in a gathering or party by using a surrogate robot to communicate with local participants while moving around freely at the party venue. A mutual Telexistence surrogate robot system was designed for achieving this aim. The prototype system was developed and its efficacy was verified through demonstration experiments. [1]. By using this theory, the paper will be able to mix augmented reality with Telexistence and

it will provide a new value which may become as Son-Goku with Scouter. [7]

Son-Goku with scouter can detect enemy power and decide to fight or not to fight and it will be very useful to protect his life from danger. Moreover, he can teleport to anywhere in the universe with just a blink of the eye just like 'Telexistence theory' can be provide. Especially, it became the most important point in TELEBee: Ubiquitouse Telexistence research. [8]

Moreover, for someone who getting ill and cannot go travel or somewhere far from home due to their illness, they need technology that can lets him to be able to go where he/she wants. For example, the writers' father cannot go to Japan due to his personal illness. He really wants to go to Japan and see writer. Writer also wants to bring him to Japan one day but it is impossible due to time and pressure inside a plane that will affect his health.

Writer was thinking what if I have one technology that can bring his father to Japan, what kind of technology is the most appropriate. Writer's answer is Telexistence Robot. Telexistence Robot can let the user goes beyond time and space contains just like Doraemon's DokodemoDoor. [9] With this technology, writer can bring his father to Japan and having fun travelling with him. That was the beginning of my journey in Telexistence.

1.4 Potential Use of Augmented Reality in Telexistence

There are many opportunity to use this kind of system in the future such as, use it for learning, instruction, designing, marketing, collaborating, guiding, translating, , entertaining and so on. Augmented reality can aid robot to be more advanced and have more capability to achieve the specific purpose.

About object properties, in short term plan, AR frame is still limited on high contrast picture and high graphic cue. If the graphic cue and contrast is low 'false positive' become high and tend to disturb the user experience. To reduce the error for selecting picture, standardization tends to become on issue to be solve. The standardization can be applied by software with automatic increase the contrast of the picture or showing the quality of picture by rating as a star. For example, good picture will get 5 star and worst picture will get 0 star. In this method, user can know which

picture is best suit for AR frame in the end.

In long term plan, AR frame can be applied for commercialize. AR frame can be used as a standard frame that can change the content of the product without losing the AR marker. For example, when Car Company wants to sell a new car name 'A0', they will plan to do it on domestic and oversea. Using AR frame, the entertainment and information provider can be use anywhere in the world. Car Company just needs to change the language of the poster while using the same picture and format. As the result, AR frame will reduce time consumption, reduce the cost and also provide more entertainment method which lead to selling value in the end.

About personal information, in short term plan, the shape and design need to be closest to human face because user tends to look at the face of opposite side rather than looking at a badge. The size of AR badge is very small and limited, so the distance of AR also limited only 1.7 meters. The future work objective is to provide the higher distance with acceptable size of marker. Moreover, there is an opportunity to use face recognition for individual human and set it as a marker in the future. If that kind of technology become commercialize, the experience and AR badge will be improve accordingly.

In long term plan, AR Badge: Layered based information will focus on the community platform. The system has an opportunity to become a center of personal information that user can share within member in community by using cloud based information that everybody can register, edit or design their own information and be able to print the personal data AR code by their own will. Moreover, the benefit on using this system is tend to become more important due to this system can be apply to use for google glass or next generation of head mounted display that can provide augmented reality. When head mounted display become normally used, layered based information can be used to provide the interaction between human and human or human and robot. At that time, human can know each other more, and can share the same interest or conversation without start asking 'what is your favorite football club? or where are you from?' the system will tell you right in front of user's eyes and user will feel more

comfortable to talk with someone who first met or even someone you want to start talking to. Relationship will become closer and we can know each other more and more.

About virtual controller, in short term plan, virtual controller need to be uses as wireless communication. Using Bluetooth or Wi-Fi system connects to Arduino board is one of an appropriate method. The data can transfer through the network and pass by signal. As a result, it will increase the ease of use, opportunity to use, potential and so on. Not only sending the data but receiving the data also provides a better interaction. For example, when user want to control another robot, he may look at robot and see whether other people is using it or not, he may know how long he can use it, what is the remaining battery and how to register and so on. So receiving data can increase more interaction and make the controlling become smoother.

In long term plan, virtual controller can be applied for robot and robot to interact between robots itself. For example, user using TELUBee Robot wants to control TelesarV to pick up the object. User can just look at TelesarV and control it by controller. Or other situation is to check hand with person near you. Because TELUBee doesn't have a hand or it can borrow hand from TelesarV to check hand or playing around with person inside the room. Virtual controller can be used for many kind of aspect and which would be useful for robot controller.

Moreover, using augmented reality in different type such as combine augmented reality in to Davinci – medical robot for remote operation. It wouls increase the potential of operation and it can detect the wrong behavior or situation and announce it to doctor in real time. As the result, operating success rate would increase and reduce time for gathering information and doctor can see the real situation while receiveing information or data that would be useful and the operation would take an action on time.

On culture aspect, augmented reality can be used to help user learn how to do the right step in the culture event such as tea ceremony in Japan. Tea ceremony has a very strict step on movement. This can be thought by

overlay information in real time. So, user just follows the guidance from system then he/she would be able to learn it from take a real action.

There is many more aspect such as engineering, architecture which will be written in chapter 2 in detail.

After the research on Telexistence technology, there is an issue about when user has to go to the place they are not familiar with, user need information that could help them achieve the specific goal. For example, when user wants to find a screw driver in the unknown lab environment, user doesn't know where to start, user need to walk randomly around to find screwdriver. So this kind of ordinary method can become easier by using augmented reality to provide information [10] when user enters the room, user will be able to get information of the room as low level detail of layer to optimize the visual disturbance and it will increase level according to the distance between user and interested object. However, augmented reality technology also has a limitation by itself, such as field of view, track able distance which would limit the area to provide information. This paper also written about how to increase the quality of tracking system to increase the user experience in the end The scope of this research will also focus on how to provide information to the user in the efficient way and useful especially when using in Telexistence robot. Telexistence robot have camera, computing power and freedom of movement which is the most appropriate to integrate augmented reality. Robot doesn't need any hardware modification. Software would be used as filter on cockpit part. After sending the video streaming from robot eyes to the cockpit, then the program from cockpit will provide augmented reality experience.

However, the way to provide information need to be concern due to limitation of the physical screen, the readable size of information, distance and field of view as mentioned.

So, this paper will describe how to categorize information inside Telexistence technology which call 'Layered Information Overlay on Telexistence using Augmented Reality Techniques'

In the result, this platform it will help user be able to understand the specific object by just look at the object and be able to get more

information by get closer to the object. And in the hope that the better information user receives it will be lead user to become more knowledgeable and have a potential to inspire the wisdom in the end. [3]

1.5 Research Goal

To create augmented reality with intuitive user interface that everybody will be able to use it without any training. When user looks at the object in the desire position, it will show the information automatically. And when user gets closer to the object, user will get deeper information.

As a result, user will be able to pick the right object or even know the owner of that object and bring it back to user. Moreover, using personal information would be useful when user want to interact with the person who user first meets. User will be able to know ordinary information and also know how to interact and impress other side.

In the hope that this paper will inspired people who interest in Telexistence theory, augmented reality technique or the way to distribute information by distance to find a better scenario to utilize layered based technology not only for Telexistence robot but for all kind of augmented reality experience to get a best result and maximize user experience in the end.

Writer believe that with this technology, the way of future interaction, way of receiving information will become more intuitive and there is no need to use any controller to select the information anymore.

1.6 Thesis Parts

This paper is divine into 4 sections. First section is introduction about how this research began and what kind of goal the research wants to achieve. Second section will talk about related research on Telexistence technology, Tele-Operation robot, ideal of information, how the user perceive the information and also how to design the interaction by concerning about user experience as a main. Moreover, the benefit of augmented reality in this present world and potential benefit in the future will be written on this section. Third section is implementation plan and design. It will focus on

detail how to create the interaction, integration, design information, user interface and so on. And last section will be the evaluation point from user study. To evaluate the satisfaction, time for achieving the goal, how the time been improved compare ordinary information provider with layer based information.

2. Related Research

Nowadays, there is Telexistence that is fundamentally a concept named for the general technology that enables a human being to have a real-time sensation of being at a place other than where he or she actually exists, and being able to interact with the remote environment, which may be real, virtual, or a combination of both. It also refers to an advanced type of tele-operation system that enables an operator at the control to perform remote tasks dexterously with the feeling of existing in a surrogate robot working in a remote environment. Telexistence in the real environment through a virtual environment is also possible. The user can feel as if user goes to the remote place by using Telexistence robot such as "TELESAR V" or "TELUBee"

However when the user go to the specific place, it will be useful, easy to use and flexible if robot have a technology that can provide information such as object properties, personal information for interaction and control the controllable device though network.

So, to achieve the goal of providing useful information to increase the understanding of the object, understanding personality of the person who you talk to and also be able to interact with the object in remote place, it necessary to understand Telexistence, Augmented Reality and the way to provide the information or even how to store the data and how to manage it. It will be able to categorize as following subjects;

1. Telexistence and Tele-presence
2. User Interface Design
3. Augmented Reality

2.1 Telexistence and Tele-Pressence

There is Telexistence theory that aims to afford a remote person the opportunity to virtually participate in a gathering or party by using a surrogate robot to communicate with local participants while moving around freely at the party venue. A mutual Telexistence surrogate robot system was designed for achieving this aim. The prototype system was

developed and its efficacy was verified through demonstration experiments.

Figure 2-1: Telexistence Theory

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2.1.1 TELSAR V

"TELESAR V" is the technology that maps a user's spinal neck, head and arm movements into a dexterous slave robot and allowing the operator to feel the robot's body as his own body through visual, auditory, kinesthetic and fingertip tactile by implemented with development of speed, robust, full upper body, mechanically unconstrained master cockpit and a 53 degrees of freedom (DOF) anthropomorphic slave robot. TELESAR V was able to provide an experience of user's body in space and that's the most simple and fundamental experience for feeling to be someone somewhere. "TELESAR V" system was evaluated technically to find out the speed limitations, reaching, and grapping capabilities. With existing system, an initial evaluation was carried out to prove the effectiveness of "Body Schema Transfer Model". [11]

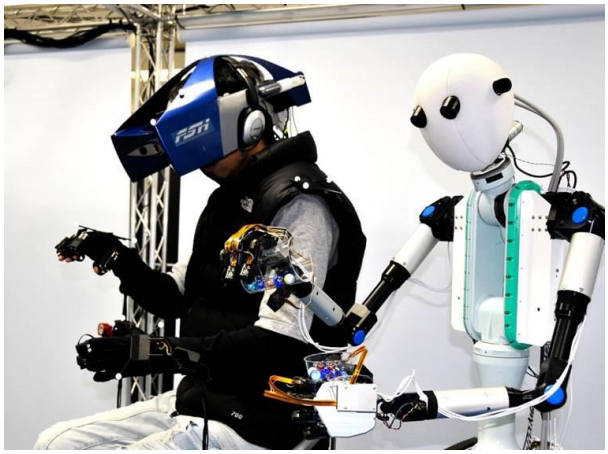

Figure 2-2: TELESAR V: Master – Slave Telexistence System

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User can feel as if he/she go there and Telexistence platform for Ubiquitous Embodied Experience called 'Telubee' which can let's user go beyond time and space contains.

2.1.2 TELUBee

"TELUBee" is ubiquitous Telexistence which is to achieve the kind of experience to go any remote location in a moment from living space or home office. The technology can provide omnipresence and real time presence. As the result, the user can feel as if they can teleport to anywhere at any time. [8]

Figure 2-3: TELUBee robot

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2.1.3 Tele-Presence robots in the market

The aim of this research is focus on Telexistence robot but it can be apply to use in many different robot in the market such as AnyBot [12], VGo [13] or even if wearable device such as Google Glass [14], OVR Vision [15] and so on.

It can create a new community through the platform and to the different robot.

2.2 Augmented reality project for specific purposes

In order to provide information to the user, the most appropriate way is to use Augmented Reality technique that will impose 3d world into the real world by catch the object as a marker. Augmentation is conventionally in real-time and in semantic context with environmental elements, such as sports scores on TV during a match. With the help of advanced augmented reality technology (e.g. adding computer vision and object recognition) the information about the surrounding real world of the user becomes interactive and digitally manipulate-able. Artificial information about the environment and its objects can be overlaid on the real world. [16] [17] Moreover, augmented reality is the technology that provides information and aid user such as following purposes;

1. Learning Purpose

Augmented reality can be provide text, video, voice and any graphic to make student be more understand on what they are learning [18] [19]. It also can be prove that student become more interesting in the specific subject by using augmented reality in the class. There is also the augmented reality that can provide the interaction of chemistry which will lead the student to get closer to the molecule level which student cannot be seen by normal eyes but it can be demonstrate thought augmented reality. [20]. Some of the research is using augmented reality to detect the rising hand can be able to determines and gain more attention when someone rising hand and wanted to speak. Compare to traditional way of raising hand without augmented reality, it shows that the teacher be able to get student's attention easier. [21]

Moreover, AR technology has matured to the point where it can be applied to a much wider range of application domains, and education is an area where this technology could be especially valuable. The educational experience offered by Augmented Reality is different for a number of reasons, including:

· Support of seamless interaction between real and virtual environments

· The use of a tangible interface metaphor for object manipulation

· The ability to transition smoothly between reality and virtuality. [22]

2. Marketing Purpose

Augmented reality is applied to use on commercial by showing more content such as link, video, content or moving 3d animation into the catalog. The well-known IKEA book is one of a good example [23]. On apparel store such as TOPSHOP also use augmented reality as a virtual fitting room that user can select what to wear and it will augmented to user's body. User has no need to wait for fitting room to be available and time consumption also reduce significantly. [24] JURA watch using augmented reality in e-commerce application that user can try the watch from the store in real size and real-time. User can test the watch become buying without going to real store to test the product. And because it is an e-commerce, so if user likes the watch, he can buy it right away. [25] OMEGA's watch also use newspaper as a trigger to show 3d watch by using mobile application. The special function on this application is the user can change the color of the watch by just shake the mobile. [26] So it can be say that augmented reality can enhance product previews such as allowing a customer to view what's inside a product's packaging without opening it. [27] Augmented reality can be used as an aid in selecting products from a catalog or through a kiosk. Scanned images of products can activate views of additional content such as customization options and additional images of the product in its use. [28] [29] AR is used to integrate print and video marketing. Printed marketing material can be designed with certain "trigger" images that, when scanned by an Augmented reality enabled device using image recognition, activate a video version of the promotional material. A major difference between Augmented Reality and straight forward image recognition is that you can

overlay multiple media at the same time in the view screen, such as social media share buttons, in-page video even audio and 3D objects. Traditional print only publications are using Augmented Reality to connect many different types of media. [30]

3. Instruction Purpose

Augmented reality can be used to aid engineer and guide him how to reassembling the engine. User have no need to be familiar with the task he is going to do, he can follow the virtual instruction and be able to reassembling the engine. The research also use traditional way of instruction such as paper instruction and video instruction then compare with augmented reality instruction. The result from this research show significant benefit in time-consumption and user satisfaction of augmented reality technique in instruction propose. [31] Moreover, complex tasks such as maintenance and surgery can be simplified by inserting additional information into the field of view. For example, labels can be displayed on parts of a system to clarify operating instructions for a mechanic who is performing maintenance on the system. [32] [33] Assembly lines gain many benefits from the usage of augmented reality. In addition to Boeing, BMW and Volkswagen are known for incorporating this technology in their assembly line to improve their manufacturing and assembly processes. [34] [35] [36] Big machines are difficult to maintain because of the multiple layers or structures they have. With the use of AR the workers can complete their job in a much easier way because AR permits them to look through the machine as if it was with x-ray, pointing them to the problem right away. [10]

4. Collaborating Purpose

Augmented reality can help facilitate collaboration among distributed team members in a work force via conferences with real and virtual participants. AR tasks can include brainstorming and discussion meetings utilizing common visualization via touch screen tables, interactive digital whiteboards, shared design spaces, and distributed control rooms. [37] [38] [39]

5. Guiding Purpose

Augmented reality widely use on guiding purpose such as GPRS, Navigation, Tourism and Travel. In traveling, augmented reality applications can enhance a user's experience when traveling by providing real time informational displays regarding a location and its features, including comments made by previous visitors of the site. AR applications allow tourists to experience simulations of historical events, places and objects by rendering them into their current view of a landscape. [40] [41] [42]AR applications can also present location information by audio, announcing features of interest at a particular site as they become visible to the user. [43] [44] In Navigation guiding purpose, augmented reality has been used as HUD (head up display) began utilize with military aircraft purpose to understand the direction. [45] Then I was adapted to be used for consumer car in the market such as BMW. The technology can provide information such as speed and GPS navigation at the location that underneath the eyes, so the user have no need to look at console which necessary to leave the eyes out of the front view and it may lead to have an accident. So, using head-up display in automobile will increase the safety of the user and provide richer and more understand information compare to the traditional technology. [46] [47] Augmented reality can augment the effectiveness of navigation devices. Information can be displayed on an automobile's windshield indicating destination directions and meter, weather, terrain, road conditions and traffic information as well as alerts to potential hazards in their path. [48] [49] [50]Aboard maritime vessels, AR can allow bridge watch-standers to continuously monitor important information such as a ship's heading and speed while moving throughout the bridge or performing other tasks. [51]

6. Design Purpose

Augmented Reality aids designer to test the designed 3d object in real world before doing mass production. For example, augmented reality can help industrial designers experience a product's design and operation before completion. Volkswagen uses augmented reality for comparing calculated

and actual crash test imagery. [52] Augmented reality can be used to visualize and modify a car body structure and engine layout. Augmented reality can also be used to compare digital mock-ups with physical mock-ups for finding discrepancies between them. [53] [54] It's not just products design but also in architecture, augmented reality can aid in visualizing building projects. Computer-generated images of a structure can be superimposed into a real life local view of a property before the physical building is constructed there. Augmented reality can also be employed within an architect's work space, rendering into their view animated 3D visualizations of their 2D drawings. Architecture sight-seeing can be enhanced with AR applications allowing users viewing a building's exterior to virtually see through its walls, viewing its interior objects and layout. [55] [56] In construction purpose of design, augmented reality can visualize geo referenced models of construction sites, underground structures, cables and pipes using mobile devices. [57] Following the Christchurch earthquake, the University of Canterbury released, City View AR, which enabled city planners and engineers to visualize buildings that were destroyed in the earthquake. [58] Not only did this provide planners with tools to reference the previous cityscape, but it also served as a reminder to the magnitude of the devastation caused, as entire buildings were demolished. Moreover, in art subject augmented reality technology has helped disabled individuals create art by using eye tracking to translate a user's eye movements into drawings on a screen. [59] An item such as a commemorative coin can be designed so that when scanned by an Augmented reality enabled device it displays additional objects and layers of information that were not visible in a real world view of it. [60] [61]

7. Entertainment Purpose

Augmented reality allows gamers to experience digital game play in a real world environment. For example, Play Station 4 made game to robot can go out of Television and walk at the real floor. The user can interact with robot by pushing the button or shaking the controller and robot will response depend on interface. [62] Another example are, AR air hockey, collaborative

combat against virtual enemies, and an AR-enhanced pool games. A significant number of games incorporate AR in them and the introduction of the smartphone has made a bigger impact. [63] [64]Augmented reality has become common in sports telecasting. Sports and entertainment venues are provided with see-through and overlay augmentation through tracked camera feeds for enhanced viewing by the audience. Examples include the yellow "first down" line seen in television broadcasts of American football games showing the line the offensive team must cross to receive a first down. Augmented reality is also used in association with football and other sporting events to show commercial advertisements overlaid onto the view of the playing area. Sections of rugby fields and cricket pitches also display sponsored images. Swimming telecasts often add a line across the lanes to indicate the position of the current record holder as a race proceeds to allow viewers to compare the current race to the best performance. Other examples include hockey puck tracking and annotations of racing car performance and snooker ball trajectories. [65] [66] Augmented reality is starting to allow Next Generation TV viewers to interact with the programs they are watching. They can place objects into an existing program and interact with these objects, such as moving them around. For example, Avatars of real persons in real time who are also watching the same program. [67] Augmented reality can enhance concert and theater performances. For example, artists can allow listeners to augment their listening experience by adding their performance to that of other bands/groups of users. [68] [69] [70]

8. Translate Purpose

Augmented reality can aid user to translate language by using mobile camera. So user just needs to face camera at the word user want to know and the programs will translate it to designed language and augmented right in front of the word. [71]

As mentioned about Telexistence that it will become robot that user can use as user's body and user can feel as if he/she goes there. User can use

Telexistence robot to interact as a normal life and do the stuff together with human. So, most of social activities can be in the scope of Telexistence which can increase the easiness and flexibility on providing information by augmented reality with layered based information platform.

So it can be say that layered based overlay information by using augmented reality in Telexistence robot have a potential to increase the capability of robot and user to support user for many specific tasks as mentioned above.

This paper may focus only on object properties, human interaction and virtual controller as a main scope of the research. But to understand how powerful augmented reality is and to lead someone who wants to create a service by Telexistence robot, augmented reality's capability should be describe in this paper also.

3. Design of Layered Information Overlay in Telexistence using Augmented Reality Techniques

The design is to provide 3 kinds of functions that it will be useful for user to enjoy the remote place and categorized it into 3 layers as following;

1. Object properties

Low Level Information	: Object brand or product name
Medium Level Information	: Explanation of the object. It can be video, picture or sound.
High Level Information	: Technical information such as system diagram or history.

2. Personal Information

Low Level Information	: Name
Medium Level Information	: Nationality, birth place and hobby
High Level Information	: Personality and type of person does him/her likes

3. Remote Controller

To Controller the controllable object by virtual controller.

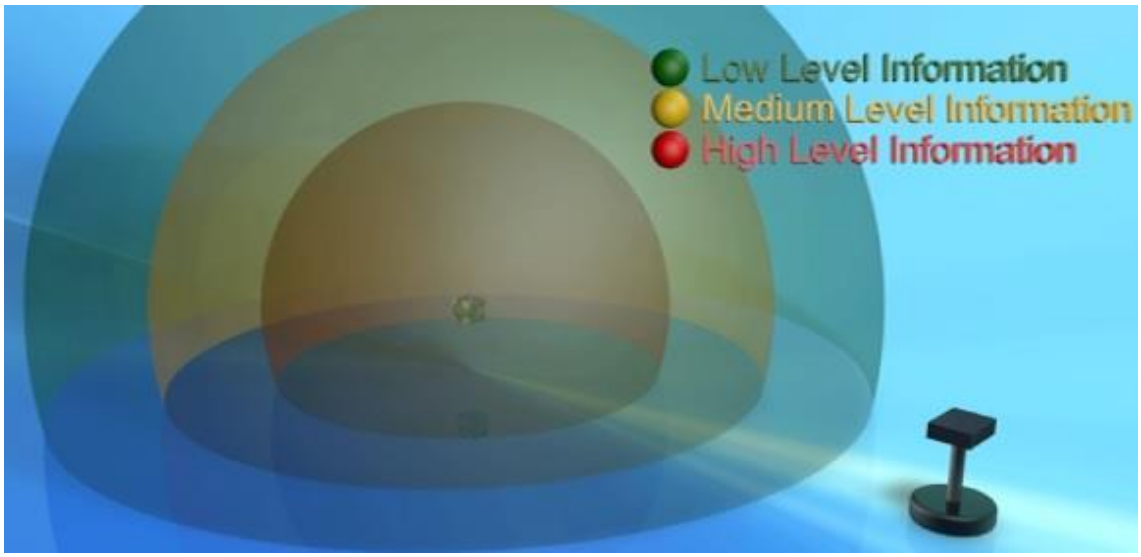


Figure 3-1: Layered information overlay with 3 levels of information

When the information been layered by the system, the user will be able to get information in one specific object without disturbing by too much information or limited information by 1 screen.

3.1 Software and algorithms

A key measure of augmented reality systems is how realistically they integrate augmentations with the real world. The software must derive real world coordinates, independent from the camera, from camera images. That process is called image registration which uses different methods of computer vision, mostly related to video tracking. [65] [72] Many computer vision methods of augmented reality are inherited from visual odometer. Usually those methods consist of two parts.

First detect interest points, or fiduciary markers, or optical flow in the camera images. First stage can use feature detection methods like corner detection, blob detection, edge detection or thresholding and/or other image processing methods. [73] [74] The second stage restores a real world coordinate system from the data obtained in the first stage. Some methods assume objects with known geometry (or fiduciary markers) present in the scene. In some of those cases the scene 3D structure should be pre-calculated beforehand. If part of the scene is unknown simultaneous localization and

mapping (SLAM) can map relative positions. If no information about scene geometry is available, structure from motion methods like bundle adjustment are used. Mathematical methods used in the second stage include projective (epipolar) geometry, geometric algebra, rotation representation with exponential map, kalman and particle filters, nonlinear optimization, and robust statistics.

Augmented Reality Markup Language (ARML) is a data standard developed within the Open Geospatial Consortium (OGC), [75] which consists of an XML grammar to describe the location and appearance of virtual objects in the scene, as well as ECMAScript bindings to allow dynamic access to properties of virtual objects.

To enable rapid development of Augmented Reality Application, some software development kits (SDK) have emerged. [76] [77] Some of the well-known AR SDKs are offered by Metaio [78], Vuforia [79], D'Fusion [80] , In2AR [81], Wikitude [82] and Layar. [83].

In able to give designer to be easy to edit information, I decided to use Unity combine with Metaio SDK to make sure that non-expert programmer like designer can use it to provide information and set up all scenario.

3.2 Capturing Introduction

3.2.1 SDK selection

In order to achieve the way to send the information, selection SDK is one of the most important to make sure that it will have capability to achieve the design goal.

The requirement for selecting the SDK show in following table;

	Metaio	D:Fusion	In2Ar	Vuforia
PC compatible	⭕	⭕	⭕	
3D Object	⭕	⭕	⭕	⭕
Animation	⭕	⭕		⭕
Multiple Tracker	⭕	⭕	⭕	⭕
Marker less	⭕	⭕		
Programming	Javascript,C#,XML	Lua, XML	Javascript,C#,XML	Javascript,C#,XML
Community	Active	Low response	Low response	Active
Special Tracking Method	CAD, GPS	Face tracking	None	GPS
Quality	Medium	Very Good	Bad	Good

Table 3-1: Requirement for selecting appropriate SDK

Telexistence robot use PC as Window7 as an operating system. So PC compatible is a must. Next things that we need to concern are the quality of tracker and functions. As the table show, it seem as D;:Fusion have a better quality compare to Metaio SDK which also have a face tracking technique that will be very useful for using to create personal information but due to D:Fusion's community is very low response and almost of the information and knowledge need to be learn by developer him/herself.

The decision has changed to Metaio which the response from community is really fast and developer can asking for more information or even be helped to solve the bug or error. Moreover, on Face tracking issue, it can be solve by using marker-less technology which will not have high performance compare to face tracking technology but it can be work somehow. The paper will show the result on the next sub-chapter.

3.2.2 Tracking Method

There are 4 types of marker that have a potential to create an implementation as following;

1. ID Marker tracking

ID marker is the way to track the marker by using binary data which be able to track only black and white and distinguish what is tracker and normal environment data. ID marker is normally use for many kind of research, service and system. This paper also desired to use this method because the advantage on quality and distance is very important for this project. This system can track marker size 8.8 centimeters with matte paper and print out with Inkjet printer set as high quality pure black and white at 4.5 meters maximum distance.

Limitation: the marker needs to be flat surface. And User will know what is tracker and it may disturb user experience if marker is too big.

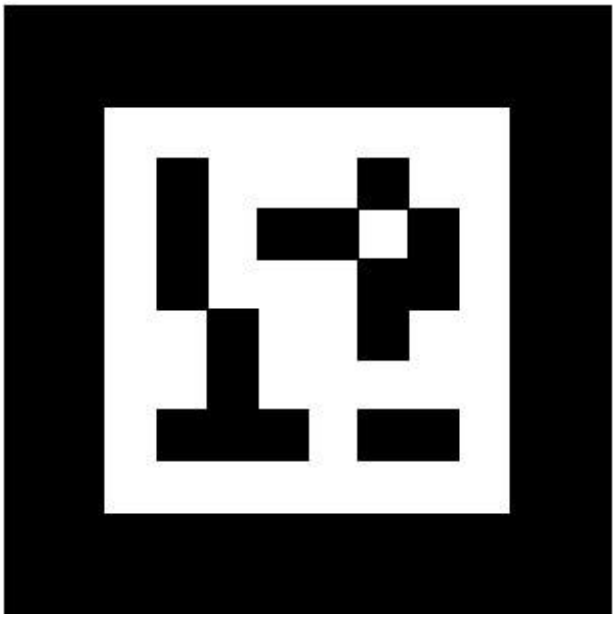


Figure 3-2: ID Marker Tracking example

2. Picture Based tracking

Picture based system has an advantage on the beautifulness because it can be use high contrast picture to track and user somehow feel difficult to define where is the marker and it make the experience become

more realistic in some factors. The distance on A4 picture can be track up to 1.5 meters.

Limitation: the marker needs to be flat surface.

Figure 3-3: Picture Based Tracking example

Copyright@ Reality Media

3. Marker-less tracking

Here is the most interesting tracking system which this paper tried to use it at first because not only flat surface that can be track but room environment itself can be track easily. But the distance and unchanged environment tend to be very strong obstacle that seems to be impossible to solve. Such as if the system want to track face of human, it can be track only within 40centimeters far from camera which is impossible to use for Telexistence robot that have a plate radius (Shortest distance at 25centimeters) moreover, if the system want to track the environment, it can be use when there is no change environment and especially the light condition which is very sensitive for this kind of tracking. One more limitation is the quality of tracking which is very sensitive and the movement also seems to become flickering and rotation, transition is very hard to decide of each marker due to the different of size and distance. When the system want to add distance-based information, it need to spend a lot of time to compare the real world with virtual world and normal algorithm to define the distance tend to get a wrong data.

So, to using distance based information by using marker less tracking was turn down and focus on the distance of marker as a main point, so using ID marker is the decision to create reliable system.

The ideal how to make tracker: the distance is depend on user desire by take a picture of the environment on the desired distance and cut only 500*500 pixel out and it will work on that position but it will not work when being look of different angle (limitation is 45degree) and the environment should not be change (error exception is 10%).

Limitation: Very sensitive on light condition, changing environment and cannot be used for moving object such as human or moving robot in long range. Due to the place for tracking tend to be only face which smaller than 250*250pixel which is the smallest size for tracking. Moreover, human face has low contrast and depth which is the most important factor to track with this method even if this is the only one way for Metaio tracking to track personal human face as the concept want to propose.

Figure 3-4: Marker-less Tracking example

4. Edge Based tracking

Edge based tracking has a very strong advantage on light condition which at first this research believe that it will improve the quality of tracking because same shape should be able to track on any object but in reality, the object even if it is a square object, human perception and camera

perception are perspective point of view which is very sensitive when seeing on different angle or even different distance. The Edge based tracking is not flexible due to one marker can be only one point of view and size which become very hard to do distance based information by using this method. Moreover, the quality is very bad and if it not exactly the same size and point of view, the tracking tend not to be activated. From the research, the error is very narrow around 10 degree angle of view and 20 centimeter different distance on front and back compare to edge-based marker.

There are advantage depend on different type of tracking system. And the condition is to utilize in Telexistence robot which need a maximum distance as a main point especially when the system will consist distance based information. The longest track able tracking system tends to be the most important factors that the system needs to be concerned as primary point. And Telexistence have a freedom to walk around and it would be very useful if the information can be provided for more than direction or point of view.

Due to the most important is distance, ID marker are the most reliable marker compare to Picture-based, marker-less and edge-based tracking system. ID marker with size 8.8 centimeter can be track around 3.2 meters by using normal paper printed by laser printer in high quality. And it can be improve quality up to 50% by using Matte paper with Inkjet printer and print out with pure black and white in high quality setting. This setting makes 8.8 centimeter marker be able to track on 4.5 meters maximum.

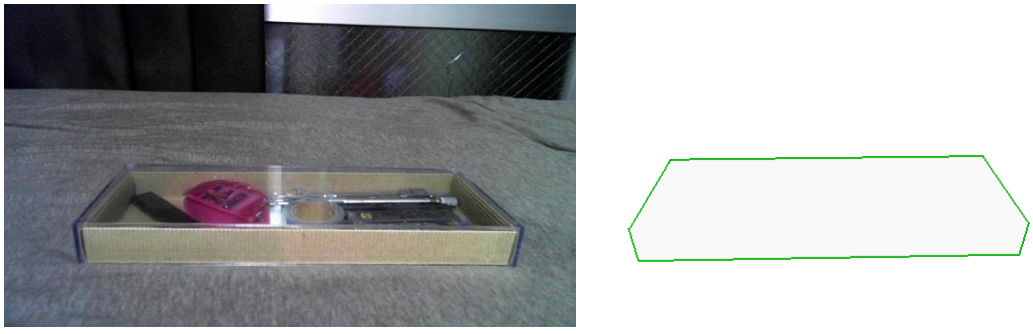


Figure 3-5: Edge Based Tracking example

3.2.3 Marker for information card design

Identifying where to overlay

Figure 3-6: Marker in exhibition scenario

Marker Type	Distance	Precision	Space consumption	Local audience disturbance
ID marker	Best	Best	Consume a lot	Yes
Picture based	Good	Good	A little	No
Markerless	Bad	Good	No	No
Edge based	Bad	Bad	No	No

Table 3-2: Marker Type comparison

To provide overlay information, one of the most important thing is marker. The traditional way of providing information is using ID marker. It provide long tracking distance and good accuracy but it's provide no meaning for local audience.

In my implementation, it will be mostly in-door and this will be use for museum or exhibition.

In those places, usually, there is poster or information card in each project. So, rather than using ID marker, I can use the existing poster or information card to be as a marker.
As the result, local audience cannot recognize it as a marker but online participant can use the same card as a marker to getting overlay information.
And compare to other tracking method such as marker-less and Edge based which cannot be used for long distance. So I decide to choose picture based in this implementation.

As project poster normally use to provide information of the project itself, this paper is going to integrate traditional way for providing information with virtual information to make normal people and augmented reality enabled people be able to receive ordinary information together. However, using augmented reality can provide more information than traditional way such as providing video, animation and interaction such as pressing a button to change the page.

Marker Size(cm.)	Maximum Track-able Distance
2.2*2.2	60cm
4.4*4.4	130cm
6.6*6.6	180cm
8.8*8.8	300cm

Table 3-3: Marker size and distance

Project size

Human use size

Figure 3-7: Marker size in specific purpose

To provide the most efficient space in limited a3 size of project poster, this paper design top left corner of the poster as a marker with following requirement;

1. Thickness of the border is 1.5 centimeters
2. Picture limited to be used as square picture or 2:3 scale rectangle pictures.
3. Minimum size of picture should 12.5 centimeters in width size to provide 5 meters length track able experience.
4. The picture should have high contrast to prevent 'false positive'

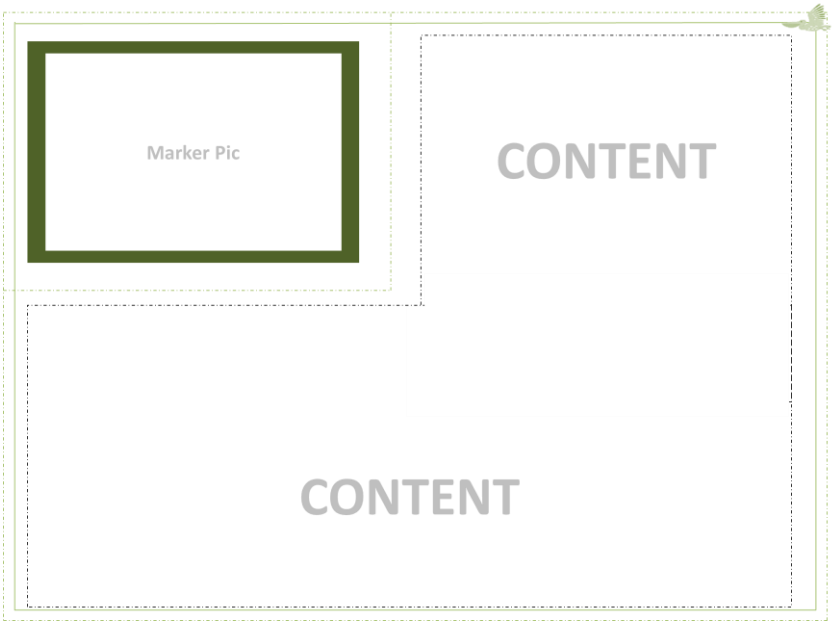


Figure 3-8: Overlay information for information card example

Because it is a picture based marker, so user may not be able to

know where is the AR enabled frame and traditional frame, so this paper design bird sign as symbol of AR frame. So when user sees the bird, user knows that user can use AR application to see more detail from the specific poster.

Figure 3-9: AR marker symbol

3.2.4 Marker for name card design

To provide the personal information on individual person, this paper believes that the badge is one of the practical ways to provide the interaction. It's easy to use, easy to print and easy to edit. It may not suit when using in daily life but for event, exhibition, student environment, and working environment or even in the lab, most of people have ID card as identification and most of people wear it at the front of their body. So using AR badge would be one of the ways that most of people get used to it.

User can select their own picture that have enough graphic cue and use as their own ID. Moreover, to interact with people, the distance between human and human is one of the most essential way to interact and we use it in normal daily life. For example, 3.6 - 1.2 meters will be social space and lower than 75 centimeters distance will be personal space as the paper will show you in chapter 3.2.1.

According to the previous research, the interaction should start from 3.6 meters which is the social space. However, with 3.6 meter, the marker size would be bigger than 6.5*6.5 centimeters square picture which is too big to become a badge.

To provide the biggest possible, 2.5*2.5 centimeters square picture with 0.3 centimeter dark border will be the most appropriate size which can provide the track-able distance at 1.4 meters that still be able to provide information on social space and also providing more information in personal space as well.

The design will be place as a desired picture place on the left side of

the badge as following;

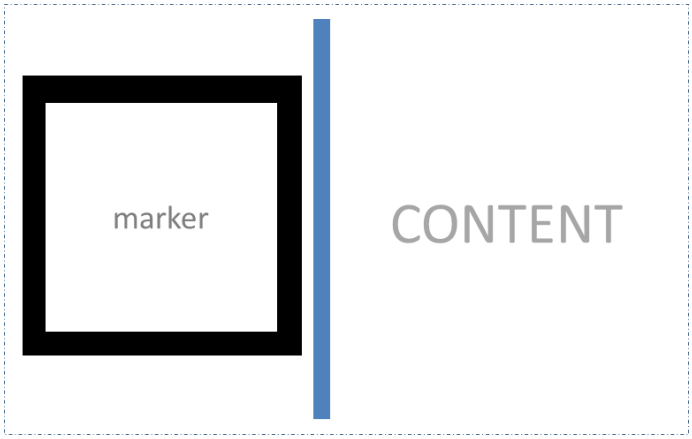


Figure 3-10: overlay information for name card sample

3.2.5 Virtual Controller

In order to create virtual controller, the paper designed to use unity with IO port library to send data through serial port and receive it by Arduino then let's Arduino to interact with the specific object.

3.3 Selecting Introduction

To create ease of use, flexible and convenience experience for using layer based information techniques, the design need to be concerned as following;

1. Appropriate distance for changing the information.
2. What kind of information should be defined as high, medium and low information?
3. What object should or shouldn't to provide information?

4. What is capability of the system?

5. How big the marker should be?

6. How big the 3d object is?

7. Do 3dobject disturb the view of user?

8. How many information will be suit according to computing power.

9. What is the limitation of TELUBeeV2?

According to the above requirement, the paper divided it into 3 main topics as following;

3.3.1 Human Visual Motion Perception

The paper is using visual information as a main subjected information to provide the experience. So understanding human visual perception [84] is important especially, with dynamic information compare with static information such as Recovering high-level views of object-oriented applications from static and dynamic information. In: Software Maintenance [85] , integrating local static and dynamic information for routing traffic [86] which said that dynamic information can provide information according to the user movement and intention.

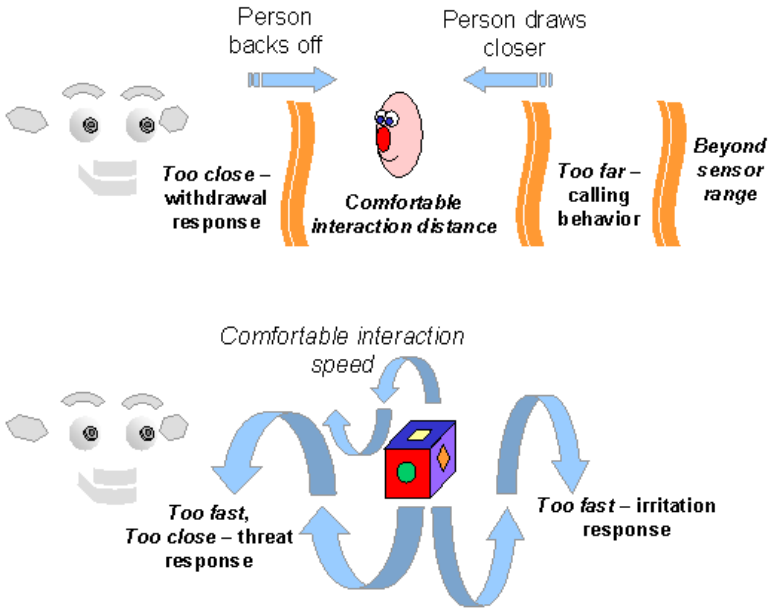


Figure 3-11: Human visual perception with human and object

3.3.2 Meaningful distances for humans

Four distances are mentioned;

- The intimate distance – effectively zero distance

- The personal distance – this is the distance separating members in a no-contact state. It might be considered as the protecting sphere that individuals maintain between their self and others. The length of the arm plays a major role in defining this distance and it ranges between 1.5-2.5 feet (1/2 to 3/4 meters)

- The social distance – this is the distance that people feel comfortable with, in a social gathering. It allows a normal voice communication and it goes between 4-12 feet (1.25-3.6 meters)

- The public distance – this is the distance considered to be well outside any social involvement. This distance goes between 12 feet and above (more than 3.6 meters) [87]

3.3.3 Distance and QR code size

Scanning distance	QR Version1 print size	QR Version2 print size	QR Version3 print size	QR Version4 print size
Personal – 1.5-2.5 feet (45-75 cm)	2.4 – 4 " (6-10 cm)	2.85-4.75″ (7.15-12 cm)	3.3 – 5.5″ (8.2 – 14 cm)	3.7 – 6.3 " (9.5 – 15.8 cm)
Social – 4-12 feet (1.2-3.6 meters)	6.3 – 19″ (16-48 cm)	7.5 – 22.6″ (19 – 57 cm)	8.7 – 26.2″ (22 – 66 cm)	9.9 – 30 " (25 – 75 cm)
Public 12-25 feet (3.6-7.6 meters)	19 – 39 " (48 – 100 cm)	22.6 – 46.5″ (57 – 120 cm)	26.2 – 53.8″ (66 – 166 cm)	30 – 61.3 " (75 – 157 cm)

Table 3-4: Distance and QR code size

3.4 Displaying Introduction

3.4.1 Hardware: Camera Selection

Microsoft Life cam camera is the most appropriate camera for this project because the resolution for USB port pc camera in the market is the top level with a reasonable price. But the field of view is not wide enough,

so the design became camera with attached 0.67 wide angle lenses. Even though, according to Table:2, 0.5 Superwide angle can provide a wider angle but the distortion makes the image go bad and usable display is smaller than 0.67 Wide angle. So the decision was 0.67 with Microsoft Life Cam camera. And here is the result from the experiment;

Date 10/28/2013

Camera condition Microsoft Life Cam Camera

Lens condition		**0.67 Wide**	**0.5 SuperWide**
Width	cm	20	30
Dist_H	cm	8	9
Dist_V	cm	20	20.4
FOV_H	deg	103	118
FOV_V	deg	53	73

Table 3-5: Lens comparison

3.4.2 Software Camera Setting Design

Metaio SDK use to catch the visual information from video texture and detect marker from plate and render 3d object inside 'Metaio Tracker' Game Object.

This paper proposed to put SDK in right eye video texture camera to run the augmented reality program.

Due to the way to create stereoscopic augmented reality doesn't have much information and ready to use system in the market is low credibility, this paper propose design to provide stereoscopic augmented reality provide specialize for TELUBeeV2 robot as following processes;

1. Create 2 cameras in the distance as same as TELUBeeV2 eyes (6.3cm.) in vertical distance.
2. Place see through video plate as depth 2 on each eyes
3. Create virtual left and right eyes camera for seeing only the plate.

- Tag the name of the plate as 'video texture'

- Command camera to see only ‘video texture’

- Set Camera to be Orthographic mode to prevent distortion.

- Set left texture to be ‘pink color’ to make it easier to understand.

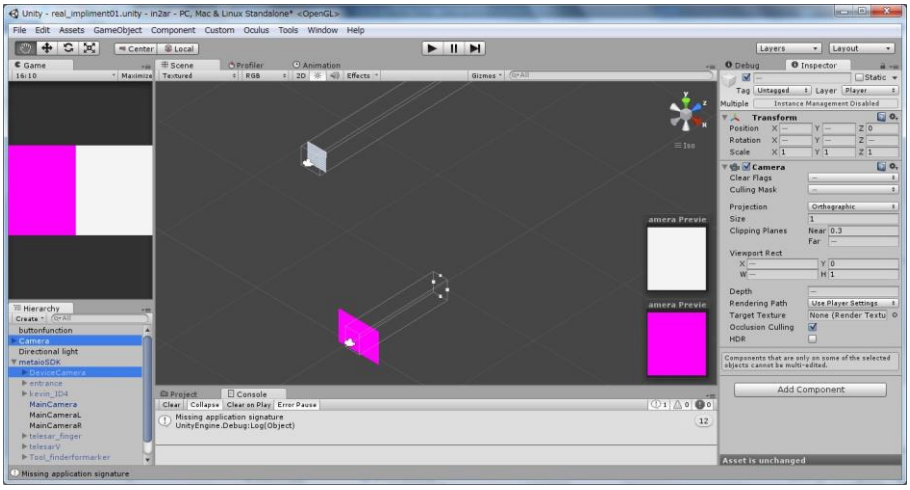


Figure 3-12: Camera for seeing video texture Design

4. Create 2 more cameras at the same position of video texture camera to use for see 3d object in virtual world.

- Command camera to see only ‘3D object’

- Set Camera as perspective mode

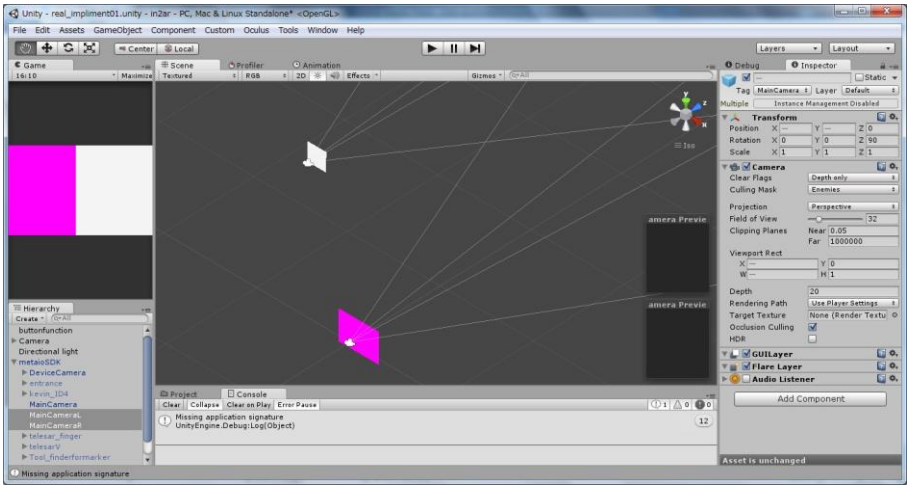


Figure 3-13: Cameras for seeing 3d object

There is some stereoscopic augmented reality system in the market such as AR vision [88] but it not appropriate for using in Telexistence technology due to the camera of Telexistence robot especially TELUBeeV2 [8] flip from horizontal to vertical. Moreover, the SDK for augmented reality is

not full-developed.

As the result from research, this paper proposed concept for integrated augmented reality into Telexistence by using following methods;

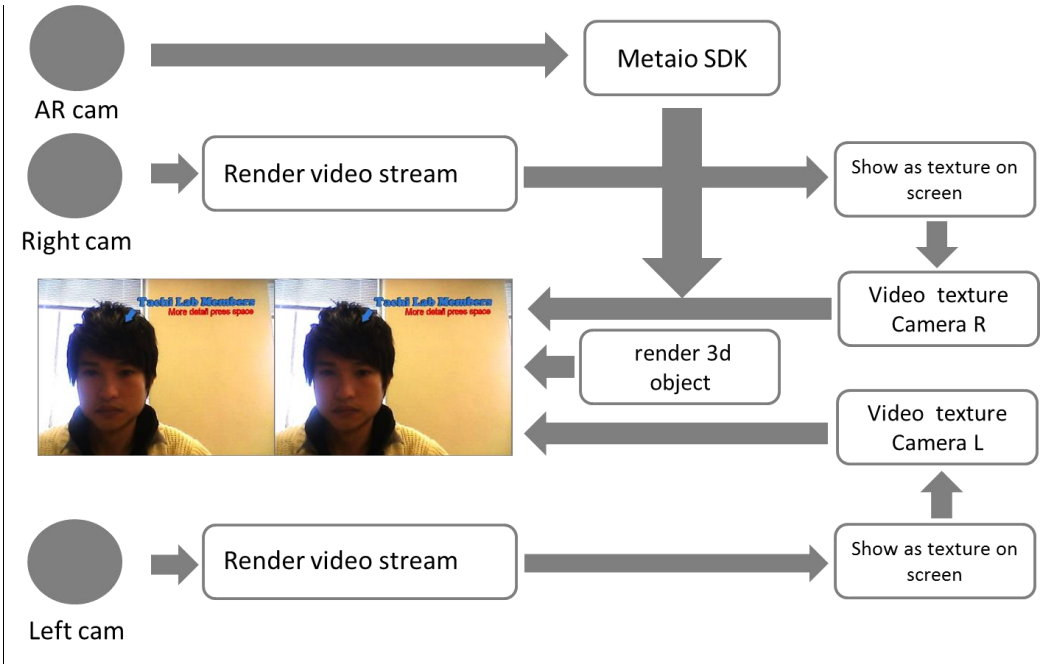


Figure 3-14: Stereoscopic Augmented Reality Platform Design

3.4.3 Layered Based information overlay design.

As Telexistence robot will let user go to remote place anytime and anywhere. User may get confuse where he is even if he choose the location but it definitely have some part that user going to miss or unable to understand by only 5 sense. So, this paper propose such an information for specific object to solve the problem.

However, the most appropriate way to provide information, including 5w2h [89] (when, why, what, whom, where, how and how much) are considerable as scenario design that will be concern on specific situation and design all the experience that user will able to feel when finish the last prototype.

Layered based overlay information aim to provide intuitive interface that user have no need to learn how to control the system itself and to maximize the user satisfaction which define as user interface design [90] .

To understand what information is useful for user, the understanding how user perceive information, what it going to be and how it increase the knowledge or even wisdom of the user is one of the concern point in this research. The paper may not aims to prove that information the system provide will increase knowledge but it can be prove to there is a connection between information and knowledge which call 'Wisdom Hierarchy' [91]

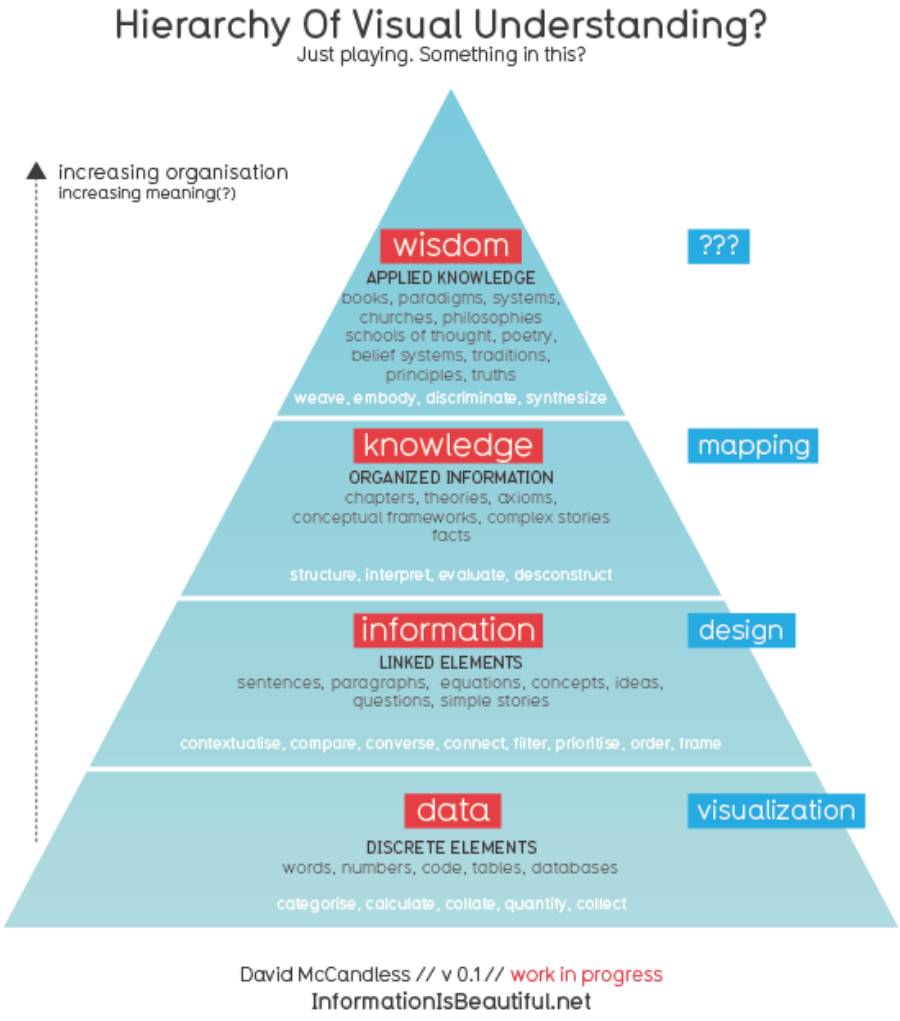


Figure 3-15: Wisdom Hierarchy by David McCandless

Layered information platform aim to standardize the way of categorize information when the world becomes full of information and big data.. So the most important of how to categorize the information is to make sure that user will be able to user it whenever user want with the most intuitive way. In order to realize the idea, 'User-Centered Design' [92] is one

of the focus design method to increase the human capabilities and user satisfaction. One of the researches using virtual world information to route the real world [93] which can be prove that virtual information can increase knowledge of the user and increase the capability of human by information.

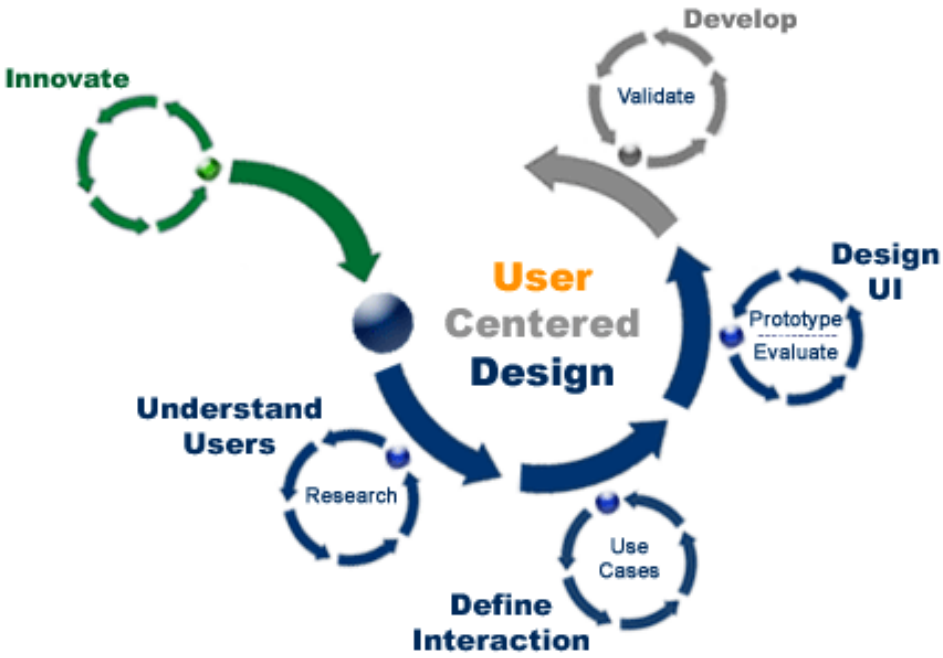


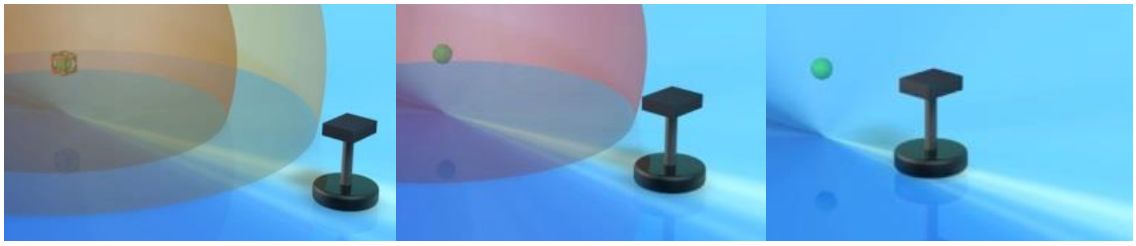
Figure 3-16: User- Centered Design Diagram

As too much information make user get confused, unable to read and limited within only 1 screen, this paper proposed the way to separate information as a layer to provide appropriate information in appropriate distance. Human behavior shows that when human have more interest in one specific object, human tend to get close to get more information. The paper utilize this intuitive method to provide dynamic information depend on the distance between user and object.

Low information

Medium information

High information



Far distance Medium distance Close distance

Figure 3-17: Layered based information by using augmented reality

4. Implementation

4.1 System Overview

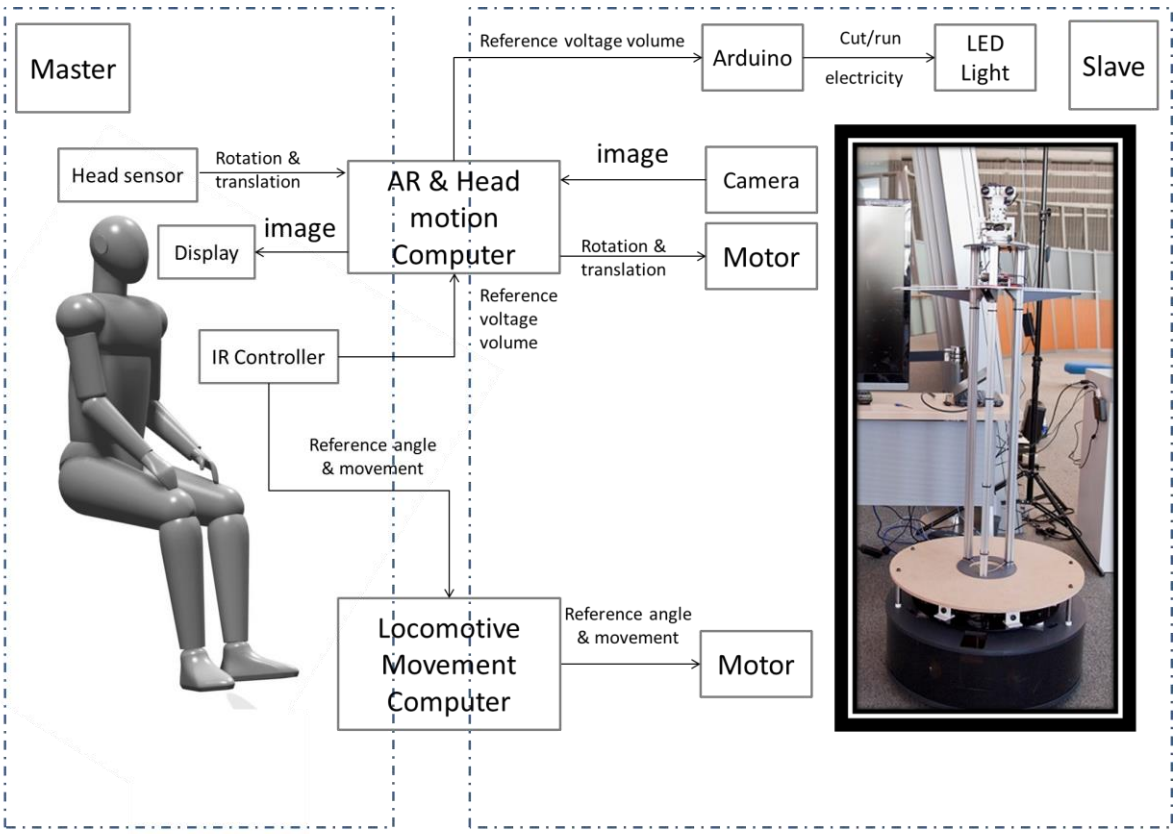


Figure 4-1: System overview

There are 2 parts on the overall system, first part is master part and second part is slave part. Master part is the part that user going to use as a cockpit to control the robot. And the second part is robot itself there will manipulate user movement, sending image data and also walk by IR controller.

Head Movement

Robot itself has 3 Degree of Freedom that can rotate, pan, and tilt just like human head without torso and neck. The user would be able to control robot head by using intuitive movement of user's head. The accelerometer and gyroscope will catch the movement and send it to computer to generate the data that can control 3 desired motors on the robot.

Displaying

Robot head use HD camera with 1920*1080 pixels with 90 degree wild angle. lens. However, to immerse with human eyes, the screen need to be distort in some level so the field of view also decrease to 75 degree and the screen ned to be divine by 2 so the resolution reduce to 810*1080 on each eyes.

On software part, displaying system was integrated with AR cameras that can catch AR code and render 3D virtual object augmented into the real world. User cannot recognize AR camera and user will know when he saw the marker and 3d virtual object was rendered.

Movement

Robot can move by wheel-based locomotion system that controlled by IR controller.

Virtual controller

The implementation use Arduino as a processor to control the controllable object such as LED in this implementation. User can use IR controller to turn on and off the light by click it when user saw the AR control panel that will show when user look at the specific object.

4.2 Setting Software environment

TELUBee V2 robot's software are updated from the previous version that using native language to receiving and sending data of head translation and rotation to be Unity based language that will increase the ease of use and editable language. And it is possible to integrate augmented reality system into the robot.

Layered Based Augmented reality system is using Unity3d [94] as software, Metaio SDK [78] as SDK and Oculus Overlay [95] for overlay the filter in Oculus Rift HMD [96]. By this method, inside Unity3d need to set the environment to be ready for use by setting OpenGL by "add –force-opengl" at the properties inside unity3d.

The implementation use serial port library call .NET to sending data to robot head and Arduino. For receiving data from Head sensor, implementation used plug-in call OVR camera specializes for receiving data

from Oculus Rift.

On augmented reality side, Metaio SDK will catch the marker and provide distance by using tri-angle formula to evaluate the distance. Due to, the camera was flip from horizontal to vertical. So the camera calibration needed to be implemented and set as a new value. This implementation has set the value of HeadEyescalibration on translations as x = 0,y = 0,z = -1500 which will provide a low movement on translation and the virtual object will stay closer to the original location that were desired. According to the HeadEyescalibration on translations was set as minus -1500, the virtual number of distance needed to be revised by -1500 from the actual world distance. Moreover, the size of marker in real world is also effect the distance value. The default value of marker is 8cm * 8cm square marker which can provide perfect distance from real world and virtual world are not going to use in this implementation and using 14cm * 9.33cm as a poster marker, 2.5cm * 2.5cm square as an AR badge and 5.5cm ID marker as a Tools marker. Each of size effect the distance value and it will be written in detail on the chapter 4.4.

4.3 Setting Hardware environment

AR marker

TELUBee V2 robot will be set at an entrance door. The lab environment was set as normal. The front of entrance door will has Torso project on the left side. On the front, there is TECHTILE toolkit project and on the right side will be TelesarV project. The implementation is going to use AR frame on 3 of these project. Moreover, when robot goes to the end of pathway, there is a tools section that also AR provided. This section will use 5 AR ID markers as hardware to place of individual object type as screw driver, scissor, tape, nipper and the biggest on at the center will show the overview of tools section.

TELUBee V2

As the layered based augmented reality system need a lot of computing power, processor that higher than 2.2GHZ. is needed to reduce the latency and provide a best experience. So, the AR and head caption

computer are PC type computer. It cannot be move and place on top of TELUBeeV2 so the implementation use under table of TECHTILE toolkit as a space for placing computer. Then connect it with TELUBee camera, motor processor and use a very long line to make sure that user can control the robot to anywhere in the room.

4.4 Setting Environment and Scenario.

The idea is to see how effective layered based information is compare to ordinary way of providing information in augmented reality. So, using in the real environment and test with ordinary person will be able to understand the result and how to improve it in the next step.

The plan of implementation is to show the detail of the project inside Tachi lab such as TELESAR V, Torso and TECHTILE Toolkit. Moreover, the design also shows the location of the tools, computer parts and electric parts as well. The diagram will be as following;

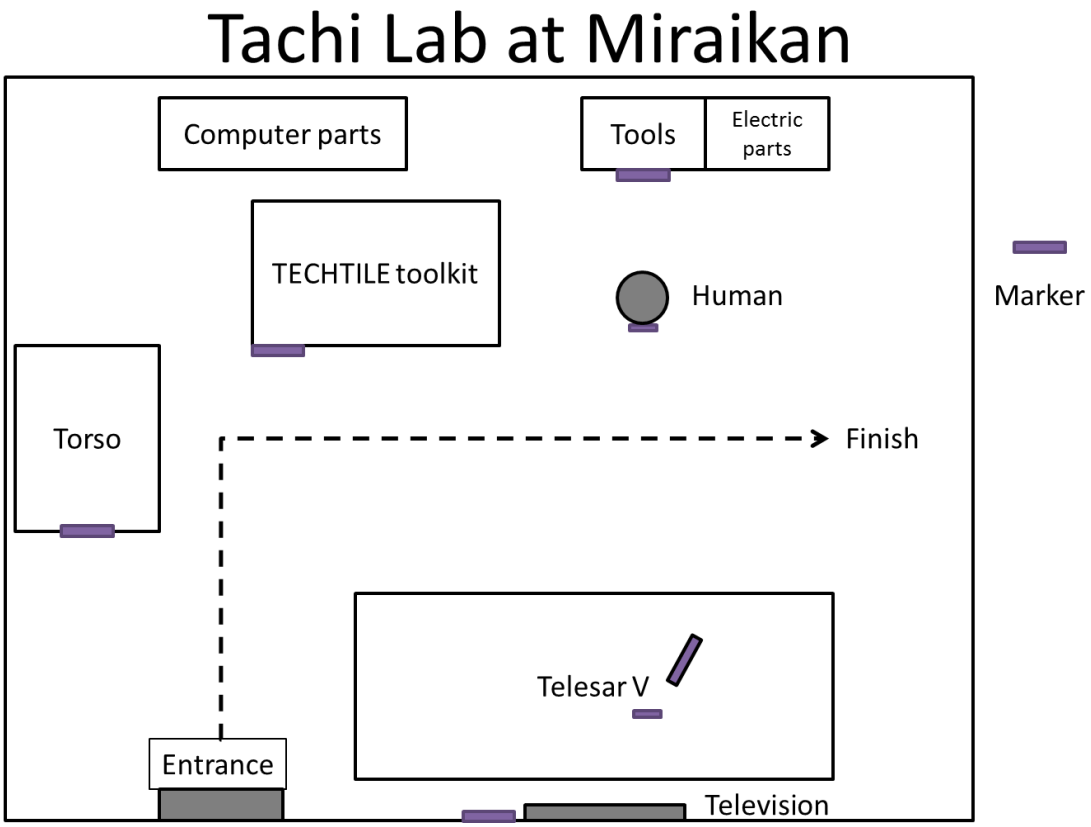


Figure 4-2: Implementation plan in Tachi lab environment

The implementation design has 3 interactions.

1. Project properties and room detail guide
2. Personal information
3. Remote controller

4.5 System Interactions

4.5.1 Project Properties and Room guide

The first function is the ordinary function in augmented reality technique but to use distance for change the information dynamically, the paper believe that user satisfaction will be increase. At the paper will show the evaluate result at the chapter 4.

Detail of design are classify as 3 level of information as mentions below;

1. Low level information = Name and picture of project
2. Medium level information = project video
3. High level information = system diagram

In addition, Press button 'Q' to show researcher information at High level information level.

The design will apply for Torso, TECHTILE toolkit and TelesarV as project properties and computer parts, tools and electric parts as room detail.

The detail of information and example picture will be shown as following;

4.5.1.1 Torso information implementation

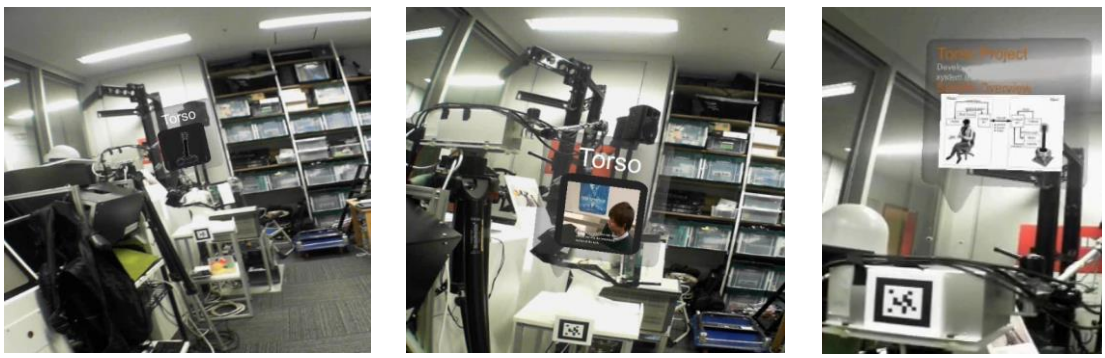


Figure 4-3: Torso information implementation

Contents/Type	Low	Medium	High
Content	1. Project Name 2. Project Picture	1. Project name 2. Project video	1. Project name 2. System Overview
Location	Poster	Poster	Poster
Distance	More than 170c.m.	170 – 80c.m.	Lower than 80c.m.

Table 4-1: Torso information detail

Torso Researcher level information (additional)

1. Project name
2. Researcher name
3. Laboratory's name
4. Researcher's university logo

Location: Place at the top of Torso's HMD.

Distance: lower than 80c.m. with pressing a button "Q"

4.5.1.2 TECHTILE toolkit information implementation

Figure 4-4: TECHTILE toolkit information implementation

Contents/Type	Low	Medium	High
Content	1. Project Name 2. Project Picture	1. Project name 2. Project video	1. Project name 2. System Overview
Location	Poster	Poster	Poster
Distance	More than 170c.m.	170 – 80c.m.	Lower than 80c.m.

Table 4-2: TECHTILE toolkit information detail

TECHTILE toolkit Researcher level information (additional)

1. Project name
2. Researcher name
3. Laboratory's name
4. Researcher's university logo

Location: Poster

Distance: lower than 80c.m with pressing a button "Q"

*Additional information**

3. Computer parts sign (include name and picture)

4. Tools sign (include name and picture)

5. Electric parts sign (include name and picture)

Location: Place at the top of TECHTILE toolkit demo desk.

Distance: more than 170c.m.

* Because TECHTILE toolkit marker places at the position that user be able to see computer parts storage, tools storage and electric part storage, so the design use only marker to show big detail of the room and show more detail when user get closer to specific location.

4.5.1.3 TelesarV information design

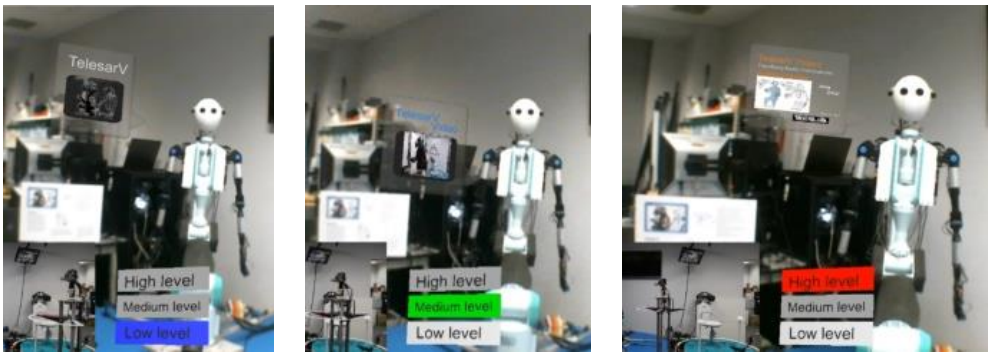


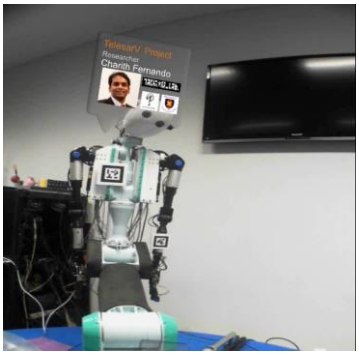
Table 4-3: TELESARV information implementation

Contents/Type	Low	Medium	High
Content	1. Project Name 2. Project Picture	1. Project name 2. Project video	1. Project name 2. System Overview 3. Finger Design
Location	Poster	Poster	Poster/Arm
Distance	More than 230c.m.*	230 – 140c.m.	Lower than 140c.m.

Table 4-4: TelesarV information detail

*The reason why distance of TelesarV and user are different from Torso and TECHTILE toolkit project because, TelesarV robot have a special ground which TELUBeeV2 robot cannot go inside. So the minimum distance between TelesarV and TELUBeeV2 robot is 120c.m.

Because of that limitation, the design desire to be a little bit longer to provide comfortable space for moving and receiving information.



TelesarV Researcher level information (additional)

1. Project name
2. Researcher name
3. Laboratory's name

4. Researcher's university logo

Location: Poster

Distance: lower than140c.m. with pressing a button "Q"

4.5.1.4 Tools information design

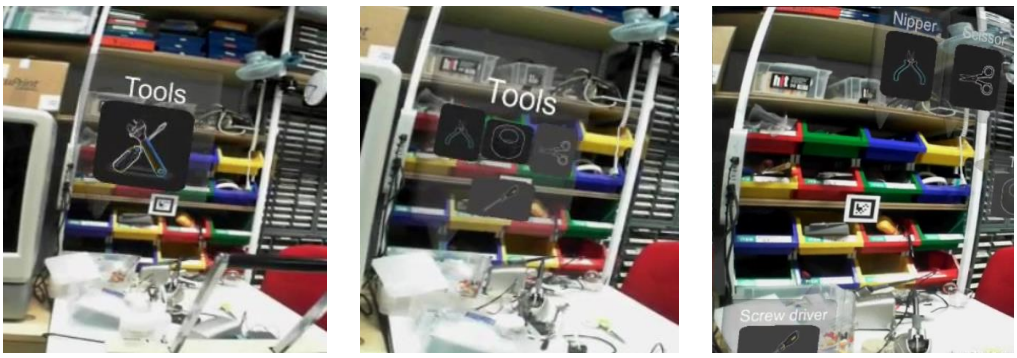


Figure 4-5: Tools information implementation

Contents/Type	Low	Medium	High
Content	1. Object name 2. Object picture	1. Object name 2. Object with detail	1. Subset object name 2. Subset object picture
Location	Center of object	Center of object	Center of subset object
Distance	More than 170c.m.	170 – 100c.m.	Lower than 100c.m.

Table 4-5: Tools information detail

4.5.2 Personal information

Figure 4-6: Marker for name card implementation

The size of marker is 2.5 * 2.5 centimeters square picture with black border. It will carry as a necklace in the implementation. The location of Badge is in the center of human with 15 centimeter far from face.

The interaction has 3 levels as following;

Table 4-6: Personal information implementation

Contents/Type	Low	Medium	High
Content	1. Person name	1. Person name 2. Status 3. Nationality 4. Hobby 5. Skill	1. Personal name 2. Personality 3. Favorite personality
Location	Name card picture	Name card picture	Name card picture
Distance	More than 170c.m.	170 – 120c.m.	Lower than 120c.m.

Table 4-7: Personal information detail

4.5.3 Remote Virtual controller

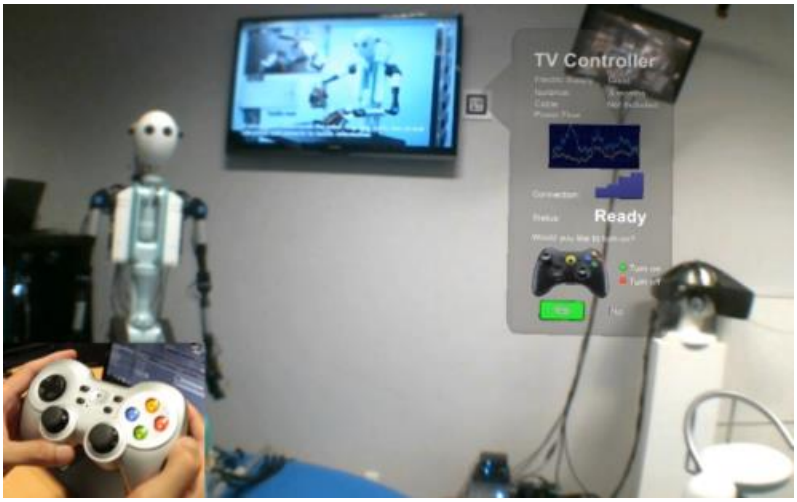


Figure 4-7: Virtual controller at television

Figure 4-8: Virtual controller for LED light

Not just the information that has been provided but this system can control controllable device through the augmented reality interface by using controller button to turn on-off the device. The implementation used television as an example.

5. System Evaluation

The experiment is using 'living laboratory' at Miraikan as a testing place. By using 5 participants age around 20 – 40 years old with random background to test the system, it would be able to get a comment and advice through the research on layered information overlays on Telexistence robot by using augmented reality. The experiment was set as following;

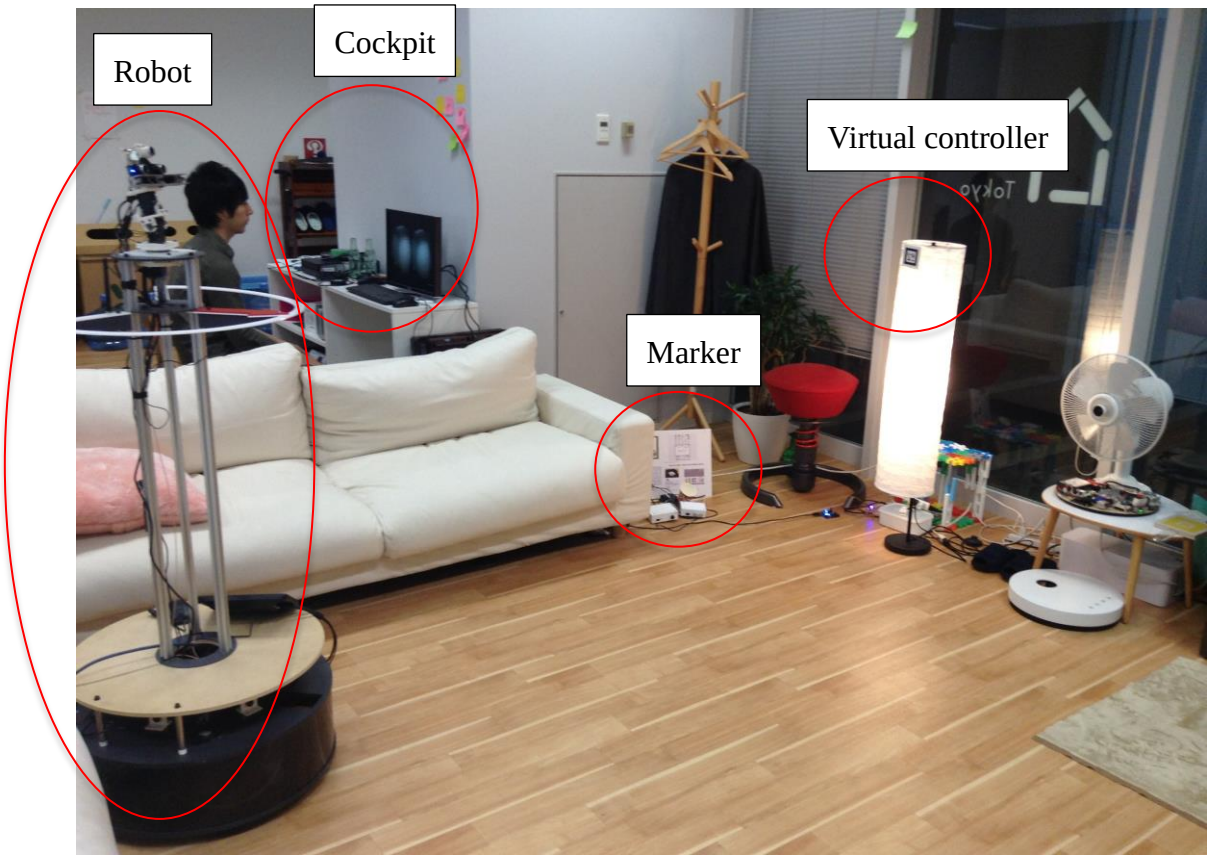


Figure 5-1: Overall Environment

Object Positioning

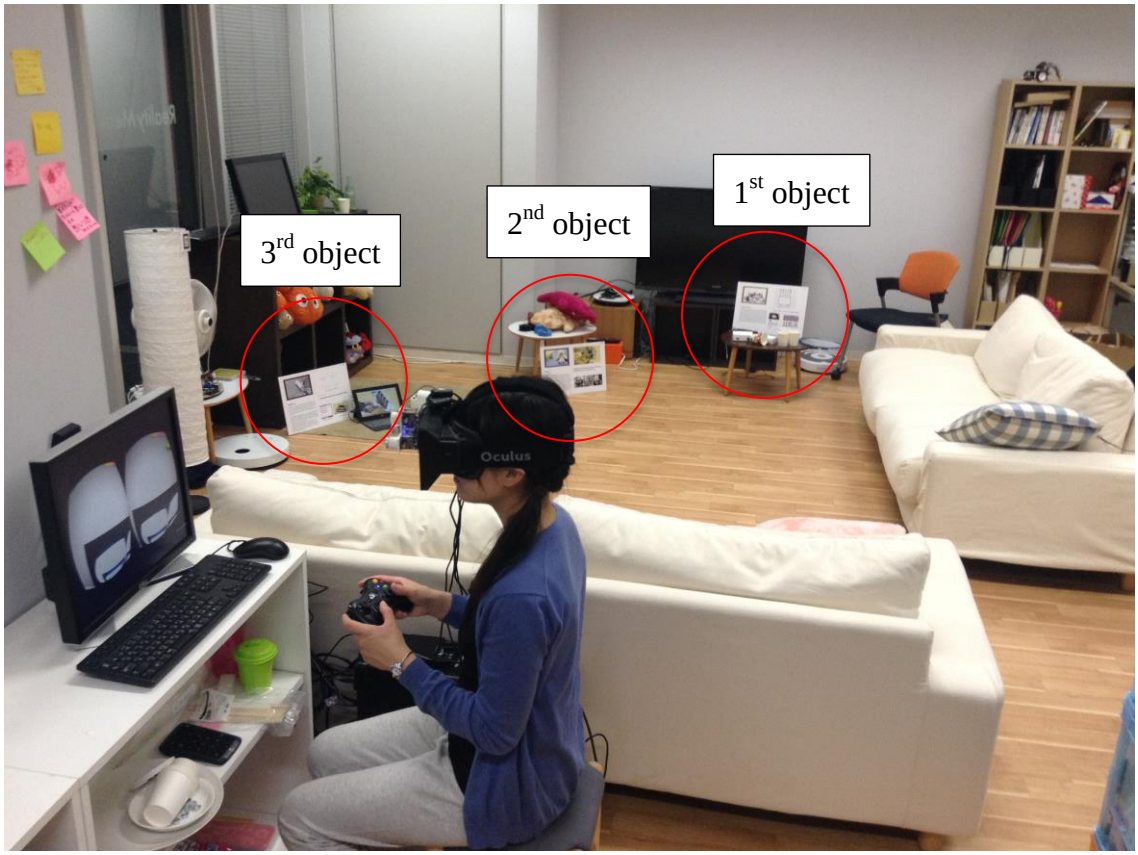


Figure 5-2: Object Positioning

There are 3 object to let the user find in the area around 5*5 meters with normal living environment. The position of the object will change randomly in each test. The user will remember the name shape of the object before start the test. And moreover, users are also study how to control the robot beforehand.

Figure 5-3: Object to be search

Telexistence and AR

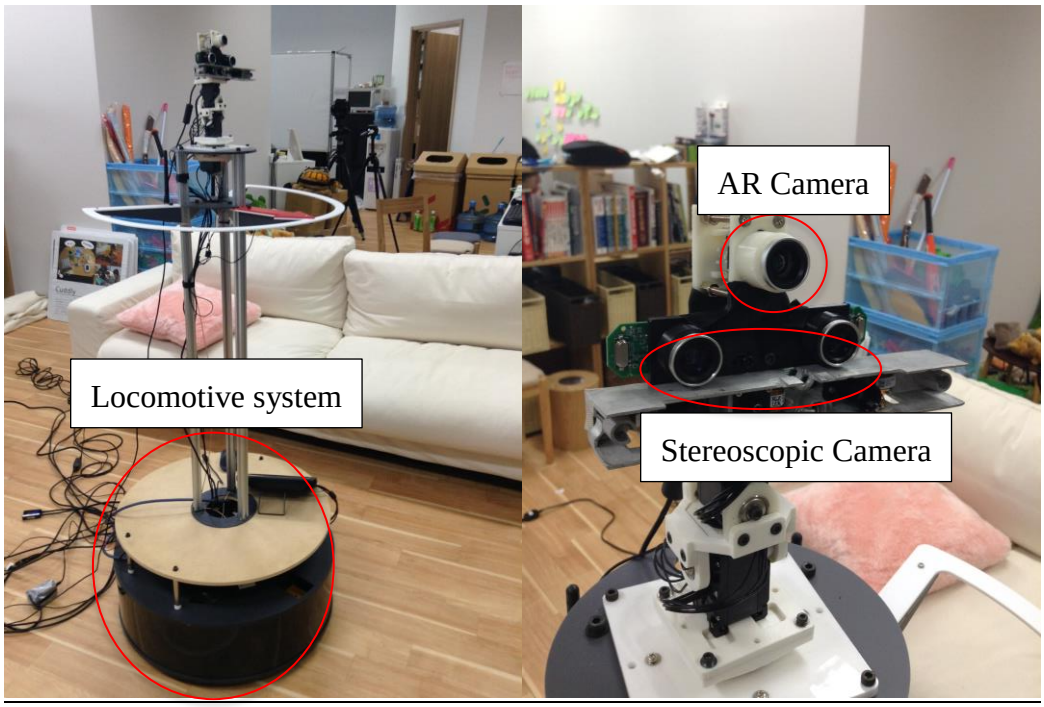


Figure 5-4: AR with Telexistence

The detail of experiment was divided into 3 parts;

1. Introduction
2. Finding Object without AR
3. Finding Object with AR

1. Introduction

Because user are new for the system, so from the start, user will use the trial on movement of the locomotive part .Then user will remember the object they need to find.

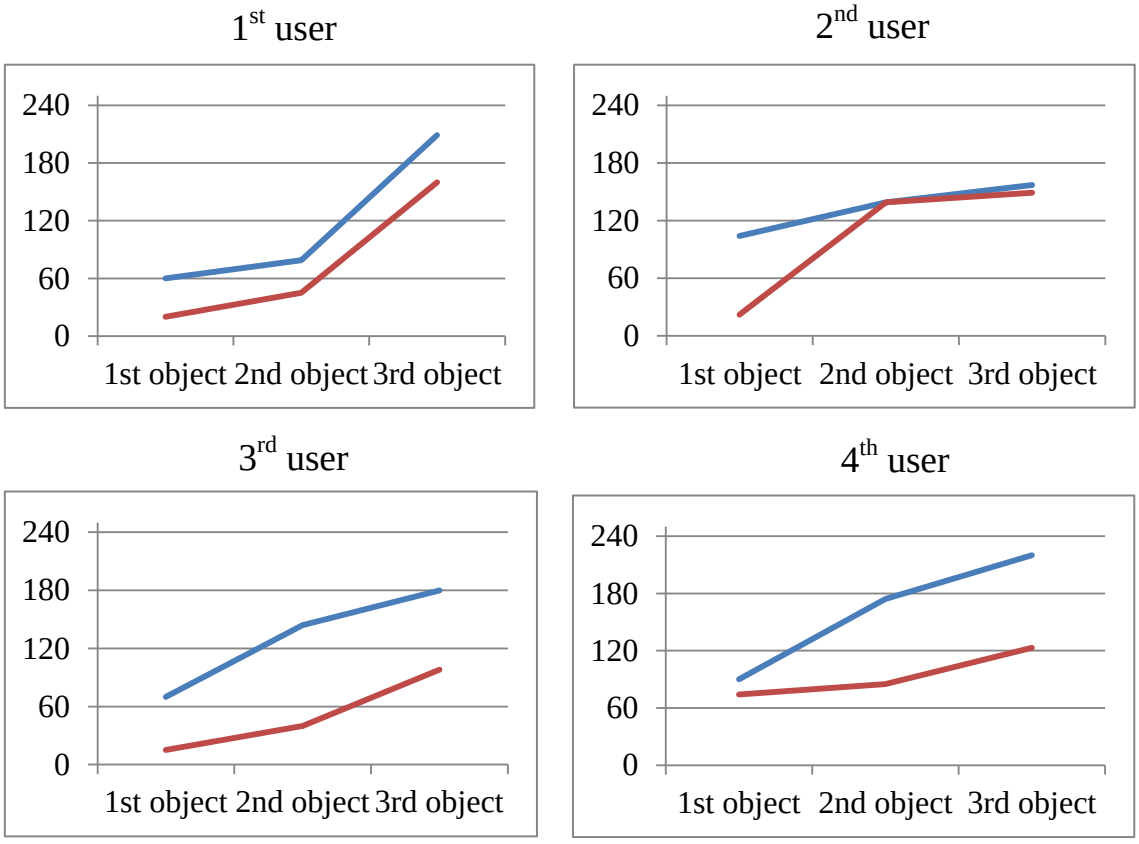
2. Finding object without AR

Participants need to control robot to find the object. Out of 5 participants, most of them start with look around the environment to find the object rather than trying to move. Some of participants cannot find any object but they afraid to move because they are not familiar with the system and afraid that it will crash the stuffs around the place.

3. Finding object with AR

Participants tend to finding the AR marker rather than looking for the object. Sometime, when the AR was display, participants tend to look at the detail of the AR but they are not trying to see all the detail especially on the video level. So, it seems like information is needed for the specific objective. If there is no connection between information and goal, participants tend not to look more on the detail of the information. Here is the result in time consumption compare between with AR and without AR. It can be used if there is a different question such as the concept of the object. One more interesting point on observation is, when AR sign displayed, user tends not to get closer to the object compare to without AR which the users will try to get closer to know what exactly the object is. On the other hand, with AR, user already got the information they need which is the project name which can reduce time consumption from 30 seconds to just 2 seconds.

Here is the chart compare between finding object without AR and with AR in minute for individual user;



5th user

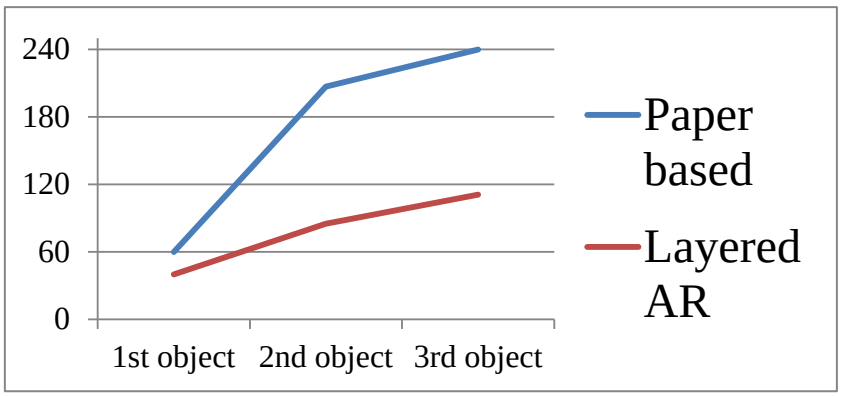


Table 5-1: Individual data from user study

As you see from these graphs, using AR makes user find the object faster than paper based in all user.

Only one time on 2nd user who consumed time for finding object by using paper based as same as layered based AR.

Here is the average data graph conclude all 5 users;

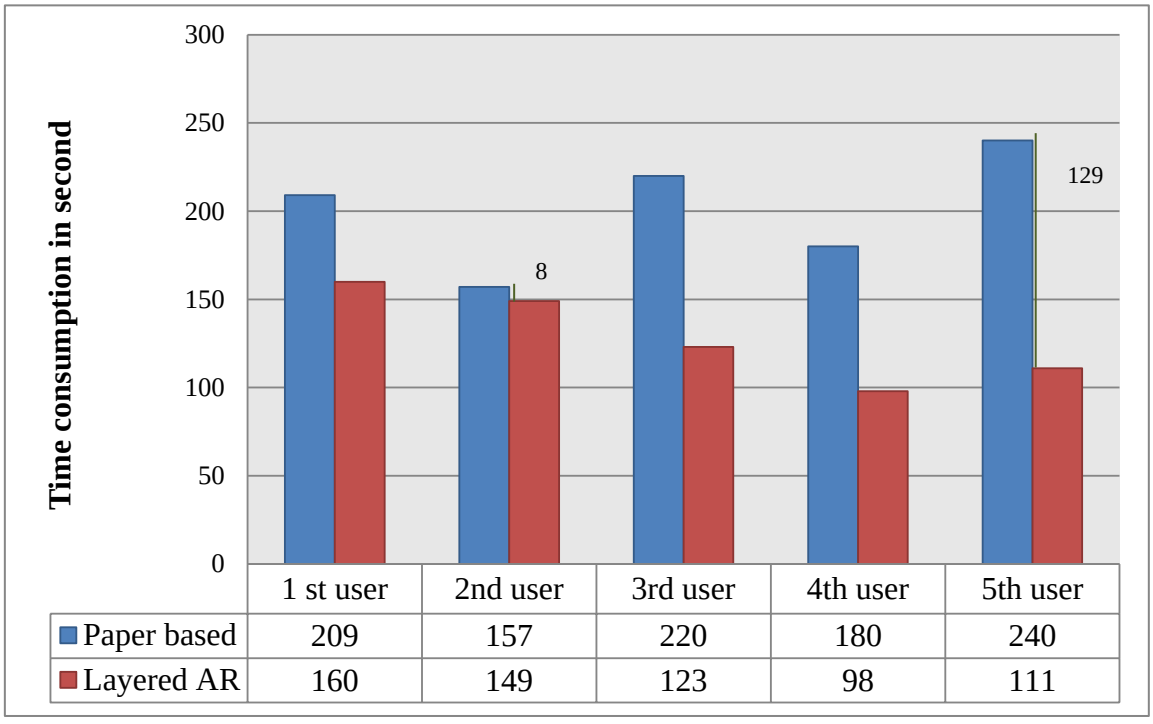


Table 5-2: Time consumption on average user

Here is the standard deviation and mean of the result;

	Mean	Standard Deviation
Finding object without AR	3.06	0.29665
Finding Object with AR	2.3	0.35355

So, it can be say that using AR will reduce time consumption on finding object by using Telexistence robot.

The closest time consumption between paper based compare to AR based is 8 seconds different.

The highest different is 5th user who consumed 129 seconds different between paper based and layered based information.

So in conclusion; Using Layered information in Telexistence can reduce time consumption on finding object in **average 73 seconds** compare to paper based information.

Additional function also applied to this experiment which is 'virtual controller to control the light. Here is the picture of the light and Arduino system controller;

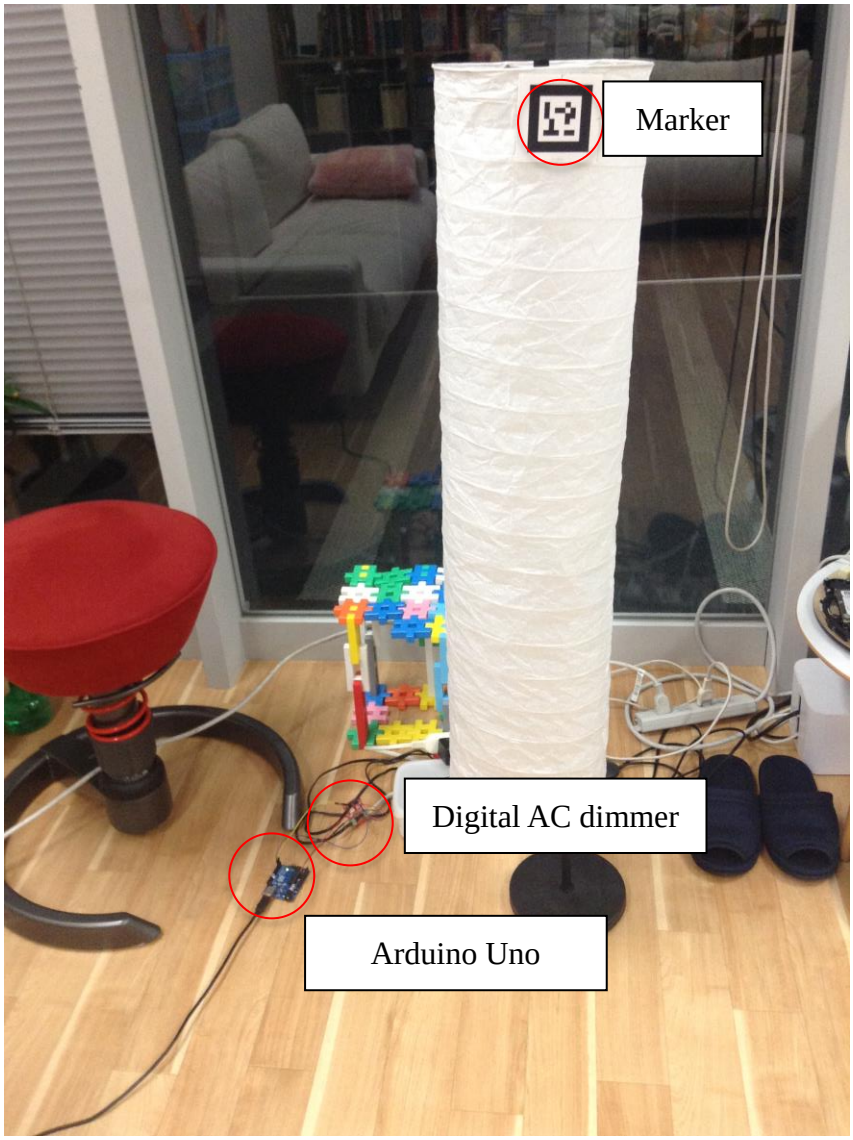


Figure 5-5: Virtual controller in a lamp

4. Discussion

The discussion took right after the user study was finished and it took about 10 minutes to finding insight, see the response, giving comment and advise.

6. Conclusion

6.1 Discussion

The discussion took place right after the user study is finish to get a good response and finding insight of the tester. The question is to find out the advantage, disadvantage, threat and opportunity of the project to improve for the future system.

As the result, there were many interesting point such as one of the testers is very familiar with the room and knows the object very well so the result becomes faster. The problem they face is how to control the body. Tester said that it is very convenience to use head movement for look around the environment but the resolution of the display is low so sometime, if tester found the object but user cannot read the detail or even see it clearly. Tester said that the sign of AR is also very small and hard to read but the color is fine. And tester also commented that it will be more fun if they can control something more than just a light. For example, a fan, light of the room or interact with a tree when tree want more water or the temperature is not appropriate. The zoom function is important because user doesn't want to get close to the object by using controller to control the locomotive movement. If there is zoom in and out function, it will be more convenient. Moreover, tester also said that if the head go beyond 180 degree and up to 360 degree, user will be able to look around the room without rotation the body which may be useful for finding the object. User also said that use traditional poster make user get closer to the sign but when using AR, user cannot feel that they want to get closer to AR sign because they don't believe that if they go closer to the sign then they will get more information. It seem like the interaction is very new in the user experience and user are not familiar in the first place but when they learned and aware that if they get closer, they will get more information, they tend to use it with different AR marker to get information also. 2 out of 5 testers said that the resolution is not so good. And one of the tester feel sick by stereoscopic. These two comments can be used to improve the project to make it more clear and reduce the sickness by stereoscopic system. One of the tester said that with

AR, Telexistence can be applied for using in more subject and the applicable use would be wider. Some response said that having AR can get attention and it is very easy to use. One more interesting point is one of test is trying to see the marker so tester stopped for a while and waiting if there will be some AR coming out of the marker but it just not appear and tester didn't try to get closer to marker which is one of the concerning point in this system. One comment said that the layered based distance information doesn't have any instruction or guiding how to use so they may not know that getting closer will lead them to get more information.

6.2 Future Works

Here is one of the services to provide overlay information on exhibition and event purpose.

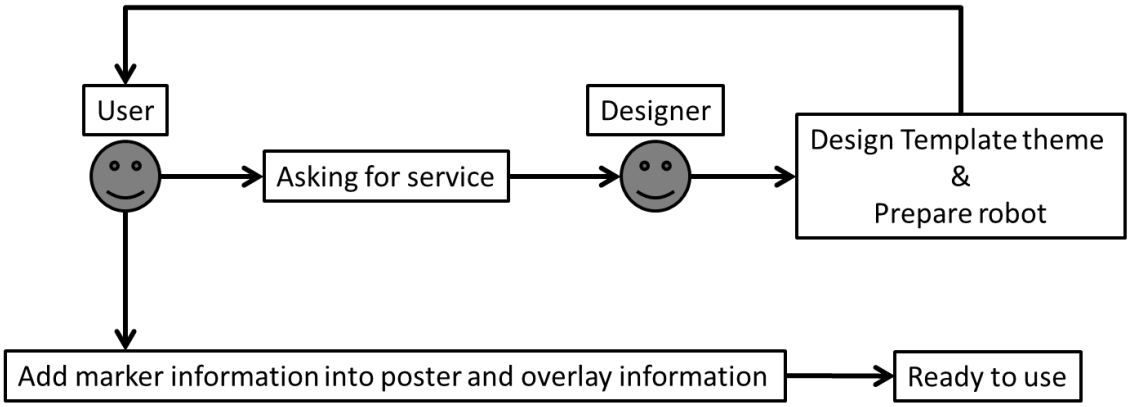


Figure 6-1: Service flow on system service

The scenario is user who wants to use the service will asking designer for service. Then Designer design template, prepare robot and send template back to user. User will add information into poster and system according to template then it finish.

Moreover, there are many opportunity to use this kind of system in the future such as, use it for learning, instruction, designing, marketing, collaborating, guiding, translating, , entertaining and so on. Augmented reality can aid robot to be more advanced and have more capability to achieve the specific purpose.

In short term plan, AR frame is still limited on high contrast picture and high graphic cue. If the graphic cue and contrast is low 'false positive' become high and tend to disturb the user experience. To reduce the error for selecting picture, standardization tends to become on issue to be solve. The standardization can be applied by software with automatic increase the contrast of the picture or showing the quality of picture by rating as a star. For example, good picture will get 5 star and worst picture will get 0 star. In this method, user can know which picture is best suit for AR frame in the end.

In long term plan, AR frame can be applied for commercialize. AR frame can be used as a standard frame that can change the content of the product without losing the AR marker. For example, when Car Company wants to sell a new car name 'A0', they will plan to do it on domestic and oversea. Using AR frame, the entertainment and information provider can be use anywhere in the world. Car Company just needs to change the language of the poster while using the same picture and format. As the result, AR frame will reduce time consumption, reduce the cost and also provide more entertainment method which lead to selling value in the end.

In short term plan, the shape and design need to be closest to human face because user tends to look at the face of opposite side rather than looking at a badge. The size of AR badge is very small and limited, so the distance of AR also limited only 1.7 meters. The future work objective is to provide the higher distance with acceptable size of marker. Moreover, there is an opportunity to use face recognition for individual human and set it as a marker in the future. If that kind of technology become commercialize, the experience and AR badge will be improve accordingly.

In long term plan, AR Badge: Layered based information will focus on the community platform. The system has an opportunity to become a center of personal information that user can share within member in community by using cloud based information that everybody can register, edit or design their own information and be able to print the personal data AR code by their own will. Moreover, the benefit on using this system is tend to become more important due to this system can be apply to use for google

glass or next generation of head mounted display that can provide augmented reality. When head mounted display become normally used, layered based information can be used to provide the interaction between human and human or human and robot. At that time, human can know each other more, and can share the same interest or conversation without start asking 'what is your favorite football club? or where are you from?' the system will tell you right in front of user's eyes and user will feel more comfortable to talk with someone who first met or even someone you want to start talking to. Relationship will become closer and we can know each other more and more.

In short term plan, virtual controller need to be uses as wireless communication. Using Bluetooth or Wi-Fi system connects to Arduino board is one of an appropriate method. The data can transfer through the network and pass by signal. As a result, it will increase the ease of use, opportunity to use, potential and so on. Not only sending the data but receiving the data also provides a better interaction. For example, when user want to control another robot, he may look at robot and see whether other people is using it or not, he may know how long he can use it, what is the remaining battery and how to register and so on. So receiving data can increase more interaction and make the controlling become smoother.

In long term plan, virtual controller can be applied for robot and robot to interact between robots itself. For example, user using TELUBee Robot wants to control TelesarV to pick up the object. User can just look at TelesarV and control it by controller. Or other situation is to check hand with person near you. Because TELUBee doesn't have a hand or it can borrow hand from TelesarV to check hand or playing around with person inside the room. Virtual controller can be used for many kind of aspect and which would be useful for robot controller.

6.3 Conclusion

Layered based overlay information in Telexistence robot by using augmented reality would be useful for finding object, controlling the real object in remote place which will be a good first step to apply to different

aspect and usability. Layered based information by using distance is very new to the normal daily life and it should have an instruction to show them how to use. Moreover, using in Ubiquitous Telexistence robot takes a lot of limitation such as movement, resolution, and head flickering are effect AR experience and it should be part to concern. AR itself reduces computing power of the head controlling robot that creates latency accordingly. As the result, head movement goes a little bit unsmooth and affects the AR experience in the end. So, all the system needs to be synchronizing to get a better experience. There are a lot of way to improve and applied the function in the system but the more function, more computing power is needed but even 2.5GHz processing power still not enough to create full-fledge system as the concept said due to the system will took a lot of computing power and lead to latency which is one of the most concern point in Telexistence robot. So, next plan is to find the most appropriate system and function that can be effectively use in Telexistence robot. In believe that, Telexistence robot will become one of the social-impact robot in the marker and helpful to the society.

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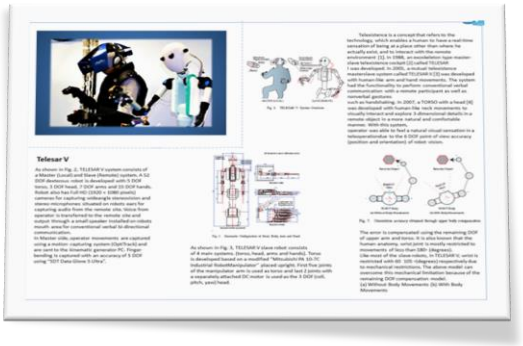
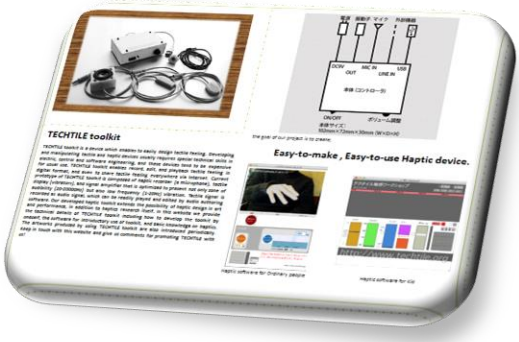
Appendix

A. Design for Picture based marker in poster and brochure use



TELESARV poster A3 size

TORSO poster A3 size



Tactile Toolkit poster A3 size

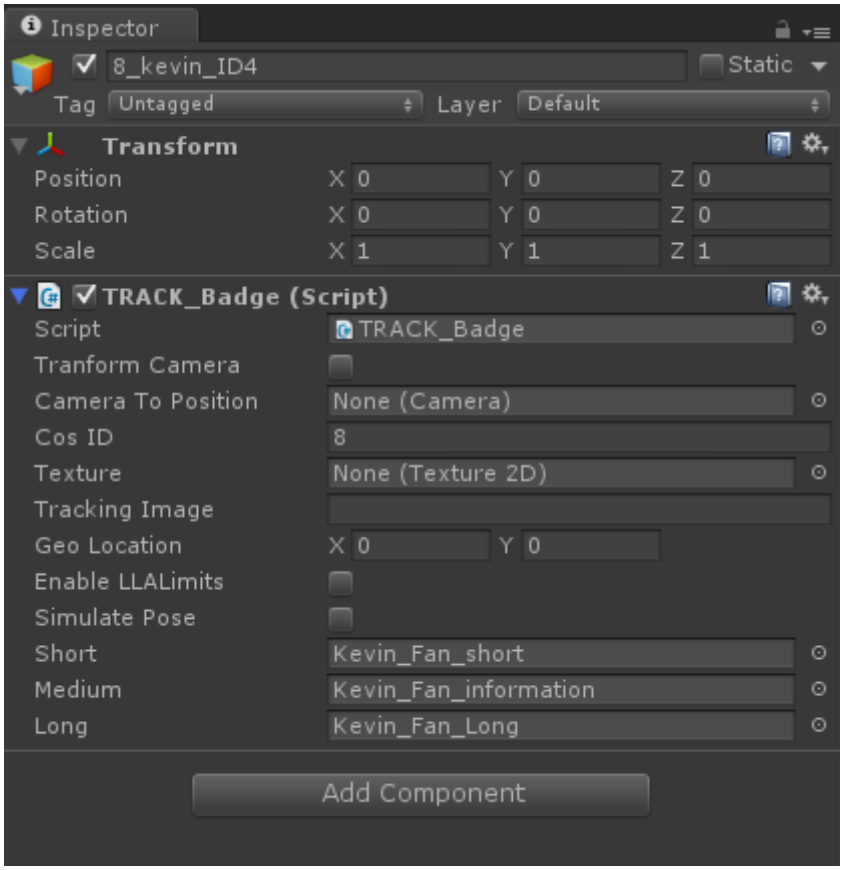
Graffiti Fur poster A3 size

PINOKY poster A3 size

TELESARV poster A4 size

Tactile Toolkit poster A4 size

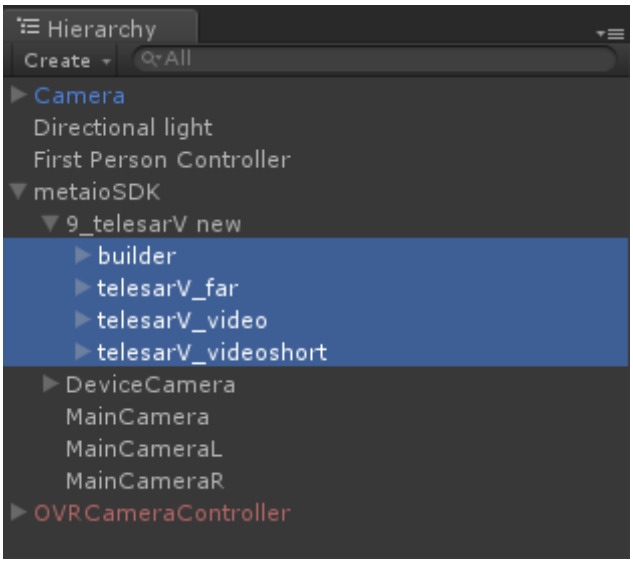
B. How to Add overlay information in distance based information in Unity3d Metaio SDK



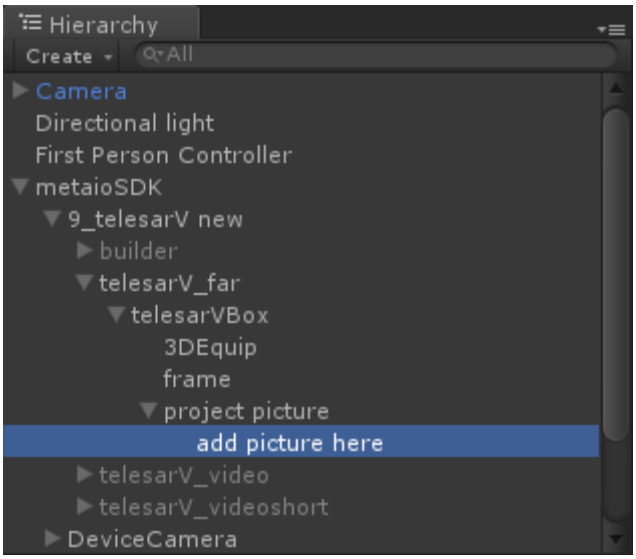
Short for 0 – 1.2 meters

Medium for 1.2 – 2.5 meters

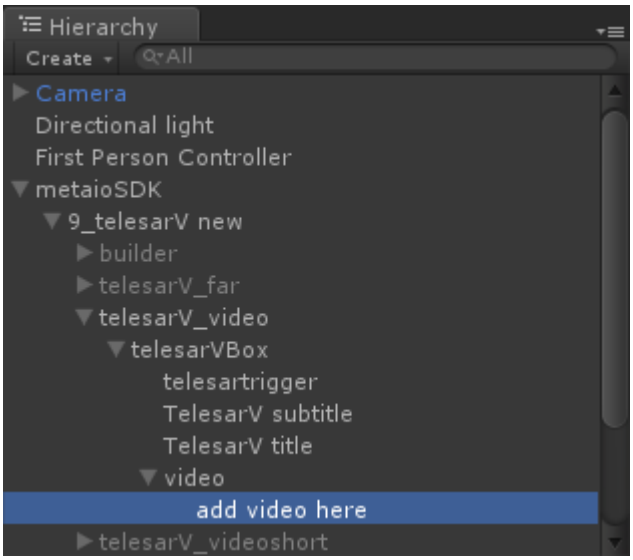
Long for more than 2.5 meters



Add information at hierarchy section inside Metaio SDK



Add project picture here



Add project video here