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Bildbox! Virtual Photo Booth that Implements Augmented Reality

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ABSTRACT

The purpose of this research is to develop a self-service photo booth that implements augmented reality which is named as BildBox! where it allows the user of this product to try on different costumes virtually. There will be discussion on the Business Analysis that is conducted in this research to know the potential of the product as well as discussing the features that are implemented in the product. The development of the product's software will be using Unity game engine and the depth image is taken by using Microsoft's Kinect v2 depth camera. Aside from the discussions mentioned above, there will be also charts shown from the results of the surveys conducted. In the end, there will be a conclusion drawn from the survey results.

Keywords: *Augmented Reality, Depth Image, Kinect, Unity*

1. Introduction

Photography is an action or art where a person takes a picture and processes it. There are different kinds of photography style such as architecture photography, fashion photography or human photography. The media for taking the picture also varies, from digital camera to mobile phones.

One of different kind of photography media is photo booth, it is a kiosk or vending machine that contains camera and film processors where people can walk inside it and take picture. It is operated automatically once a coin is inserted to the machine. However, with the rapid development of technology, this kind of photo booth has been outdated. The modern generations who are exposed to new and intriguing photography features such as slow-motions, looping features, etc. are not interested anymore with those kind of photo booths.

Rapid development of technology also introduces to many new photography techniques such as augmented technology. One of the most popular augmented technology photography mobile application is Snapchat, where it allows users to add virtual accessories such as mask on their faces, change the background of the pictures and even voice manipulation that creates different sound effects. With these kinds of features, Snapchat has become popular with the millennials.

Augmented Reality can also be implemented in fashion industry, Espiegel is an example for this statement. Espiegel is a prototype where it allows shoppers to try clothes virtually with the help of augmented reality technology. Shoppers can browse the clothes that are available in the store through the prototype and select the clothes they want to 'try' by choosing the options in the tablet that served as the interface. BildBox! is actually developed from the Espiegel prototype with several features added to fit the features for photo booth.

From preliminary observation, conventional photo booths in malls or entertainment centre such as Timezone or Amazone is lacking of visitors. An assumption can be drawn that people think it is boring as there is nothing special in it. From this research problem, we have the idea of developing a digital photo booth that implements augmented reality that might attract people to try and use it. Therefore, the objectives of the research are:

- Implementing the Espiegel algorithm into BildBox! by adding some photo box features such as taking picture and previewing them.
- System Testing to BildBox! in order to know whether the features are functioning as it is supposed to.

There are several research questions regarding the research:

- What modifications that should be made in Espiegel algorithm so that it can fulfill the needs of BildBox!?
- Are the features developed for BildBox! can function as it is supposed to?

The scope of the research is limited to design and develop a virtual photo box where it can allow customer to choose the costume they want by waving their right hand to the left or right, triggering the camera by hovering their hand on the camera button which allows them to take a picture of them 'wearing' the costume and display it to the customer before print the picture.

In the report written by Lechat, et.al. (2015), Kinect v2 is equipped with two cameras; one RGB camera and one infrared (IR) camera. The RGB camera has a resolution of 1920 x 1080 pixels whereas the IR camera has only a resolution of 512 x 424 pixels.

The maximum framerate that can be carried out by the sensor is 30Hz. Field of view for depth sensing of the sensor is up to 70 degrees horizontally and 60 degrees vertically. Unlike the predecessor, the latest version of Kinect can work outdoor. Lachat et al concluded that it can work in a sunny day as long as the sensor is not directly illuminated.

2. Related Works

Augmented Reality is a leading-edge technology that project computer graphic to reality Kato (Kato, 2012). On the other hand, augmented reality is inside a generalized context called Mixed Reality, that touch on a multi-axis spectrum of area which also includes telepresence, augmented reality, and other related technologies. Billinghurst (Billinghurst, 2004) defined that augmented reality has a goal to refine and strengthen human's recognition of the surrounding through integrating three different technologies; sensing, computing and display. To support the AR Technology, in the report written by Zhang (Zhang, 2012), Kinect is said to be made up of several advance sensors such as depth sensors, infrared sensors, colour camera, four-microphone array that allow the capture of full-body 3D motion capture, facial recognition as well as void recognition capabilities. The depth sensors are made up of two components, infrared projector and also infrared camera. These two components are responsible for detecting the depth of an object.

Espiegel is a technology that allows fashion shoppers to have the chance to experience trying on clothes virtually. The reason of the development of this technology is due to the current situation in the real world where shoppers need to try their clothes in a fitting room, which takes time and is not efficient. Espiegel believe that in this digital era, it is possible to have shoppers to try clothes virtually, by using Microsoft Kinect and also by providing 3D cloth models, allow shoppers to have the chance to experience trying on clothes virtually. One of the issues faced by shoppers in a fashion department store is the limitation on number of clothes that are allows to be brought inside the fitting room thus leads to the shoppers to go back and forth when trying a lot of clothes. Not to mention that the products displayed might not be available at the store at that moment due to being out of stock, therefore shoppers do not have the chance to try the clothes.

The development of Espiegel software is concerned with how to make Kinect able to detect the user's body and registering the virtual 3D cloth model on the user's body. Aside from this, the development of interaction methods for the user to interact is also a concern of the development. In the beginning of the development, the option of gesture and pose method is chosen, however after receiving some feedback from the users and the survey done, many felt that it is not natural as there are some gestures that need to be made for the user to execute an action. The software is also tested several times after being developed to make sure that the main functions of the software are running and there are no major bugs. The software has also been tested on the public several times and received a good response from them although most of the input for the development concerns the calibration of the virtual image and the body of the user. Unfortunately, due to time constraints and several other circumstances, the development of the hardware for Espiegel was not conducted. Espiegel has only setup television and Kinect sensor as well as a tablet as the UI for the demonstration to the public. The television was setup in a vertical way so that it looks like a mirror whereas the Kinect sensor was placed below the television. The tablet that provides the interface was placed in a stand so the user could choose the clothing that they want.

Interacive Mirror is a real-time virtual dressing room that also implements augmented reality. They converted real catalogue images into 3D digital clothing on male and female mannequin,

hence the digital catalogue is fitting correspondingly to the models. Interactive Mirror do a full body tracking which can detect the neck and feet joints. These joints are then calculated for the distances to be used as an estimated user's height. The scale of the digital clothing is then resized accordingly to the height of the user. (Bansidhar et al., 2017)

ARDressCode finds that the conventional way of trying clothes in clothing stores is both tiring and time consuming. They find that it could be better for customer to see or try clothes that fits them without having to take off their own clothes and waiting for the long line in order to use the fitting room. To address this problem, ARDressCode aimed to improve the customer's shopping experience by avoiding them spending time in changing clothes and waiting for their turn using the fitting room but instead focus on the finding clothes and fit them on the customer's body.

In developing the system, ARDressCode finds that in order to make the best judgement of the garment, customer needs to touch, smell and see them before. This consideration is taken in developing the system. When customer is going to try clothes by using ARDressCode, they need to take a garment they wanted to try without needing them to find the exact size or colors. This garment has an RFID tag which later will be need by the system. Once the customer is in front of ARDressCode, there will be a bar located on the left of the mirror where the selected garments need to be hanged. A box on the right side of the mirror will store the customer's phone. This mobile phone will transmit the customer's precise body measurement through Bluetooth, these data will be used to process the image that will be projected to the user. It is possible for customer to get suggestions for other clothing that fits to the cloth the customer is trying on that time. Once the customer finish trying the clothes, sales associates will have lesser clothes to return to the hanger. However, 3D model of clothes might fail in giving reliable impressions of how it would fit on the body and each model is modelled in high poly and this might cause them to render slowly; which will hamper the illustration that will be projected (Kjærside et al., 2005)

Table 1. Related Work Comparison

No	Product Name	Advantages	Disadvantages
1	Espiegel	• Provide touch interface that is simple to understand for the user. • Giving the possibility to try different clothes without spending too much time and effort. • Ability to try clothes that are out of stock as well as available ones.	• Disturbance of trying clothes may occur since there is no specified room for the product. • Bigger database is needed to store more model. • Interaction using a tablet PC is redundant as Kinect camera has the ability to detect gestures.
2	BildBox!	• Augmented reality imple-mentation on the user's whole body. • Have features of a photobooth (taking picture, preview picture, print picture). • Sharing image features such as email, social media and QR Code.	• Augmented reality projection at the current development is still not giving real impression due to the noises and the fitness of projection. • Projection of virtual content can be altered if the user stretches the body. • One of the main features of a photo booth has not been im-plemented (printing feature).

3	Interactive Mirror3	• Scale clothes based on the customer's height • Real clothing catalogue and convert them into 3D models. • Select user that is the nearest to the mirror as the main subject of trying.	• Can only recommend clothes that are on the catalogue. • Might have the same problem as BildBox! as it uses the same concept for fitting the virtual clothes on the body.
4	ARDress Code	• Tag based virtual reality fitting room. • Give suggestions for the customer based on the selected garment.	• High poly clothing model can cause more time to render in real time as it is more detailed. • Need to bring physical clothes to project the virtual content as it needs to read the RFID tag.

After reading several related works, we summarized the advantages and disadvantages of each research work that we have searched into Table 1. From each of the advantages and disadvantages we have concluded, it might be useful as the future reference of BildBox! photo booth. The current BildBox! development is still not able to implement the printing feature and the virtual projection of the costume is still far from satisfying.

3. Methodology

The main goal of this research and development is to develop BildBox!, a self-service photo booth that implements the Augmented Reality on the user's body and allow them to print picture of the implementation of the projected virtual costumes on their body. As shown in Figure 1 there are several steps that need to be taken and done in order to finish BildBox! prototype. The software will be taken from Espiegel software prototype and there will be several changes and tweaks that will be done on it, therefore there will be system analysis on both the existing and proposed ones. As for the hardware, it will be built from scratch based on the design and it will be integrated with the software and tested to ensure that future users will find it easy to use. Business Analysis will be needed as BildBox! needs to define it targeted market as well as how it can promote itself to its targeted customers. To ensure that BildBox! has a minimum amount of bug, there will be an internal testing and after passing the internal testing, it will be then tested to the public. This testing aims to receive feedback and inputs from the potential users.

Figure 1. Research Methodology Overview Diagram

Furthermore, an analysis on the business model of Espiegel and BildBox! is required in order to find out the SWOT (Strength, Weakness, Opportunities and Threats) of each model, we will be using the SWOT analysis table in order to analyze the business models of both products as shown in Table 2.

Table 2. SWOT Analysis of Espiegel and BildBox!

	Espiegel	**BildBox!**
Strengths	• Helpful for customers in choosing and trying clothes. • Reduce time and effort to find the right clothes. • Useful for clothing stores.	• Developing an interesting entertainment option to customers by implementing augmented reality. • Wear costumes virtually and take picture. • 3D costumes collection is small and changed based on request or season.
Weaknesses	• Need a lot of models and frequently updated which can increase the price. • Need manual work in order to maintain the service.	• Niche market. • Manual maintenance services for product's services. • Lacking of printing feature which is essential in a photobooth.
Opportunities	• Replace the function of a fitting room. • Can be implemented and interesting for clothing business.	• Emerging option of entertainment that can replace conventional photobooth.
Threats	• Cost for modelling and hardware is still troubling.	• Photobooth might be not interesting anymore for public to use.

From the analysis, Espiegel is useful for customer to reduce the time and effort taken in order to find the right clothes and moreover, it is also beneficial for clothing store to have these as it can replace the function of a fitting room. As for BildBox!, it implements new technology to an old entertainment product; the conventional Japanese photobooth. With its small but updated collections of virtual costumes, customers can try and take picture with the virtual costumes.

The weaknesses of Espiegel are that it needs a large amount of effort and resource to have the collections of clothes converted into virtual product. This might affect the price of the product and it also needs manual work in order to maintain it, just like BildBox!. Moreover, the collection of clothes might also be updated frequently alongside with the collection of the clothing store. BildBox! has a niche market; which is junior and senior high school students as well as university students in urban cities in Indonesia. The printing feature that will be implemented in the future also need manual work in order to keep the ink level and photo paper in stock.

Espiegel has the opportunity of replacing the position of conventional fitting room in a clothing store and during several exhibitions, some business owners are interested in using the product on their store. Just like Espiegel, BildBox! also have the opportunity to replace conventional photobooth for entertainment. This statement can be proven by the result of the survey done.

The cost for making the 3D models for clothes is high due to the number and frequency it needed might result in hard sales for Espiegel while for BildBox!, the concern will be whether the idea of photobooth is still interesting for the public; especially teens and young adults to

use. There are several modifications on the existing Espiegel software in order for it to be compatible for the features of BildBox! Aside from the name itself, there are several additions of hardware that needs to be connected with the software, especially printer so it can print pictures when the features are turned on. The algorithm for 3D model fitting will also be improved so it can be more accurate and precise to the user's body. The way user interact with the system will be also different; in Espiegel, customer will interact through a web-based interface whereas in BildBox! hand gesture will be the sole interaction method.

3.1. Existing System Analysis

Figure 2 shows the system architecture diagram of Espiegel. It works when the user stands around 1.5m in front of the Kinect camera. The camera will capture the depth image of the user where it will be converted into a skeletal joint. The Kinect will be connected to the USB port. The skeletal joint will be merged with the 3D model clothes that has already a joint.

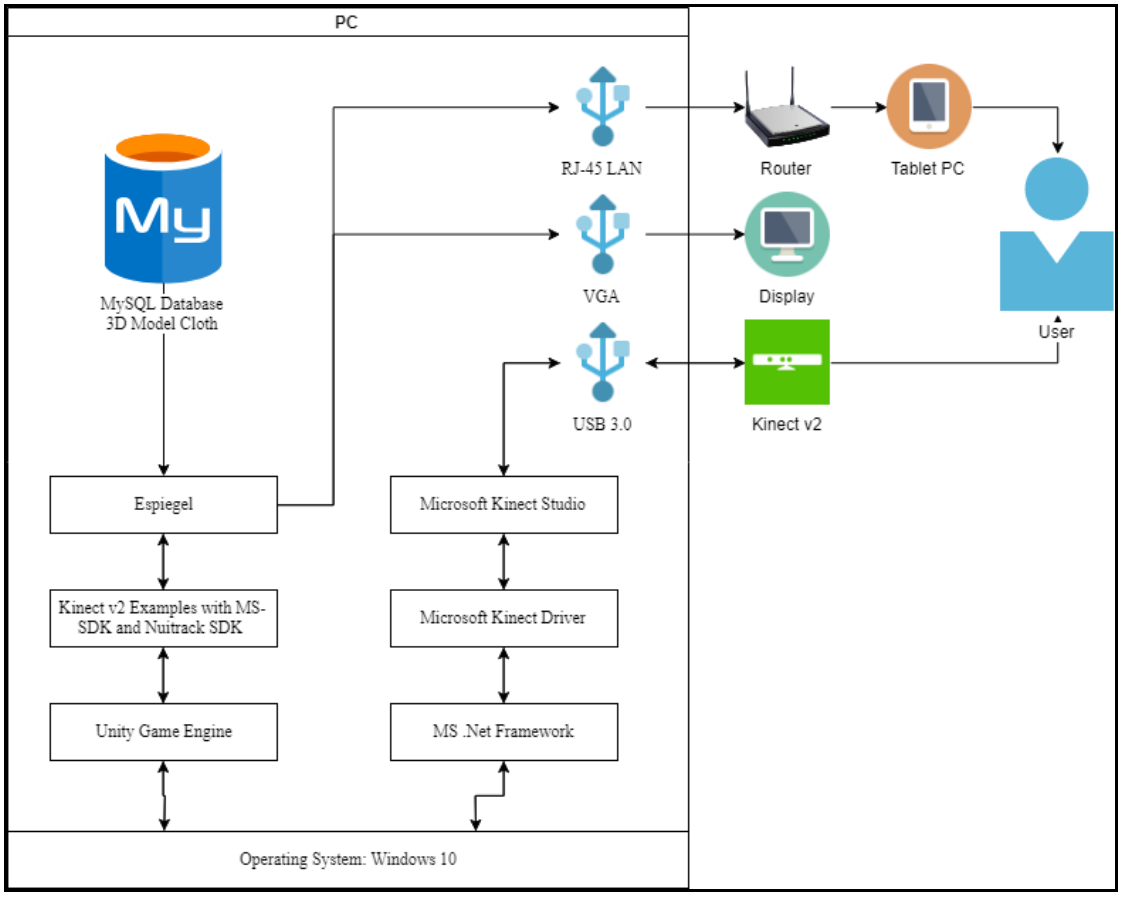

Figure 2. System Architecture Diagram of BildBox!

The PC of Espiegel operates with Windows 10 that has already installed with .Net Framework that is usually found in Microsoft's operating system. This framework provides many libraries of programming language thus it is called Framework Class Library. Aside from those, the PC also needs Kinect driver as well as Kinect Studio in order for the Kinect camera to work. Kinect Studio is a Software Development Kit (SDK) that allows the developer to create application that support body gestures and voice recognition with the technology of Kinect sensors on computer that runs the operating system Windows 8 and above.

The brain of Espiegel is the Unity game engine. The algorithm of synchronizing the real image (skeletal joint) with the 3D model clothing that are stored in the database runs on this software. VGA port will be connected with the display system of Espiegel, where the display system will show the result of the augmented reality. User can also choose their clothes through a PC tablet that is connected to a Local Area Network (LAN) that is the same with Espiegel. The process of Augmented Reality in Espiegel can be simplified as a flowchart shown in Figure 2. The Kinect camera will first obtain the depth image of the user and this depth image will be converted in a skeletal joint. The skeletal joint will contain the coordinates of each body part where it will be merged with 3D model clothes from the MySQL database. Each of the clothes will also have joint coordinate and will be 'stick' to the corresponding joint. The result of the merging of both skeletal joint and 3D model clothes will be shows on the display.

3.2. Proposed System Analysis

Overall, the architecture of BildBox! is partially the same like Espiegel as it is developed from Espiegel prototype. The difference of the two system can be seen in the hardware BildBox! is using. Figure 3 shows some differences when compared with the Figure 2. In this system architecture diagram of BildBox!, there are several new hardware that will be used in BildBox!.

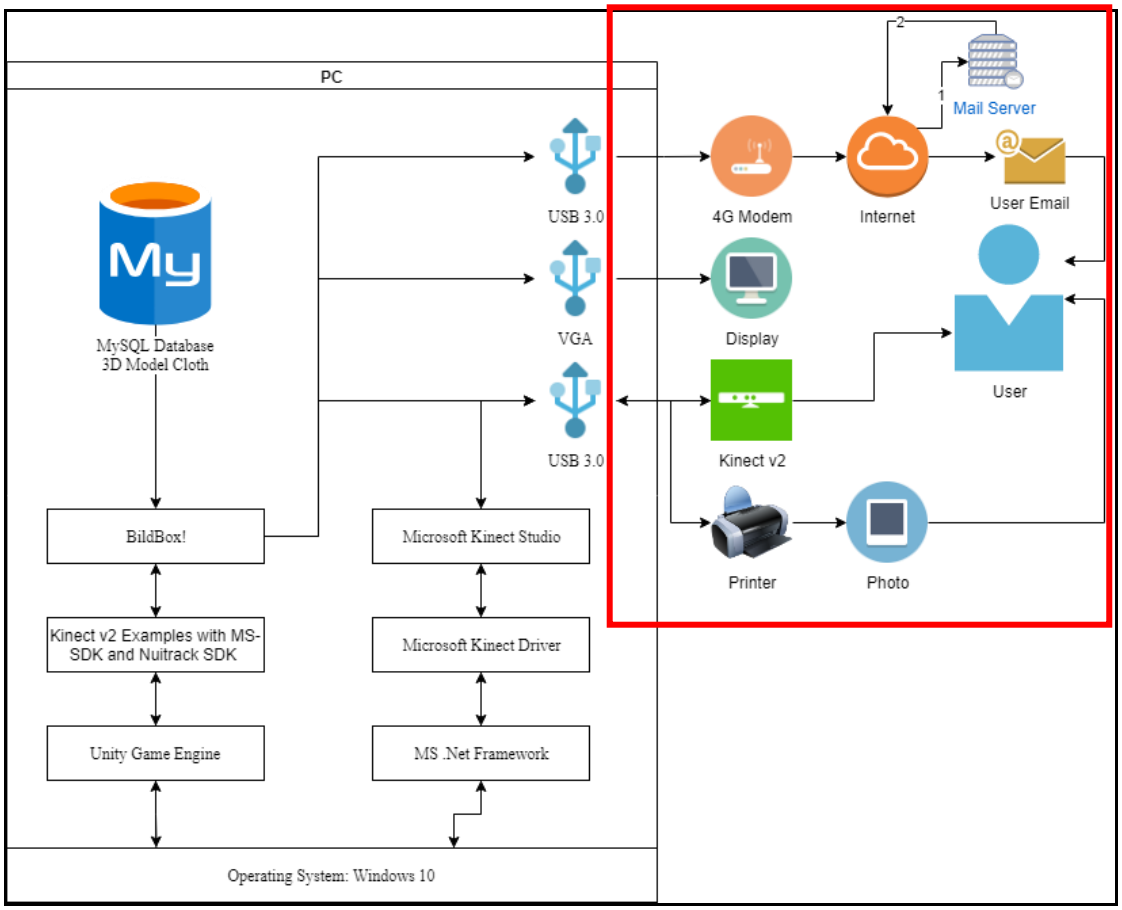

Figure 3. System Architecture Diagram of BildBox!

When a customer is going to use BildBox!, they will need to stand an estimation of 1.5m in front of the BildBox!. To choose the costumes they want to wear, the customer can swipe left or right to choose the previous or the next costume respectively. After choosing the costume

they want, customer then can take a picture by raising his/her hand to the camera button located on the screen. The picture then can be printed or sent to the email of the customer.

4. Results and Analysis

4.1. BildBox! Overview

As illustrated in Figure 4, there are several phases of interactions that a customer needs to go from the beginning until the end of BildBox! usage. The first phase is the payment phase where the customer needs to pay for the service first before able to continue. This feature is still not available in the current prototype as it is still in development process.

The next phase that will the customer go through is the detection and customizing phase. Here the Kinect camera will detect the customer's body and the software will project a default costume. In order to choose the costume, they want, the customer can use their right hand as a cursor and swipe left or right in order to choose the costume they want to use.

In the middle of the screen, there will be an input field where the customer needs to fill in with their email. This is necessary for the sharing feature that BildBox! has. After filling it, the customer then can proceed to the next phase which is called the photography phase; where there will be picture taking, previewing and sharing. In order to reach this phase, after choosing the costume they want to use for the picture taking, customer need to raise their right hand and reach the camera button which is located on the top right of the screen.

There will be a three second countdown and after it reaches zero, the picture will be taken and the user can have a preview of the picture. If the customer decided that picture taken is nice and wanted it to be shared, they just need to hover the share button by using the right hand.

The process of choosing clothes, picture taking is repeated until three cycle and after it finished, the customer needs to pay again in order to use the product's service or they can walk out of the booth. The figure 4 shows screenshots of some phases in BildBox! as well as the initial UI design.

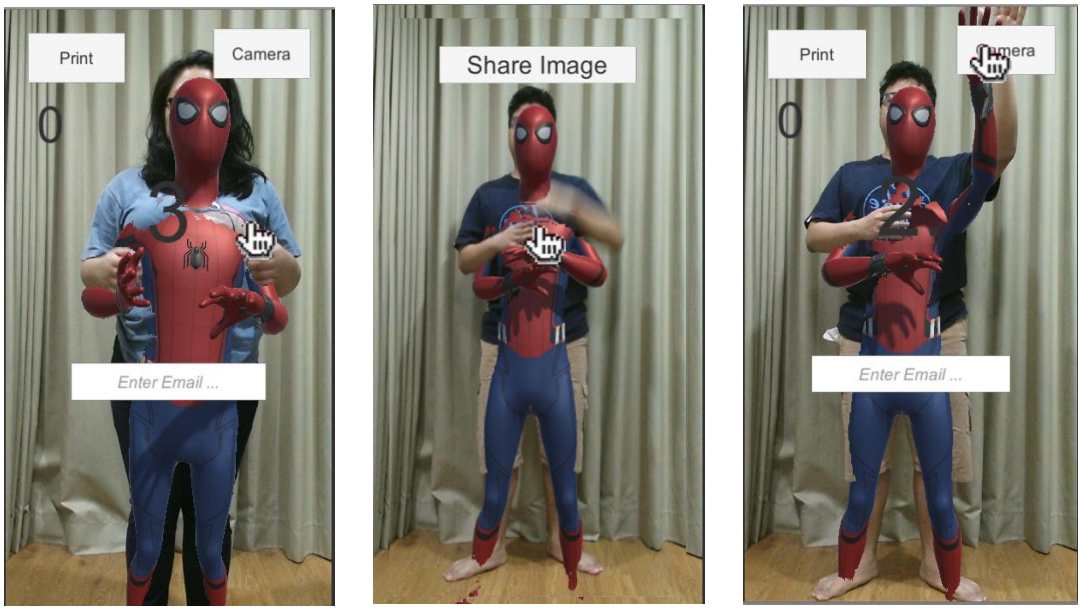

Figure 4. Several phases in BildBox!

In Figure 5, we can see the features that are in BildBox!. Since the idea is to have the customer to do payment first before able to use the product, first feature is the scanning of virtual payment barcode which has not been implemented in the current product development. Another feature that has not been implemented in the product is the printing feature. This feature allows the use to print the picture that has already been taken. The development of printing feature will be placed as priority in the future development as it is one of the main functions of a photo booth. The rest of the features that are listed have been implemented in the product but however, those features such as projection of virtual content on the user's body as well as the gesture motion need more improvement in order to give the users better experience.

The solution for the synchronization in Espiegel is by buying a plugin from the unity store. The plugin has already prepared the algorithms for synchronizing the 3D costume model to the human body and the developers just need to implement it. Since BildBox! is developed from the prototype of Espiegel, there is no need to create an algorithm from the scratch. The idea of the synchronization process is by to glue the rigged human body with the 3D costume model that has already been rigged, which means that the model has been made a skeleton so it can be moved. Joints such as head, shoulders, hips, etc. can be detected by using Kinect.

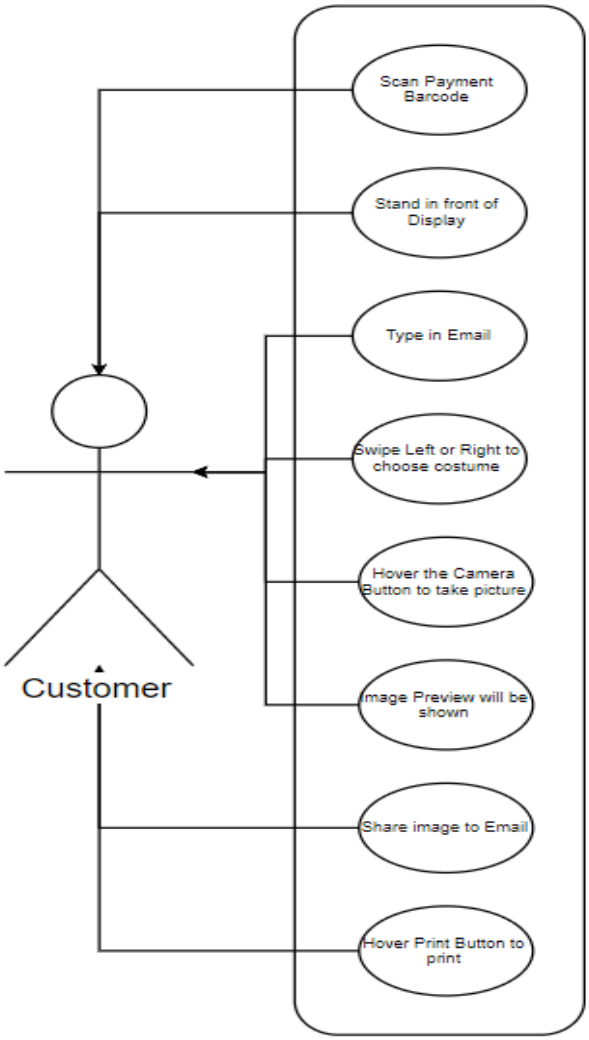

Figure 5. Use Case of BildBox!

4.2. Application Testing

There are also surveys that are conducted in this research. The survey itself is breakdown into several parts where each has its own purpose. The idea is to let the customer try the product and then answer the questions afterwards. In Table 3, it contains the lists of questions that are asked and the method of answering; by ticking the box to show agreement with the statement. It has two different type of answer; the first is to know the existence of the function while the second is to know the functionality of the function.

Table 3. Unit and System Testing Questions

No	Usability Testing Questions	Existing?	Functioning?
1	Kinect Camera can detect your body and able to project 3D costume on the screen.	☐	☐
2	You can do gesture motion to interact and choose your desired costume by swiping left or right.	☐	☐
3	Email input field exists and you can fill in your email in the field.	☐	☐
4	Camera countdown exists and visible. It start to countdown once camera button is clicked.	☐	☐
5	Image counter is visible and count the number of pictures taken.	☐	☐
6	After picture is taken you can preview the picture in the preview section.	☐	☐
7	Share button is visible on the preview scene and you can share image once the button is clicked.	☐	☐
8	Print button exists and you can print the picture automatically once it is clicked.	☐	☐

The conclusion that can be drawn from the result of the testing are:

- A majority of the testers agreed that the swipe feature exists, however they still find it buggy, as sometimes the swipe gesture will run even when the tester is not swiping at all.
- Print button does not exist and therefore not functioning at all. This is because the current development still has not implement the feature.

Aside from analyzing the questionnaires result, we do observe the testers while they are testing the product and from the observation there are many points that should be improved.

1. Gesture motion
We notice that the testers are still confused for the current gesture motion implementation. Before they start testing the product, we have briefed them on how to use the product; especially for the gesture motion, we have said that the cursor is only located on the right hand. However, they unconsciously try to swipe to the left by using their left hand too. From this observation, a conclusion can be made; the current gesture motion is not 'natural' for them. Therefore, the future implementation, both hands will have the capability of gesture motion.

2. Augmented Reality projection
The fitness of the 3D costume models that are projected to the testers' body is still not 'real'. Testers also think that the design of the models can be better in terms of the details too.

3. User Interface
We do realize that the placement of several buttons are not in a comfortable position and we have changed the positions before the testing take place. However, even with the changes, some testers are still having problem with it. Testers with shorter stature are having hard time reaching buttons such as share button that are located in the top left of the screen. We might need to learn more for the placement as well as the sizes of the user interfaces in order to improve the user experience for the future users.

The other purpose of the research is to know more about the targeted market's demography, psychography and also their feedback on the product.

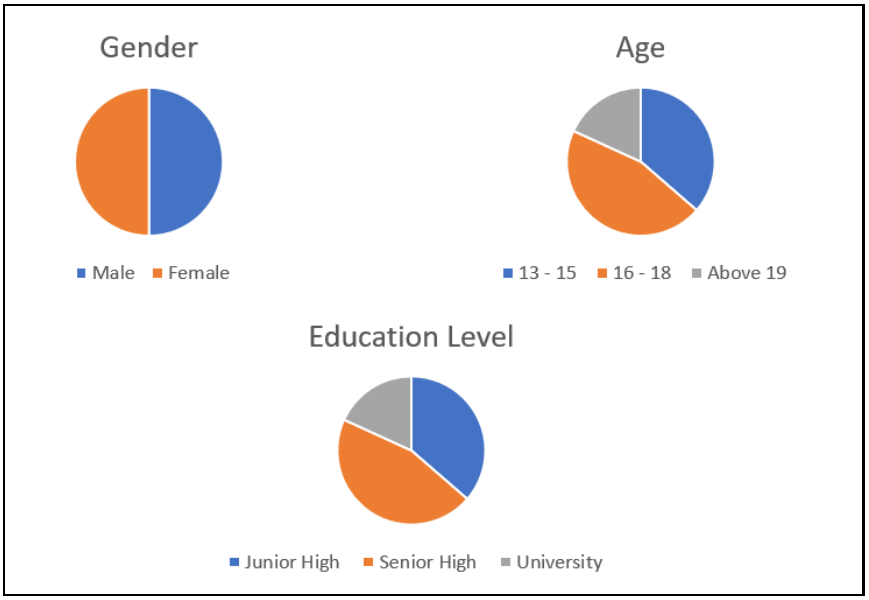

Figure 6. Respondents Demography

The figure 6 shows the demography of the respondents of the survey. There is a total of 22 respondents for the survey and all of them have answered the previous questions already. The amount of female and male respondents is the same too. However, the difference of respondents based on the age or education level are different; most of respondents come from senior high school followed by junior high school and university level.

Table 4. Psychography Questions

No	Questions	Yes	No
1	Have you ever done cosplay or dress up?	☐	☐
2	Do you enjoy seeing others doing cosplay or dress up?	☐	☐
3	Have you ever attended event that has cosplay in it? (Example: Anime Festival Asia, Comic Con or Mall Events)	☐	☐
4	Have you ever tried photo booth in Timezone or Amazone?	☐	☐
5	Do you like to take pictures or selfies?	☐	☐
6	Are you interested in taking photo in a digital photo booth that has project 3D costume models on your body?	☐	☐
7	Do you want to try or use this photo booth if it is available?	☐	☐

The table 4 shows the questions that are asked to the respondents. These questions aimed to get the respondents' behavior and preferences; whether they ever done cosplay, whether they like to take pictures or selfies, have they experienced in using conventional photo booth, etc. The results of the respondents regarding these questions can be shown in Figure 7.

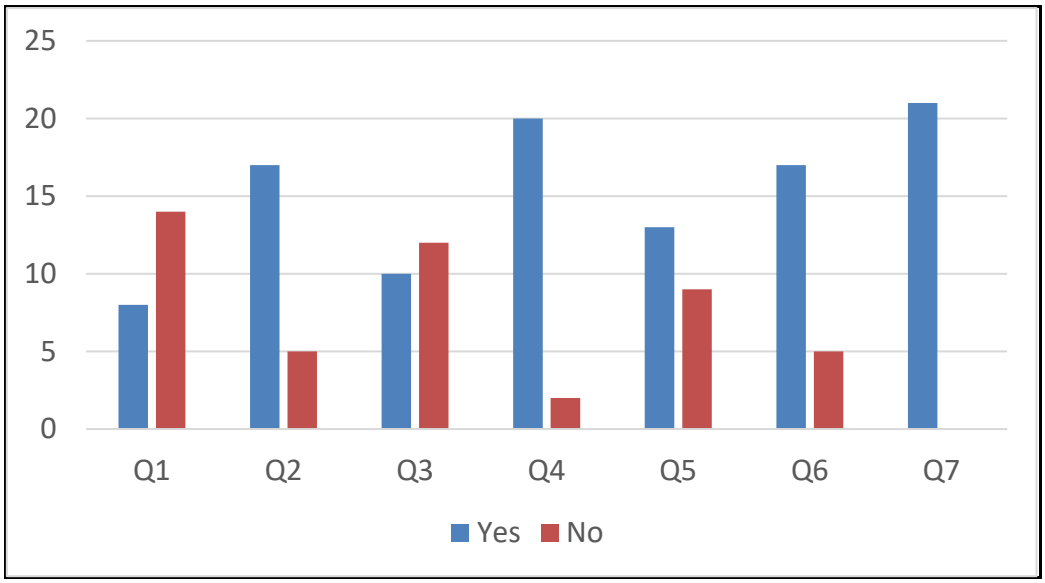

Figure 7. Psychography Results

From the results shown in Figure 7, we can conclude that most respondents have never done cosplay however, most of them enjoy seeing others doing cosplay. Almost all respondents have ever tried conventional that can be found in entertainment places such as Timezone, Amazone, etc. Although only half of the respondents do enjoy taking pictures or selfies, most of them are interested in the idea of a digital photobooth that can project 3D costume on their body. All of are interested to try or use the product in the future if it is available.

The last type of questions that were asked to the respondents will be the product feedback. The aim of these type of questions is to know their satisfaction of the product. The them answering

method is by using Likert Scale, where there will be a scale from 1 to 5, where 1 shows disagreement and 5 shows agreement with the statement. A detailed scale and their value will be shown below and following table 5 that contains the lists of questions regarding the product feedback:

1 = Disagree; 2 = Somewhat disagree; 3 = Neutral; 4 = Somewhat agree; 5 = Agree

Table 5. Product Feedback Statements

No	Questions
1	Gesture movement for interactions is easy and comfortable to use.
2	Buttons are placed in the right position for user interaction.
3	3D costume models are well made and designed.
4	3D costume models are fitting well on the body.
5	Clear information is given for time before picture is taken.
6	Clear information on how many pictures are taken already.
7	Time given (3 seconds) for picture taking is long enough.
8	Maximum number of pictures taken is enough (3 pictures per transaction).
9	Overall, idea is interesting and I want to try or use the product in the future if it is available.

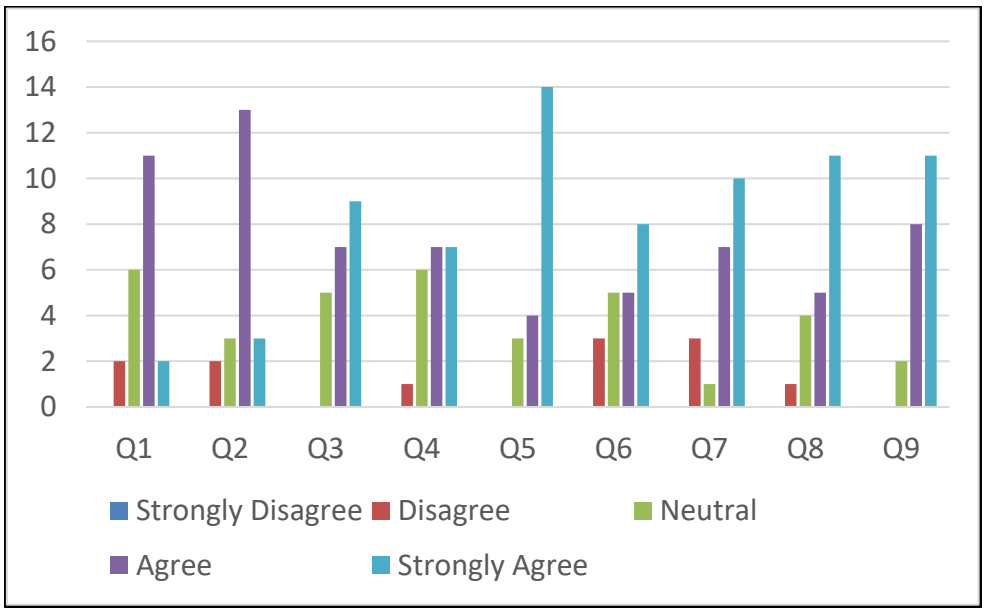

Figure 8. Responses on Product Feedback

From Figure 8, there are some conclusions that can be made. For the gesture motion feature that we implemented for BildBox!, half of the respondents agree that it is easy and comfortable however, eight of the respondents do not think that way. This give us an indicator that the gesture motion should be improved for the customers' comfort as well as easiness in using the

product. As for the placement of the user interfaces, more than half of the respondents agreed that the current placement is at the right position.
Many respondents have a good impression on the current detail of the costume that we made. However, one third of the respondents do not agree that the fitness of the model is good enough. Improvement of the fitness of the model should be taken note as well for the future development of the product.

The information that is shown to the testers regarding the number of pictures taken already as well as the time left before the picture is going to be taken is clear enough for the customer. However, for the information on pictures that are already taken should be improved as eight of the respondents do not think that way. A possible solution for this problem might be the placement of the information should be changed or the size of the letters showing the information should be bigger. Overall, the idea of this product is interesting for the testers and majority of the respondents are interested in trying the product in the future.

5. Conclusion

In these few months of research, BildBox! has successfully implemented basic features of a photobooth such as taking pictures, preview them and choosing the costume. However, one of the basic features is still missing and that is the printing feature. Although there is a missing feature, the result of the unit and system tests show that the product need many improvements in the other features as well such as the easiness of interaction between a customer and BildBox! as well as the projection of the virtual content.

Additional feature such as gesture motion has also been implemented in BildBox! to replace the web-based interaction that is used in Espiegel. This response of the respondents toward this feature is positive, the found it easy and comfortable to use however from the observation towards the testers during the testing, we found that it should be improved as well. The current gesture motion uses only the right hand as the cursor for interaction and this is quite unnatural for the tester to do.

We have also developed an email sharing feature in BildBox! where they can share the picture taken to their own email after taking picture. In the future development this feature will be changed in order to simplify the sharing feature. We planned to have a QRCode sharing feature and direct share to the social media of the user in future.

The current projection of the augmented reality need improvement as the current projection still has noises and it has not fully covered the customer's body. During a testing, we also have realized that when a customer is stretching the body, the model projected will also stretch too which results in an undesired projection. The current algorithm scales the 3D model based on the customer's body and the hypothesis is that since it scales up the model based on the customer's body it will be stretched when the customer stretches as well. Therefore, to improve the projection, the change of algorithm for fitting the model should be able to solve the problem. Perhaps, instead of scaling all the model based on the customer's body, maybe it should scale each part of the model based on the body part; head model scaled based on the customer's head size.

Another possible way is to have an edge detection so aside from having the model scaled based on the user's body size, it can also stretch the virtual content according to the edge detected on the body.

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