ShopEasy

submitted in partial fulfillment of the requirement
for the award of the Degree of

Bachelor of Technology
in
Computer Engineering

by

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May 2023

Certificate

This is to certify that the Project entitled "ShopEasy" has been completed to our satisfaction by Mr. Malhar Bangdiwala, Ms. Sakshi Mahadik and Ms. Yashvi Mehta under the guidance of Prof. Abhijeet Salunke for the award of Degree of Bachelor of Technology in Computer Engineering from University of Mumbai.

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Project Approval Certificate

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(signature)	**(signature)**
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Date:	**Date:**

Seal of the Institute

Statement by the Candidates

We wish to state that the work embodied in this thesis titled "ShopEasy" forms our own contribution to the work carried out under the guidance of Prof. Abhijeet Salunke at the Sardar Patel Institute of Technology. We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission.

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Abstract

The project discusses the increasing use of machine learning (ML) models in the retail industry to improve customers' shopping experiences. The focus is on virtual trial rooms, self-checkout, and personalized recommendations. Virtual trial rooms allow customers to try on clothes virtually, while self-checkout provides a faster and more convenient checkout process. Personalized recommendations based on customers' purchase history and preferences can also improve the overall shopping experience. The project reviews the literature on the use of ML models and mentions advanced models that correctly map clothes to customers' pictures and use geolocation in barcode scanners to avoid long waiting queues.

Chapter 1

Introduction

In the retail industry, customer experience plays a vital role in driving sales and revenue. As a result, retailers are constantly looking for innovative methods to improve their customers' overall shopping experience. With the recent advancements in Machine Learning, retailers can now leverage these technologies to provide customers with a personalized and seamless shopping experience.

This project investigates the potential of ML models to enhance customers' shopping experiences. Focus is on three specific ML models, namely virtual trial rooms, self-checkout, and personalized recommendations. These concepts have received a lot of attention recently and have been effectively adopted in a number of retail locations throughout the world.

Virtual trial rooms are a type of augmented reality (AR) technology that enables customers to try on clothes virtually. Before purchasing a garment, customers can use this technology to see how it will look on them. Self-checkout systems, on the other hand, provide customers with a faster and more convenient checkout process, thereby reducing checkout times and waiting lines. Personalized recommendations use customer data such as their purchase history and preferences to suggest items that they are likely to be interested in, making the shopping experience more relevant and enjoyable for them.

In this paper, a comprehensive review of the literature on the use of ML models in enhancing the shopping experience of customers. The paper also presents a case study where virtual trial rooms, self-checkout, and personalized recommendations have been implemented in a retail store to evaluate the effectiveness of these models in improving the shopping experience of customers. Our findings show that the implementation of these models significantly enhances the overall shopping experience of customers.

Ultimately, this study demonstrates how ML models have the potential to revolutionize the retail business by offering customers a personalized and seamless purchasing experience. Retailers can leverage these technologies to increase customer satisfaction, reduce operational costs, and ultimately drive sales and revenue.

1.1 Objectives

The objectives of our project are:

- To implement virtual trial room feature

- To suggest user recommendations
- To implement barcode detection from the dataset
- To implement geolocation features to enable payments

1.2 Problem Statement

The long queues at clothing stores for fitting and billing are the main bottlenecks for customers. On holidays, the customers to staff members ratio is more and it can get tedious to scan each product separately by one person. Furthermore, after Covid most of the retail stores restricted or limited the use of trial rooms to avoid long queues. The availability of each product is not transparent to customers. Moreover, at times, customers do not find similar clothes in the same section. As a solution, we have implemented a system that can help the customers to self checkout by simply scanning the barcode on the product and pay for it using the payment methods. We have implemented a virtual trial room feature which enables users to trial clothes virtually which can save time as well as can adhere to Covid restrictions. Our system also consists of recommendations based on user's purchase history.

1.3 Contributions

The contribution to the project to solve the problem includes

- Barcode Recognition - recognizing the barcode on the clothing item
- Virtual Trial Room - allowing users to try on clothes virtually and avoid waiting in long queues
- Clothing Recommendations - feature for users to see similar clothes based on the product selected
- Keeping available stock of each product - Availability of every product would be known
- Payment Gateway - Users can pay online for the clothes
- Geolocation - To track the user's location if the user is paying online from the store

1.3.1 Constraints and Boundaries

The Constraints and Assumptions of the project include

- Barcode, clothing item and human image should be clearly visible in the respective uploads - To scan barcode, the image of barcode should be clear. For virtual trial room feature the clothing item and the user's image should be clearly visible
- Stable internet connection - There should be a stable internet connection while clicking the picture for barcode scanning and virtual trial room

- Product stock data must be provided initially by the store - The retail store must provide all the initial information about the clothes available

1.3.2 Future Work

The Future Work of the project includes

- Detect multiple barcodes in a single picture
- Expand trial room dataset to more than women's clothing
- Recommend clothing items based on the user's purchase history

1.4 Layout of the Report

A brief chapter by chapter overview is presented here.
Chapter 2: A literature review of different real-time applications for barcode scanning, virtual trial room, and clothing recommendation is presented.
Chapter 3: The proposed system and algorithm details will be described in this chapter.
Chapter 4: In this chapter, the actual implementation of the application is presented.
Chapter 5: Results of the algorithms are discussed.
Chapter 6: Conclusions and discussion on future course of research work.
Chapter 7: The research publication is given here.

Chapter 2

Literature Survey

In the paper titled Virtual Trial Room, Akshay Shirsat et al. [1] suggested a system that allowed users to try clothes virtually using augmented reality. They achieved this by using Kinect Sensor for calculating parameters such as the effective distance between the user and the sensor and the dimensions of the clothing item and the customer to augment the cloth on the virtual body. Blender3D software has been used to create an object model for both male and female users. This model helped to create geometric figures. The system displayed the dresses which matched the users' dimensions and allowed users to control the GUI using hand gestures.

Syed Sanzam et al. [2] implemented a virtual trial room using Generative adversarial networks (GANs) and various image processing methods in the paper Image-to-Image Attire Transfer for Virtual Trial Room. Liquid Warping Gan has been used to estimate human body structure and the U-net model combined with the Grab-cut algorithm has been used to extract only clothes from the user's body. This method allowed them to transfer attire from a one person to another but with some noise in some of the cases.

The authors of the paper titled A Virtual Trial Room using Pose Estimation [3] and Homography built a virtual trial room application using OpenCV and Tensorflow lite. Pose Estimation model was used to map the clothes/ garments on the user's body. This model was integrated into the android application using Tensorflow lite. For live mapping, Homography from OpenCV has been implemented.

Anagaha Ramesh et al. [4] proposed an application for a virtual trial room using augmented reality which only changes the color and logo on the T-shirt. OpenCV was used to perform RGB normalization and contour detection on the image of the user to identify the boundaries and different objects in the frame. After detection, the user can change colors and add logos according to their preferences. Raffiee et al.[5] used GANs to perform image-based garment transfer. They do so by mapping body characteristic points.

Han et al.[6] were one of the first to propose a system that did not use any 3D information. They proposed a double-model architecture to achieve the goal. Wang et al.[7] built on top of that by enhancing the fitting method. Instead of computing the interest point correspondences, a Geometric Matching Module was used. A composition mask was also added to smoothen the final rendered image. Neuberger et al.[8] simplified the training process by requiring only 1 image as the input. They also used 3D methods to provide more realistic outputs. The output consists of an entire outfit that is picked from the base dataset.

Yun-Rou Lin et. al [9] developed a clothing recommendation system by considering clothing attributes identification, gender recognition, and the user's body height. InceptionV3 is used for gender recognition and attribute identification which gave an accuracy of about 98% and 87.59% respectively. The results from gender recognition and attribute vectors were used to find similarities with the clothes gallery and accordingly recommendation list was generated. The similarity was calculated using the products among the clothing features of customers and the clothing gallery.

N. Palanivel et al. [10] proposed a billing automation system using a recommendation system. The idea was to recommend products to users based on the product detected and the user can then add those recommended products to their shopping cart. The object detection was done using YOLO algorithm. A recommendation list is generated based on the products detected through the camera.

Batuhan A. et al. [11] proposed a clothing recommendation system based on a single picture of the attire instead of the user's previous purchase history. They have used the Haar-cascade model for gender prediction and feature extraction. These features extracted are then used for finding the best fit for the user. Two inception-based CNN models are developed. The first one is for gender prediction and feature extraction and the second one is for color prediction. They achieved an accuracy of 86% for gender prediction, 98% for pattern recognition, and 86% for color prediction.

Mahir Jain et al. [12] explored different machine-learning algorithms for recommending clothes from the user's personal wardrobe. They have performed a comparative analysis between these algorithms and concluded that Random forest works best in terms of precision for the given dataset.

Tanmay Singh et al. [13] built a self-checkout system based on detecting multiple products simultaneously without any labels/tags. YOLO algorithm and BBox label tool are used for object detection and product recognition from the dataset. Based on the products identified, product name and price is fetched from the database.

Maged Shoman et al. [14] suggested a region-oriented deep learning approach for automating the process of counting the number of products using YOLOv5 for object detection followed by object tracking using the DeepSort algorithm. Similarly, Namitha James et al. [15] have utilized Yolov4 object detection in their proposed system for self-checkout system. Their system involved generating bills based on the products identified and the count of similar products.

Chapter 3

Design

3.1 Use Case Diagram

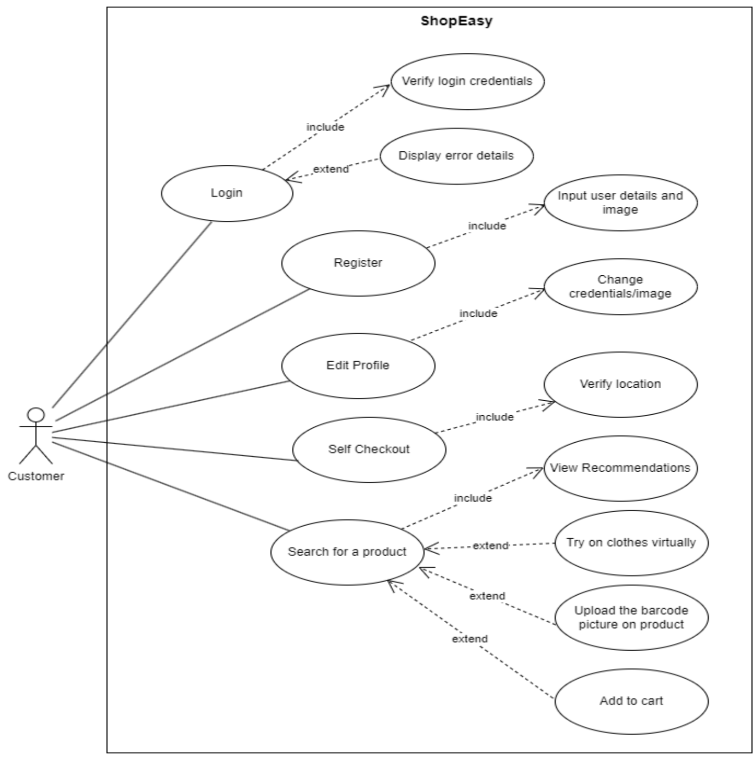

Figure 3.1: Use Case Diagram

The use case diagram shown above shows the users (actors) involved and their interaction with the system. It depicts a high-level overview of the relationship between use cases, actors, and systems involved in our project.

3.2 Algorithm Details

3.2.1 Barcode Recognition Algorithm

For the barcode recognition, ZBar[16] bar code reader has been used under the hood. Pyzbar[17] library has been used to make use of it in Python. Preprocessing on the image has been performed to enhance the accuracy. The image is first converted to greyscale. The gradient is then calculated using the Sobel Filter. The image is then blurred and a binary threshold(intensity=225) is applied. Morphology, followed by erosion and dilation(4 iterations each) is performed. Finally, the biggest contours are found. This image is now sent to pyzbar which returns the barcode number as the output. The block diagram for this entire process can be seen in Figure 1.

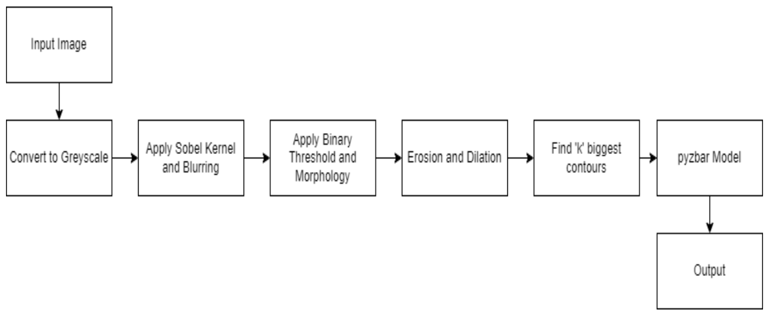

Figure 3.2: Block Diagram of Barcode Recognition Algorithm

3.2.2 Virtual Trial Room Algorithm

The virtual trial room algorithm primarily employs a two-stage process. During the first stage, the algorithm uses Convolutional Neural Nets to identify the upper body shape of the target and configures the clothing image accordingly while retaining the supplemental body parts such as the skin and hair. Firstly, it is important to obtain the full body silhouette from the human image, but in the VITON dataset[18], the neck and bare chest are wrongly labeled as background, and hair occlusion can distort the body shape. To address this, a new label "skin" was added and the corresponding areas were re-labeled based on the original image and joint locations. Hair occlusion areas were identified by the intersection of the upper clothing's convex contour and the hair-labeled area, and then re-labeled as upper cloth. Secondly, the network uses binary masks, silhouettes, joint heatmaps, and colored try-on clothing instead of a pair of color images. In the second stage, the clothing image is warped over the target body while preserving the non-target clothing areas. To keep all the human features except the targeted clothing area, the input for the second stage includes the face, hair, lower clothes, and legs. Then, a supervised ground truth mask is used instead of a Composition Mask in the second stage loss function to obtain a strong alpha mask. Lastly, the binary mask of the warped clothing is added to the second stage network input because it was unable to recognize the white clothing area as part of the in-shop clothing image background. Adam optimizer with a β_1 value of 0.5 and a β_2 value of 0.999 is used to ensure the masking of cloth image is done precisely. Both networks were trained for 200,000 iterations with a batch size of 4. The learning rate was initially set to 0.0001 for the first 100,000 iterations and then gradually decreased to zero for the remaining iterations. The block diagram for the same can be seen in Fig.2

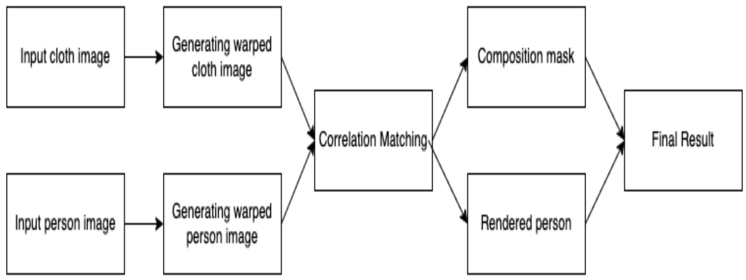

Figure 3.3: Block Diagram of Virtual Trial Room Algorithm

3.2.3 Clothing Recommendation Algorithm

The model developed for generating the recommendations is a combination of a Convolutional Neural Network and k-Nearest Neighbours. The CNN is created with the help of transfer learning. ResNet50[19] model is used for the same. This model is trained on the Imagenet[20] dataset. A Global Max Pooling layer is attached on top of it. The weights of this trained model is then saved. Features from a new dataset consisting of the required images is extracted and saved as embeddings. Now, when an image is given as input, it first converted into the list of features. k-Nearest Neighbours algorithm is applied on it to obtain the 5 closest images. These images serve as the recommendations. In the nearest neighbours algorithm, brute force algorithm is used to compute the euclidean distances, as the size of the dataset is not very large. A block diagram of the entire process can be seen in Fig.3

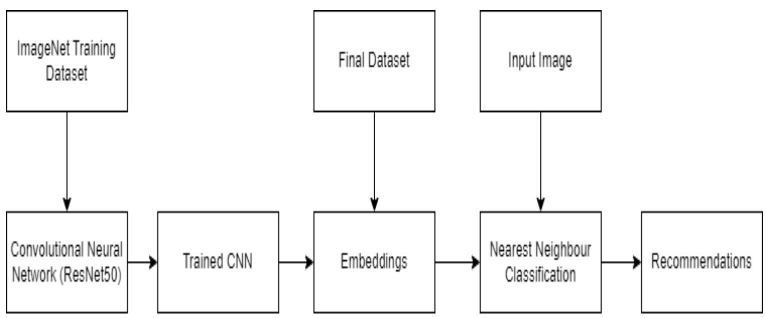

Figure 3.4: Block Diagram of Recommendation System

3.3 Proposed System

The above-mentioned algorithms are bundled into an android app. The app first consists of a sign-up/login module. Here, the user would have to provide basic information like name, email, etc. An image can also be uploaded to enable the virtual trial room feature. This can be edited at a future instance on the 'edit profile' page. The authentication and user information will be done with the help of Firebase[21].

The app consist mainly of a search feature, wherein the user can search for products. The search can also be conducted by clicking an image of the product's barcode. This feature is to reduce lines at the billing counter in physical stores. The idea is that a user can choose all the items physically present and checkout by paying online. The checkout option would only be enabled if the location of the user is in the physical store (to be checked using geolocation).

After searching, the user can proceed to the product page. Here, the product and all its available sizes and customizations can be chosen. The user can use the virtual trial room feature here, to see how the apparel would look in real life. This would also help shorten lines in the physical trial rooms. Recommendations based on the apparel would also be shown on this page. The user will also have the option to add the product to the cart. Finally, on the checkout page, the user can pay for the items and a bill will be generated. The payment system is implemented with the help of Razorpay[22].

The app has been built using Java. The 3 modules containing machine learning have been built using Python. These modules are then bundled into a Flask app, with each module being assigned an API endpoint. Retrofit[23] is used to communicate between the Flask app and the Android application.

Chapter 4

Implementation

4.1 Screenshots

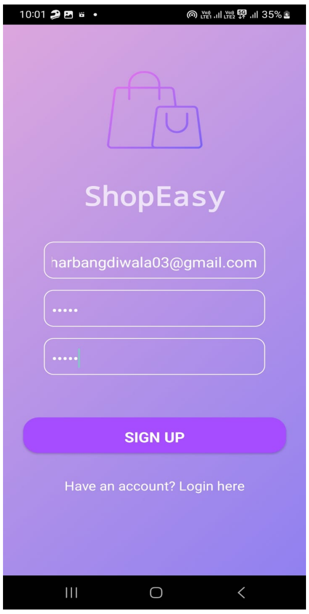

Figure 4.1: Sign In Page - 1

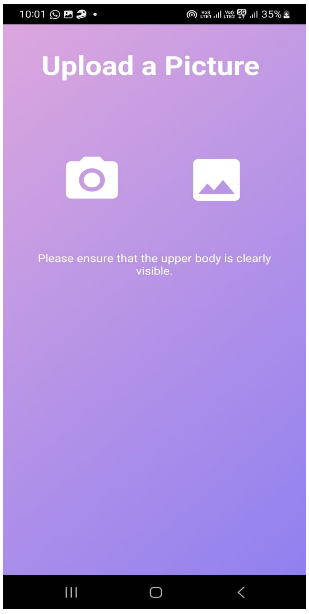

Figure 4.2: Sign In Page - 2

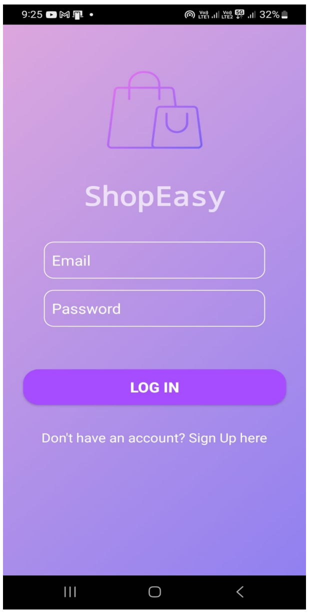

Figure 4.3: Login Page

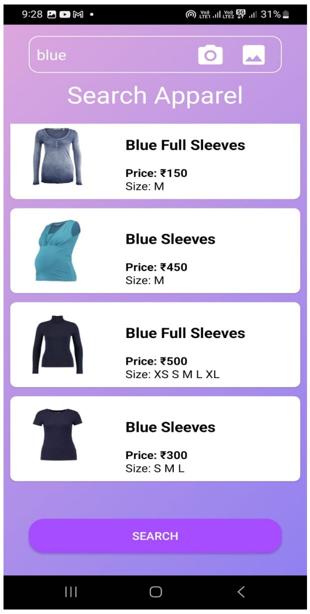

Figure 4.4: Search Page

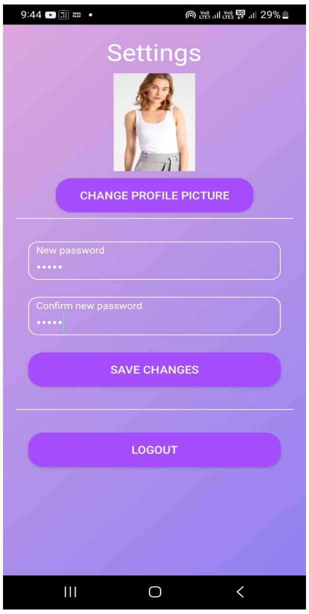

Figure 4.5: Edit Profile Page

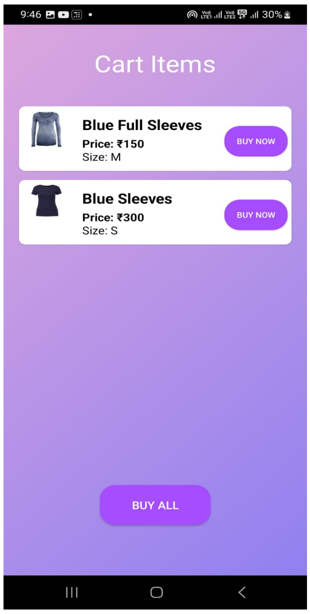

Figure 4.6: Cart Page

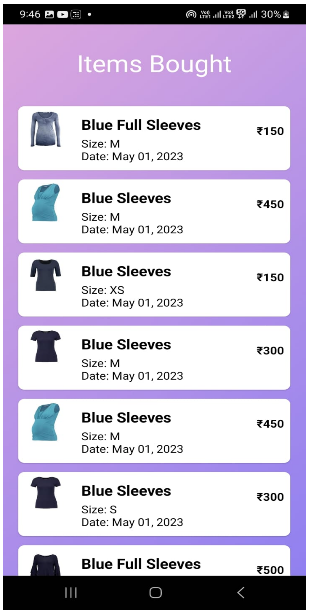

Figure 4.7: History Page

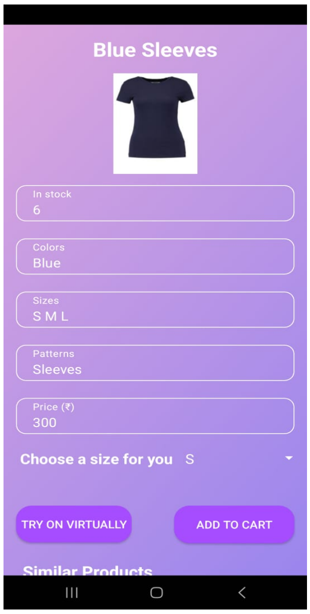

Figure 4.8: Cloth Information Page - 1

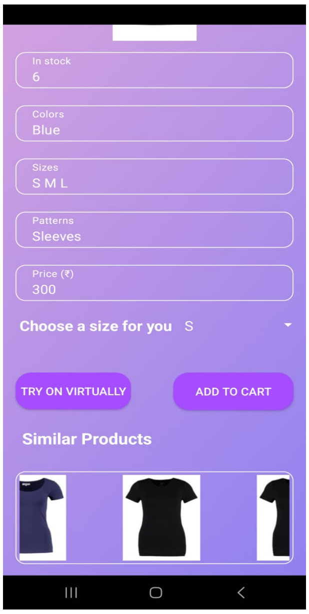

Figure 4.9: Cloth Information Page - 2

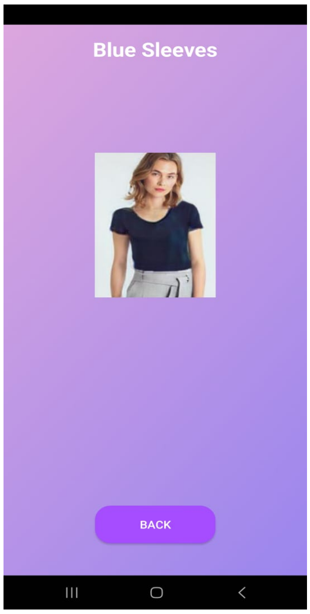

Figure 4.10: Virtual Fitting Result Page

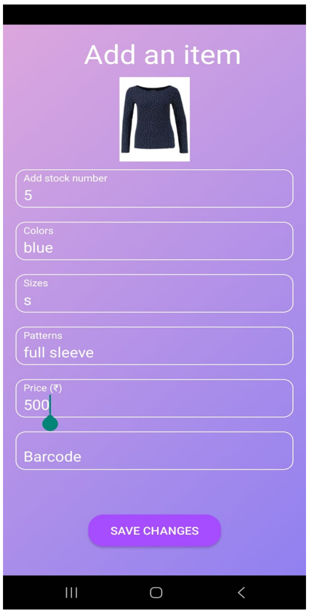

Figure 4.11: Add Item (Admin) page

Figure 4.12: Cloth Information (Admin) Page

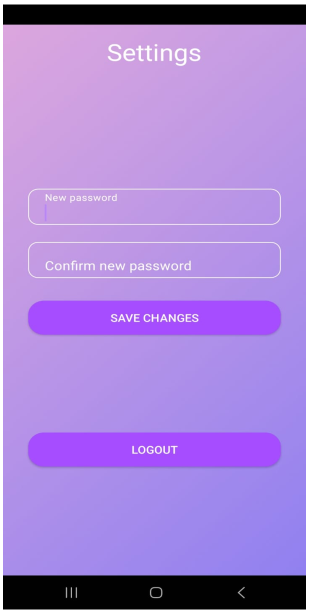

Figure 4.13: Edit Profile (Admin) Page

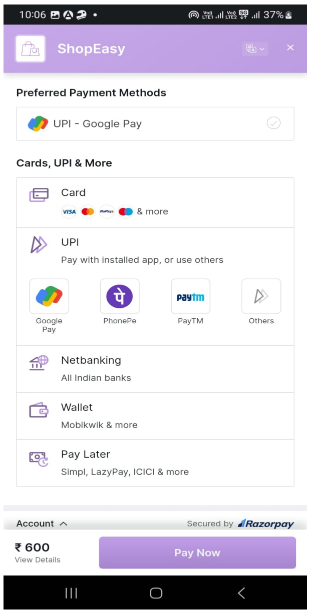

Figure 4.14: Payments Page

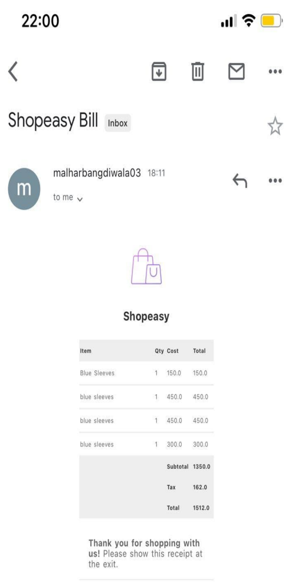

Figure 4.15: e-Bill on Gmail

Chapter 5

Results and Discussion

5.1 Barcode Recognition Algorithm

The code for barcode recognition was tested with the help of a dataset consisting of 235 images. An accuracy of 97.02% was obtained. This is a major boost from the existing accuracy of around 89% for pyzbar[24]. The accuracy has been charted as shown in figure 2. The exact break-down of the result can be seen in Table I.

Table 5.1: Barcode Detection Algorithm Results

Sr. No.	Class	Quantity
1	Correct	228
2	Incorrect	6
3	Unrecognized	1

5.2 Virtual Trial Room Algorithm

The performance metric chosen for this was the Inception Score(IS)[25]. An technique called the Inception Score is used to rate the quality of images produced by generative image models like generative adversarial networks. A high inception score means that the GAN can generate many distinct images. In this case, the final images were produced by using human and cloth combinations on the given dataset[18]. More than 2000 images were generated. The IS obtained was 3.078 with a standard deviation of 0.18. This is a mark up over the existing Virtual Trial Room Algorithms. Their scores have been tabulated in Table II. The table has also been visualised in Fig. 4.

Table 5.2: Comparing results of Virtual Trial Room Algorithms

Sr. No.	Algorithm	IS
1	**Proposed Algorithm**	3.078±0.18
2	Garment GAN[5]	2.774 ±0.082
3	VITON[6]	2.514 ±0.13
4	CP-VTON[7]	2.636 ±0.077
5	O-VITON[8]	3.02 ±0.07

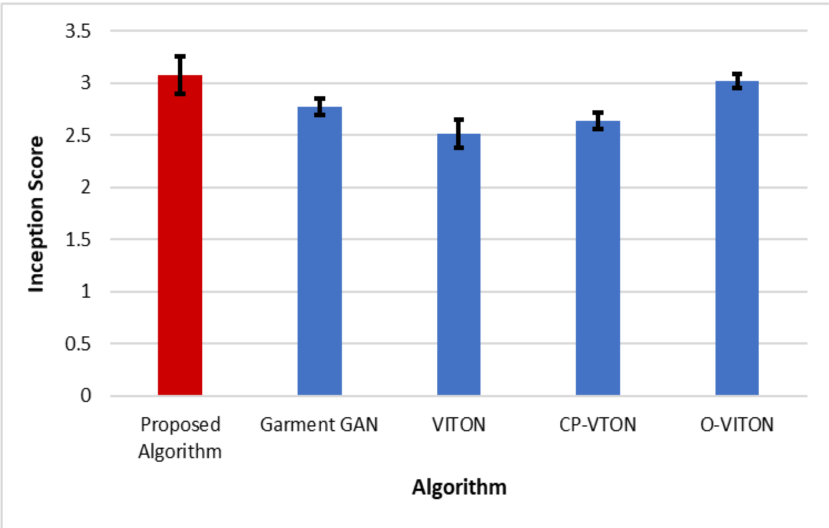

Figure 5.1: Graphical Comparison of Different Algorithms

5.3 Clothing Recommendation Algorithm

The performance metric chosen for this algorithm was the Relative Root Mean Squared Error (RRMSE)[26]. It is given by the formula:

$$RRMSE = \sqrt{\frac{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(\hat{y}_i)^2)}} \tag{5.1}$$

The testing dataset is the same as used for the virtual trial room algorithm discussed above. The RRMSE was calculated between each input image and its corresponding 5 recommendations. A total of 500 images were chosen at random from the dataset and used as the input. The average RRMSE obtained was 0.021 with a standard deviation of 0.001. A sample of the recommendations can be seen in Fig.5.

Figure 5.2: Recommendation Example

Chapter 6

Conclusion and Future Scope

In conclusion, an application which bundles barcode detection, apparel recommendations and virtual trial room has been built. The modules have successfully built upon the work done in these fields so far.

Currently, the virtual trial room only contains of women's tops. In the future, expanding the dataset would be detrimental. Further, the application can only work for a single barcode and single human/apparel images. Extending it to multiple images would be key to expanding its use case.

Chapter 7

Research Publication

The paper corresponding to this project, titled 'ML-Based Retail Innovations: Virtual Fitting, Scanning and Recommendations' has been presented at 2023 Second International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT 2023). IEEE publication is now awaited.

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ML-Based Retail Innovations: Virtual Fitting, Scanning and Recommendations

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***Abstract*—This paper discusses the increasing use of machine learning (ML) models in the retail industry to improve the shopping experience of customers. The focus is on virtual trial rooms, self-checkout, and personalized recommendations. Virtual trial rooms allow customers to try on clothes virtually, while self-checkout provides a faster and more convenient checkout process. Personalized recommendations based on customers' purchase history and preferences can also improve the overall shopping experience. The paper reviews literature on the use of ML models and mentions advanced models that map clothes correctly to customers' pictures and use geolocation in barcode scanners to avoid long waiting queues.**

***Keywords*—** Virtual Trial Room, Recommendation, Barcode Scanning, Computer Vision , Retail Shopping

I. Introduction

In the retail industry, customer experience plays a vital role in driving sales and revenue. As a result, retailers are constantly looking for innovative methods to improve their customers' overall shopping experience. With the recent advancements in Machine Learning, retailers can now leverage these technologies to provide customers with a personalized and seamless shopping experience.

This research paper investigates the potential of ML models to enhance customers' shopping experiences. Focus is on three specific ML models, namely virtual trial rooms, self-checkout, and personalized recommendations. These concepts have received a lot of attention recently and have been effectively adopted in a number of retail locations throughout the world.

Virtual trial rooms are a type of augmented reality (AR) technology that enables customers to try on clothes virtually. Before purchasing a garment, customers can use this technology to see how it will look on them. Self-checkout systems, on the other hand, provide customers with a faster and more convenient checkout process, thereby reducing checkout times and waiting lines. Personalized recommendations use customer data such as their purchase history and preferences to suggest items that they are likely to be interested in, making the shopping experience more relevant and enjoyable for them.

In this paper, a comprehensive review of the literature on the use of ML models in enhancing the shopping experience of customers. The paper also presents a case study where virtual trial rooms, self-checkout, and personalized recommendations have been implemented in a retail store to evaluate the effectiveness of these models in improving the shopping experience of customers. Our findings show that the implementation of these models significantly enhances the overall shopping experience of customers.

Ultimately, this study demonstrates how ML models have the potential to revolutionize the retail business by offering customers a personalized and seamless purchasing experience. Retailers can leverage these technologies to increase customer satisfaction, reduce operational costs, and ultimately drive sales and revenue.

II. Literature Survey

In the paper titled Virtual Trial Room, Akshay Shirsat et al. [1] suggested a system that allowed users to try clothes virtually using augmented reality. They achieved this by using Kinect Sensor for calculating parameters such as the effective distance between the user and the sensor and the dimensions of the clothing item and the customer to augment the cloth on the virtual body. Blender3D software has been used to create an object model for both male and female users. This model helped to create geometric figures. The system displayed the dresses which matched the users' dimensions and allowed users to control the GUI using hand gestures.

Syed Sanzam et al. [2] implemented a virtual trial room using Generative adversarial networks (GANs) and various image processing methods in the paper Image-to-Image Attire Transfer for Virtual Trial Room. Liquid Warping Gan has been used to estimate human body structure and the U-net model combined with the Grab-cut algorithm has been used to extract only clothes from the user's body. This method allowed them to transfer attire from a one person to another but with some noise in some of the cases.

The authors of the paper titled A Virtual Trial Room using Pose Estimation [3] and Homography built a virtual trial room application using OpenCV and Tensorflow lite. Pose Estimation model was used to map the clothes/ garments on the user's body. This model was integrated into the android application using Tensorflow lite. For live mapping, Homography from OpenCV has been implemented.

Anagaha Ramesh et al. [4] proposed an application for a virtual trial room using augmented reality which only changes the color and logo on the T-shirt. OpenCV was used to perform RGB normalization and contour detection on the image of the user to identify the boundaries and different objects in the frame. After detection, the user can change colors and add logos according to their preferences. Raffiee et al. [5] used GANs to perform image-based garment transfer. They do so by mapping body characteristic points.

Han et al. [6] were one of the first to propose a system that did not use any 3D information. They proposed a double-model architecture to achieve the goal. Wang et al. [7] built on top of that by enhancing the fitting method. Instead of computing the interest point correspondences, a Geometric Matching Module was used. A composition mask was also added to smoothen the final rendered image. Neuberger et al. [8] simplified the training process by requiring only 1 image as the input. They also used 3D methods to provide more realistic outputs. The output consists of an entire outfit that is picked from the base dataset.

Yun-Rou Lin et. al [9] developed a clothing recommendation system by considering clothing attributes identification, gender recognition, and the user's body height. InceptionV3 is used for gender recognition and attribute identification which gave an accuracy of about 98% and 87.59% respectively. The results from gender recognition and attribute vectors were used to find similarities with the clothes gallery and accordingly recommendation list was generated. The similarity was calculated using the products among the clothing features of customers and the clothing gallery.

N. Palanivel et al. [10] proposed a billing automation system using a recommendation system. The idea was to recommend products to users based on the product detected and the user can then add those recommended products to their shopping cart. The object detection was done using YOLO algorithm. A recommendation list is generated based on the products detected through the camera.

Batuhan A. et al. [11] proposed a clothing recommendation system based on a single picture of the attire instead of the user's previous purchase history. They have used the Haar-cascade model for gender prediction and feature extraction. These features extracted are then used for finding the best fit for the user. Two inception-based CNN models are developed. The first one is for gender prediction and feature extraction and the second one is for color prediction. They achieved an accuracy of 86% for gender prediction, 98% for pattern recognition, and 86% for color prediction.

Mahir Jain et al. [12] explored different machine-learning algorithms for recommending clothes from the user's personal wardrobe. They have performed a comparative analysis between these algorithms and concluded that Random forest works best in terms of precision for the given dataset.

Tanmay Singh et al. [13] built a self-checkout system based on detecting multiple products simultaneously without any labels/tags. YOLO algorithm and BBox label tool are used for object detection and product recognition from the dataset. Based on the products identified, product name and price is fetched from the database.

Maged Shoman et al. [14] suggested a region-oriented deep learning approach for automating the process of counting the number of products using YOLOv5 for object detection followed by object tracking using the DeepSort algorithm. Similarly, Namitha James et al. [15] have utilized Yolov4 object detection in their proposed system for self-checkout system. Their system involved generating bills based on the products identified and the count of similar products.

III. Design and Methodology

A. Algorithm Details

1) Barcode Recognition Algorithm: For the barcode recognition, ZBar [16] bar code reader has been used under the hood. Pyzbar [17] library has been used to make use of it in Python. Preprocessing on the image has been performed to enhance the accuracy. The image is first converted to greyscale. The gradient is then calculated using the Sobel Filter. The image is then blurred and a binary threshold(intensity=225) is applied. Morphology, followed by erosion and dilation(4 iterations each) is performed. Finally, the biggest contours are found. This image is now sent to pyzbar which returns the barcode number as the output. The block diagram for this entire process can be seen in Figure 1.

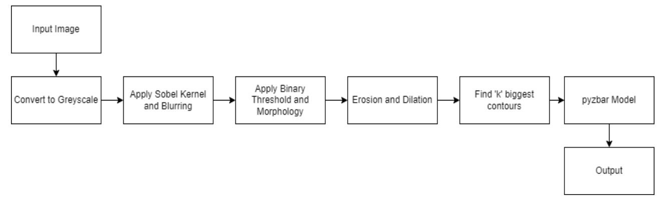

Figure 1. Block Diagram of Barcode Recognition Algorithm

2) Virtual Trial Room Algorithm: The virtual trial room algorithm primarily employs a two-stage process. During the first stage, the algorithm uses Convolutional Neural Nets to identify the upper body shape of the target and configures the clothing image accordingly while retaining the supplemental body parts such as the skin and hair. Firstly, it is important to obtain the full body silhouette from the human image, but in the VITON dataset [18], the neck and bare chest are wrongly labeled as background, and hair occlusion can distort the body shape. To address this, a new label "skin" was added and the corresponding areas were re-labeled based on the original image and joint locations. Hair occlusion areas were identified by the intersection of the upper clothing's convex contour and the hair-labeled area, and then re-labeled as upper cloth. Secondly, the network uses binary masks, silhouettes, joint heatmaps, and colored try-on clothing instead of a pair of color images. In the second stage, the clothing image is warped over the target body while preserving the non-target clothing areas. To keep all the human features except the targeted clothing area, the input for the second stage includes the face, hair, lower clothes, and legs. Then, a supervised ground truth mask is used instead of a Composition Mask in the second stage loss function to obtain a strong alpha mask. Lastly, the binary mask of the warped clothing is added to the second stage network input because it was unable to recognize the white clothing area as part of the in-shop clothing image background. Adam optimizer with a β_1 value of 0.5 and a β_2 value of 0.999 is used to ensure the masking of cloth image is done precisely. Both networks were trained for 200,000 iterations with a batch size of 4. The learning rate was initially set to 0.0001 for the first 100,000 iterations and then gradually decreased to zero for the remaining iterations. The block diagram for the same can be seen in Fig.2

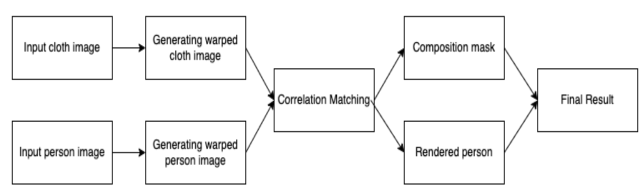

Figure 2. Block Diagram of Virtual Trial Room Algorithm

3) Clothing Recommendation Algorithm: The model developed for generating the recommendations is a combination of a Convolutional Neural Network and k-Nearest Neighbours. The CNN is created with the help of transfer learning. ResNet50 [19] model is used for the same. This model is trained on the Imagenet [20] dataset. A Global Max Pooling layer is attached on top of it. The weights of this trained model is then saved. Features from a new dataset consisting of the required images is extracted and saved as embeddings. Now, when an image is given as input, it first converted into the list of features. k-Nearest Neighbours algorithm is applied on it to obtain the 5 closest images. These images serve as the recommendations. In the nearest neighbours algorithm, brute force algorithm is used to compute the euclidean distances, as the size of the dataset is not very large. A block diagram of the entire process can be seen in Fig.3

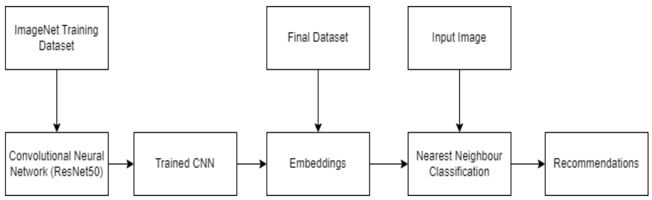

Figure 3. Block Diagram of Recommendation System

B. *Proposed System*

The above-mentioned algorithms are bundled into an android app. The app first consists of a sign-up/login module. Here, the user would have to provide basic information like name, email, etc. An image can also be uploaded to enable the virtual trial room feature. This can be edited at a future instance on the 'edit profile' page. The authentication and user information will be done with the help of Firebase [21].

The app consist mainly of a search feature, wherein the user can search for products. The search can also be conducted by clicking an image of the product's barcode. This feature is to reduce lines at the billing counter in physical stores. The idea is that a user can choose all the items physically present and checkout by paying online. The checkout option would only be enabled if the location of the user is in the physical store (to be checked using geolocation).

After searching, the user can proceed to the product page. Here, the product and all its available sizes and customizations can be chosen. The user can use the virtual trial room feature here, to see how the apparel would look in real life. This would also help shorten lines in the physical trial rooms. Recommendations based on the apparel would also be shown on this page. The user will also have the option to add the product to the cart. Finally, on the checkout page, the user can pay for the items and a bill will be generated. The payment system is implemented with the help of Razorpay [22].

The app has been built using Java. The 3 modules containing machine learning have been built using Python. These modules are then bundled into a Flask app, with each module being assigned an API endpoint. Retrofit [23] is used to communicate between the Flask app and the Android application.

IV. Results

A. *Barcode Recognition Algorithm*

The code for barcode recognition was tested with the help of a dataset consisting of 235 images. An accuracy of 97.02% was obtained. This is a major boost from the existing accuracy of around 89% for pyzbar [24]. The accuracy has been charted as shown in figure 2. The exact break-down of the result can be seen in Table I.

Table I
Barcode Detection Algorithm Results

Sr. No.	Class	Quantity
1	Correct	228
2	Incorrect	6
3	Unrecognized	1

B. *Virtual Trial Room Algorithm*

The performance metric chosen for this was the Inception Score(IS) [25]. An technique called the Inception Score is used to rate the quality of images produced by generative image models like generative adversarial networks. A high inception score means that the GAN can generate many distinct images. In this case, the final images were produced by using human and cloth combinations on the given dataset [18]. More than 2000 images were generated. The IS obtained was 3.078 with a standard deviation of 0.18. This is a mark up over the existing Virtual Trial Room Algorithms. Their scores have been tabulated in Table II. The table has also been visualised in Fig. 4.

Table II
Comparing results of Virtual Trial Room Algorithms

Sr. No.	Algorithm	IS
1	**Proposed Algorithm**	3.078$\pm$0.18
2	Garment GAN [5]	2.774 $\pm$0.082
3	VITON [6]	2.514 $\pm$0.13
4	CP-VTON [7]	2.636 $\pm$0.077
5	O-VITON [8]	3.02 $\pm$0.07

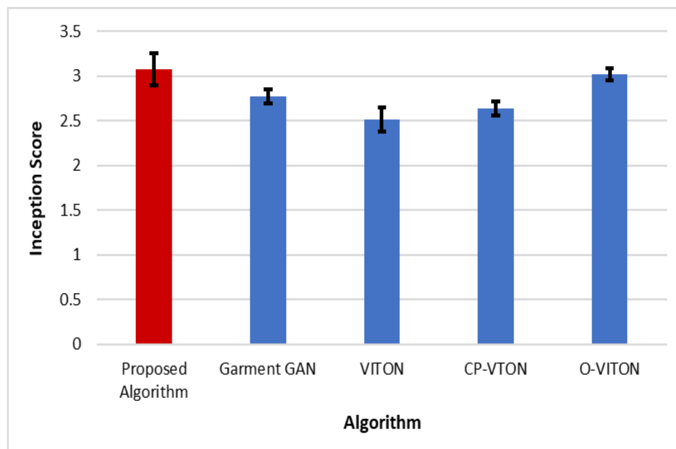

Figure 4. Graphical Comparison of Different Algorithms

C. *Clothing Recommendation Algorithm*

The performance metric chosen for this algorithm was the Relative Root Mean Squared Error (RRMSE) [26]. It is given by the formula:

$$RRMSE = \sqrt{\frac{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(\hat{y}_i)^2)}} \tag{1}$$

The testing dataset is the same as used for the virtual trial room algorithm discussed above. The RRMSE was calculated between each input image and its corresponding 5 recommendations. A total of 500 images were chosen at random from the dataset and used as the input. The average RRMSE obtained was 0.021 with a standard deviation of 0.001. A sample of the recommendations can be seen in Fig.5.

Figure 5. Recommendation Example

V. Conclusion & Future Work

In conclusion, an application which bundles barcode detection, apparel recommendations and virtual trial room has been built. The modules have successfully built upon the work done in these fields so far.

Currently, the virtual trial room only contains of women's tops. In the future, expanding the dataset would be detrimental. Further, the application can only work for a single barcode and single human/apparel images. Extending it to multiple images would be key to expanding its use case.

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