Virtual Dressing Room: Smart Approach to Select and Buy Clothes

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***Abstract*—The clothing industry portrays a major part of a respective country`s economy. Due to the predilection for clothing items of the people have led to the increasing of physical and online clothing stores in all around the world. Most of the people are used to go to the physical shopping and purchase their desired clothing items. But, as a consequence of the current pandemic situation, most of the people are unable to step out from their homes. This application is intended to cater an opportunity to the customers, who are not able to reach the physical clothing stores due to a pandemic situation and mobility difficulties. In addition, this application diminishes the time wastage, clothing size mismatches and the lesser user satisfaction ratio inside a physical clothing store. A customized 3D model has featured in the application to cater the virtual fitting experience to the customer. And the AI chatbot assistant in the application interacts with the user while catering virtual assistance for a better cloth selection process. In addition to that, this application has concentrated on the clothing shop by providing a future sales prediction component utilizing the K-Nearest Neighbors algorithm to provide an aid to their business commitments.**

Keywords—3D model, Artificial Intelligence, Machine Learning, Image Processing, Root Mean Square Error

I. INTRODUCTION

Fashion changes one form to the next and never been constant. Due to those expeditious and dynamic characteristics of the fashion, the economy growth of a country has aided by the clothing industry all around the world. This varying nature of the fashion industry have caused to making of new fashion trends and the charisma of the respective fashion trends have induced to attract people to the fashion while making them fashion lovers. As consequences of the high demand and favorability of the people towards the clothing items, physical and online clothing stores have appeared to the people for purchase the desired clothing item.

Whereas a customer visits a physical clothing store, the clothing store has catered a fit-on facility to the customer as an aid to select the best matching cloth from the available clothing item selection in the store. Still, the most of the online shopping platforms have not facilitated that fit-on experience to the customer. Due to the inability of providing fitting features has caused to the contraction of the customer interest to purchase the clothing items from the online shopping stores [1]. Variety of body shape of the people and the changeability of the dress sizes [2] have caused to the previously mentioned problem. In addition to that, some customers are experiencing some difficulties due to lack of skills for selecting best matching clothes for them. In a physical clothing store, a sales assistant cooperates with the customer to pick suitable clothing items by suggesting clothes according to the to the size, body shape and skin tone of the customer. The sales assistants also guide the customer throughout the selecting and purchasing process of the clothing items from the beginning. But when it comes to an online clothing store, the customer has to select the desired and best matching clothes without aiding and the guidance from the online shopping platform. The people with the lack of ability to select best matching clothes for themselves will face difficulties when selecting clothing items from an online clothing store and purchasing the unsuited clothes will be led to a bad user experience and the dissatisfaction toward online shopping platform. Losing the customers will be affected to the clothing store negatively and can be a great loss to the business. In addition to that, an online shopping platform should focus both the customer and the seller. Focusing only the side of the customer can be affected to the quality of the system and the sellers can be dissatisfied toward the system due to the lack of features. Providing features to assist sellers to increase the sales while decreasing business losses will broaden the satisfaction of the sellers towards the online shopping platform.

After utilizing the nowadays sophisticated technology aspects, a solution was devised by the research team to address the previously mentioned problems. The mobile application addresses the inability to facilitating the cloth fitting problem in online shopping platforms by catering a customized 3D model according to the body shape of the customer. The 3D model generates by utilizing the body measurements and the skin color of the customer. The generated 3D model facilitates customer to put on selected clothing items and probe the suitability of the clothing item to the body shape of that customer. Moreover, the mobile application filters the suitable clothing items according to the skin color of the customer by availing the machine learning algorithms to hand over a better user

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experience while deprecating the time wastage in the shopping process.
Accompanying the intention to provide the sales assistant experience inside the online shopping platform, an AI based chatbot has used in the mobile application to alleviate customers for the cloth selection process. The AI bot interacts with the customers for the clothing selection process by suggesting clothing items and the bot motivates customers to checkout additional clothing items.

Along with the mobile application, our solution includes a web application with the intention of fulfilling the needs of the clothing shop. The web application contributes a future fashion sales prediction component by utilizing the Machine Learning algorithms. Thereupon sellers will be able to obtain future predictions regarding clothing items according to the different factors including seasonal factors, festivals, month of the year. The management of the shop will be able to study the predictions generated by the system when ordering new items and maintaining stocks while enhancing the business usability by shrinking business failures like lack of availability of trending clothing items.

The rest of the paper is organized as follows: Section II demonstrates the literature review on this research area. Section III defines the methodology of the study. Section IV discusses the achieved results. Finally, section V concludes the paper by presenting the key findings and suggesting future areas related to the research.

II. LITERATURE REVIEW

The survey results at the initial stage indicated the most common problems when purchasing clothing items through online platforms. Since the fitting rooms are not available, people have less awareness of the size of the clothing items they are buying. Most of the times, the purchased clothes cannot be exchanged if the item was not good enough. The other highlight was the look and feel are not good enough after buying even the size is perfect. Also, most people consider their skin tone when selecting clothes because generally it illustrates the first impression of a person. But for some people, matching skin tone is more difficult without asking someone else. By the time the survey was conducted more than half participants were using online platforms to purchase clothing items. These issues are most common in online platforms because normally in a physical clothing store, people have facilities to try out clothes in a fitting room or get an assistant from sales assistant or ask and discuss with his/her friend or partner. But online platforms have a lack of services than traditional shopping way.

Many researches were conducted in the past decade to address above situations. The main feature of all the researches were introducing Virtual Fitting Rooms. A virtual fitting room is a software generated virtual environment that facilitates to try out clothes virtually. Each research has taken different approaches with different architectures and technologies to propose solutions and each of them have benefits and drawbacks. Also, most of the solutions were based on web environment. The overall solutions can be identified Real time 2D image-based systems, 2D / 3D mannequins-based systems.

Real time 2D image-based systems superimpose 2D graphical models of clothes on top of input image of the user in real-time. These virtual rooms are shown the uploaded image of the customer which can put clothes onto the image. The existing systems which based on this category are listed described as follows. Fittingreality.com [3] is one solution which provides virtual room facility via web environment. Basically, the website allows users to apply clothes onto a model. It uses the same body model for each user, but the shape is different from each. First users have to create a profile called *Shape-id* before using the model. To create shape-id, users have to upload at least three photographs with a specific dress. In addition, the website allows users to create Shape-ids using Microsoft Kinect technology. After the model is created, it can be used to try out clothes virtually. The drawbacks of this solution are, it does not support 3D modelling and displays the overlaid object as 2D images. Users cannot get a clear idea of how the dress really fits onto their body. Facecacke's Swiwel [4] is another fitting room where facilitates clothes are applied to a real-time image of the customer. It allows customers to see how it looks in a more appealing way. Only uses non-flexible 2D models of clothes and does not follow the person's curves and movements. LazyLazy [5] is another platform where facilitates clothes are applied to a real-time image of customers. The clothes consist of images in the center of the screen which customer can scale up and down in size to get a close as possible fit to the size (distance to the camera) of the body.

2D/3D mannequins-based systems based on web environments mostly. The web-application uses the body measurements provided by the customer and render a 3D model according to the provided measurements. Fits.Me [6] is a cloth company that maintain a large database with their clothing models and mannequins. The most fitting model is shown to the user when they input their measurements. My Virtual Model [7] is a social network solution where 3D clothes are generated by the user base and applied to a generic female 3D mannequin. The model can be rotated and check in different angle. Upcloud [8] is a webcam-based solution for body measurement. This is not really an interactive virtual dressing room but serves solely for measuring the proportions of the costumer.

3D camera and laser technology-based systems use 3D/range cameras or lasers to acquire 3D information of the costumer, enabling estimation of the body shape and measurements. Bodymetrics [9] is Microsoft Kinect based solution which can measure customer's body proportions. Fitnect [10] is a solution similar to the virtual real-time 2D image/video techniques, however, instead of standard image/video input, the Microsoft Kinect is used to acquire input video and depth/3D information of the user.

III. METHODOLOGY

The "Fitton" Mobile application and web application is developed to automate the cloth selection process and maintain the preferrable stock. "Fitton" mobile application focus to solve some main problem that customers face when their buying clothes online. Those problems as follows:

- Can't match skin tone and clothes when order online
- Haven't fit-on facility
- Haven't assistant to guide when selecting clothes

The mobile and web applications are divided into the following three components to provide solutions for above mention problems. Those are determining the skin tone of the customer through the image and suggest most suitable items, render a female/male 3D model and provide the virtual fit-on facility and add animation to the model and implement an intelligent bot to assist customers for the selecting and ordering clothes and analyze the purchased data to predict the future trends, indicate sales statistics. The overview of system shown in Fig. 1.

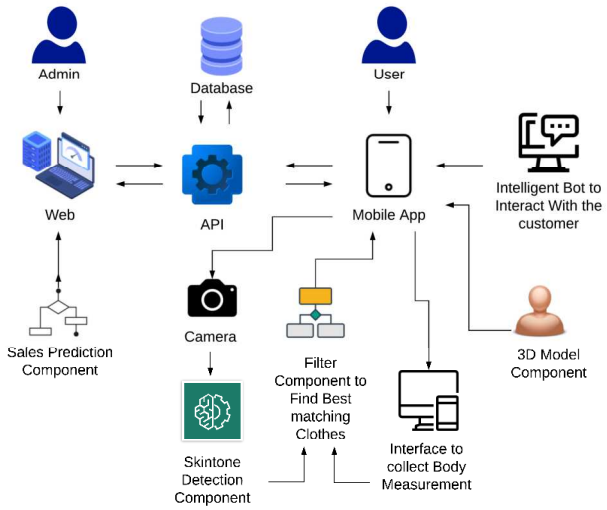

Fig. 1. System Overview Diagram

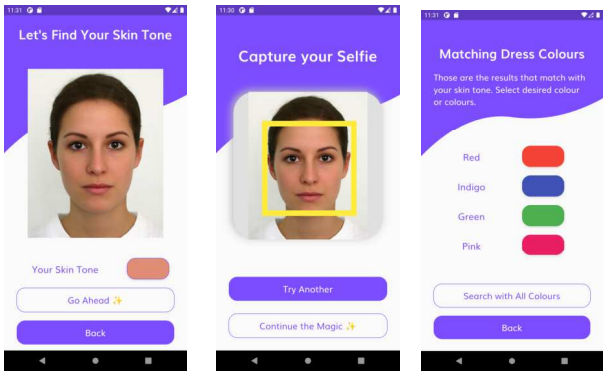

Fig. 2. Suggest matching dress color after detecting face and skin tone

The proposed "Virtual Dressing Room." is a mobile app with more functionality than the standard shopping app. It can suggest the best matching clothes while providing virtual fit on the facility. When narrow to the "Identifying Skin Tone and suggest clothes" component, it has the capability of Detect the skin tone of the customer, suggest dress colors according to skin tone, Analyze Body measurement and suggest best matching clothes. Customer can use the mobile app to select and buy the best matching clothes for their appearance. When the customer tries to buy clothes app asked some details about the customer's body measurements as user inputs. The app collects all entered details and store them in the database. These measurements use to filter clothes that match the customer's body measurements. After collecting the data app, ask to take a photo. In this step, under some condition users need to capture a selfie/image. Conditions are good light condition and the captured image quality.

As shown in Fig. 2 app ask for a selfie to capture the skin tone. Users need to capture a selfie using "Fitton" mobile application. After that process app will analyze the image and check for a face. If face is found user can continue the process. Else app will ask for another selfie. This face recognition functionality build using Firebase ML vision [11]. After that process, the image will analyze to detect the exact skin tone [12]. The selection of the appropriate clothes colors is determined by the least square fitting method. This method can be used to determine the overall fit and production efficiency of a corporate garment. It does so by monitoring the various aspects of the skin color and determining the appropriate color for the clothes based on the input camera. A fuzzy membership function was formulated that relates to the variation of skin color input and its appropriate clothes.

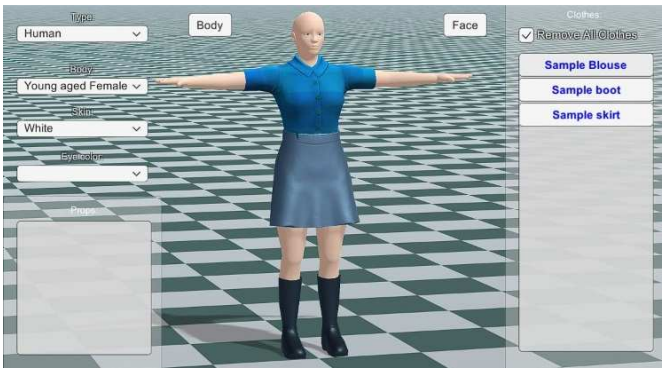

Fig. 3. Rendered model for fit-on component

The proposed virtual fitting room should be able to process following features: accurate and fast 3D model rendering by matching skin tone, applying suggested clothes onto the model, show behavior animation with cloth animations and provide cloth customization facility. The model rendering is done using "Blender" which is free and open-source software.

One of the main objectives is rendering the 3D model(s) that reflect customers' body shape as shown in Fig. 3. Body measurements which provided by customers in the initial stage are being utilized when rendering the related model. Although the model rendering process require a various number of measurements, a minimum number of measurements are taken from the customer in order to make

the process easier [13]. Primary measurement shown in TABLE I. Those measurement take from the user as user inputs through mobile application.

TABLE I. PRIMARY MEASUREMENT FOR MODEL

Primary Measurements	Description
Height	Vertical distance between crown to the ground
Bust girth	Length around fullest part of chest
Under bust girth	Length around below busts
Waist girth	Length around waist
Hip girth	Length around fullest part of hips
Inside leg girth	Length around upper part of leg
Arm length	Length from shoulder to wrist
Neck-base girth	Measurement around the neck

In addition, a secondary set of measurements are necessary to render the model [14]. Secondary measurements are shown in TABLE II. Those measurements are not taken from the user, instead of that, a standard set of body measurements were taken related to different body sizes. When rendering a model, the most appropriate measurement set is taken from secondary table which most compatible with user inputs.

TABLE II. SECONDARY MEASUREMENT FOR BODY

	Standard Body Size	XS/34	S/36	M/38	L/40	XL/42
Primary Measurements						
1	Height	168	168	168	168	168
2	Bust girth	80	84	88	92	96
3	Under bust girth	71	74	77	80	84
4	Waist girth	65	68	72	76	80
5	Hip girth	90	94	97	100	103
6	Inside leg girth	78.3	78.3	78.1	77.9	77.7
7	Arm length	59.6	59.8	60	60.2	60.4
8	Neck-base girth	34.8	35.4	36	36.6	37.2
Secondary Measurements						
9	Outside leg length	106	106	106	106	106
10	Back waist length	41.4	41.4	41.6	41.8	42
11	Back width	33.5	34.5	35.5	36.5	37.5
12	Shoulder slope	72	74	76	78	80
13	Shoulder length	12	12.1	12.2	12.3	12.4
14	Front waist length	41.9	42.8	43.7	44.6	45.5
15	Grith 8cm below waist	81	84	88	92	96
16	Waist to Hips	21	21	21	21	21
17	Thing girth	52	53.8	55.6	57.4	59.2
18	Head girth	55.4	55.6	55.8	56	56.2
19	Upper arm length	34.8	35	35.3	35.4	35.6
20	Upper arm girth	26.2	26.8	28	29.2	34
21	Wrist girth	15	15.4	15.8	16.2	16.6
22	Neck shoulder point	25.5	26.5	27.5	28.5	29.5
23	Knee height	45	45	45	45	45

A generic body model is created at first which is dynamically adjustable according to the relevant measurements. Therefore, no need of rendering the whole body from the scratch in each time. The skin tone of the model is also changed dynamically according to the identified skin tone by the photograph. In addition the model is injected motion libraries to show behavior animation (walk) [15].

Garment rendering is another objective to be achieved in fitting room. Here also generic garment models are created for most common women related clothes (blouse, trouser, frock and skirt) and then change its sizes and designs according to related parameters [16]. Similar as 3D model, the garments are also injected related animation libraries in order to perform well with behavior animations. The rendered clothing items can be applied on to the body model to check the appearance. In addition, the clothing items are customizable which means, customers can see it with different fashion styles such as sleeve or sleeve-less views. Collision handling needs to be done properly between skin layer of the model and cloth surface in order to provide a proper simulation.

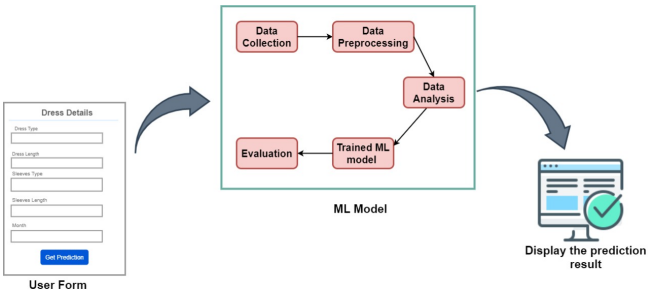

Fig. 4. Future sales prediction component workflow

The prediction component of the system has capability to predict the demand of the existing or new clothing item in the future. Workflow of the future prediction component in shown in Fig. 4. Supervised machine learning methods were used for the demand prediction of cloth items. Therefore, the methodology for implementing the prediction component includes data collection, data analysis, trained model using ML algorithm and evaluation.

For the data collection phase, a dataset was taken from Kaggle Machine Learning and Data Science Community which contains 8000 cloth item purchase records with 10 attributes (Item code, Age group, Item visibility, Item MRP, Cloth type, Cloth size, Gender, Shop location, Month, Item sales). The collected dataset was pre-processed before applying to the algorithms using Python library Pandas. During the data preprocessing stage, impute missing values, convert categorical variables into binary variables and normalizing continues variable in the dataset were performed. Consisted missing values in the raw dataset were imputed using the mode value, due to the categorical nature of the variables. The Category Encoders library was used to convert the categorical variables into the binary variables and the continues variables were normalized using Standard Scaler function in Python scikit-learn library.

A machine learning algorithm should use to train the data set for get predictions. K-Nearest Neighbors algorithm was used as the machine learning algorithm and processed dataset applied to the algorithm for the training [18]. KNN algorithm uses ‘feature similarity’ to predict the value for any data point. Algorithm trained the dataset using the

features of a clothing item. Python language libraries were used to implement the KNN algorithm for the trained model. In the evaluation phase, the demand for existing and newly clothing items will be predicted and comparing the obtained demand value with the actual demand value the accuracy of the prediction process will be determined.

The proposed system will be complied with a generative based AI chatbot assistant using RASA NLU [19]. The chatbot assistant will be able to perform two different tasks. Those are analyzing the user request and Responds to the user with appropriate outputs.

Chatbot has the ability to process the user inputs and identify the intention of the user. Text-based inputs from the user will be taken by the chatbot and after the input received, the input text will be analyzed using the NLU training data for understand the intention of the user. NLU training data contains the sentences the user can enter to the chatbot and appropriate intent to each sentence. RASA chatbot complies with a domain module and the module contains intent, entities, slots and actions the bot should know.

After understanding the intention of the user, the chatbot will prepare the response for sent to the user. In our proposed system, the chatbot aid customers by suggesting clothes when they are not satisfied with the showed list of clothes and providing recommendations to the customer if they are looking for a suit of clothes and also, the chatbot will motivate the customers to purchase a suit of clothes. If the customer does not satisfy with the previewed item list, according to the provided features of the cloth that seeking by the customer, the system will be filtered the cloth items and respond to the customer. If the customer wants to purchase a suit of clothes (trouser for a T-shirt, skirt for a blouse etc.) the chatbot has capability to recommend the suitable cloth items for the user. And after a customer add a cloth item to the cart, the chatbot will motivate customer to purchase another cloth while recommending cloth items.

Collaborative filtering that comes under unsupervised learning will be used for recommending clothes to the user. The filtering approach will be the user-based filtering and the item-based filtering. The filtering algorithms will be implemented using python libraries. The body features of the user (body measurements and skin tone) will be compared with the other users who purchased items from the system. The nearest neighbor's approach will be used for this process and the system will be found-out the top-N neighbors who have same body features with the target user. The purchased item list of the filtered users will be retrieved. Then the nearest neighbors' approach will apply for the item-based filtering and comparing the preferences of the user for the needed cloth with the features of the clothes from the retrieved list the top-N neighbors which have same features with the user preference features will be retrieved and the retrieved list will be send as a response to the user.

The implemented chatbot will be integrated with the database and API of the virtual dressing application using the features of the RASA framework. The view of AI chat bot shown in Fig. 5.

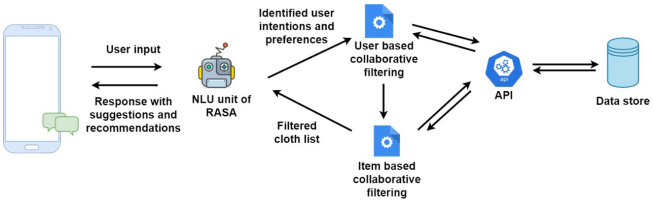

Fig. 5. The view of AI chat bot

IV. Results and Discussions

'Virtual 3D Fitton Room' has been developed for allows shoppers to try on clothing items without touching them. The mobile application is implemented using android, MongoDB database, Flutter and the backend of the application is NodeJS. The research has been used machine learning concepts and algorithms, image processing in the implementation.

The mobile application analyzes uploaded image by the user to identify the exact skin tone of the customer using image processing and machine learning algorithms with the assist of trained dataset. Additionally, body measurement collects from the customer as user inputs. Suggest the most preferable color range of clothes, based on identified skin tone. User may pick a color and move forward. Filter and suggest the best matching clothing items along with the selected color and body measurements that provided initially using ML algorithms. Display the filtered clothing items list to the user for proceed to checkout process.

Analyze the body measurements given in the initial step and utilize them to render a 3D model of the customer. Render a 3D model according to identified body measurements and apply the exact color that identified by analyzing the photo, as the skin tone of the model. Apply selected clothing item onto the rendered model to demonstrate the view of how it looks after wore by the customer.

Generate statistical information and conduct predictive analysis processes using ML algorithms based on pre-ordered items data. The obtained RMSE value for the KNN algorithm was 70% and 68% for the train dataset and the test dataset accordingly. After the analysis of the trained model using KNN algorithm, Item MRP, Item visibility and Cloth type features mostly impacted to the total sales count of a particular month. Utilizing the trained ML model, the application shows the predictive sales count for a given clothing item.

Comprehensively analyze previously collected data (body measurements, skin color, pre-ordered items) and suggest the best matching clothing items for new customers. Implement an intelligent bot to interact with the customer to pick the best matching clothing items by making new suggestions, when the customer need an extra assistant to

determine clothes. Indicate sales statistics to employees by utilizing pre-ordered item data.

V. Conclusion

Clothing industry plays a major role in every country in the word since ancient times. The traditional way of shopping is going to the shop physically and purchase desired clothes after a proper selection. When it comes to modern society, everyone is in a busy lifestyle with a limited time. Typically, clothing store is a main place that people have to waste a lot of time to purchase desired clothes. Also, in a situation like a pandemic, people are forced to seek solace in carrying out their daily activities online. People are moving towards online platforms because it effortless than usual way. Online platforms can be accessed at any time within the day regardless of time and without much effort. However, online cloth shops are limited in facilities when compared to physical shops because customers cannot interact with clothes physically, until the purchase is completed. The main difficulty is lack of identifying proper clothes which pair with body the shape. Since various cloth brands are possessing with various size standards, it is difficult to identify the optimal size even if the customer has solid idea on his/her preferred cloth sizes. In addition, there might be situations like, the cloth is not fit to the body in a proper way if there are no issues with size determination.

This paper proposes a virtual shopping app (Fitton) which is designed to address and avoid above problems and limitations. Fitton is a mobile application which provides a rich experience from cloth selecting to ordering clothes. Determining the skin tone of the customer through the image and suggest most suitable items, rendering female/male 3D model(s) to provide the virtual fit-on facility and add behavior animation to the model(s), implementing an intelligent bot to assist customers for the selecting and ordering clothes are the highlighted features of the application. In addition, the system contains a web-based system to manage the store. The web system can analyze the purchased data to predict the future trends, indicate sales statistic which supports to make decisions for the shop management. The mobile app is limited for handling customer-related procedures. It does not contain store related functionalities which handles by the web system. The system does not contain any payment handling unit to purchase items, the final step is to make an order with selected clothing items.

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