Real Time Virtual Mirror

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In the name of ALLAH, the Most benevolent, the Most Courteous

CERTIFICATE OF CORRECTNESS AND APPROVAL

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under my supervision and that in my judgement, it is fully ample, in scope and excellence, for the degree of Bachelor of Electrical (Telecom.) Engineering in Military College of Signals, National University of Sciences and Technology (NUST), Islamabad.

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DECLARATION OF ORIGINALITY

We hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification in either this institute or anywhere else.

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Allah Subhan'Wa'Tala is the sole guidance in all domains.

Our parents, colleagues and above all our supervisor, Asst Prof Dr. Mir Yasir Umair with your guidance.

The group members, who through all adversities worked steadfastly.

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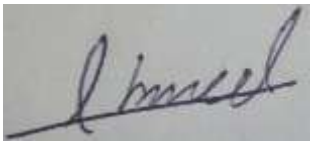

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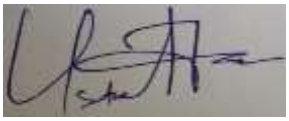

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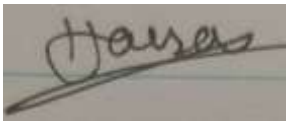

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ABSTRACT

Clothing industries are always in a competition of providing the best products to their customers and to keep themselves up-to-date they have to keep on designing new clothes that become a trend in the market, and yet they have not failed their customers. But there lies a huge problem, that whether the trend could best fit us or not in terms of size. In addition to this, online shopping has enhanced that problem to an extent that one online store offering a medium size would fit well and the same size from a different website would be tight to us. Even though the exchange policy is there, “Time is Money”. We are providing a solution to it by designing an online website that has the feature of putting clothes on the customer’s model generated through a script that is implemented on the customer’s picture taken through a camera, and from there the customer can judge the outfit’s appearance on their model.

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CHAPTER 1: INTRODUCTON

Science and technology combined have a principle of making our lives easier and effortless, and yet they have not failed on this task. Science is the study of nature on scientific grounds which includes observational, experimental, and most importantly depth descriptions of the natural phenomena. Technology on the other hand builds on the foundation set by science, keeping the statistical data and the risks involved in building something that can provide a solution to a problem that may arise or is already present. So, it explains enough about them both working together, in better words Science is a prerequisite of Technology, we cannot separate them if we want a benefit out of them. So, there are multiple benefits of Science and Technology, e.g., the Efficiency of our work increases, our communication gets better, and most importantly our standard of living gets exceptional.

Innovation in the clothing sector is a never-ending process; Fashion designers are competing now and then to prove their designs as the best and in that process of proving themselves, customer engagement becomes a huge challenge, keeping the people aligned to the trends and their availability becomes important, this is where science and tech come into play.

In the past, the Clothing sector had little publicity, but ever since social media came into being, everybody knows about the trends and has attracted a huge community of teenagers, so Customer satisfaction becomes a priority, putting pressure on Science and Tech. Promoting designs is never a problem, making them fit perfectly with the customers is a hectic job.

1.1 Problem Statement

People had to go-to brands to check the outfits, a time-consuming job, and if they still did not fit, an unsatisfied customer leaving the store. Moreover, handicapped citizens cannot try outfits every time so they too are unsatisfied. Online Shopping was then introduced; to save customers' time and also to make them aware of the availability of the designs and sizes. The problem remained the same, size issues were not resolved. Even though a refund facility and exchange policy were available, the sole purpose of saving time wasn't achieved. Despite the issue, people started relying more on online shopping during the pandemic, and so the room for improvement became quite big as eventually the reviews about these websites made them gain and lose customers, and losing a customer leaves a bad reputation, and this is never an option. It became an important task for them to make their interface more user-friendly. Mitigating compatibility flaws is all we are striving to achieve now as people are getting home delivery services for nearly every product and they have a huge expectation of getting the desired product and not getting into the mess of exchanging and complaining.

1.2 Proposed Solution

Introducing a website that has all the features customer desires, from the availability of designs and sizes to whether it would fit them or not. An interface that would change the way we buy clothes. An experience that could save time, from the point of availability to the point of buying, all a user has to do is to just put that outfit on his 3-D model and just analyse how it looks, if it perfectly fits on his 3-D model, it would fit him in reality. Then the only thing that would stop him from buying is that price tag. The solution proposed would not only save time but would also achieve the goal of customer satisfaction. Most importantly, amongst our satisfied customers are disabled citizens as well, they too get the opportunity of trying multiple clothes, providing a whole new set of traffic visiting the website.

1.3 Working Principle

This picture shows a simple and birds' eye view of the methodology used in this project. The process starts with the person taking his/her picture when he/she visits the website for the very first time. This image is then sent to the processing unit where it is processed by proper machine learning algorithms implemented that will convert this image to the corresponding 3D Model. The database contains all the datasets for developing the 3D model and rendering clothes on top of them. Every time a picture comes, the processing unit will refer to the database to make the algorithms work.

The admin will have the privilege to place new outfits in the database and remove the old ones.

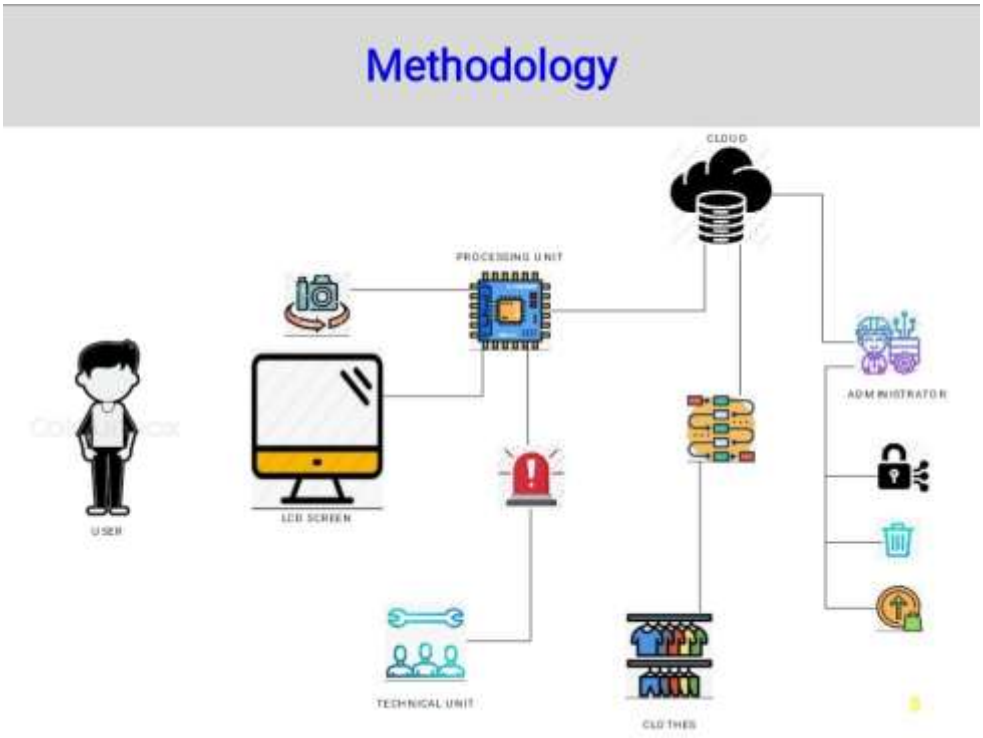

Figure 1 Methodology

Chapter 2: Literature review

A new service or product is introduced by the deliverables of an older service or introducing a new service or interfacing some different phenomena or techniques to serve a different purpose. Our work is based on the third technique. We interface three to four different ideas to enhance shopping these days. Our research is divided into these steps.

1. Industrial background
    1.1. Advancements and advantages
2. Motivation
3. Phenomena and Techniques
    3.1. Shop On
    3.2. PiFuHD
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4. Research Papers

2.1 Industrial background

Our target area is the shopping industry. In today's world, the shopping industry increases exponentially and that is why the competition is very high in this area. Due to this competition, every brand is trying to introduce different things and get attention. Our work (which is Virtual trying on the clothes on one's 3D model and checking whether it is fit his/her physique or not) is new in Pakistan. Previously, it is 2d based project which only fit shirts to the human picture. There are some problems which are faced by customers during shopping. Firstly, the customer always wants to check several clothes to check which one suits them best but here time is the issue. Secondly, in Pakistan, some cases were reported where cameras are secretly installed in trying rooms of clothing brands which has always been a big concern for

the customers. The third drawback is that handicapped people have a hard time trying on some clothes there. All these problems can be solved by introducing our project as a product or service in the industry.

2.1.1 Advancements and advantages

As discussed earlier, the project was introduced which only fits clothes to the human picture. We extend this idea to make a 3D model of a human by taking a single picture of a customer and then trying the clothes on that human model. There is a framework in the trying room where a camera and screen are placed. The customer can check all database of clothes and select which he/she want. In this way, one can check virtually whether that type of cloth is for himself/herself or not. Where this is an innovation for customers, it is also a great relief for the workers of the outlets.

2.2 Motivation

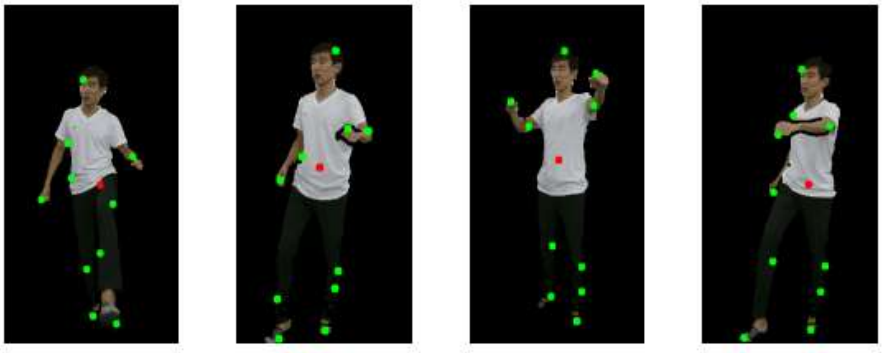
One of the biggest challenges online fashion faces is the large volume of returns. According to a survey, more than 20% of clothing gets returned and its 64% of customers say that it is not fully fit in their size. Size and fit are a multi-Dimensional problem influenced by various factors like different body types and individual fit choices. Moreover, many times people prefer offline shopping by going to outlets to see how that particular garment looks on them. But that try on are also time consuming. So, we combine the characteristics of both modes of shopping and introduce a interface that can also work on website as well as on outlets.

2.3 Phenomena and techniques

There are different types of new products and services. Our project is an interface of different phenomena. Firstly, we introduce a feature that collects the picture of customer and paste the pictures of clothes by making them filters. These garments are going to fit according to the shape, size and pose of the customers. This technique will determine which part of the cloth is applied to which part. For example, the t-shirt should be applied on the shoulder part and how the t-shirt would've moulded in the arms area. These all should be done by using a screen where a user interface is available. All one should do is use the screen just as he/she is using a computer. The next step is to implement the same idea in 3D. it is done by using a phenomenon called PiFuHD. It will simply take that picture of the customer and make a 3D human body. And at the end, we will apply the clothes on that human model by making them 3D filters. The human model and filters, both are OBJ files. We only have to interface these meshes to make a perfect clothed 3D human model.

2.3.1 Shop-On

Shop-On is an interface which we created for both online and outlets of the clothing brands. It consists of different steps. The first thing to notice is the front end of that interface which is similar to most of the eCommerce websites. The next step is to take a picture from which is performed by running a python script. This picture of that customer is then processed through which the body parts of that human pictures are identified.



There are several methods to identify key points of the human body, like Hidden Markov Model, through Support vector Machine etc. But one of the easiest ways is to use OpenPose library. It process's the RGB picture and firstly identify the boundary of the human model. Then through its neural network, it identifies the key points of human like head, belly, shoulders, knees, ankles, feet, elbows and hands etc. Then using PyTorch which is a framework for image processing and is used basically in Computer Vision, will process those key points and make it a skeleton type image which joins those key points. This will be a format which is dependent on the pose of human in that picture.

The above figure shows us that the first two pictures are of human and garment respectively. Then it makes skeleton type image which depends on the pose of the human and then reshape the garment. The last task is to impose that picture of shirt on to human picture. In this way our first goal is completed and now we will implement this technique into 3D. This will be discussed in detail in the next section of this chapter.

2.3.2 Multi-level Pixel-Aligned Implicit function (PiFuHD)

PiFuHD is a Multi-Level Pixel-Aligned Implicit function for high-resolution 3D human digitization. This technique is one of the best in creating a 3D human model by using a single image. Considering the current other techniques, two main problems are faced during the creation of 3d human modelling. These accurate predictions required large context, but precise predictions required high resolution. These are going hand in hand, if we ignore one

thing, the other will be sabotaged. Due to memory limitation, other techniques are using images with low resolution to avoid high computation. This technique is resolving this limitation by using a multi-level architecture which is using details of image level by level to create a high resolution, 3d human model. High fidelity in human modelling has many applications in virtual reality and other fields. Previously 3Dmodelling oh human is very costly (using a large number of cameras and controlled illumination) but their performance is also not good compared to the resources spent on it. In this model a single picture is taken of a human and processed through different levels of PiFu and using a deep neural network, creating a perfect and detailed 3D model.

Several recent approaches doing 3d modelling by using a 3d texture or geometry by making use of texture map representation which is dependent on geometry or color and details in the human body. An approach called Tex2Shape et al [5] is making 3D geometry by using UV radiation. The geometry depends on the depth of the source of radiation. But this approach has a limitation if we used it in those areas where people are wearing somehow loose clothes. Like specifically if we are talking about Pakistan, it will be a great problem for 3D modelling because here, women mainly wear loose and long clothes. This method is a framework where we upload a 512x512 resolution picture as an input. Then we down sampled that image to a 128x128 resolution image and process it through the first level. It creates a low detailed front and back model of the picture. Then for higher details, it again passes through a next level PiFu which is taking input as of resolution of 1k. This second level predicts the small and high levelled details by interfacing that high-resolution picture and the result of the previous level as shown in Fig 1. In this way, without using more detailed input because of limited graphics hardware we created a high detailed human 3D model.

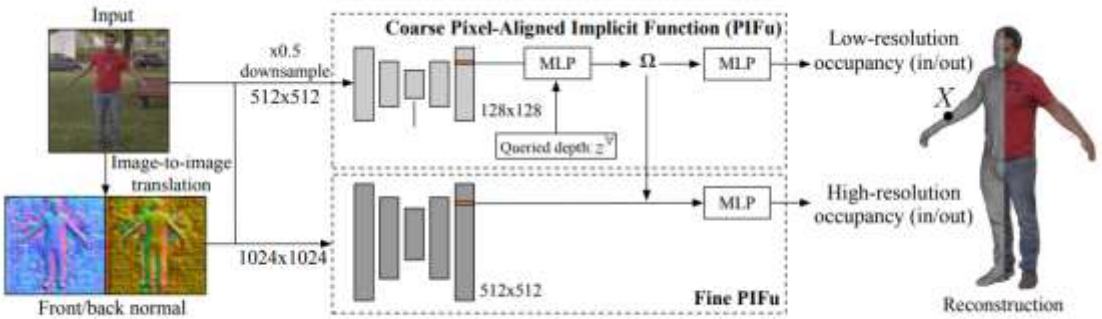


Figure 2: Overview of PiFuHD. There are two levels, the upper part is the first level which is using down the sampled images and the lower level is the second which processes the highly detailed images with the first level output.

Human digitization is achieved by estimating the occupancy of a dense 3D volume. This finds out whether that point is inside the human body or not. This will be going for every pixel of the picture. Previous works are based on the approach where the target 3D space is discretized and each point or pixel is processed explicitly. PiFu changed its dimensions and it only predicts binary occupancy of the space such as $X= (X_a, X_b, X_c) \epsilon \in \mathbb{R}^3$.

The PiFu function i $f(X,Y) = \begin{cases} 1, & if\ point\ is\ outside\ body \\ 0, & point\ is\ outside\ the\ body \end{cases}$

where Y is the RGB picture. On its first level, it only gets a two-dimensional picture where $X' = (X_a , X_b) \epsilon \ \mathbb{R}^2$. and on the next level it uses 3D space and determines whether that point is inside the body or not.

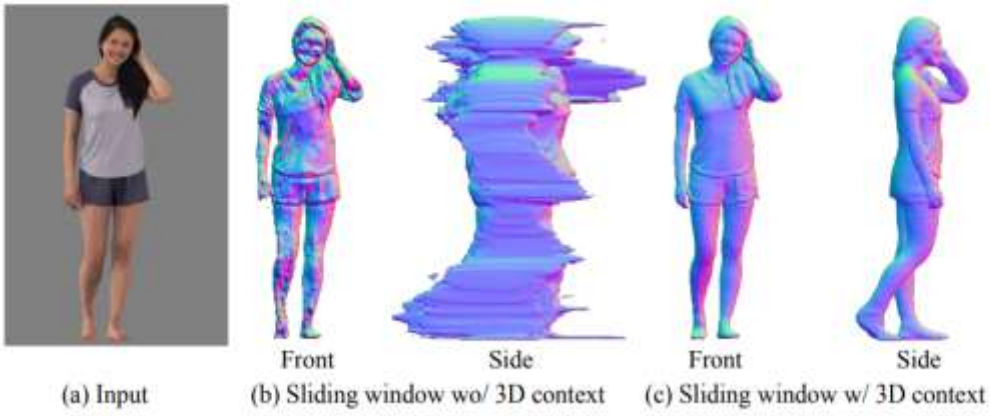


Figure 3: Result of the human model with and without 3D space

Now we will discuss one of the prominent features of PiFuHD which is predicting the backside of the 3D human model which is a very difficult task because it is not present in the input picture. This backside will be predicted through Multi Level PiFuHD neural network. The back side of that model should be perfect, and this will be done by making these layers learn complex functions.

It is later found that this process is performed in the stage where the feature extraction process is working because it gives the best result there. In the first stage, a prediction of the backside of that model is made. Then in the second stage where estimation and feature extraction techniques are held, the neural network learns and moulds the data that is collected from the previous stage into a perfect human 3D model. This feature is one of the most excellent features of this technique. The result of this feature is given below,

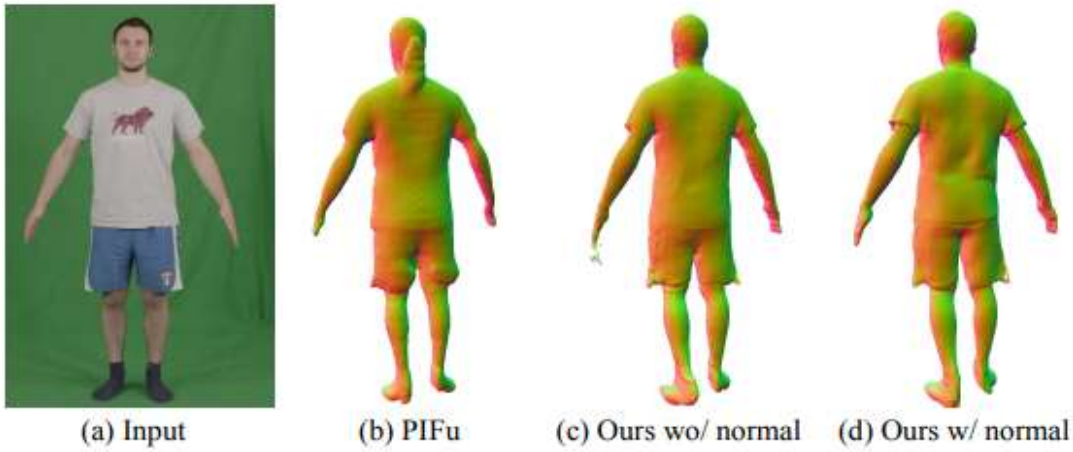


Figure 4 Results after predicting the back

In this picture, it is clearly shown that previous work predicts the back without any assumptions. Then in recent work, it not only predicts which type of shirt it wears but also moulds those clothes into the fit-sized back using neural network functions.

We conclude this technique by saying that PiFuHD is one of the best techniques which is suitable for our project. It has features that we want like we want to develop a 3D human model using a single image that not only detects and converts the picture into a model but also predicts the back of the human presence in the picture perfectly. It also reduces time complexity compared to the image resolution it is using which is the main problem due to graphic hardware limitations.

The first part of the project is discussed above which is making a 3D human model. Now our next goal is to make clothes for that 3D model and make it possible for a model to wear that model. This work is similar to that of the game developing area. Like they put clothes on the characters, similarly, we want to put clothes on that virtual model.

2.3.3 Learning to transfer texture from clothing images to 3D humans

Now the next task is to apply clothes to that 3D model. It seems as simple as in our real world but there is a whole phenomenon through which we make a 3d virtual cloth from a clothes picture and put it on our model. The first task is to convert the front and back pictures of cloth-like t-shirts into the 3D mesh. It will become an OBJ file. Then as we have made our human model which is also an OBJ file, we only configure that meshes and interface these two meses. This is done by computing image pairs with the aligned 3D garment. By using these pairs, it mapped the 3D garment surface from pixels. It makes a 2D UV map of a 3D garment surface by using only the information of the shapes. Compared with the other techniques which are thin-plate-spline warping and image-to-image translation networks, it is proved that this method is more accurate and faster. It gives us the gateway to a more technological world where augmented reality is more common and easy to implement.

Our task is to make a 3D geometry of a garment template from only two pictures, front, and back. This gives us a vast amount of application in the field of art and design, virtual reality, augmented reality, 3D modelling, etc. most of the work is revolving around image-based person re-posting [6,7,8,9,10] or virtual try-on [11,12,13]. These virtual try-on techniques only check the orientation of the image of a human and apply the picture of clothes on that picture accordingly. However actual work is far from this. There is a difference between website images of clothes and the clothes worn by actual persons in the real world. In this work, we leveraged the Multi-Garment Net [14] to fit the image silhouettes as shown in the picture given below.

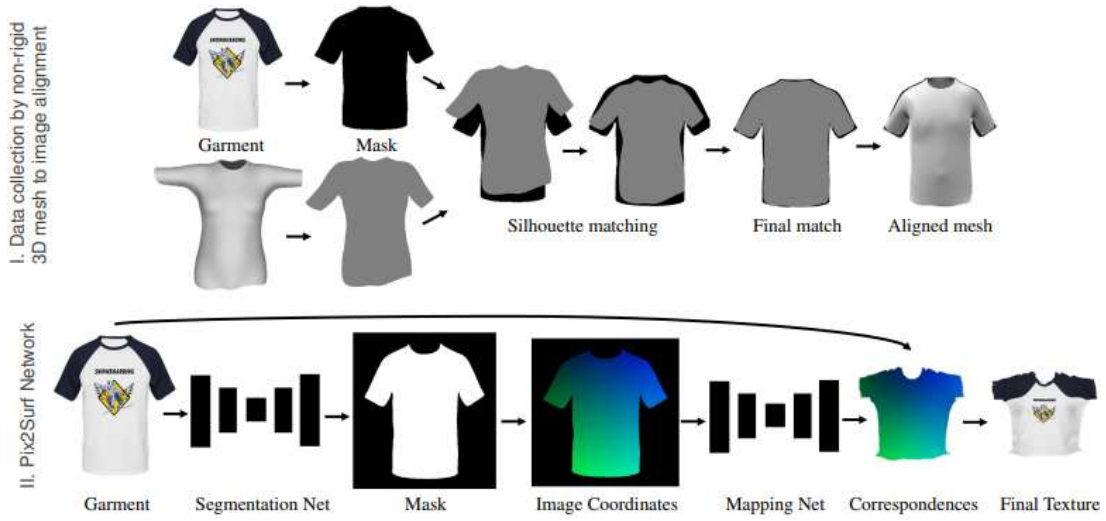


Figure 5 Overview of the method (Pix2Surf)

In this picture, it is shown that firstly a garment and model silhouettes are made, and then silhouettes are matched. Then a final result is made which is later aligned according to the mesh of the 3D model. These functions are the basics of the pix2surf model. These functions work in a way that interface garments file with human model file by firstly finding the joints of the model and considering all parts of that model. Then apply the vertex of the garment geometry to the vertex of the human 3D model. The results of this work are as below:

2.3 Research Papers

- PiFuHD: Multi-Level Pixel-Aligned Implicit Function for High-Resolution 3D Human Digitization [1].
- Learning to Transfer Texture from Clothing Images to 3D Humans [2].
- SMPL-X: Expressive Body Capture: 3D Hands, Face, and Body from a Single Image [3].
- Multi-Garment Net: Learning to Dress 3D People from Images [4].

Chapter 3: Design and development

In this chapter, the project design, features, and certain machine learning algorithms are provided which were used in the development of an eCommerce website that enhances the online shopping experience as people will be able to upload their pictures and determine which outfit is looking best on them.

3.1 Software review

The project requires the following software related tasks:

3.1.1 Visual Studio Code

Python is a high-level language that is easy to learn and use and has a fairly simple syntax. It is used to develop GUI, web apps, and websites. It makes programming easier with the wide variety of built-in libraries that it provides. On the other side HTML, CSS and JavaScript have been widely used all over the world to develop websites. Visual Studio Code is an integrated environment used for all kinds of languages. For this project, we used Visual Studio Code version 1.69.

Figure 6 VS Code Logo

3.1.2 OpenCV

The OpenCV-Python library is a set of Python bindings for solving computer vision issues. It focuses primarily on image processing, video recording, and analysis, including capabilities such as face and object detection. In Real Time Virtual Mirror, this library is used for capturing the images from the camera and process those images.

Figure 7 OpenCv Logo

3.1.3 Pytorch

Pytorch is an open-source machine learning based on the Torch library used in Python. It is developed by Facebook's AI Research lab and is used in computer vision and natural language processing. In this project, this has been the backbone of the processing involved in developing the 3D model.

Figure 8 PyTorch Logo

3.2 Setting up the environment

This section gives a brief description of all the equipment used in developing the setup for the project.

3.2.1 LCD

Displaying the results is an important part of this project and for this purpose, we are using a Dell LCD. The main reason to use this LCD is that it is a well-known brand and its durability and displaying results are better than others present in the market.

Figure 9 LCD

3.2.2 DELL CPU

To process the extensive machine learning algorithms, a dell CPU with intel Core i7 11^{th} generation has been used. Intel Core I7 11^{th} generation is one of the latest processors present in the market and is the best option for us in this scenario. Moreover, the DELL CPUs are known for their low rates as compared to the others present in the market and they fit well in the customer's pocket. Also, they can be easily upgraded. Our setup requires a lot of external attachments and upgrades, therefore this CPU is the best option for this project. Also, the processor used (intel core I7 11^{th} generation) is very fast due to the turbo boost and advanced technologies such as hyper threading technology.

Figure 10 CPU

3.2.3 Nvidia GEFORCE GTX 1660 TI

Apart from the processor used in the development of the CPU, we have been using a GPU to enhance the processing speed, we are using an NVIDIA GPU 1660 TI with 6 GB memory. The GeForce GTX 1660 TI has been built with the breakthrough graphic performance of the NVIDIA architecture and they are the best option for image processing and greatly reduce the time required in running the machine algorithms.

Figure 11 NVidia GPU 1660 TI

3.2.4 Webcam

This is an eCommerce website that is providing the facility to take pictures of the customers on runtime if they do not have their picture on their device. Since all of this has been implemented on a standalone device, therefore we are compelled to use a webcam that will take the picture of the user.

Figure 12 Webcam

3.2 Capturing the picture by the camera

As we have already stated that we are providing a facility to the customers to capture their pictures on runtime, therefore we have interfaced a webcam with the CPU. This will be done through a code written in python 3.9 by using the open-cv library. We will capture the video by initializing cv2.VideoCapture(). We have declared a variable named read and it will read the video frames from the camera by calling the cam. read() function and they will be shown by the img.show() function. The image taken will be saved by the img. write command in the current directory. This process will be terminated by the cv2.release() command.

The code for this process is

```python
import cv2
cam = cv2.VideoCapture(0)

cv2.namedWindow("capturing image")

img_counter = 0

while True:
    ret, frame = cam.read()
    if not ret:
        print("failed to grab frame")
        break
    cv2.imshow("test", frame)

    k = cv2.waitKey(1)
    if k%256 == 27:
        print("Escape hit, closing...")
        break
    elif k%256 == 32:
        img_name = "opencv_frame_{}.png".format(img_counter)
        cv2.imwrite(img_name, frame)
        print("{} written!".format(img_name))
        img_counter += 1
cam.release()
cv2.destroyAllWindows()
```

Figure 13 Code for capturing picture from camera

This code will be saved in the directory as app.py. This script will run when the user presses a button made on the website. When the button is pressed this code is run on the backend resulting in a popup window in which the person will be able to see himself and capture the best picture for him.

In this project, we require that there should be a full pose picture of the person so that his/her 3D model should be made perfectly with the position of the webcam such that it is aimed at the waist of the person resulting in a pose that is best for the machine learning algorithm which is developing the 3D model through this picture.

3.3 Developing the website

This project is implemented through a web application because the main target of this project is to create ease for the customers in online purchasing. So this is an e-commerce website that is a perfect platform for online purchasing of clothes. The website's front end is made by using HTML, CSS, and JavaScript whereas the back end is made by using the Django framework.

3.1.1 developing the home page

This home page will contain several options for the user. It is the front page of our website and will open on clicking the link for the website. This page will contain options such as 'home' which will guide us to the main page and 'Products' which will guide us and give us information about the products available on this platform. Then there 'About' and 'Contact' that will give the information about this platform and the means to contact the authorities respectively. The users can log in to their account with their preferences by clicking on the login button and providing their credentials.

The homepage is looking like this

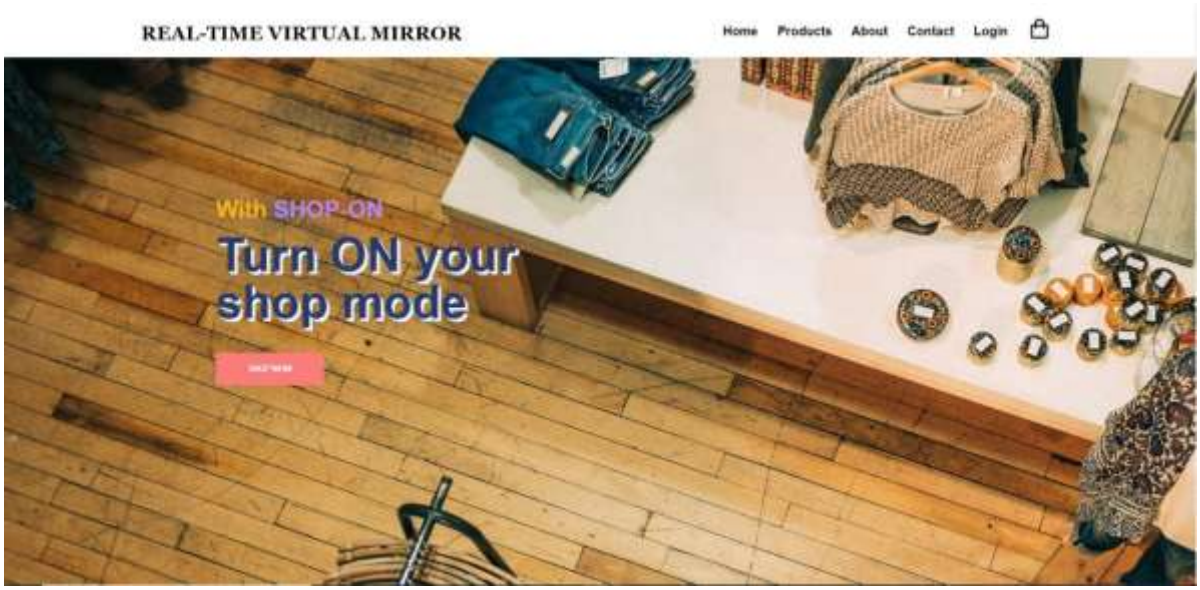


Figure 14 Website front [age

3.3.2 Developing the signup table

The new users on the platform are required to the first signup to use the website. The users have to provide a username and an email with a password to do so. The <form> tag in HTML produces a form that will accept the inputs from the user. The method used in this form is posted because it appends the data into an HTTP request and does not have any size limitations.

```
<form method="POST" action="">
```

Now, in this case, we have developed a separate box for getting the user name. the {{form.username}} attribute will be responsible to accept the user name.

```
<div class="input-group mb-3">
    <div class="input-group-append">
        <span class="input-group-text"><i class="fas fa-user"></i></span>
    </div>
    {{form.username}}
</div>
```

Now we have the same code for getting the email address.

```
<div class="input-group mb-2">
    <div class="input-group-append">
        <span class="input-group-text"><i class="fas fa-envelope-square"></i></span>
    </div>
    {{form.email}}
</div>
```

Similarly for the password

```
<div class="input-group mb-2">
    <div class="input-group-append">
        <span class="input-group-text"><i class="fas fa-key"></i></span>
    </div>
    {{form.password1}}
</div>
```

We have used the option of getting two passwords from the user so he/she could set their password correctly. All the tags, in this case, have been given the same class so we can style them all together just by mentioning their class. The signup form is shown below

Figure 15 Signup Table

3.3.3 Developing the login page

This page will be for the customers that already have an account and they want to log in to their account for purchasing the outfits. The users will be required to provide their email addresses and the password to access their accounts. There is also an option of 'signup' for the users that have arrived at the login page but don't have an account. This signup page will guide them to the signup page to set up their account.

The login page is looking like this

Figure 16 Login Form

3.3.4 Developing the product detail page

On clicking on any product, the user will be guided to a page that will provide the details for that specific item. It will provide the details such as the description of the product and its price. Moreover, it will also have an option to put that item into their cart if they like it and are willing to purchase it.

The description page for any item is looking like this.

Figure 17 Product Description Page

3.3.5 Developing the cart

After the user adds anything to his cart, he/she will be directed to the cart page by clicking the cart icon on the top of the website to proceed to the payments. This will require the address of the person and his contact details. Similarly, the user will be required to provide their account details if they are willing to pay online.

The cart of any person will look like this

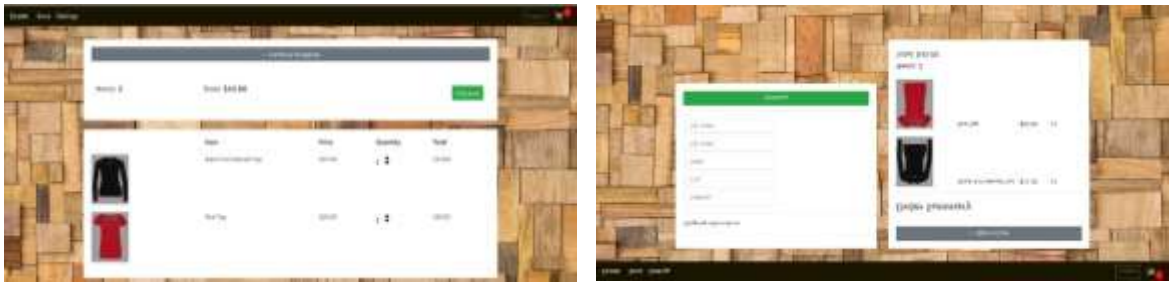


Figure 18 Shopping Cart

3.4 Developing the 3D model

The backbone of this application and the foundation for this innovation in the field of online purchasing is the development of the 3D model on which people will be able to try their clothes. This application requires a picture of the person and that picture is converted into a .obj file by using proper machine learning algorithms.

3.4.1 Preparing the datasets

Dataset refers to a compilation of instances that share a mutual attribute and it is used to sculpt a machine learning algorithm going forward. It is a collection of data pieces that can be used by the computer as a single unit for prediction and analytical purposes. The more data is provided, the more efficient is the model. The basic principle of this model is that there are a lot of 3D models placed at the back-end. Hence to produce excellent results, Render people

Data has been used in this as it contains scans of high-resolution pictures that are commercially available. This data set has been divided into 2 parts.

1. **Train**

   In this dataset, we have put 450 images and they will be used to train the model

2. **Test**

   The remaining images are put in the test folder and the working of the model is determined by testing the model on these images.

Therefore whenever a picture comes, the models get the key points from the picture and adjust the most related model according to those key points.

3.4.2 Front to back inference

The main problem with this model is that back has to be predicted to make the 3d model because it is not visible in the pictures. Therefore, the back has to be predicted entirely by the MLP prediction network and due to the multi-model nature of this problem, the back tends to be smooth and featureless.

To cater to this problem, we have predicted the normal maps as the proxy for 3D geometry in 3D space and they are provided as a feature of the predictors used in this model. The 3D reconstruction is then guided by these maps to make a particular 3D geometry and make things easier for the MLP to produce details.

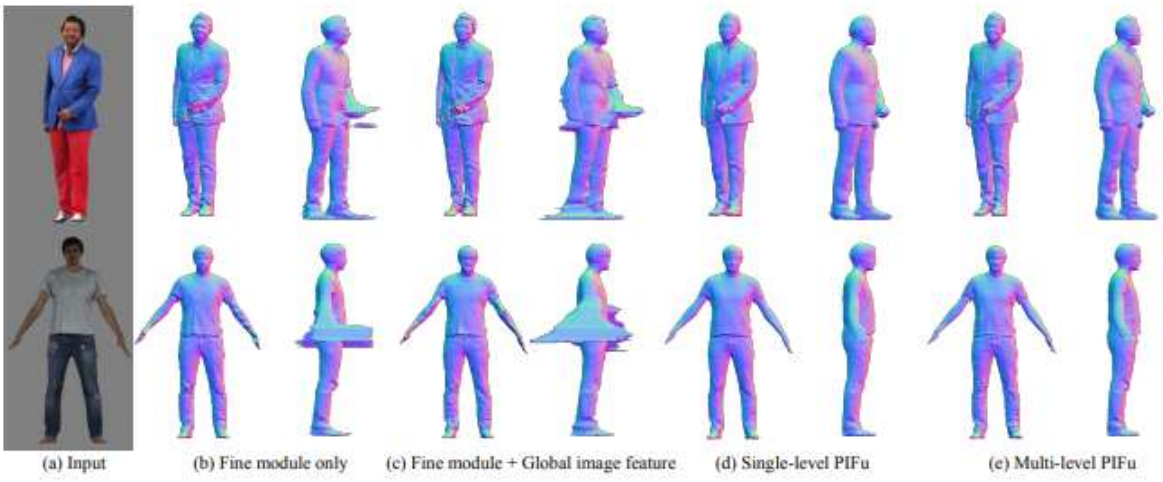


Figure 19 Qualitative evaluation of our model

Note how detailed and good results are produced by this model. The previous techniques have a lot of flaws as you can see whereas the results of our model are perfect and detailed.

3.5 Rendering clothes on 3D models

After developing the 3D model, the main task is to render the clothes on these models. These clothes will be in form of 3D meshes that will be adjusted and resized according to the 3D model and placed on the 3D models.

3.5.1 Developing the datasets

To train our models, we create datasets of garment images by scraping the websites of clothing stores. The back view of clothing images is not available on the internet, so creating a dataset large enough to train the mapping algorithm was not possible. we are depending upon the fact that the front and back of most of the garments are the same. Therefore either we can predict the backside of the T-shirt or we can only use the front of the pictures for training the model. We have developed the dataset by using the front images of 2267 T-shirts. The networks about the back are trained using a dataset of 2267 images of which 964 are back view images and the rest are front

images. The front shorts dataset has 2277 items. We have collected more than 3000 front views of pants to create the dataset and the back has been predicted just by flipping the front pictures.

3.5.2 Photo realistic rendering of clothes

This technique allows the rendering of an infinite number of textures on the top of 3D models automatically and in Realtime. The main advantage of this model is that it runs in real time which is best for such applications.

Chapter 4 Analysis and Evaluation

4.1 Website Evaluation

The codes written for developing the website have been executing perfectly and all the functionalities of the website are working well.

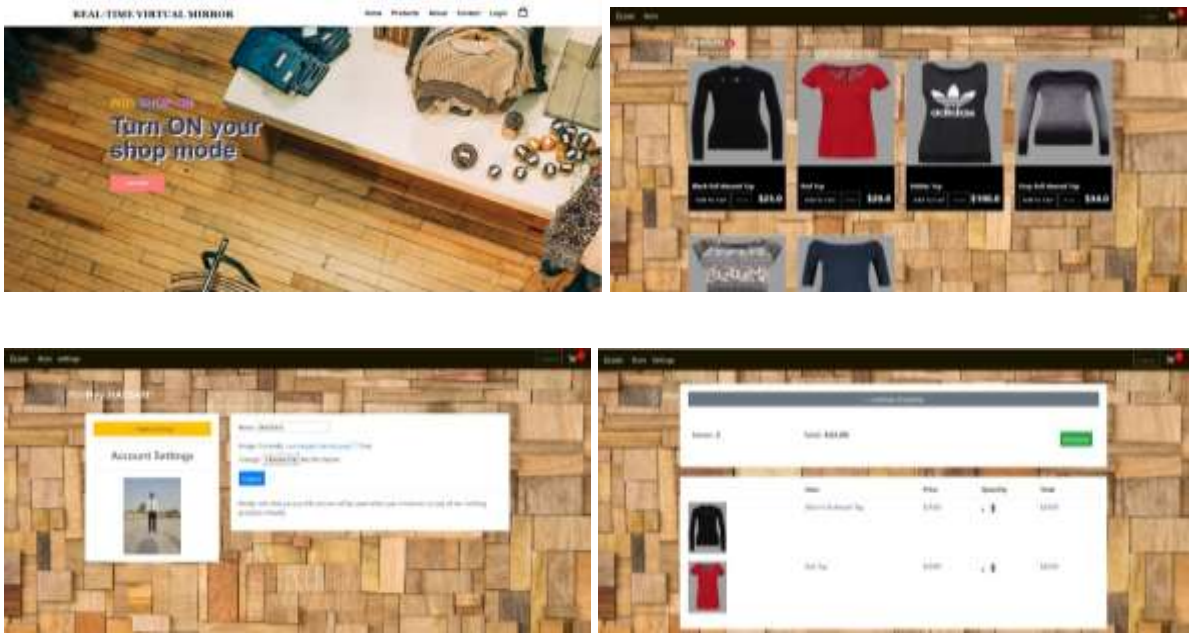
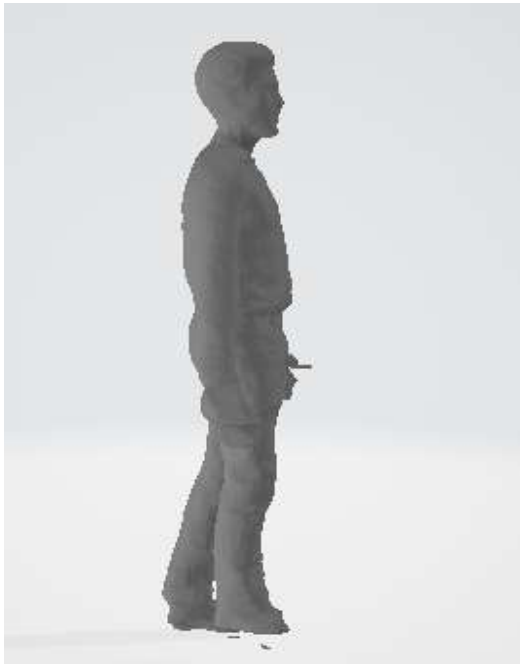
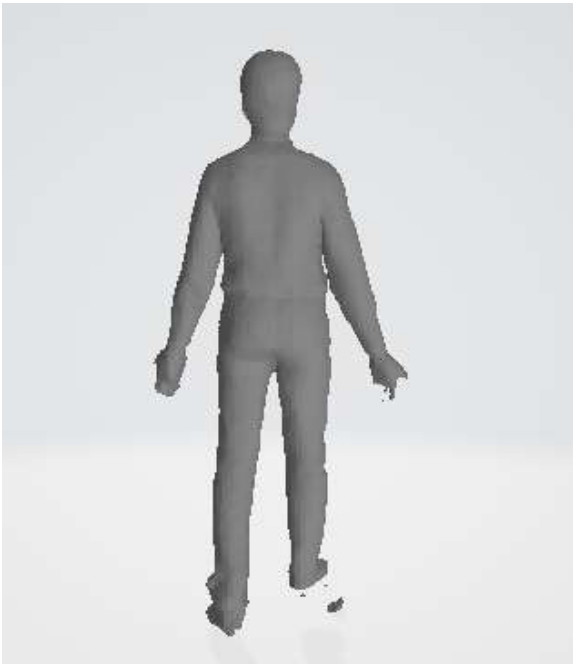


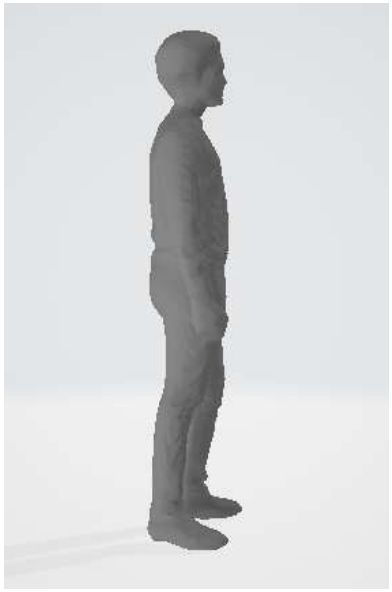
Figure 20 Website snapshots

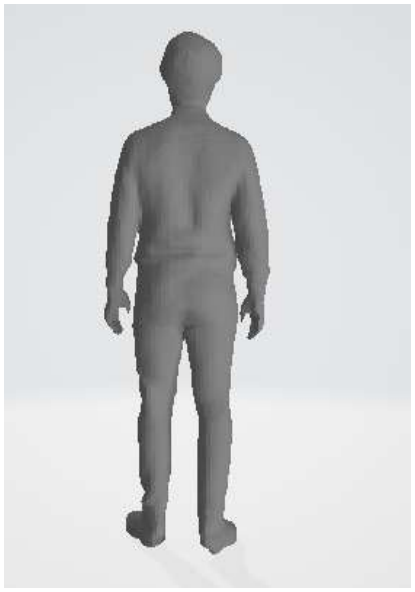
4.2 3D model testing on a real person

The model used for developing the 3D model has been tested on real scenarios. This model is working well and the models generated are also realistic and very detailed.









Chapter 5: Conclusion

In this thesis, we discussed how technology has brought innovation to the clothing industry by bringing the concept of online shopping. People had to go-to brands to check the outfits, a time-consuming job, and if they still did not fit, an unsatisfied customer leaving the store. Moreover, handicapped citizens cannot try outfits every time so they too are unsatisfied. Online Shopping was then introduced; to save customers' time and also to make them aware of the availability of the designs and sizes. The problem remained the same, size issues were not resolved. Even though a refund facility and exchange policy were available, the sole purpose of saving time wasn't achieved.

This method brings in the concept of Virtual Try-on in this field making online shopping a more interesting and new experience for the users. This Real Time virtual Mirror is an eCommerce website that requires a single picture of the person and makes a 3D model of the person according to that picture by using machine learning algorithms as the customer will be able to try on clothes of their favourite brands on their 3D model before purchasing them giving a more realistic experience.

Chapter 6: Future Work

Our future work for this model is

6.1 Making more realistic models

This model has been using PIFU-HD as its main technique for developing the 3D models. Although these models are quite realistic and detailed the problem that lies here is that these models are still. In the future, we hope to bring some simulations to the models and introduce different poses so that the people will be able to perfectly choose their outfits based on different poses and judge whether an outfit is made for or is looking good in that particular pose. Moreover, these models will be improved to such an extent that the skin colours will be adjusted according to that of the person.

6.2 Simulations in clothes

The next target is to bring simulations in clothes so that they are rendered perfectly on the model of the person. In this way, as the model moves, the clothes will also move accordingly giving a more realistic experience for the users while purchasing their clothes.

6.3 Interacting with brands

As this project is an eCommerce application and is a platform for the users to buy their favourite outfits with a new experience and they will be expecting their favourite brands to be on this platform. So, our next goal will be to interact with the brands and make simulations for their clothes. The users will be able to buy from their favourite brands with a new experience.

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