Social Clothing Sampler

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The trends of shopping have greatly changed with the advent of technology. Customers now prefer staying home and ordering clothes online to going to an actual store. This gives a great opportunity to the customer to browse through various e-commerce websites and find something they like without having to step out. A major disadvantage in this scenario is that although customer likes the apparel on the screen, it might be not of the right fit. This results in additional costs to the e-commerce apparel website to handle the returns. The main motivation for this project is to address this disadvantage by simulating an online shopping experience in a virtual environment. The customer can choose an apparel of their liking and try it on "virtually" on a 3-D model built based on their measurements before they decide to buy. In addition, one can even choose a background to see how an attire looks in various events.
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Chapter 1

Introduction

1.1 Background

E-commerce websites have come as a boon to the millennials by making it easy to adapt and embrace the ever changing fashion sense. But many of those customers are skeptical about the fabric, quality and fitting of the clothes they buy online. While few customers agree that they order clothes just to try them on, others return the clothes they like because of poor quality or ill fitting. Due to the flexibility of return policy, customers order different sizes of the same garment to choose the best fit among those and return the rest. This results in unnecessary costs to the apparel industry in handling returns. According to a survey [10] about 56% of customers had returned their clothes back at least once.

1.2 Problem and Motivation

The objective of the project is to develop an application which helps the customers to choose their desired garment and virtually "try it" on their avatar. The users will get a 3rd party perspective of how the style would look in different occasions.

1.3 Terms and Definitions

- Armature is a hierarchy of joints and bones that constitute the skeleton of a body. A body without an armature is a simple static mesh.

- The vertices in different parts of the body i.e. vertex groups are attached to different
bones in the armature. This process of defining a skeleton and assigning vertices and weights to the bones is called rigging. A character rig is mainly used for movement of different body parts like stretching, bending and rotating etc. and a group of these movements help to define animations.

- Unity Cloth Framework provided in Unity helps to create cloth components easily. PhysX 3.3 is a physics engine used in Unity to handle physics calculations like collision detection, friction and other external forces etc.

- Colliders in Unity and in general are used around the object to detect collisions. If a game object is not enclosed by a collider, then any object can pass through it.

### 1.4 Description

The application has been developed in Unity. The scope of the project does not cover scanning the user’s body and obtaining their 3D avatar. It is assumed that the 3D model of the user is already available. A 3D model of a simple T-shirt using a 3D modeling tool Blender is created. The problem is solved by two approaches. The first approach considers the modeled T-shirt as an object in Unity. Both the body and the T-shirt are rigged to a base armature and their armatures are mapped dynamically. In the second approach, the T-shirt is used as a Unity Cloth and colliders and constraints are set to it.

### 1.5 Agenda

The paper first describes about the related work done in this field and the existing applications that focus on the similar problem in Chapter 2. In Chapter 3, the paper describes the implementation details including the assumptions, approach and the technologies used. Chapter 4 provides the results and Chapter 5 concludes the current work followed by future work and lessons learned.
Chapter 2

Related Work

The work related to this field can be broadly classified into two categories - 2D and 3D approach.

In 2D approach [14], a model (who is not a customer) wears the clothes and the poses are recorded in a video. A sufficient number of pose snapshots are taken and stored in the database. When a customer tries on an apparel and poses in front of a virtual mirror, the closest pose matching the customer’s pose is retrieved from the database using data mining techniques. This retrieved pose is then superimposed on the customer’s body. In order to enable smooth transitions between poses, certain number of poses that closely match the current pose are obtained and superimposed on the customer.

In 3D approach [12], the customer’s body measurements are taken as input and a 3D model is generated which can be accessed online by the customer. In much advanced systems, instead of giving measurements as inputs, a 360-degree body scan can also be taken using a camera to generate this 3D model. Once the model is generated, the customer can select from the clothes available online and can see how the style looks on it. To achieve this, a mathematical model of both the body as well as the garment is created and the appropriate size is selected based on the fit factor. The selected garment is then mapped onto the customer and the fit analysis is performed.

A lot of augmented reality applications are available which are related to virtual fitting rooms. Apart from the applications like KinectShop, Bodymetrics, Fitnect VIPodium etc. mentioned in [13] following are few other applications:
2.1 Virtual Fitting Applications

2.1.1 Fitle

Fitle [5] is a virtual fitting room that helps users create their avatar online. They provide photo-realistic rendering of clothes and perform analysis on the fit parameters and customer buying habits by using machine learning techniques. By using the height and just four pictures of the user in different angles a 3D avatar is created in few seconds. The user can then try different clothes on their avatar and see the look and style of the apparel. It also recommends sizes by considering few parameters like age, height, weight and the size of the brand that fits them best. In addition, the user can also create a virtual wardrobe and add preferred clothes to try later.

2.1.2 Virtusize

Virtusize [4] is a an online fitting tool that allows fashion companies to illustrate size and fitting for customers. The users can compare the clothes with the ones they already own as a reference. They can either select a preferred size or measure the desired garment and check the fitting.

2.1.3 Krify

Krify [2] is a mobile app that provides 3D interactive virtual trail room experience to online shoppers. The user has to upload their photo into the app using a camera or from the gallery. Once uploaded, user can view variety of apparels and pick any of them to try it on their body. They can zoom, pan, pinch, readjust and straighten out the attire to place it accurately on their picture and see whether it suits them or not. It is based on facial-recognition technique and it reads gesture-controlled signals from User. Through this app, users can also share new outfits with their friends and families to get their opinion.
2.1.4 Fits.Me

Fits.me [3] is a 3D model generator that helps apparel industries to create a personalizing experience. Fits.Me aims at making size ubiquitous and fit an invisible element in customer shopping experience. Fits.me has created a virtual fitting room product, which can be embedded as a tool on their clients’ online shopping websites. Shoppers input their exact measurements, which are used to create an avatar that can try on apparel of different sizes. The product also has a ”Fit Advisor” tool that draws on a user’s measurements and fit preferences to recommend the right size.

2.1.5 Fitfully

Fitfully [7] is a mobile app helps customers find footwear of the right fit online. It creates a 3D model of the customer’s feet, so that they can virtually try on a pair of shoes. Creating a 3D model is quite simple using this mobile app. First the customer places a newspaper on floor and takes an aerial picture of it, providing a perspective. Then a credit card is placed on the paper and another picture is taken which provides a sense of scale,and the app understands how big the customer’s foot is. As a final step, the user places their foot in the middle of the newspaper and takes a 360-degree video of your foot. Based on the accuracy of these pictures and videos, Fitfully generates a 3D model of the user’s feet which can provide with color coded legend, how the footwear is going to fit.
Chapter 3

Design

The project has been developed using Unity Engine. Two approaches were used to solve the problem. The first approach considers cloth as usual Unity game object while the other uses the cloth as a mesh attached to Unity’s Cloth component.

3.1 Garment as Object

In this approach, the T-shirt is initially modeled using a 3D modeling tool. The model of the body is rigged to an armature. The cloth is rigged to the copy of the same armature. Then the cloth is dynamically mapped onto the body by assigning the cloth’s rig to the model’s rig.

![Design flow for garment as object]

Figure 3.1: Design flow for garment as object
3.2 Garment as Unity Cloth

The T-shirt mesh is attached as a Unity Cloth mesh and different constraints are set for the cloth to show how it moves in the presence of external forces like air, gravity etc. In order to detect collisions, small spherical colliders are added to the cloth so that it detects the body and does not go through.

Figure 3.2: Design flow for garment as cloth
Chapter 4

Implementation

4.1 Assumptions

Some assumptions have been made to build the application. This project is a mainly a proof of concept and focuses on the mapping of cloth onto a human body. In order to simply the scope and focus on the main issue, the following assumptions have been made.

- It is assumed that the customer’s body is already scanned and a 3D scanned model body is available as input to the application.

- Currently only female body is considered in the scope of the project. Since female body structure is complex compared to a male body structure, this decision has been made. Also since most of the online returns were from the female customers, the application showcases a female model.

- Simple cloth is modeled with plain design and fabric. The project does not deal with clothes with intricate designs or different fabrics like velvet, fur etc.

- For now, the user has the option to choose only T-shirts in different colors and skirts in different colors and textures.

- The application showcases only the T-pose of the body as well as the garment.
4.2 Modeling the T-Shirt

The T-shirt is modeled using Blender, a modeling tool, based on the process used in the tutorial series [8]. The tutorial covers concepts like texturing, rigging and other useful information related to making clothes.

The ”plane” objects were used to build a very basic model for the front part of the t-shirt and mirrored it for the back part. Then the two parts were stitched together along the vertices of the edges using lines.

After joining the two parts, the shirt was subdivided using loop-cut to increase the number of faces and make the shirt smoother.

For better fitting and realism, shrink wrap modifier was applied and some sculpting was done on the cloth. The edges of the arms neck and waist have been extruded to the inside and smooth shading has been applied to give a realistic experience.
4.3 Rigging

In order to have more control on the objects and manipulate them, they have to be rigged to an armature(skeleton). The body and the t-shirt were rigged so that they could be moved, rotated or scaled dynamically. Avatar Workbench by Machinimatrix [11] is a blender plug-in comes up with a female character with default female rig and weights. This was used to rig both the body and the cloth.

- First the body’s pose is aligned with the default female character provided by the avatar workbench. This is required to transfer the weights easily.

- Next the rig of the female character is parented to the body and weights are transferred to the body. This means that the vertex groups of the different parts of the body are mapped to the bones of the armature.

- Once the weights are transferred, we need to inspect each bone and check if the vertices have been properly grouped. Some processing may have to be needed in case of deviations. This task is necessary if animations are to be done. For now, animation of the body is not considered in the scope of this project.
Figure 4.3: Back view of the model

Figure 4.4: Front view of rig

Figure 4.5: Back view of the model

Figure 4.6: Back view of model. Gap in cloth near the left underarm
It can be seen in the right image above that the vertices near the left underarm did not move properly due to improper weight mapping of vertices to the bones. Hence, a gap is formed in the cloth in that region.

The T-shirt is also rigged by following the above mentioned process. Both these rigged models are exported as .fbx files in Blender and imported into Unity as assets. Appropriate scale factor has to be set while exporting the models in Blender as it differs from the scale factor in Unity.

4.4 Cloth Constraints and Collisions

In the second approach mentioned in section 3.2 where the cloth is attached as a mesh to Unity’s cloth component, we can set various parameters that affect the cloth. Parameters like damping, friction, gravity and other external forces can be set for the cloth. The main features are the constraints and the colliders. From Unity 5 onwards, the support for "Interactive Cloth" has been discontinued. So the new cloth does not react to the rigid bodies on its own. Colliders have to be added to the cloth explicitly and only capsule and spherical colliders are allowed.

This leads to the task of identifying different body parts so that colliders can be added to the cloth at those positions for the cloth to detect the body and not go through. Some approaches which have been tried in this project are as follows:

- Initially all the mesh vertices of the body were retrieved and small spherical colliders were added. There are 8249 vertices in the body. Though the cloth reacts to single sphere collider, it goes through the body when so many colliders are added. Also it is computationally expensive and the processing slows down.

- Since the cloth is a T-shirt, the colliders are not needed for the bottom part of the body. So the waist of the body is estimated manually and all vertices which are present above the waist are considered while adding colliders. This brings down the number of colliders added to 4010. But this does not solve the issue.
Next, the mesh vertices are stored in a graph and vertices for adding colliders are chosen in such a way that no two adjacent vertices are present in the list of colliders attached to the cloth. This greatly reduces the number of colliders from 4010 to 330. With this approach, though the processing is faster, it does not address the main issue of cloth detecting the body.

Figure 4.7: Small spherical colliders added to T-shirt

Different body parts that can be enclosed within capsules and that need to be detected by the body are considered for adding colliders. For example, if collider is added to the chest region then the waist can be skipped assuming there is no or very less wind in that direction. But in this case the waist region has to be considered to add colliders. Capsule colliders have been added to arms, chest, above the chest, waist and thighs (for skirts). Three spherical colliders have been added around the front portion of the waist. For the waist, we can also set constraints and make the vertices unmovable than setting spherical colliders.
For the skirt, the vertices along the waist are restricted to move. They were fixed in the current position as in the current scene, the model is stationary. This would not work if animations are enabled on the body.

4.5 **User Interface**

A simple user interface has been provided to help the user choose the clothes. The Unity skybox is used to provide different lighting effects. The UI mainly consists of a panel to the left with three buttons at the top:

- **Tops** - displays different colors of T-shirt modeled.

- **Skirts** - displays different colors and textures of a pleated skirt. This skirt model has been taken from [1] and consists of 154 vertices and 285 polygons.

- **Background** - displays various lighting options like night, dusk, bright day, clouds etc. Skybox [6] is set to the main camera dynamically to enable this feature.
The model is displayed towards the right with the shirt and skirt on the body. The shirt is placed slightly above the actual position so as to show how it falls on the body (over the shoulders) when the application is run in Unity.

4.6 Tools and Technologies

The tools and technologies used for building this project are:

- Blender 2.77 is used to model the clothes and assign vertex groups to the character rig or armature.
- Avatar Workbench-263 provides the basic rig that has been used in the project.
- Unity 5.5.1f1 and its Cloth framework has been used for building the application and its UI.
Chapter 5

Results

The cloth is modeled and simulated over the body under external forces. As the force increases, the cloth starts to shear and eventually flies away. The cloth renders fine under normal conditions but it can be seen to go inside the body in few places with the increase in external acceleration or damping coefficient. This happens due to minimal colliders attached to the cloth.

Following are the screenshots of the application with different clothes and under various lighting conditions.

Figure 5.1: Scene in dark background
Figure 5.2: Scene in night background

Figure 5.3: Scene in bright background
Figure 5.4: Scene in dusky background

Below are the screenshots with different values of damping coefficient and external acceleration.

Figure 5.5: Damping Coefficient = 0.5  Figure 5.6: Damping Coefficient = 1
Figure 5.7: External acceleration = (1, -2, 2)

Figure 5.8: External acceleration = (2, -4, 2)
Chapter 6

Conclusions

6.1 Current Status

Currently [9] both the methods used need some manual pre-processing i.e. the body and the cloth need to be rigged. Unity Cloth allows only spherical and capsule colliders to be attached to a cloth which makes it difficult to create an arbitrary shaped collider mesh.

6.2 Lessons Learned

The project has been a huge learning experience in terms of understanding the cloth model as well as learning the tools Blender and Unity. Following are few lessons learnt in the process of building the Social Clothing Sampler application.

- Explored the work done related to this field and the different approaches followed to tackle similar problems.

- Learned how to model a cloth using Blender and the challenges involved in it.

- Rigging is a tedious task and it needs some patience to get it properly done.

- Learned about why Unity cloth no longer supports collisions and how to do it the new version.

- Found some cool virtual reality applications built to enhance the shopping experience of customers and increase the sales and decrease returns for fashion websites.
Chapter 7

Future Work

The current work was an attempt to understand the cloth model and the concepts involved in its simulation. The project can be extended further in many aspects. The process of rigging is a tedious and time consuming task. A customer would not want to wait too long to get their avatar generated to shop online. This process can be automated by using tools that provide rigging automatically. Identifying different body parts in the key aspect of the whole process. Recognizing various sections of the body and storing this information will also help in adding the cloth colliders.

Currently the fitting analysis is not taken care of in the project. Effective fitting can be determined with the help of interactive user interface. To make it actually useful and appeal to a wide range of customers, the color, texture, fabric and design has to be rendered in real-time.
Bibliography


