The 3D Glasses Try-On System of Augmented Reality Using Intel RealSense Camera

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Abstract
"Consumers first" is a well-known fact in the market. In order to meet with the preferences and demand of customers, personally customized process has become a trend. Following the trend of customization, this paper presents an eyeglasses try-on system based on augmented reality to fulfill the needs of customized eyeglasses. The system is equipped with Intel Realsense Camera to detect facial characteristics. With the camera and a designed eyeglasses model, customers can try on, adjust, and eventually find the best fit. In the past, it was lengthy and complicated to construct an eyeglasses try-on system. Therefore, in this paper, we adopted the game engine, Unity, plus the Intel Realsense Camera and its assistance SDK. Using its special function of catching numerous facial characteristics, we are able to substantially improve the time-consuming defect before, and serve different customers in time. After the customization is done, the digital data of the glasses are selected and adjusted according to the 3D facial scan. Then the digital model of the glasses is converted into STL format, which is used for 3D printing. A desktop 3D printer of DLP SLA technology is used to fabricate the legs and frame of the selected pair. Through the accurate process of solidifying photocurable resin, the frame is built up within four hours. Without the need of polishing, the surface of the frame is then coated by the UV Inkjet printer, which can present in any color selected and customized solely by the consumer.

Keywords: Augmented Reality, Intel Realsense Camera, Unity, Customization, 3D Printing

1. Introduction

Following the improvement of living standards, the demand for product customization increases. Customers have their own tastes, and they expect to stand out from the public, or even show off their social status. However, customization isn't only for those with higher social status. Nowadays, young people who are willing to show their personality or go with the trend have begun to purchase personalized products. Since "Customers first" has long been the well-known fact, product customization, such as eyeglasses customization, emerged as a trend as a response to specific needs and preferences.

Most of the AR try-on system you can see now is mainly restricted in its feature, color and size, and it is actually just an AR try-on of the store's eyeglasses. It is basically in a strict form, and almost every customer goes through the same process while picking their own eyeglasses. That is, the AR try-on system in stores are only used for promoting their own product, which makes it hard to meet customers' personal needs if they want to change the texture, size or even color. Therefore, to go with the trend, we will introduce the idea of 3D design and printing, paired with the AR try-on system, in order to materialize the AR try-on object, and at last produce the unique and satisfying product for customers.

Due to undeveloped technology, the process of building the AR try-on system used to be time-consuming and complicated. Lots of time are spent in the computer computing process, and computer vision technology such as calibration, feature tracking, or projective reconstruction also needed improvement. Besides, the insufficient accuracy of integrating virtual world with reality and the additional time spent in machine learning to enhance the accuracy both added extra time to the process. However, with the advance of technology, the AR try-on system is ready for development anytime, as long as you have the camera and the Software Development Kits (SDK) provided by the company, which greatly shorten the developing time and make it easier to construct a feasible virtual eyeglasses try-on mode.

The key technology to the authenticity of virtual eyeglasses try-on is augmented reality. It is a kind of interactive technology which combines digital information and expand it into real life. The digital information it combines includes voice, picture, video, etc. With the overlapping of the digital information of 3D virtual objects and the real world, everything is possible. Gerber (Gerber, 2013) even predicted that, "Augmented reality and the digitization of the physical world around us via image-recognition technology is the new frontier.", and that "Augmented reality today is equivalent to the Internet in 1995.", making a great impact to the world that nobody could have imagined.

2. Background

To define Augmented Reality, Azuma (Azuma, 1997) has proposed at least three characteristics: combines real and virtual, interactive in real time, and registered in 3D. In practice, Augmented Reality emphasizes on the display and recognition technology. Since AR is a vision-enhancing technology, it has a lot to do with display technology, which can be divided into head-mounted, non-head-mounted display, transparent panel, holography etc. The image shown by the technology includes real and virtual objects. The recognition technology, its core technology, is then needed to identify objects in the real world, and accurately attach the virtual object to the right position in the world. This kind of technology includes specific marker, image recognition, features recognition, GPS or compass orienting, and it could be applied in diverse circumstances.

Generally, the easier practice of AR is to use a specific marker or image, transform it into a virtual object via identification, and then put it on an actual plane object or 3D model. However, this practice is especially not suitable for virtual eyeglasses try-on. Human face is a curved surface; if the marker or image is put on the eyes, it will cover the view, eventually causing restriction in the usage. To prevent obstructing the view, feature identification in the real world is mostly applied. But since the feature identification technology is quite complicated and hard to handle, when it comes to handling virtual glasses try-on, two main practices are primarily used: 3D face scan and depth sensor (Feng, Jiang, & Shen, 2018). The former uses facial feature point and affine transformation technology (Huang, Yang, & Chu, 2012), the latter uses head pose estimation, accurately situate the actual position of the eyes and glasses (Lu, Wang, & Zhao, 2015). Huang et al. (Huang, Yang, & Chu, 2012) used the 3D scanner, completed a face scan, and looked for the feature point of eyes. However, the scan and verification was complicated, the process was time-consuming, and there were also problems with accuracy and the 3D effect. Feng et al. (Feng, Jiang, & Shen, 2018) later proposed using 3D facial recovery, head pose estimation, and depth buffer algorithm, which did improve the outcome, but due to their usage of Matlab, it couldn’t be easily commercialized. In conclusion, the depth sensor should be an easier practice compared to others.

The main equipment you need to build an AR system includes a monitor, tracker (sensor), and computer and software for graphic design. Recently, the efficiency of these equipment has advanced significantly, at the same time, increasing the application of AR. Among these equipment, besides monitor, computer and software for graphic design, 3D sensor is also an important device. Webcam, formerly used, is basically a flat RGB Sensor, making it difficult to handle with information concerning depth. As game industry rapidly developed, depth information is gradually taken into consideration, expanding into RGBD depth sensor. Main companies, including Kinect, Leap Motion, Intel RealSense etc., provide SDK for self-developing. To understand more about the differences in performance, Leong et al. (Leong, et al., 2015) compared user needs, evaluated according to movement identification of gestures, supporting of SDK, portability, development, light-weighted etc., and proposed the advantages and competency of the Intel RealSense: the ability of depth identification, smaller size compared to Kinect, and stronger functionality.

For both RGB and RGBD tracker, to enhance the performance of Augmented Reality, advanced video identification computing technology or excellent SDK is needed to execute the main functions like corner detection, feature matching, recognition, etc. Due to rapid development of computer vision technology, RGB sensors now also provide Augmented Reality SDK. Also, in response to the popular application of AR commercialization, SDK developing companies like ARCore (Android), ARKit (iOS), Vuforia, ARTollkit, EasyAR, Kudan, Pikkart, etc., mostly provide free trial, but with different functions. If there is excess demand or revenue, there may be extra charge. Application of AR is also seen in other fields (Feiner, 2002), including creative industries (Ardito, et al., 2007), education (Hackett, & Proctor, 2016), self-learning (Wang, et al., 2011), recreation (Mendenhall, et al., 2012), training (Liarokapis, & Freitas, 2010), medical area (Ha, & Hong, 2016; Hackett, & Proctor, 2016) etc.

Virtual Glasses Try-on equipment has attracted attention in recent years, mainly benefited from the advanced development of the Internet. Some of the reasons of the boom includes instant experience, easy-to-use, and styles to pick by yourself. Virtual glasses Try-on is not only used in RGBD sensors but also in basic RGB sensors. The RGB Sensors are the common 2D cameras in computers, and it supports the virtual try-on glasses system. Main companies, including Eyeconic, EyeBuyDirect, Vint & York, BONLOOK, etc., adopt SDK and webcam, and carry on the test of the virtual glasses try-on system. However, the system is modeled according to the glasses in store or in stock for virtual try-on, which fails to satisfy the personalize needs of users. It may be difficult for users to make some change to the glasses frame, or set their own material or color. Thus, we propose the virtual glasses try-on system to solve the problems mentioned above.

3. Executive Conception

Plane RGB sensors are generally not good at retrieving depth information. Also, as mentioned above, Leong et al. (Leong, et al., 2015) proposed that the Intel RealSense depth sensor has advantage and competency in its function. Moreover, the Intel Company has sponsored the Intel RealSense depth sensor via the Institute for Information Industry of Taiwan. Under these circumstances, we are able to use the Intel RealSense sensor as an image tracker for Augmented Reality. At the same time, the Intel RealSense SDK is compatible with many kinds of software. With the combination with Unity, development time can be shortened and application fields can also be expanded. This combination will be used as the basic components of building the AR glasses try-on system.

In addition, unlike general virtual glasses try-on system, which only provides on-screen display of the virtual try-on, we propose to implement 3D design printing, and expand the usage of digital data, in order to provide the preliminary design for actual production.

3.1 Introduction to the Intel RealSense sensor

Intel RealSense Sensor is equipped with somatosensory interaction technology of depth image. There are two forms: short range and longer range. We adopt the former, the Intel RealSense depth sensor F200. F200 is the front camera for desktop computer. The sensor is able to retrieve an indoor image of the user in front of the camera. The depth sensing method is coded light. With shorter sensing distance (20-120/200cm), the sensor is able to provide depth image with VGA 60 fps and a Full HD 30 fps colored image. Basically, what’s special about the sensor is that it is able to produce a depth image by a set of infrared projector and receptor, with a color camera deployed between them to retrieve a colored image. Below is a brief explanation of the basic specification of the Intel RealSense F200.

Table 1: the basic specification of F200

Intel RealSense F200	
RGB Camera	1920x1080 @30fps
Depth Sensor	640x480 @60fps
Microphone	Dual array microphone
Range	0.2 to 1.2 m
Horizontal FOV	70^0
Vertical FOV	43^0
Gesture tracking	Yes
SDK	Yes
Portability	Yes

3.2. The function of the Intel RealSense SDK

The Intel Company developed the Intel RealSense SDK to increase the developers' usage of the Intel RealSense camera. If the goal is to experience the sensory feeling, simply go to the Intel RealSense App Website, download the software you want, and install the driver. For developing, you will need to install the Intel RealSense SDK as well. After installing the SDK, an example written with computer languages such as Java, C#, JavaScript, C++, Unity, Unity Toolkit etc., will be available for developers to practice. Through these examples, functions of the Intel RealSense like the identification and control of gestures, human face, and voice message will be shown clearly.

When it comes to gesture identification, the Intel RealSense is able to detect the open and contract of hand gesture, control the knuckles freely, and use its camera to capture the movement in the real world. Then, it can control the virtual object in the screen to complete the interaction. This is a basic application of Augmented Reality. For human face identification, the Intel RealSense is able to identify eyebrows, eyes, nose, mouth and face frame, generating about 78 feature points to increase the accuracy of identification, as shown in Figure 1. Hence, in real life, the human face feature points are collected via sensors. The sensors can detect the movement of the face in all directions, control the virtual objects in the screen, and complete the interaction.

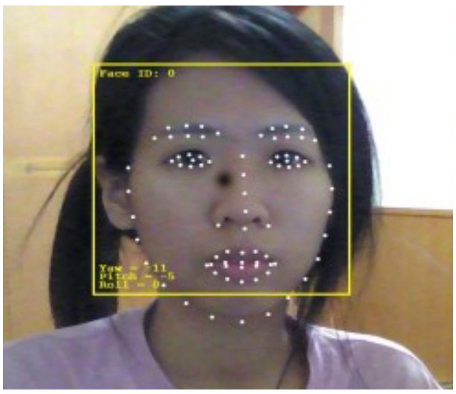

Figure 1: The 78 feature points of the face.

3.3 System framework

The AR Virtual Glasses Try-on System is equipped with the Intel RealSense Camera to capture face feature points. To identify where to put the virtual glasses, the camera captures the feature points by situating the eyes, eyebrows, and face frame. Then, to further accommodate the design of the glasses to the face, customers can try on and make some adjustments. In no time, they can find the best fit for them. The AR system framework is shown in Figure 2. The main framework is composed with computer and related device including unity game engine, Intel RealSense F200 depth sensor, Intel RealSense SDK and eyeglasses database.

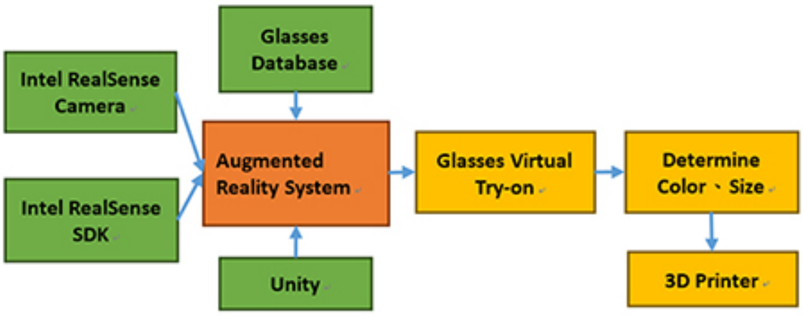

Figure 2: The AR System Framework.

3.4 Implement Process

To prevent from the complex and lengthy implement process, we adopt Unity, Intel RealSense sensor and its SDK to compose the AR Virtual glasses try-on system. The Intel RealSense SDK is the computing core, which mainly retrieves the actual image of the user's face from Intel RealSense sensor and include it into the 3D virtual glasses model in the glasses database. Then, the sensor refers to the software development example as the base of implementing the AR system. After editing and adjusting in the Unity game engine software with C#, the AR Virtual glasses try-on system is eventually completed. One of the advantages in the facial identification part is that the sensor can directly detect the feature points of the face without having to adopt machine learning, which significantly shorten the computing time.

3.5 3D Printing for glasses

3D printing is a state of the art technology for rapid prototyping. Particularly for stereo lithology (SLA) method invented in 1984, many advanced facilities and materials were developed with improved quality and accuracy. SLA 3D printers utilize ultra-violet laser, DLP or LED as the light sources to solidify photo-curable resin, which create the 3D shape layer by layer.

For instance, in Figure 3, selected model can be printed out with STL format by an UV laser printer. Afterwards, it can be finished by spraying coatings as shown in Figure 4. The prototype made of traditional photo-curable resin tends to be too fragile for actual wearing.

Figure 3: A glass frame printed by an UV laser 3D printer.

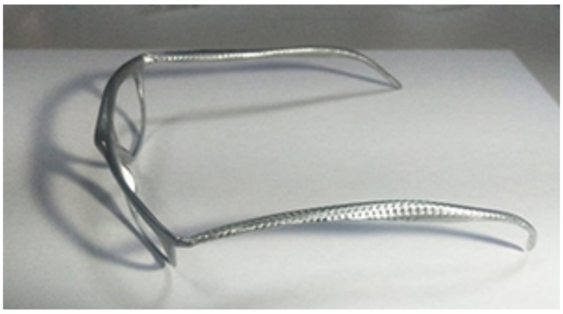

Figure 4: The prototype with spray coating.

In this research, a DLP SLA (Stereo lithography) 3D printer “Phrozen make XL” in Figure 5 was utilized for producing selected 3d model. Made of ABS-like photo-curable material, the frame in Figure 6 is elastic enough for regular bending, which is even more robust than current frame available in the market.

Figure 5: Phrozen Make XL.

Figure 6: Elastic and bendable glass frame.

On the other hand, utilizing a UV printer for surface coating, as shown in Figure 7, makes it possible to customize graphic or patterns selected by the user. Compared to the traditional method using CNC machine for wood cutting in Figure 8, which releases a lot of trifles and requires a lot of manual finishing. Integrating water transforming technique (Figure 9) to attach wood texture on the 3D printed frame is an affordable state-of the-art practice for mass customization.

Figure 7: UV printer for surface coating.

Figure 8: wood frame made by a CNC machine.

Figure 9: water transformed wooden texture on the 3D printed frame.

4. Results

The main design of the system's primary interface is aimed to let the customers connect fashion and affection with the virtual glasses try-on system. The design is a girl with her hair blown by the wind, and its ends are obscurely shaped like glasses. Her face is dressed with flowers and plants and also some tangled hair, which not only express the mild beauty of women, but also add in a young and spirited atmosphere with the light coloring. During the design process, light color is set as the base, and diverse diamond-shaped images are put in the background to combine with the tangled elements. At last, the main design of the girl's face is completed as Figure 10.

Figure 10: The initial interface of the AR Virtual Glasses Try-on System.

According to the implementation concept mentioned above, below are some results of the establishment of the system:

4.1 Choose the type of glasses

Choose the type of glasses you like, import the source material of eyeglasses, and then use the face identification to complete the process and put on the virtual glasses, as shown in Figure 11. In the interface setting, you can control where you want to turn your head to, make some adjustments as Figure 12, 13, and observe the virtual try-on from a lateral side as Figure 14. After your first try-on, customers can pick from the other glasses models in the database, and replace it by themselves.

Figure 11: Choose the type of glasses you want and put on the virtual glasses.

Figure 12: Adjust vertically.

Figure 13: Adjust horizontally.

Figure 14: Turn your head around and observe on lateral sides

4.2 Change the style of glasses

If customers have already tried on their favorite type of glasses and finished the first step, they can further request to change the frame, color of the lenses, or adjust the size. If you want to adjust its width, length, size as Figure 15, 16 or even texture, you can ask for customization as Figure 17. At the same time, in the process of trying on, you can also turn your head freely, and see if the glasses conform to what they want.

Figure 15: Widen the frame of the glasses.

Figure 16: Narrow the frame of the glasses.

Figure 17: Change the style of the glasses.

4.3 Export customized design to printing

At last, to make virtual glasses try-on a real thing and conform to the customer's customization demand, we decided to add 3D Design Printing. As customers try on glasses via the AR virtual trial, they can choose the texture, model, color and size they want, and then a personal database is built. The selected design takes only five hours to complete the printing with ABS-like material as shown in Figure 18.

It was then coated with preferable color and glossy protective coating to reinforce the overall strength. Finally, with the integration of optical lenses, a pair of wearable and customized glasses frame is then created as Figure 19.

Figure 18: 3D printed frame.

Figure 19: Final prototype of the frame.

5. Conclusion

In this research, we propose an AR virtual glasses try-on system equipped with the Intel RealSense Sensor. The sensor has the ability to detect depth and this characteristic assists with the virtual glasses try-on. The whole project is a cross-domain collaboration. We combine digital media with product design to meet the needs of customers and establish a customized fit for them. Moreover, during the fitting process, customers can not only try on glasses in stock, but also change the color, size, texture or style of the glasses. Later on, with the help of 3D design printing, they can even really get the customized glasses. Through cross-domain collaboration, we get to verify the feasibility of a customization process, and as a result, we can be sure that the combination of AR virtual glasses try-on system and 3D design printing is a developable market with great potential. The research team is currently working on creating more stylish templates for glass frames that will then be imported in a cloud database for online customization in the near future.

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