

## **A Survey for a Virtual Fitting Room by a Mixed Reality Technology\***

**Charlee KAEWRAT and Poonpong BOONBRAHM\***

*School of Informatics, Walailak University, Nakhon Si Thammarat 80161, Thailand*

(\*Corresponding author's e-mail: [charlee.qq@gmail.com](mailto:charlee.qq@gmail.com), [poonpong@gmail.com](mailto:poonpong@gmail.com))

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### **Abstract**

Mixed Reality (MR) has become popular in recent years, due to the fact that it can be applied to many areas, including new learning media, medical training, and manufacturing. Since MR can simulate 3D objects and environments, bringing the user into a virtual world, it allows more perspectives than are seen by using traditional media. MR can be applied to simulate a real fitting room, where the user can try on a virtual dress without taking off any of their clothes. Additionally, it can estimate the size of the user, so they will know their correct clothing size before buying. This MR technology is a powerful decision-making tool for customers in an online clothes shopping environment. By simulating a virtual garment superimposed upon the user body, users can try on virtual clothes as a mirror image, with several angles viewable as they move. This technique can also help customers shop online to select the correct size or type of garment. This should increase confidence when buying garments from websites. Due to advancements in computer technology, a new way to create virtual fitting rooms can be used. In this paper, we have surveyed methodologies and experiments conducted in building virtual fitting rooms. From the survey, it was found that making a good virtual fitting room relies on 2 important factors, i.e., the method of detecting the user's body size, position, and movement, and the method of displaying the virtual garments superimposed on the user's body. The first factors are usually solved either by using devices, like Microsoft's Kinect or the Image Processing technique. The second factor can be accomplished by using augmented reality technology.

**Keywords:** Virtual fitting room, mixed reality, augmented reality, virtual reality, virtual

### **Introduction**

Mixed Reality (MR) is a combination of the virtual world and the real world, used to make new environments where virtual objects and real objects co-exist and can interact with each other in real time. MR covers Augmented Reality (AR) and Virtual Reality (VR) (see **Figure 1**). The difference between AR and VR is that AR is the simulation of virtual objects or environments that can be superimposed on real world space, but VR involves the movement of real people into a virtual environment. Virtual objects or environments involve computer generated objects including 3D models, sound, or images.

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**Figure 1** Mixed reality.

Mixed reality technology can be applied in many fields, including education, medicine, manufacturing, etc., because it can simulate virtual objects or bring a user into a virtual world with a computer generated environment. In AR technology, there are 2 aspects to consider;

1. The Detective aspect: This part allows a virtual object to be display in a position in the real world. There are 2 techniques that can be used for this. The first uses “Maker”, which is a marker-based technique. When a marker is detected, it will be processed in order to simulate virtual objects in the position required. The second technique does not use the marker (“marker-less”), but uses a camera to detect objects or bodies, along with a device such as Kinect, or a depth camera, in order to detect movements or positions of users.

2. The Display aspect: Currently, there are many devices for virtual displays such as head mounted displays (HMD), Google Glass, Hololens from Microsoft, or various smartphones. These devices let users see the virtual world or virtual objects superimposed on the real world.

VR technology can display information through a new technique, to make new media that attracts user attention. The importance of VR technology is that it can be adapted for e-commerce. Due to the current highly-competitive selling rates, especially in clothing and apparel, many e-commerce stores have implemented features to attract customer attention which use virtual fitting rooms to help customers make clothes-buying decisions easily. By simulating a virtual garment superimposed upon the user’s body, users can try on virtual clothes as a mirror image, with several angles viewable as they move. This technique can also help customers shop online to select the correct size or type of garment.

With the features and advantages of mixed reality, i.e., VR and AR, a virtual fitting room, where customers can try on virtual garments without taking off their clothes, can be established. Since the system can measure the size of the customer’s body automatically and then suggest suitable garments for the customer, they can see whether the garments fit them well or not, which will increase their confidence in buying garments and make decision making easier.

## Review of the literatures

In order to make a perfect virtual fitting room, we have to consider 3 specific areas: the method of measuring the user body size, the method of adding reality to the display, and the method of making realistic movement. In this paper, we have surveyed research on mixed reality technology to find a technique and the accompanying results for creating a virtual fitting room which is easy to use. The details are as follows;

### Measuring the body

The purpose of body measurement is to find the right size of the user so that choosing the wrong size of virtual garments will not happen. In the real world, the standard sizes of garments that customers can choose from are S, M, L, or XL. Customers can choose any size depending on their body sizes. Measuring body sizes in the real world can be done easily using a tape measure and then comparing those parameters with tables that can tell the size of garments that would fit the customer best. There are many standard sizes of garments, such as standard US apparel size and standard Asian apparel size, because the

body sizes of people in different parts of the world are different; for example, Asian people have smaller body sizes than people in the US. A comparison of apparel sizes of different standards is shown in **Table 1**.

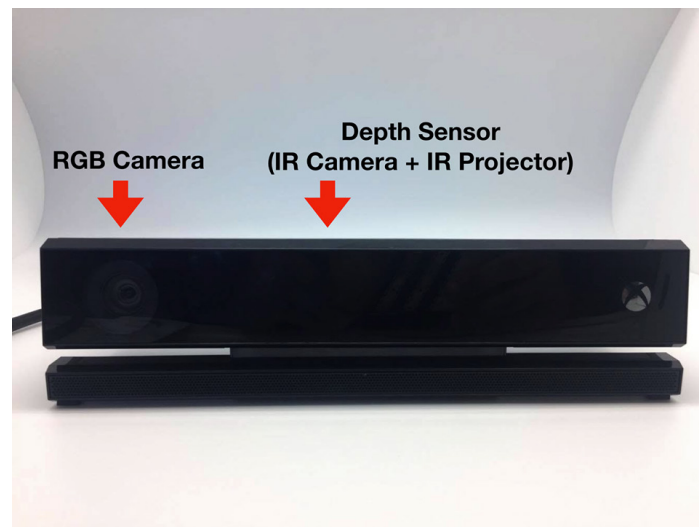
**Table 1** Standard garment sizes.

Size Asia/EU&US	Length (cm)	Chest (cm)	Shoulder (cm)	Height (cm)
S/XS	68	96	42	165
M/S	70	100	44	170
L/M	72	104	46	175
XL/L	74	108	48	180
XXL/XL	76	112	50	185
3XL/XXL	78	116	52	190

Measuring user body size is the main aspect involved in simulating virtual garments in a virtual fitting room. There are many techniques and methodologies, but the most popular ones are as follows;

***Measuring body size with Kinect***

Some researches [2,4,7,11-13] used Microsoft Kinect as a device for tracking users or measuring their bodies. With the functions and sensors of Kinect (see **Figure 2**), real-time tracking of objects or finding the positions of objects can be done. **Table 2** shows details of the techniques, methodologies, and results from researches using Kinect as a tool in a virtual fitting room.



**Figure 2** Microsoft Kinect version 2.

**Table 2** Techniques, methodologies, and results from researches using Kinect for measuring body size.

Article	Technique or methodology	Results
A dynamic fitting room based on Microsoft's Kinect and augmented reality technologies [2].	<ul style="list-style-type: none"> <li>- Use Kinect for tracking the user's movement</li> <li>- Use 2 Kinects to measure the user's body by capturing one from the front view and the other from the side view of the user.</li> </ul>	<ul style="list-style-type: none"> <li>- After measuring the user's body and estimating user's size, the system will simulate virtual garments superimposed on the user's body, which can move when the user moves.</li> </ul>
A real-time virtual dressing room application using Kinect [4].	<ul style="list-style-type: none"> <li>- Use Kinect to extract the user's body from background and then extract a body part, such as arm, leg, etc.</li> <li>- Kinect can track the user's skeletal movement.</li> </ul>	<ul style="list-style-type: none"> <li>- Virtual garments are in 2D image and simulation of virtual garments will be superimposed on the user's body.</li> <li>- Users can see themselves on the screen, just like looking in a mirror</li> </ul>
Estimation method of clothes size for virtual fitting room with Kinect sensor [7].	<ul style="list-style-type: none"> <li>- Extract a user from background by using "Contour tracing" with Kinect sensor.</li> </ul>	<ul style="list-style-type: none"> <li>- This technique can increase accuracy to extract the user's body from objects or background for estimation of real size.</li> </ul>
Magic mirror: A virtual handbag shopping system [11].	<ul style="list-style-type: none"> <li>- Use Kinect to track the body's movement and specify user's arm for adding display of a virtual handbag</li> <li>- Extract a user from background.</li> </ul>	<ul style="list-style-type: none"> <li>- When tracking the user's arm, the system generates a virtual handbag there. If the user changes position, virtual garments will change position, following the arm's movement.</li> </ul>
A mixed reality virtual clothes try-on system [12].	<ul style="list-style-type: none"> <li>- Use Kinect to track user's skeletal movement, so when the user moves, virtual garments can move along with them.</li> </ul>	<ul style="list-style-type: none"> <li>- The system scales a 3D model of user's body size after tracking the user's body and measuring their body size.</li> <li>- When the user moves, the model moves along with them. Then, the system generates 3D virtual garments, superimposed on the 3D model.</li> <li>- If the user changes position or moves their body, virtual garments will follow the 3D model.</li> </ul>
Real Time Virtual Mirror Using Kinect [13].	<ul style="list-style-type: none"> <li>- Use Kinect to track the user's skeletal movement, so when the user changes position, the skeleton changes position as well. By connecting the positions of the user's skeleton and the virtual garments, when the user moves, the garment will move along in the same pattern.</li> </ul>	<ul style="list-style-type: none"> <li>- When the system detects the user, it will generate 2D virtual garments superimposed on the user's body.</li> <li>- Users can see themselves on screen as a mirror image.</li> </ul>

### *Measuring with cameras or webcams*

The work in [3,4,8] mentioned using cameras with an image processing technique to measure the user's body or tracking the position of users, so that displaying virtual garments on the body can be done. Since the system did not have high accuracy sensors like Kinect, an image processing technique was used for detecting users and displaying objects instead. Using the image processing technique can extract the user from the background, or filter objects in order to prevent user tracking errors. **Table 3** shows details of the techniques, methodologies, and results from using the image processing technique in a virtual fitting room.

**Table 3** Techniques, methodologies, and results using the image processing technique.

Article	Technique or methodology	Result
Image processing design flow for virtual fitting room applications used in mobile devices [3].	<ul style="list-style-type: none"> <li>- Use OpenCv to extract the user's body from the background and filter with thresholding and canny edge detection to find border lines for measuring the user's scale.</li> <li>- Use Haar-like feature to specify the position of the user's head and neck.</li> <li>- Use maker base for tracking the user's position to display virtual garments.</li> </ul>	Those techniques can specify the user and display a virtual garment superimposed on the user's body.
Virtual try-on through image-based rendering [4].	<ul style="list-style-type: none"> <li>- Use multiple cameras to capture the user's garments, to simulate virtual garments by extracting the user's garments from the user or the background with a silhouette image</li> <li>- Silhouette difference or likeness can be measured, and standard algorithms used to search the space and specify the user's position.</li> <li>- Use image-based visual hull algorithm to estimate depth map from camera image to extract some part of the body from virtual garments.</li> </ul>	<ul style="list-style-type: none"> <li>- When the system detects the user's position, the virtual garments will be superimposed on the user's body.</li> <li>- The system can extract some part of the body overlay from virtual garments, such as the user's hand.</li> </ul>
Vision based human pose estimation for virtual cloth fitting [8].	<ul style="list-style-type: none"> <li>- Comparison of image between foreground and background to specify the user's position.</li> <li>- Make contours of the object to measure the size of the user and to specify the user's parts, such as a high curvature point being the head.</li> <li>- When the border of the user is found the system shifts virtual garments to the correct point on the display.</li> </ul>	When the user poses in a T- pose, the system generates virtual garments, superimposed on the user's body.

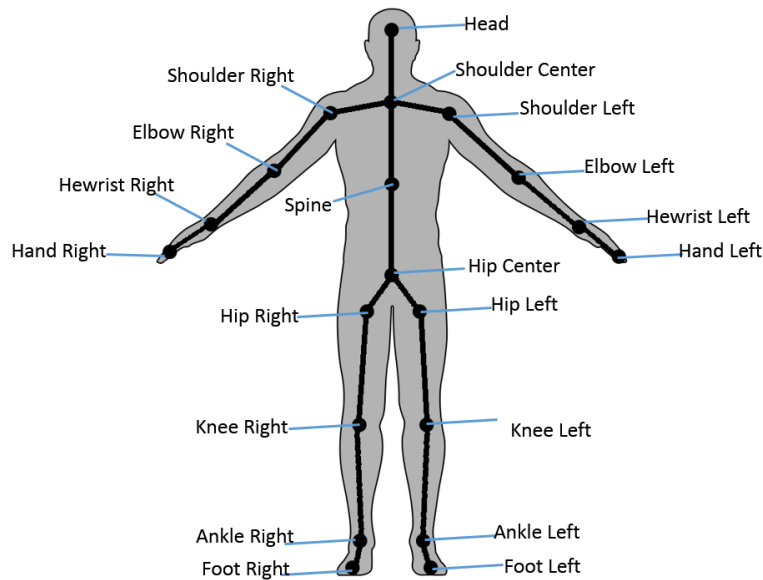
### Adding reality to the display part

In the traditional fitting room, a user can touch or wear real garments, and the garments can move following the user's movement. However, in the virtual world, it is just a vision, or a virtual display, of the garment that the user can experience. By adding reality to virtual reality, the user can interact with virtual garments, or make virtual garments move realistically. Usually, most of the display for this purpose should be big enough so that the whole body of the user, wearing virtual garments, can be seen, just like in a traditional fitting room. By using big screen monitors or TVs, a display of the whole user's body and virtual garments can be seen. From the literature survey, we have found that there are 2 types of garment displays available for virtual fitting rooms, i.e., 2D and 3D. With the 2D display of virtual garments, a 2D picture of the garment will be attached to the user, which he or she can see through the screen. If we look straight, it will look like the user is wearing those garments, but if the user changes their position, the 2D virtual garment will not move along with the body, or only move along with a limited angle, making it an unrealistic visualization. Using a 3D image of the garments superimposed on the user's body, the user can see multiple viewpoints of what he or she is wearing, and if the user moves, the virtual garment follows. Therefore, to make a real display is an important part for simulating a virtual fitting room, and many researchers have tried different techniques to do that, as can be seen in [2,10-13] (Table 4).

**Table 4** Techniques for making realistic virtual fitting rooms.

Article	Technique or methodology	Result
A dynamic fitting room based on Microsoft Kinect and augmented reality technologies [2].	- Add reality to a virtual fitting room by using Kinect to track the user's body.	- Display a 3D model of a virtual garment that can follow the user's movements.
Key design in Implementing online 3D virtual garment Try-on system [10].	- Use physical property to simulate the movement of garments by Uniform Grid algorithm.	- Make realistic movements when a virtual garment moves or collides with the user's body.
Magic mirror: A virtual handbag shopping system [11].	- Use Kinect to track the user's arm to display a virtual handbag and use physical property for interaction between the 3D model of the virtual handbag and the human body. - Extract the user from background.	- Display a 3D model of a virtual handbag when the user changes poses. - A virtual garment can change position, following the user. - The system can change the user's background by simulating a virtual environment.
A mixed reality Virtual clothes try-on system [12].	- For simulating the skin tone of the user's 3D model, using color skin tones in the cheek area. - Use Kinect to track the user's movement.	- The user's 3D model has the same skin tone as that of the user. A virtual garment can follow the user's movements.
Real Time Virtual Mirror Using Kinect [13].	- Use Kinect to track the user's skeletal movements and match the correct position between a user part and a virtual garment part.	Display 2D virtual garments; a virtual garment can follow the user's movements.

In order to make realistic movements of garments that move along with the body, Microsoft Kinect is required. Kinect has the ability to track skeletal movements of the user and can specify bone positions such as the head, neck, shoulders, arms, etc., as can be seen in **Figure 3**.



**Figure 3** Kinect skeleton joints.

In the case where Kinect is not practical, using cameras or webcams and an image processing technique is also possible, but this requires complex processes and procedures, because a user's body has to be extracted from the background or noise eliminated. This technique also has some display limitations, such as only displaying 2D images, or user not being able to change poses. Another area that makes the virtual fitting room look more realistic is the fabric itself. In a real fitting room, there are a lot of fabrics or garments types. The customer can try-on with real fabric to feel the surface of the fabric and experience the weight of the materials. There are many types of fabrics in the store which are made from different materials, such as cotton, linen, and wool. Each type of fabric makes the movement different from others. For example, denim fabric, made from tightly woven cotton, is strong and heavy-weight, as opposed to silk or nylon. If we drop denim fabric on the floor, it can retain its shape, as seen in **Figure 4**.



**Figure 4** (a) Drop test fabric in real world (b) Drop test virtual fabric in virtual world (First: Jean fabric, second: Cotton fabric, third: Chiffon fabric and fourth: Satin fabric).

From **Figure 4**, by applying different physical properties of each fabric, simulations of various fabrics will look more realistic as comparing with the real ones.



## Conclusions

We have surveyed methodologies and experiments on how to build a good virtual fitting room. Two important things to consider are 1) methods of detecting the user's body size and the position of the user, and 2) methods of making a realistic display of the user wearing the best-fitted virtual garment. The first problem can be solved using Kinect or a camera with an image processing algorithm. There are many techniques that can be used to solve the second problem, but the results are still not satisfying. In order to give a realistic feel, users must be able to move freely, and the garments must move along with them. Realistic fabric movement is another question, since each fabric has different physical properties, so the parameter for each simulation is different. In order to make a perfect virtual fitting room, details on specific areas, i.e., methods of measuring the user's body size, methods of adding reality to the display, and methods of making it realistic, have to be considered.

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