CIS 400 Senior Project
Spring 2018 Final Report

1. Student Information

DreamFit

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2. Advisor Information

Dr. Camillo J. Taylor

We met with him once this semester where we described our project from both design and technical standpoints. Since our advisor changed in the middle of the year, we had already made a lot of design decisions for our product so our meeting with Dr. Taylor was mainly a progress report. He commented critically about the decisions we had made and asked us some key questions that helped us solidify our implementation.

3. Summary

Using Kinect to help customers visualize how clothes look on them virtually, we are solving the problem of having to physically try on an outfit to see what it would look like.

4. Overview of Problem and Approach

The problem we are trying to solve is that online shoppers and busy shoppers have difficulty making purchasing decisions on clothing as the only way to know if the article of clothing would look good on themselves is by physically trying it on. Further, this puts online retailers at a disadvantage compared to brick & mortar stores, because online retailers have no fitting rooms where consumers can try on clothing before buying it.

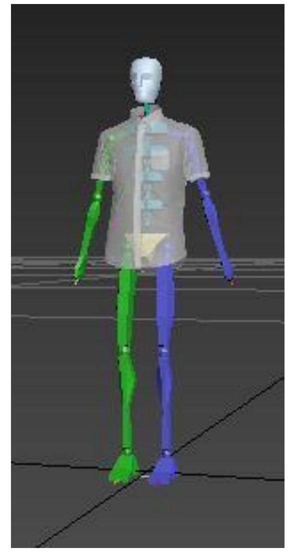
Our group is seeking to create an augmented reality solution that allows users to visualize clothes on their body in the comfort of their own home. Using a Kinect v2 plugged into a computer, users will be able interact with the Kinect sensor in order to select a clothing item and project that item onto their body, rendering the projection on the user's computer. We are hoping to facilitate virtually trying on clothes in a way that is accessible to the everyday person.

5. Implementation

First, let us describe a high-level overview of our implementation before we dive into details. This app was built using Kinect's Official SDK, the game engine Unity 5, and Microsoft Kinect's plugin for Unity. When a human is registered in the app as a user by standing in the Calibration Pose (T-Pose), they are given access to our menu system controlled by the motion of their hands. This menu is based off of Kinect's Gesture Detection demo and a prefabricated menu bar found in the Unity asset store. When the user selects a piece of clothing they want to try, our menu instantiates the selected GameObject (clothing model) and loads it into Unity. Two scripts are attached to the new GameObject. An AvatarScaler, which is responsible for scaling the selected model to the user's body size, and an AvatarController, responsible for gathering the joint pose info and applying the transformations to the model.

Now we will go into detail about the implementation. The menu, implemented in the ModelSelector script, is our main script. The rest of the app's functionality cascades from this menu. Each time a user selects a new piece of clothing, it instantiates a new Unity GameObject of the selected model, and then attaches two scripts to it as described above. AvatarScaler is responsible for going through each of the user's joint positions and estimating the size of their arms, legs, torso, and shoulders by measuring the euclidean distance between the relevant joints given by the Kinect. Then, based on the scaling factors we provide it at runtime (used for fine-tuning later on), it scales the avatar to match the size of the user body. The AvatarScaler also employs the OverlayController script. The OverlayController script is a module that computes the coordinate transformations between Kinect's 3D RGB-D image and the 2D coordinates of the game scene to find the game-scene position of the user's body in physical space. The AvatarController is the script responsible for applying bone transformations to the models. That is, this script takes the static, t-pose clothing model and transforms the mesh based on the user's current body orientation. The AvatarController has access to the bone structures we manually added to each clothing model. The process of creating these bone structures is called Rigging, and is described below. It then polls the Kinect to get the bone position and orientation, and applies these orientations to the model's rigged skeleton. All Body Pose info, including X,Y, Z positioning and joint rotations, is taken from KinectManager provided by Kinect's Unity plugin.

As mentioned previously, we had to manually apply a bone structure to each clothing model we wanted to use. When we received our clothing models, they were rigid and static, and could do nothing but rotate. So, we went through the process of learning how to apply "Rigging and Skinning" to each of the models. For both processes, we used

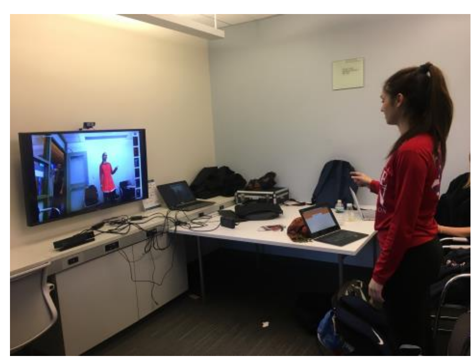


3DS Max, a CAD program designed for creating game avatars. Rigging is the process of associating a skeleton with a 3d avatar. We used a simple humanoid skeleton, because we expect a majority of our user base to be humans (confirmed by our evaluation). A completed rig of one of our t-shirt models is shown to the right. Once the skeleton is scaled, manipulated and placed perfectly inside the model, we could begin skinning. Skinning is a computationally heavy one-time process that determines how each individual polygon in the mesh should deform when each bone is moved in any direction. 3DS Max luckily has skinning algorithms built into it, which still allow a huge amount of customization of your skins. We opted to use Dual-Quaternion skinning as opposed to Linear Blend Skinning because it allows for nonlinear transformations, such as the rotation of a forearm or leg. We found that this type of deformation looked most realistic in our app, as it made the mesh appear tight to the user's skin.

Once our model is rigged and skinned in 3DS Max, we could export the object and add it into our Unity resources folder. After importing the rigged model into our resources folder, it was quick process to let Unity automatically detect the skeleton and its associated skinning. When Unity recognizes our rig, our AvatarController module can individually reference and manipulate each bone.

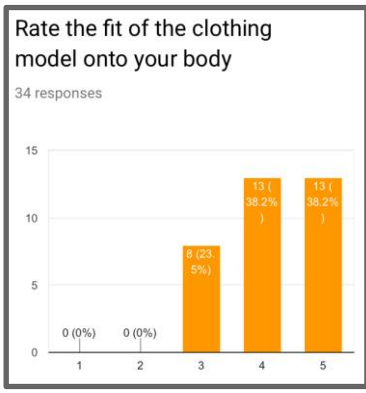
We initially had problems with the visualization appearing somewhat jumpy on the screen, as well as noticeable latency between user movement and that change being reflected in the selected clothing. We first fixed the latency issues by adding a cache of Bone Transforms, which saves a user's common body positions and its associated clothing model deformation. This provided us a mild latency boost, because it stopped Unity from recomputing the skin deformation 60+ times per second and allowed it to reuse similar deformations seen in the past. To fix the jumpiness, we were able to add an adjustable smoothness factor that let the model glide between two positions rather than jump discretely from (x1, y1) to (x2, y2) on each update.

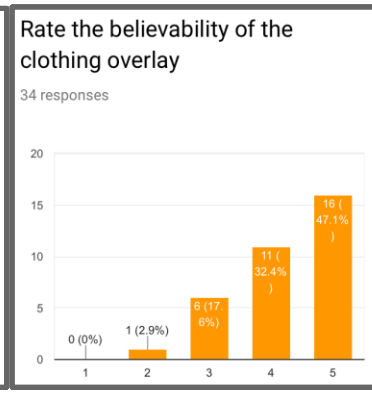
6. Evaluation

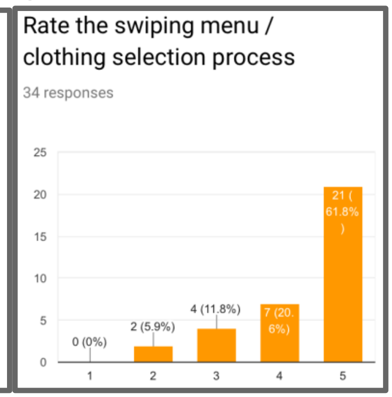


To evaluate our product, we held a demo day and allowed users to test and evaluate our product. We wanted the evaluations to be unbiased and organic, so we held the demo in a public place- a group study room in Huntsman. We played music and invited a few friends to attract a crowd to our product. We have a basic explanation of how to navigate our product when using it (gesture information, for example) and allowed them to get a feel for the different articles of clothing available on the application (a mix of dresses and shirts). After about 5 minutes of using our product, the user filled out an evaluation survey to collect metrics on users' opinion on the fit of the clothing and usability of the app. The 34 people who participated were asked to rate certain aspects of the product from 1 to 5 (5 being the best). Some of these aspects are as follows: the fit of the clothing model onto your body, the believability of the clothing overlay, the ease of clothing selection process, and the overall experience of the product.

We found that participants generally liked our product. For example, the average ranking for believability was 4.24, and the rating for the fit for the models was 4.15. Participants also exclaimed that they really enjoyed using the product, and 97% of them said that they would use this product while online shopping.







In terms of ethical implications, we respect the privacy of the user that is trying on clothing, so our application does not save or record any information about the user standing in front of the Kinect motion sensor.

7. Individual Contributions

Ben's main contribution to DreamFit was learning how to interface the multiple technologies used. He was responsible for learning enough Graphics terminology to understand the avateering process. This involved learning to use 3DS Max for Rigging and Skinning, learning how to import the new rigged models into Unity, and how to reference individual bones programmatically. Ben also wrote the OverlayController script to compute the coordinate transformations between Kinect coordinates and Game Scene coordinates.

Meghana and Sydney's main contributions had to do with the testing and evaluations module of the project. They ensured that the project implementation stayed true to the design and helped develop the evaluation rubric based off documentation from last semester. Meghana also worked on the business analysis aspect of the project for the M&T Integration Lab.

Nikhil's main contributions revolved around overall software development and testing. Specifically focusing on the design and implementation of the menu for the program and looking at different ways for the user to interact with our final product.

Different strategies for various types of pre-screen menus were explored and implemented before we ultimately landed on and developed a menu that was fully integrated, on the same screen, with the rest of the fitting room experience.

Tyler's main contributions involved working with our clothing renders. He was responsible for the research and implementation of our clothing's air mesh collisions. He worked with Unity's physics engine to produce force-based fabric simulations targeted at emulating the resistance air and gravity would produce on cloth in a bare room with minimal airflow. This ensured realistic clothing renders when subjected to movement, helping DreamFit achieve a dressing room like feel.

8. Business Analysis for M&T Integration Lab

1. *Market Assessment & Need for Product*

Through extensive research on the fitting room industry, we have found that there is a significant market for this product. Currently, for the everyday shopper to see what an article of clothing looks like on their own body, the shopper must physically try on the article of clothing. To factor this into a purchase decision, the shopper must either try on the article of clothing in a physical store or purchase the article online, try it on, and then return it. This not only is tedious for the customer, but also limits retailers who are seeking to expand their online presence because not all customers are readily willing to purchase the article before trying it on.

Through informal interviews of students on campus in the Fall, we found that there was an increasing need for virtual fitting rooms in individuals' homes. Being able to visualize what an article of clothing would look like before making a purchase decision would ease the shopping stresses of online and busy shoppers.

Our product tries to solve the problem of the everyday shopper, which means the product is simple and easy-to-use as well as accessible and inexpensive yet useful.

2. *Competitive Landscape*

We examined the current market for virtual fitting rooms and concluded that there are no products that solve the exact problem we are trying to solve of being useful, accessible, and inexpensive. Current products in the market include:

- ➢ Try-Live: Realtime AR solution which allows people to try on glasses and jewelry in a virtual fitting room setting. Similar idea to ours, but confined just to glasses and jewelry/watches. The technology works across different platforms (mobile and desktop), using just a webcam to detect the user's face or wrist and fit the product to them.
  - This product does not solve the problem of serving as a virtual fitting room because it's capabilities are limited to jewelry and eyeglasses.

- ➢ Von Bismark (Microsoft venture funded): They built a virtual fitting room mirror product that essentially operates like an ordinary mirror but it visualizes clothing onto the user standing in front of the mirror. There is a menu functionality built into the mirror where the user can select what to try on.
  - This product could be very useful for high end stores that have high traffic, such as wedding dress shops, because installing such fancy mirrors would be an expensive investment. Therefore, it is not suitable for the homes of everyday shoppers.
- ➢ Zugara: Virtual dressing room using similar technologies (webcams and Kinect). The product is built for both home users as well as in-store retailers.
  - The product, however, only projects a static image over the user and does not provide and real time movement with user. This makes the product less useful and does not solve the problem of allowing the user to get a realistic feel for the clothing before buying.
- ➢ Fitnect: This product is most similar to the product we built. It is a software as a service product that can be downloaded by anyone and works with motion sensors such as the Kinect.
  - The pitfall of this product is that it costs $900 for 3 months.
- ➢ FitURight: This product scans a 3D avatar of the user's body, and fits the clothing models to their body shape. This product actually calculates the size and fit of the clothing it recommends to the user, solving a different problem from our problem statement.
  - The product ultimately does not visualize the clothing onto the user's body, so it does not solve the problem our product tackles.

3. *Business Model*

Our product is a B to C product: we link retailers to shoppers. Our value proposition is that we can help retailers expand their consumer base and help shoppers alleviate their online shopping process. There is a current disconnect between online retailers and their everyday customers, and we are filling that gap to build a bridge between the two parties.

4. *Target Consumer*

The target customer for our product, as described briefly before, is a user who is either too busy to go shopping in store or relies heavily on online shopping. Our target shopper is likely:

- ➢ Tired of ordering clothes online that don't look good on them in person once it arrives
- ➢ Despises the process of returning clothes by paying to ship them back to the retailer

- ➢ Living in an area that does not have stores for the brands they are interested in, or too busy to go out of their way to shops they are interested in
- ➢ Young and uses technology in their everyday lives, especially to understand how an AR product would work
- ➢ Looking for a cheap and permanent solution that can be used in their homes
- ➢ Have access to a Kinect or would be willing to buy a Kinect. Given that the Kinect is typically used for gaming purposes, it is unlikely that a user would buy a Kinect for the purpose of using our application. Instead, we hope that our target user will be in a household that uses a Kinect for multiple purposes.

On the other hand, the larger revenue generator will be the online retailers who can use our service as a way of attracting more consumers. Our application will be a platform for those retailers to display their clothing as options for shoppers to try on. Our target consumer on this end is seeking to expand their consumer base by making their clothing more accessible to try on.

5. *Pricing Strategy*

In the case of most products, pricing the product depends on the cost of producing the service. In our case, there are costs involved in skinning each clothing model that is to go on the application and maintaining the clients and consumers, so all our costs will be in maintaining man-power. If we are to make our product into a company, we would kickstart it through seed funding or grants from angel investors or early stage VCs.

Since this product is an application for the Kinect, we would sell the product on the Xbox Kinect app store (Windows store). We aim to price our product based on the willingness to pay of our consumers. Based on the surveys we conducted and testimonials we received on our demo/testing day, we seek to price our product at around a $15 per year subscription fee for shoppers trying to use our product to try on clothes.

For the retailers that will use our product to reach more consumers, we aim to price our product by a matrix of the number of clothing models that they put on our platform and the number of people that try on that article of clothing. We have not created any partnerships with retailers yet, so we have not understood their willingness to pay and therefore cannot price the product just yet. As we move forward and project our revenues from the shopper consumers, we can forecast how many users will be trying on clothing, which will help us understand how many users will try on each article of clothing.

6. *Future of the Product*

a. Risks

Building out this product involves working with several different moving parts including but not limited to pitching the product to several giant retailers, advertising to everyday shoppers, working with Windows store, and hiring graphics help to work on skinning the clothing models with us as we continue to scale.

In addition to business challenges in scaling, we will face technical challenges as well. Different clothing models need to be skinned in different ways as we predict there will be very little consistency among the retailers since designing 3D clothing models is such a new space to begin with. The fitting of the skinned models can always be improved as it fits each user differently.

Lastly, our product is only useful for shoppers that own a Kinect, so we should potentially consider making our product available on other platforms, too, if we are to continue scaling.

b. Opportunities

While the risks are clear, there are several opportunities for our product if we are to move forward with it. First is that the need is clear and great. 100% of the users that demoed our product said they would recommend it to a friend, even though multiple respondents said they would not use the product themselves. This goes to show that we have an incredible opportunity to catch on among the everyday shopper crowd.

We foresee significant partnership opportunities with retailers. Access to virtual fitting rooms will not only allow shoppers to try on clothing but also will disrupt the shopping-from-home experience. This product will increase the amount of shopping home users do from home. Due to this, we view tremendous opportunity to work with several different types of clothing retailers.

As we scale our operations, we foresee that companies can actually use our product in stores to ease fitting room lines and draw more shoppers into the store.