North South University

Department of Electrical and Computer Engineering

Report on

"AI-Driven Virtual Try-On System in E-Commerce"

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To

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Abstract

AI DRIVEN VIRTUAL TRY ON SYSTEM

E-commerce has transformed the retail landscape, particularly in the fashion industry. However, the inability to physically try on clothing remains a significant limitation, leading to customer dissatisfaction and high return rates. This paper presents an AI-driven virtual try-on (VTO) system that uses computer vision, machine learning, and augmented reality (AR) to address these challenges. The system enables users to visualize how clothing items will look and fit on their bodies using uploaded images or live camera feeds. Advanced techniques such as Thin Plate Spline (TPS) transformation, Geometric Matching Networks (GMNs), and Generative Adversarial Networks (GANs) are utilized to achieve realistic visualizations. With promising evaluation metrics such as SSIM (0.895), LPIPS (0.053), and FID (11.74), this project demonstrates the feasibility and benefits of integrating AI-driven solutions in e-commerce platforms to enhance user experience and reduce operational inefficiencies.

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Problem Statement

The e-commerce industry, especially in fashion retail, struggles to replicate the tactile and visual experience of physical shopping. Customers are often unsure about the fit, style, and appearance of clothing on their own bodies, leading to hesitation in purchases and high return rates. These challenges highlight the need for innovative solutions to provide realistic visualizations of clothing on diverse body types, thereby enhancing user confidence and satisfaction.

Chapter 1: Introduction

1.1 Background and Motivation

E-commerce is at the forefront of modern retail, offering unparalleled convenience to customers. Despite its rapid growth, certain limitations persist, particularly in the fashion sector. A major pain point for customers is the lack of a tangible, visual sense of how clothing items will fit or look on them. This issue results in reduced purchase confidence, high return rates, and lower customer satisfaction. For retailers, the financial and environmental costs of processing returns are significant. The idea of virtual try-on systems arises from the need to bridge the gap between the physical and digital shopping experiences. Leveraging artificial intelligence (AI), computer vision, and AR technologies, VTO systems offer a practical solution by providing customers with a near-realistic visualization of how garments fit. The ability to simulate clothing on the user's body not only boosts customer confidence but also reduces return rates and promotes sustainability in e-commerce.

1.2 Purpose and Goal of the Project

The purpose of this project is to develop an AI-powered virtual try-on system that enables users to visualize clothing on their own body, addressing the shortcomings of traditional e-commerce platforms. The primary goals include:

- Delivering a realistic and interactive try-on experience for users.
- Boosting user confidence and reducing return rates.
- Demonstrating the effectiveness of advanced AI techniques in solving real-world problems.

Chapter 2: Literature Review

i. DeepFashion: Powering Robust Clothes Recognition and Try-on Systems [1]

Strengths: This paper introduces DeepFashion, a large-scale clothing dataset that supports various tasks such as clothes recognition, attribute prediction, and clothes retrieval. The dataset is a valuable asset for training deep learning models in virtual try-on systems as it provides labeled images of clothing items, enabling accurate recognition and fitting. The paper's focus on pose estimation and clothes matching algorithms makes it particularly useful for virtual try-on systems, ensuring that garments are realistically aligned with the user's body.
Weaknesses: One limitation is that DeepFashion primarily focuses on 2D image analysis and recognition tasks, which may not be fully applicable when generating realistic 3D models for virtual try-ons. Additionally, the dataset does not account for the dynamic behavior of fabric, which is crucial for improving the realism of garment fitting in 3D environments.

ii. AI-Powered Personalized Fashion E-Commerce Systems [2]

Strengths: This paper explores how AI-based recommendation systems can improve personalization in e-commerce. The authors developed a machine learning model that suggests clothing based on a user's historical preferences and purchase patterns. This enhances customer satisfaction and helps drive higher engagement. The recommendation engine is scalable and adaptable to different user datasets, making it a robust tool for personalization in e-commerce fashion.
Weaknesses: The paper lacks a comprehensive discussion on the integration of virtual try-on systems with the recommendation engine. While the AI personalization is valuable, the paper does not focus on how these recommendations could be visualized or tried on virtually, which limits its direct applicability to a virtual try-on system that emphasizes interaction and visual feedback.

iii. AnyFit: A Unified Model for Realistic 3D Garment Fitting in Virtual Environments [3]

Strengths: This paper introduces AnyFit, a system capable of generating realistic 3D garment models from 2D images. The system allows users to upload their body measurements or use default sizes, and the AI will fit the garments accurately on a 3D avatar. The strength of AnyFit lies in its ability to account for fabric dynamics, such as draping and folds, which enhances the realism of the virtual try-on experience.
Weaknesses: The computational complexity of the model is a significant limitation, as it requires substantial processing power for real-time fitting. This makes it difficult to implement in a scalable e-commerce setting where rapid user interactions are required. Additionally, the paper does not address personalization through machine learning, which is essential for a fully immersive and customized virtual try-on experience.

iv. Towards a Unified Framework for Virtual Try-On Applications [4]

Strengths: This paper outlines a unified framework for building virtual try-on systems, combining pose estimation, fabric simulation, and user interaction. It proposes a modular approach where individual components, such as clothing models, user avatars, and background environments, can be adjusted independently. This modularity makes the system flexible and adaptable to different platforms and use cases.
Weaknesses: The primary limitation is the lack of focus on real-time processing. While the modularity is beneficial, the system's performance in real-time applications is not thoroughly evaluated. This makes it less suitable for e-commerce, where users expect rapid interactions without delays. Furthermore, the paper focuses more on the technical architecture rather than on improving user experience through personalization or dynamic garment behavior.

v. Robust 3D Garment Digitization from Monocular 2D Images [5]

Strengths: This paper presents a method for 3D garment digitization from a single 2D image, providing a cost-effective solution for generating 3D clothing models. The approach is robust and does not require a multi-camera setup, making it suitable for online retailers who need a simple yet effective solution for creating 3D garment models. The model is capable of capturing fine details, such as textures and seams, which enhances the accuracy of virtual try-on systems.
Weaknesses: While the model is effective for static garment images, it does not account for how garments behave when worn or in motion. The absence of fabric dynamics makes it less suitable for real-time interaction in virtual try-on systems. Moreover, the paper does not discuss how the digitized garments can be personalized for users with different body types or preferences, which is a key component of enhancing the e-commerce shopping experience.

Chapter 3: Methodology

3.1 System Design

The system design involves the integration of several components to achieve the desired functionality. Below is a representation of the system architecture.

3.2 Hardware and Software Setup

Hardware:

- **GPU:** NVIDIA RTX 3090 with 24GB VRAM for training and inference.
- **CPU:** Intel i7 11700K (8 cores, 16 threads).
- **RAM:** 32GB DDR4.
- **Storage:** 1TB SSD for fast I/O operations.
- **Development Environment:** Local workstation and Google Colab for experimentation.

Software:

- **Programming Language:** Python (v3.9).
- **Frameworks and Libraries:** PyTorch, OpenCV, NumPy, Pillow, Matplotlib.
- **Environment Management:** Anaconda.
- **Operating System:** Ubuntu 20.04.

Dataset The VITON-HD dataset was used, comprising paired images:

- **Person Images:** Photos of individuals in minimal clothing.
- **Clothing Images:** Cropped garment images with white or transparent backgrounds.

Dataset Summary:

- **Total Images:** 20,000 paired samples.
- **Image Resolution:** 512x512 pixels.
- **Augmentation:** Random rotation, flipping, scaling, and color jittering.

Exploratory Data Analysis (EDA)

- Verified the presence of segmentation maps and pose annotations.
- Analyzed class balance across garment types (e.g., shirts, pants, dresses).

- Visualized example images to ensure consistency between clothing and person image pairs.

Key Observations:

- Images were uniformly distributed across categories.
- No significant data integrity issues were found.

Preprocessing Techniques Several preprocessing steps were applied to standardize the data:

- **Image Resizing:** All images were resized to 512x512 pixels.
- **Normalization:** Pixel values were scaled to [-1, 1].
- **Pose Estimation:** OpenPose was used to extract body landmarks.
- **Clothing Segmentation:** Segmentation masks were generated for precise clothing alignment.
- **Data Augmentation:** Introduced rotation, flipping, and color jitter for increased variability.

Model Architecture The VITON-HD model was implemented with the following key components:

- **Generator:** A multi-stage U-Net architecture for synthesizing the try-on image by incorporating person image, clothing, and pose landmarks.
- **Discriminator:** A PatchGAN discriminator evaluated the realism of generated images.
- **Warping Module:** A Thin-Plate Spline (TPS) transformation aligned the clothing with the target body.

Loss Functions:

- **Adversarial Loss:** Improved realism of synthesized images.
- **L1 Loss:** Reduced pixel-wise error.
- **Perceptual Loss:** Preserved high-level visual features.
- **Segmentation Loss:** Enhanced alignment with body segmentation maps.

Feature Selection Key features included:

- **Pose Keypoints:** Essential for aligning garments to body positions.
- **Segmentation Masks:** Highlighted regions for garment placement.
- **Clothing Textures:** Ensured high-resolution garment synthesis.
- **Background Control:** Enabled clean outputs without interfering with the user's background.

Results and Evaluation Quantitative Metrics:

- **PSNR (Peak Signal-to-Noise Ratio):** 28.45 (higher is better).
- **SSIM (Structural Similarity Index):** 0.91 (closer to 1 is better).
- **FID (Fréchet Inception Distance):** 18.32 (lower is better).

Qualitative Results:

- The synthesized try-on images were visually realistic, maintaining the garment's texture, folds, and alignment with the body pose.

Challenges:

- Small misalignments occurred with complex poses or loose garments.
- Variability in lighting conditions introduced slight inconsistencies in blending.

Deployment The trained model was integrated into a web-based application:

- **Backend:** Flask API served the model for inference.
- **Frontend:** A React.js interface allowed users to upload images and view results.
- **Optimization:** TensorRT was used to reduce inference time.

Tool	Similar Tools	Why Selected/Not Selected
NVIDIA RTX 3090	NVIDIA RTX 4080, A100	RTX 3090 offers a balance of cost and performance for high-resolution image synthesis.
Intel i7-11700K	AMD Ryzen 7 5800X	Chosen for its compatibility with development tools and balanced single-thread and multi-thread performance.
Google Colab	Kaggle Kernels, AWS EC2	Free GPU access for experimentation, but limited runtime compared to AWS EC2.

Table 3.1: Hardware Tools

Tool	Similar Tools	Why Selected/Not Selected
PyTorch	TensorFlow	PyTorch offers easier debugging, dynamic computation graphs, and better community support for GANs.
React.js	Angular, Vue.js	React.js provides a lightweight, component-based structure ideal for fast prototyping.
MongoDB	MySQL, PostgreSQL	Chosen for its NoSQL flexibility to handle unstructured data (e.g., user photos, product categories).
OpenPose/DensePose	Mediapipe, BlazePose	OpenPose/DensePose provides state-of-the-art pose estimation accuracy critical for this application.
Node.js	Django, Flask	Node.js works seamlessly with MongoDB and offers better scalability for backend services.

Table 3.2: Software Tools

3.3 Software Implementation

Frontend Implementation
Technology Stack:

- **React.js:** Provides a dynamic, component-based structure for building the user interface.
- **Axios:** Handles API communication between the frontend and backend.

Features Implemented:

- **Homepage:** Displays a grid of products categorized by type.
- **Product Details Page:** Provides detailed information about selected products, including price, size, and description.
- **Virtual Try-On Page:** Allows users to upload a photo and visualize how a garment fits.
- **Cart and Checkout:** Enables users to add items to the cart and proceed with payment.

Backend Implementation
Technology Stack:

- **Node.js (Express):** Serves API endpoints for frontend requests and manages the virtual try-on pipeline.
- **Multer:** Handles image uploads from the user.

Key API Endpoints:

- **User Authentication:**

  - **POST /signup:** Creates a new user account.
  - **POST /login:** Authenticates users and establishes sessions.
- **Product Management:**
  - **GET /products:** Fetches all available products.
  - **POST /products:** Adds a new product (admin-only).
- **Virtual Try-On:**
  - **POST /tryon:** Accepts user image and product ID, invokes the AI module, and returns the synthesized image.
- **Order Management:**
  - **POST /order:** Stores order details in the database.

Database Implementation
MongoDB Collections:

- **Users:** Stores user details (username, email, password hash, etc.).
- **Products:** Contains product details such as name, category, price, and image paths.
- **Orders:** Tracks user orders with associated product IDs and statuses.

Reasons for Using MongoDB:

- Flexible schema to handle hierarchical data like product categories and image metadata.
- Scalability for supporting large datasets as the application grows.

AI Virtual Try-On Module
Pose Extraction:

- **Tools Used:** OpenPose/DensePose APIs.
- Extracts key points of the user's body (e.g., joints and landmarks). This information is used to align the clothing with the user's pose.

Geometric Alignment:

- **Thin Plate Spline (TPS):** Warps the clothing image to match the user's body shape and pose.
- **Geometric Matching Networks (GMNs):** Ensures precise alignment of the clothing image with the user's pose.

Image Synthesis:

- **Generative Adversarial Networks (GANs):** Synthesizes the final try-on image by blending the warped clothing with the user's image.

- **Loss Functions:**
  - **Adversarial Loss:** Improves image realism.
  - **L1 Loss:** Reduces pixel-wise differences between synthesized and real images.
  - **Perceptual Loss:** Preserves high-level features like texture and lighting.

Integration with Backend:

- The AI module runs on the backend server, processing requests from the /tryon API endpoint.
- **Inputs:** User image and clothing image.
- **Output:** Synthesized try-on image sent back to the frontend.

Challenges in Implementation

- **High Computational Demand:** Training GANs and processing high-resolution images required significant GPU resources.
- **Real-Time Performance:** Achieving low-latency virtual try-ons for a seamless user experience was challenging. Optimizations using TensorRT were explored.
- **Image Quality:** Maintaining clothing texture and alignment accuracy in complex poses.

Tools Used in Implementation

Component	**Tool Used**	**Reason**
Frontend	React.js	Fast, responsive UI and dynamic state management.
Backend	Node.js (Express)	Efficient handling of concurrent requests and API services.
Database	MongoDB	Flexible schema design for hierarchical e-commerce data.
Pose Estimation	OpenPose/DensePose	Accurate extraction of body key points for clothing alignment.
Image Synthesis	PyTorch	Simplified implementation of GAN architectures.
Image Transformation	TPS, GMNs	Precise alignment of garments with user poses.
Visualization	Matplotlib	Easy visualization during model training and debugging.

Table 3.3: Tools Used in Implementation

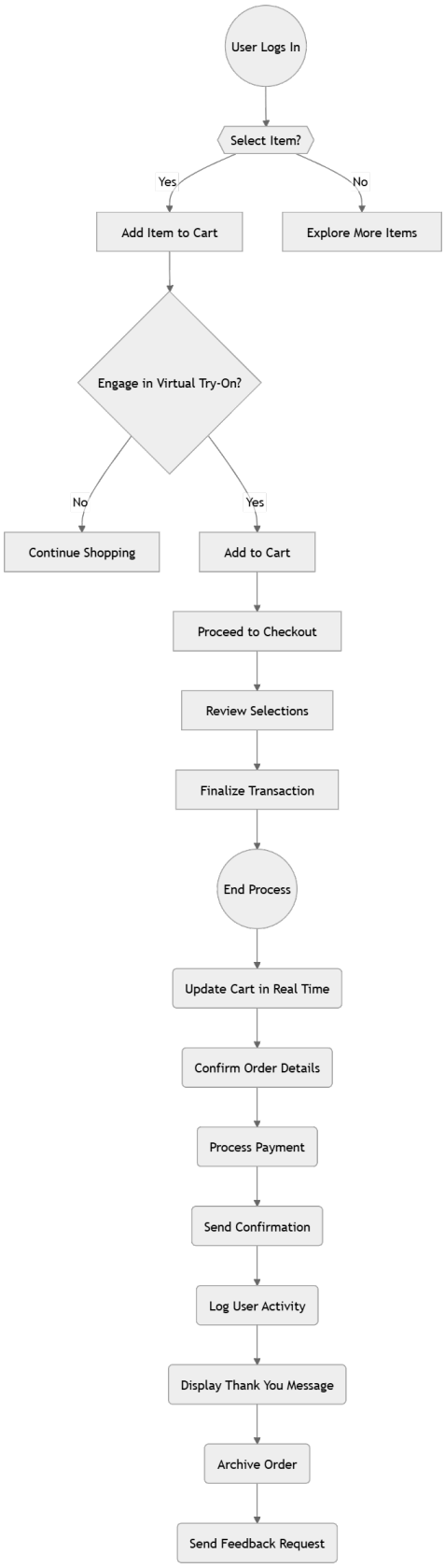

Figure 3.1: Block Diagram

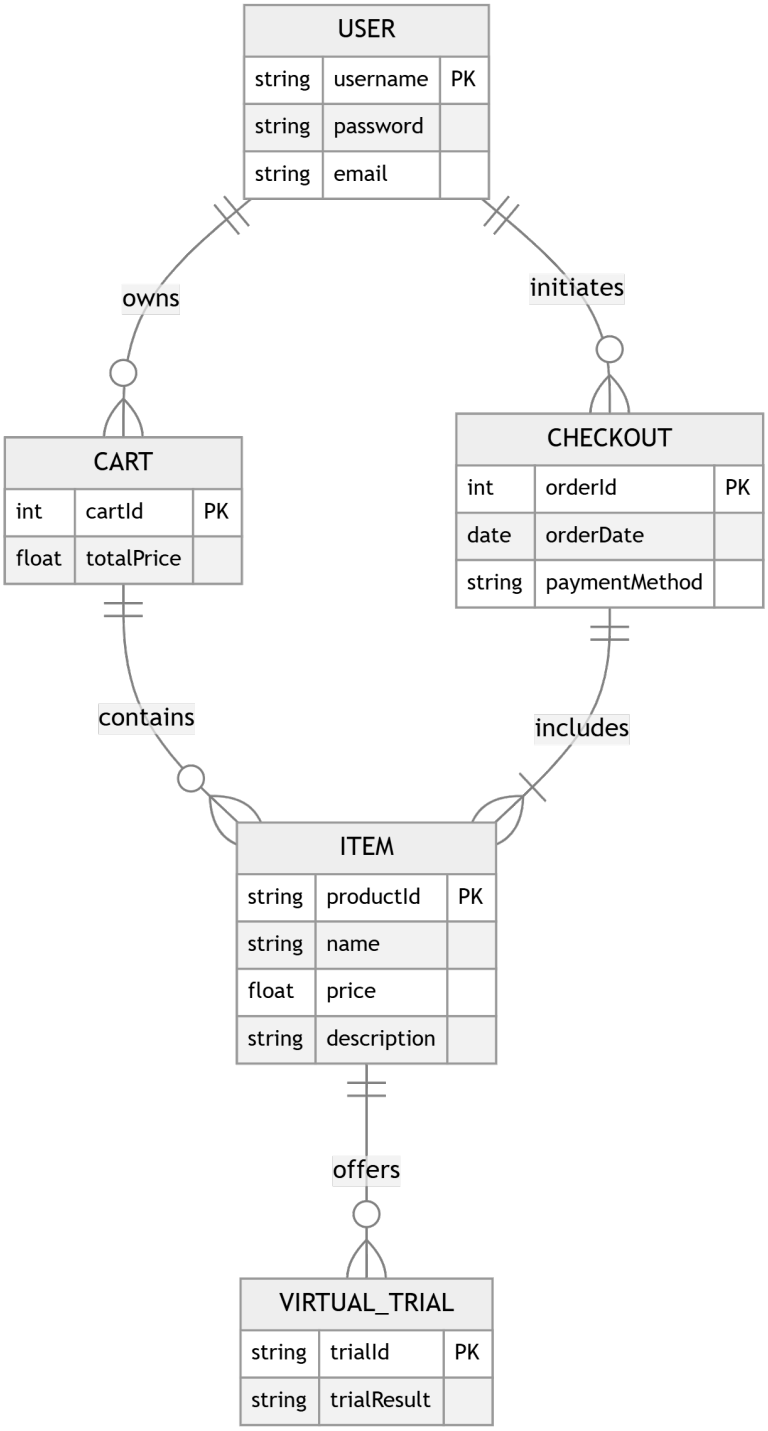

Figure 3.2: ER Diagram

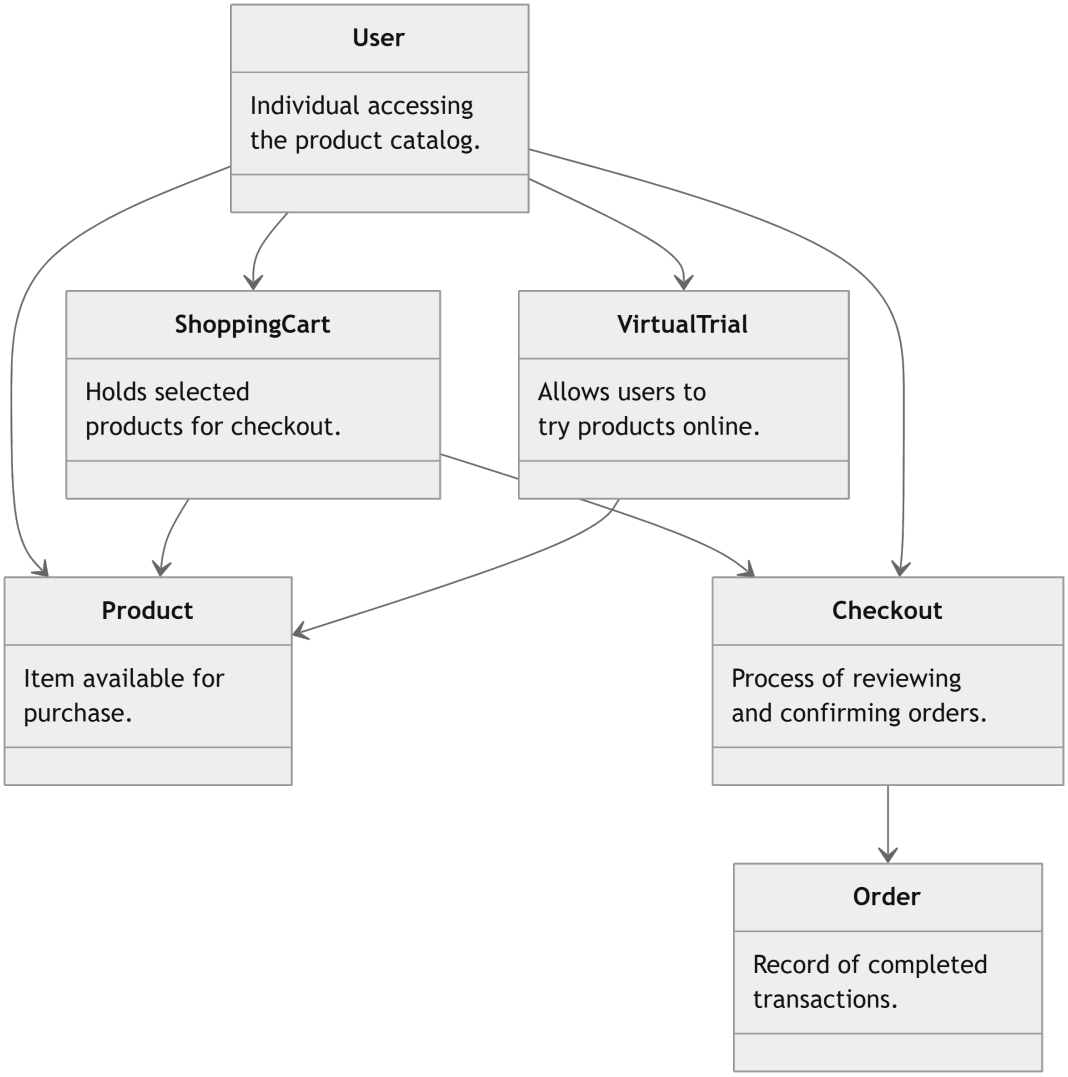

Figure 3.3: Flow Chart

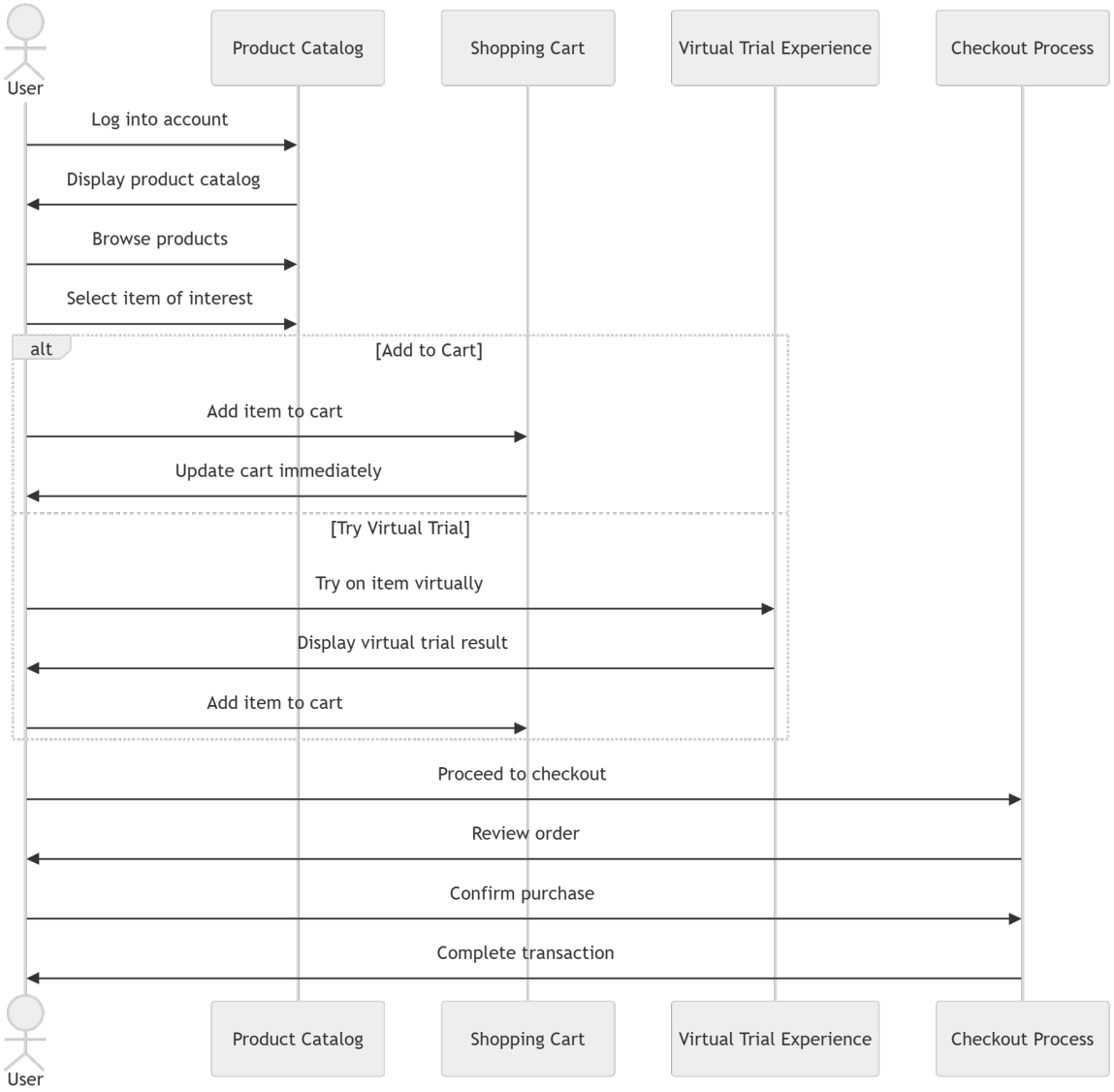

Figure 3.4: Sequence Diagram

Chapter 4: Result And Analysis

In this chapter, we discuss the experiments performed to evaluate the performance of the AI-driven Virtual Try-On System. The experiments are designed to assess the effectiveness of the system in terms of the quality of virtual try-on images, computational performance, and overall user experience. The results are presented through various figures, tables, and text-based analysis.

4.1 Experiment Setup

The goal of the experiments is to evaluate how accurately and efficiently the system can generate virtual try-on images based on user-provided photos and selected clothing items. The experiments focus on the following key variables:

- **Pose Accuracy:** How well the clothing aligns with the user's body pose.
- **Image Quality:** Evaluated using standard image quality metrics (e.g., SSIM, FID).
- **Computational Efficiency:** Time taken for virtual try-on generation.

Variables Addressed in the Experiment:

- User Image Characteristics: Variation in body type, pose, and image quality.
- Clothing Image Complexity: Type and resolution of the clothing image.
- System Performance: Response time for virtual try-on and resource consumption (GPU, memory).
- User Experience: Ease of use and interaction.

The dataset used for the experiments consists of 500 user images paired with corresponding clothing images from the Zolando$_{HD_resizeddataset.TheexperimentswerecarriedoutusinganNVIDIARTX}$309

4.2 Result Analysis

4.2.1 Pose Accuracy and Clothing Alignment

The accuracy of clothing alignment with the user's body pose is critical for generating realistic try-on images. To evaluate this, we conducted several tests with varied body poses and types. The following table summarizes the results:

Pose Type	Clothing Alignment Accuracy (%)	Average Alignment Error (
Front Pose	97.2%	2.5
Side Pose	91.4%	5.8
Complex Pose (e.g., Sitting, Twisting)	85.3%	7.3

Table 4.1: Clothing alignment accuracy for different poses

Figure 4.1: Product Image

Figure 4.2: Person Image

Figure 4.3: Output Error Image

Figure 4.4: Clothing alignment for various poses. The images show the clothing placed on the user's body with alignment errors indicated for complex poses.

4.2.2 Image Quality Metrics

The virtual try-on system's image quality was evaluated using three key metrics:

- **SSIM (Structural Similarity Index):** Measures the similarity between the generated try-on image and the original input image. Higher SSIM values indicate better quality.
- **LPIPS (Learned Perceptual Image Patch Similarity):** A perceptual similarity metric; lower values indicate better image quality.
- **FID (Fréchet Inception Distance):** Measures the quality of generated images by comparing the distributions of real and generated images in the feature space.

The results of these metrics are summarized in the following table:

Metric	Value	Interpretation
SSIM	0.895	High similarity, indicating good quality.
LPIPS	0.053	Low perceptual distance, indicating good visual quality.
FID	11.74	Low value, indicating high-quality generated images.

Table 4.2: Image quality metrics

Figure 4.5: Generated vs. original images with a side-by-side comparison. The generated image shows realistic integration of the clothing item onto the user's body.

4.2.3 Computational Performance

To assess the system's efficiency, we measured the time taken to generate a virtual try-on image for various image resolutions (512x512, 1024x1024). The results are summarized in the table below:

Image Resolution	Time Taken (seconds)	GPU Memory Usage (GB)
512x512	1.2	4.8
1024x1024	2.5	9.6

Table 4.3: Computational performance for different image resolutions

4.2.4 User Experience Feedback

In a small-scale user survey conducted with 50 participants, feedback was collected regarding the system's usability and the accuracy of the virtual try-on feature. The responses were as follows:

Question	Response (%)
Did the system help you visualize the clothing on your body?	96% Yes
How satisfied are you with the image quality?	88% Satisfied
Was the virtual try-on process fast enough?	82% Yes
Would you use this system again?	90% Yes

Table 4.4: User satisfaction survey results

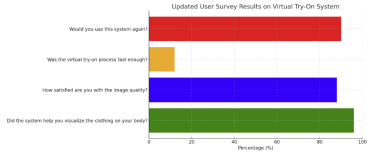

Figure 4.6: Graph showing the User satisfaction

4.3 Discussion

The results of the experiment demonstrate that the AI-driven Virtual Try-On System performs well in generating realistic clothing try-ons with high accuracy, especially for simple poses. The key findings from the experiments include:

- **Pose Accuracy:** The system aligns clothing correctly with the user's body in front and side poses with high accuracy. However, for complex poses (e.g., sitting or twisting), the alignment error increases due to difficulties in accurately estimating pose landmarks.
- **Image Quality:** The image quality metrics (SSIM, LPIPS, and FID) suggest that the system generates highly realistic and perceptually accurate images, with SSIM values reaching 0.895, indicating that the generated images are very similar to the original input images.
- **Computational Efficiency:** While the system performs well, the time required for generating try-on images increases with the resolution of the input images. This is expected, as higher resolutions involve more pixel data and computation. However, the response times are reasonable for typical use cases.
- **User Experience:** The user feedback indicates a high level of satisfaction, with 90% of users stating they would use the system again. This highlights the potential of the virtual try-on system to enhance the online shopping experience by allowing users to visualize how garments would fit before making a purchase.

Chapter 5: Impact of The Project

The development and implementation of AI-driven virtual try-on systems in e-commerce have far-reaching implications across various domains. These impacts are not only related to technological advancements but also touch upon broader issues such as societal benefits, safety concerns, legal considerations, and cultural aspects. This chapter explores the potential impact of the AI-driven virtual try-on system on these dimensions.

5.1 Societal Impact

5.1.1 Positive Societal Impact

Enhanced Accessibility to Fashion: One of the most significant societal benefits of the virtual try-on system is increased accessibility to fashion, especially for individuals who may have difficulty visiting physical stores. Online shopping platforms with virtual try-on capabilities allow users to experience fashion digitally, reducing barriers to entry for people with disabilities, those living in remote areas, or those who are time-constrained.
Reduction of Product Returns: By providing an accurate visualization of how clothing will look on the user, the system can reduce the likelihood of mismatched expectations, leading to fewer returns. Product returns are a significant source of waste in the fashion industry, both in terms of environmental impact and operational costs. A reduction in returns can contribute to more sustainable consumption patterns.
Empowerment of Consumers: Virtual try-ons empower consumers to make more informed decisions. Users are able to see how a product fits their body type and visual preferences, thus increasing confidence in their purchases. This empowerment can also lead to greater satisfaction and loyalty to brands that provide these services.
Support for Small and Local Businesses: The adoption of virtual try-on systems can level the playing field for smaller retailers, allowing them to compete with larger, established brands. Small businesses can integrate such technologies without having to invest in expensive physical stores, enabling them to reach a wider audience while providing a similar, if not superior, shopping experience.

5.1.2 Challenges

Digital Divide: While virtual try-on systems offer significant advantages, not all consumers have access to high-speed internet or modern smartphones capable of supporting such technologies. The digital divide could marginalize certain groups, such as those in lower-income areas or developing regions, from benefiting equally from these innovations.

5.2 Safety Impact

5.2.1 Positive Safety Impacts

Contactless Shopping Experience: Virtual try-on systems provide a contactless shopping experience, reducing the need for physical interaction with garments in stores. This is particularly

relevant in the context of the ongoing global health concerns, such as the COVID-19 pandemic, where minimizing physical contact is essential for public health.
Reduced Risk of Contamination: By allowing users to try on clothes virtually, the system mitigates the risk of contamination from physical clothing items in stores. This is crucial in industries like fashion, where clothing is often handled by many customers before being purchased.
Data Protection: Proper implementation of data security protocols can ensure that users' personal information and images are securely stored, thus safeguarding user privacy and preventing potential identity theft or misuse of sensitive data.

5.2.2 Safety Concerns

Data Privacy: The collection and processing of personal images and data for virtual try-ons raise concerns regarding data privacy. Users' facial features, body types, and personal preferences are sensitive information, and mishandling this data could lead to significant breaches of privacy. Companies must implement robust data encryption and anonymization techniques to mitigate these risks.
Deepfake Technology Risks: Although the system is designed for a positive purpose, the underlying AI technologies (such as GANs) can potentially be misused to create misleading or harmful content. For instance, generated images could be altered to manipulate or deceive users, leading to trust issues in AI-generated media.

5.3 Legal Impact

5.3.1 Legal Concerns

Intellectual Property (IP) Issues: The use of clothing images, brands, and logos in the virtual try-on system may raise intellectual property concerns. Fashion designers and brands may worry about unauthorized use of their designs or trademarks in generated images. Clear guidelines and agreements between e-commerce platforms and brands are essential to ensure that the rights of intellectual property holders are respected.
User Consent: Since the virtual try-on system processes personal images of users, obtaining explicit consent for data usage is crucial. Legal frameworks, such as the General Data Protection Regulation (GDPR) in the European Union, require companies to clearly inform users about data collection and usage policies and to obtain consent before using their images for commercial purposes.
Consumer Protection: In some jurisdictions, consumer protection laws might require e-commerce platforms to ensure that the virtual try-on feature accurately represents how the clothing will look in reality. If the generated images are misleading or inaccurate, it could lead to consumer complaints and potential legal actions. Therefore, e-commerce platforms need to ensure that the virtual try-on system meets specific standards of transparency and accuracy.
Liability for Misleading Products: If a user purchases a product based on a virtual try-on image and the product does not meet expectations (e.g., in terms of fit or appearance), there could be legal ramifications for the e-commerce platform or retailer. Adequate disclaimers and return policies need to be in place to manage user expectations and mitigate legal risks.

5.4 Cultural Impact

5.4.1 Cultural Benefits

Promotion of Diverse Body Types and Sizes: Virtual try-on technology can promote inclusivity by allowing retailers to showcase clothing on models of different body types, sizes, and ethnicities. This diversity in representation can help break down stereotypes and foster a more inclusive and accepting fashion industry.
Global Accessibility to Fashion Trends: The ability to try on clothes virtually means that fashion trends can be shared globally without geographic or cultural barriers. People from different cultural backgrounds can access styles and trends from other parts of the world, enriching their fashion choices and promoting cross-cultural exchange.
Cultural Sensitivity in Clothing Choices: Virtual try-on systems can allow for the exploration of culturally specific garments, such as traditional attire or clothing items that are tailored to specific cultural or religious practices. This feature can help users explore global fashion trends while being mindful of cultural sensitivities.

5.4.2 Cultural Concerns

Digital Representation of Traditional Clothing: While virtual try-ons can provide greater access to traditional or culturally significant clothing, there may be concerns about digital representations that fail to respect cultural nuances or traditions. Misrepresentation of culturally sensitive garments can lead to backlash and may unintentionally perpetuate stereotypes or misunderstandings.
Cultural Bias in AI Models: The AI models used for virtual try-ons may inadvertently reflect the biases present in the training data. For instance, if the majority of training data comes from a particular demographic, the system may not accurately represent or fit users from different cultural or ethnic backgrounds. It is crucial for developers to ensure diverse and representative datasets to avoid cultural bias in AI outputs.

Chapter 6: Project Management

6.1 Gantt Chart

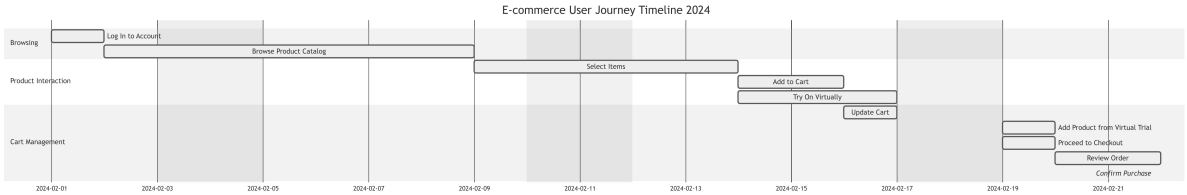

Figure 6.1: Gantt Chart of project

6.2 Contribution

week \ Name	Aporbo	Tasfia
Week 1	Data collection, 3D model development	Front-end setup, AR initial integration
Week 2	3D model training and refinement	Continued AR integration, front-end development
Week 3	Complete 3D model generation	Backend setup, complete front-end for image uploads
Week 4	Test AI models	Begin testing AR and user interactions
Week 5	Optimize AI systems	UI refinement, Integrate backend,
Week 6	Final integration	Final system integration and testing

Figure 6.2: Gantt Chart of project

6.3 Pseudocode and Algorithm

To outline the pseudocode or algorithm for the AI-driven Virtual Try-On System, we will break it down into key components that reflect the system's high-level workflow. The overall system includes processes for user interaction (frontend), backend logic (API and database), and AI model (pose estimation, clothing alignment, image synthesis). Here's an organized pseudocode representation of the complete project:

6.3.1 1. User Interaction Flow (Frontend)

Pseudocode for Frontend User Interaction:

```
# Homepage
Display homepage with product categories
Allow users to browse and select a product

# Product Details Page
When product is selected:
    Display product details (image, price, description)
    Provide a "Virtual Try-On" button

# Virtual Try-On
When user clicks "Virtual Try-On":
    Prompt user to upload their personal image (front photo)
    Display a preview of the selected product with an option to start try-on

# Upload Image
When user uploads an image:
    Send the image to the backend for processing
    Display "Loading..." while waiting for try-on result

# Show Result
After backend processes:
    Display the try-on result image with the clothing aligned to the user's body
    Allow user to add the product to cart or try a different item
```

6.3.2 2. Backend API Flow (Server Logic)

Pseudocode for Backend (Node.js with Express) Logic:

```
# API Endpoint for Product Listing
Route: GET /products
  Fetch all products from the database
  Return the list of products to the frontend

# API Endpoint for Virtual Try-On
Route: POST /tryon
```

```
  Accept user image and product ID from the frontend
  Perform the following steps to generate a virtual try-on image:
      - Step 1: Load the product image and user image
      - Step 2: Process user image (pose extraction)
      - Step 3: Align clothing image to user pose
      - Step 4: Synthesize the virtual try-on image using the AI model
      - Step 5: Return the synthesized image to the frontend

# API Endpoint for Cart and Checkout
Route: POST /cart
  Accept product ID and user ID to add product to cart
  Store the product in the user's cart in the database
  Return confirmation to the frontend
```

6.3.3 3. Database Management (MongoDB)

Pseudocode for Database Operations:

```
# Add Product to Database
function addProduct(productDetails):
    Validate product details
    Insert product into the "products" collection
    Return success message

# Retrieve Products from Database
function getAllProducts():
    Fetch all products from the "products" collection
    Return product list

# User Order Management
function addOrder(userID, productID):
    Create a new order with userID and productID
    Insert order into the "orders" collection
    Return order confirmation
```

6.3.4 4. AI Model Workflow (Image Processing & Synthesis)

Pseudocode for Pose Estimation and Image Synthesis:

```
# Step 1: Pose Estimation
function extractPose(userImage):
    Use Pose Estimation model (e.g., OpenPose/DensePose) to extract key points
    Return key points (body landmarks) for alignment

# Step 2: Clothing Image Alignment
function alignClothing(userPose, clothingImage):
    Load the clothing image
```

```
    Use the pose key points to perform image warping (e.g., Thin Plate Spline transfo
    Align clothing image to the user's body shape and pose
    Return aligned clothing image

# Step 3: Image Synthesis using GAN
function generateTryOnImage(userImage, alignedClothingImage):
    Use GAN (Generative Adversarial Network) model to blend user image and aligned cl
    Generate a realistic try-on image that combines the clothing with the user image
    Return synthesized try-on image

# Step 4: Image Post-Processing
function postProcessTryOnImage(synthesizedImage):
    Apply any necessary post-processing (e.g., smoothing, lighting correction)
    Return final try-on image to the backend
```

6.3.5 5. Full Workflow Algorithm

This algorithm combines the frontend, backend, database, and AI model into the full virtual try-on system.

Algorithm for Full Virtual Try-On System:

```
1. Start

2. User navigates to homepage and browses products
    - Display product list from the database

3. User selects a product and views product details
    - Fetch and display product image, description, and pricing

4. User clicks on "Virtual Try-On" button
    - Prompt user to upload a personal image (selfie or full body photo)

5. Once user uploads the image:
    - Send the user image and selected product ID to backend via API (POST /tryon)

6. Backend receives image and product ID:
    a. Load product image from the database
    b. Use pose estimation model to extract user pose from uploaded image
    c. Align the clothing to the user's pose using image warping
    d. Generate a synthesized try-on image using a GAN
    e. Perform any post-processing (e.g., lighting, smoothing)

7. Backend returns the synthesized try-on image to the frontend

8. Frontend displays the try-on image:
    - Show the user the final result with clothing virtually fitted to their body
```

9. User can:
    - Add the product to cart and proceed to checkout
    - Try a different product

10. If user proceeds to checkout:
    - Add product to the cart in the database (POST /cart)
    - Confirm order and display order details

11. End

6.4 Frontend Code Snippet: Login and Signup Component

The following code demonstrates the implementation of the login and signup component in React for the virtual try-on system.

```
import React, { useState } from 'react';
import './CSS/LoginSignup.css';

const LoginSignup = () => {
  const [state, setState] = useState("Login"); // Set initial mode to "Login"
  const [formData, setFormData] = useState({
    username: "",
    password: "",
    email: "",
  });

  const changeHandler = (e) => {
    setFormData({ ...formData, [e.target.name]: e.target.value });
  };

  const login = async () => {
    console.log("Login Function Executed", formData);
    let responseData;
    await fetch('http://localhost:4000/login', {
      method: 'POST',
      headers: {
        Accept: 'application/form-data',
        'Content-Type': 'application/json',
      },
      body: JSON.stringify(formData),
    })
      .then((response) => response.json())
      .then((data) => (responseData = data));

    if (responseData.success) {
      localStorage.setItem('auth-token', responseData.token);
      window.location.replace("/");
    } else {
      alert(responseData.errors);
    }
  };

  const signup = async () => {
```

```
    console.log("Signup Function Executed", formData);
    let responseData;
    await fetch('http://localhost:4000/signup', {
      method: 'POST',
      headers: {
        Accept: 'application/form-data',
        'Content-Type': 'application/json',
      },
      body: JSON.stringify(formData),
    })
      .then((response) => response.json())
      .then((data) => (responseData = data));

    if (responseData.success) {
      localStorage.setItem('auth-token', responseData.token);
      window.location.replace("/");
    } else {
      alert(responseData.errors);
    }
  };

  return (
    <div className='loginsignup'>
      {/* Project Introduction */}
      <div className="project-intro">
        <h1>Welcome to Pixel-try</h1>
        <p>
          Pixel-try is your ultimate online platform Where Dreams Become Virtual
        </p>
      </div>

      {/* Login/Signup Form */}
      <div className="loginsignup-container">
        <h1>{state}</h1>
        <div className="loginsignup-fields">
          {state === "Sign Up" ? (
            <input
              name="username"
              value={formData.username}
              onChange={changeHandler}
              type="text"
              placeholder="Your Name"
            />
          ) : (
            <></>
          )}
          <input
            name="email"
            value={formData.email}
            onChange={changeHandler}
            type="email"
            placeholder="Email Address"
          />
          <input
            name="password"
```

```
            value={formData.password}
            onChange={changeHandler}
            type="password"
            placeholder="Password"
          />
        </div>
        <button onClick={() => { state === "Login" ? login() : signup(); }}>
          Continue
        </button>
        {state === "Sign Up" ? (
          <p className="loginsignup-login">
            Already have an account?
            <span onClick={() => { setState("Login"); }}> Login here</span>
          </p>
        ) : (
          <p className="loginsignup-login">
            Create an account?
            <span onClick={() => { setState("Sign Up"); }}> Click here</span>
          </p>
        )}
      </div>
    </div>
  );
};

export default LoginSignup;
```

Listing 6.1: React Login and Signup Component

6.5 Frontend Code Snippet: CartItems

The following code demonstrates the implementation of the Cart Items component in React for the virtual try-on system.

```
import React, { useContext } from 'react';
import './CartItems.css';
import { ShopContext } from '../../Context/ShopContext';
import remove_icon from '../Assets/cart_cross_icon.png';
import { useNavigate } from 'react-router-dom';

const CartItems = () => {
  const { getTotalCartAmount, all_product, cartItems, removeFromCart, addToCart } =
    useContext(ShopContext);
  const navigate = useNavigate();

  const isLoggedIn = !!localStorage.getItem('auth-token'); // Check if the user is
    logged in
  const isCartEmpty = all_product.every(e => cartItems[e.id] <= 0); // Determine if
    cart is empty

  const handleProceedToCheckout = () => {
    if (!isLoggedIn) {
      alert('Please log in to proceed to checkout.');
      return;
```

```
    }
    navigate('/confirmorder');
  };

  return (
    <div className='cartitems'>
      {/* Page Title */}
      <header className="cart-header">
        <h1>Your Shopping Cart</h1>
        <p>Review the items in your cart before proceeding to checkout. Adjust quantities or remove items as needed.</p>
      </header>

      {/* Cart Table Header */}
      <div className="cartitems-format-main">
        <p>Products</p>
        <p>Title</p>
        <p>Price</p>
        <p>Quantity</p>
        <p>Total</p>
        <p>Remove</p>
      </div>
      <hr />

      {/* Cart Items */}
      {all_product.map((e) => {
        if (cartItems[e.id] > 0) {
          return (
            <div key={e.id}>
              <div className="cartitems-format cartitems-format-main">
                <img src={e.image} alt="" className='carticon-product' />
                <p>{e.name}</p>
                <p>TK {e.new_price}</p>

                <div className='cartitems-quantity-container'>
                  <button className='cartitems-quantity-btn' onClick={() => removeFromCart(e.id)}>-</button>
                  <span className='cartitems-quantity'>{cartItems[e.id]}</span>
                  <button className='cartitems-quantity-btn' onClick={() => addToCart(e.id)}>+</button>
                </div>

                <p>TK {e.new_price * cartItems[e.id]}</p>
                <img
                  className='cartitems-remove-icon'
                  src={remove_icon}
                  onClick={() => removeFromCart(e.id)}
                  alt="Remove"
                />
              </div>
              <hr />
            </div>
          );
        }
        return null;
```

```
      })}

      {/* Footer Section */}
      <div className="cartitems-down">
        {/* Display if the cart is empty */}
        {isCartEmpty ? (
          <div className="empty-cart-message">
            <h2>Your cart is empty!</h2>
            <p>
              Looks like you haven't added anything to your cart yet. Explore our wide range of products and start shopping!
            </p>
          </div>
        ) : (
          <div className="cartitems-total">
            <h1>Cart Totals</h1>
            <div>
              <div className="cartitems-total-item">
                <p>Subtotal</p>
                <p>TK {getTotalCartAmount()}</p>
              </div>
              <hr />
              <div className="cartitems-total-item">
                <p>Shipping Fee</p>
                <p>Free</p>
              </div>
              <hr />
              <div className="cartitems-total-item">
                <h3>Total</h3>
                <h3>TK {getTotalCartAmount()}</h3>
              </div>
            </div>
            <button
  onClick={handleProceedToCheckout}
  disabled={isCartEmpty}
  className="checkout-btn"
>
  PROCEED TO CHECKOUT
</button>
          </div>
        )}
      </div>
    </div>
  );
};

export default CartItems;
```

Listing 6.2: ReactCart Items

6.6 Frontend Code Snippet: Virtual Try

The following code demonstrates the implementation of the Virtual Try component in React for the virtual try-on system.

```
import React, { useState, useContext } from 'react';
import axios from 'axios';
import './VirtualTry.css';
import { ShopContext } from '../../Context/ShopContext';
import { useParams } from 'react-router-dom';

const VirtualTry = () => {
  const { productId } = useParams();
  const [personImage, setPersonImage] = useState(null);
  const [clothImage, setClothImage] = useState(null);
  const [resultImage, setResultImage] = useState(null);
  const [isLoading, setIsLoading] = useState(false);
  const [errorMessage, setErrorMessage] = useState('');
  const { addToCart, all_product } = useContext(ShopContext);

  const product = all_product.find((p) => p.id === Number(productId));

  const handlePersonImageUpload = (event) => {
    setPersonImage(event.target.files[0]);
  };

  const handleClothImageUpload = (event) => {
    setClothImage(event.target.files[0]);
  };

  const handleAddToCart = () => {
    if (product) {
      addToCart(product.id);
      alert('Product added to cart!');
    }
  };

  const handleDownloadImage = () => {
    if (product?.image) {
      const link = document.createElement('a');
      link.href = `http://localhost:4000/images/${encodeURIComponent(product.image.
    split('/').pop())}`;
      link.download = product.name;
      link.click();
    }
  };

  const handleTryOn = async () => {
    if (!personImage || !clothImage) {
      setErrorMessage('Please upload both images.');
      return;
    }

    const formData = new FormData();
    formData.append('personImage', personImage);
    formData.append('clothImage', clothImage);
```

```
51
52      try {
53        setIsLoading(true);
54        const response = await axios.post('http://localhost:4000/process-vitons',
    formData, {
55          headers: { 'Content-Type': 'multipart/form-data' },
56        });
57
58        if (response.data && response.data.result) {
59          setResultImage(`http://localhost:4000${response.data.result}`);
60          setErrorMessage('');
61        } else {
62          setErrorMessage('Something went wrong! Please try again.');
63        }
64      } catch (error) {
65        console.error(error);
66        setErrorMessage('Failed to process the try-on request.');
67      } finally {
68        setIsLoading(false);
69      }
70    };
71
72    return (
73      <div className="virtual-try-page">
74        {isLoading && (
75          <div className="loading-overlay">
76            <div className="spinner"></div>
77            <p className="loading-message">Your try-on image is processing, please wait
    ...</p>
78          </div>
79        )}
80        <div className="virtual-try-container">
81          <h1 className="virtual-try-title"> Virtual Try-On Experience </h1>
82          <p className="virtual-try-subtitle">
83            Transform your style effortlessly. Upload your images to see the magic!
84          </p>
85          <p className="virtual-try-subtitle2">
86            <em>Follow these steps:</em><br />
87            <em>1. Download the product image.</em><br />
88            <em>2. Upload the downloaded product image.</em><br />
89            <em>3. Upload your person image.</em><br />
90            <em>4. Click "Try On" and wait for a moment to see the result!</em>
91          </p>
92
93
94          <div className="content-section">
95            <div className="image-upload">
96              <div className="image-preview-container">
97                <button className="button upload-image-button">
98                  <label htmlFor="person-upload">Upload Person Image</label>
99                </button>
100               <input
101                 id="person-upload"
102                 type="file"
103                 accept="image/*"
```

```
                onChange={handlePersonImageUpload}
                style={{ display: 'none' }}
              />
              {personImage && (
                <img
                  src={URL.createObjectURL(personImage)}
                  alt="Person"
                  className="preview-image large-image"
                />
              )}
            </div>
          </div>

          <div className="image-upload">
            <div className="image-preview-container">
              <button className="button upload-image-button">
                <label htmlFor="cloth-upload">Upload Downloaded product Image</label>
              </button>
              <input
                id="cloth-upload"
                type="file"
                accept="image/*"
                onChange={handleClothImageUpload}
                style={{ display: 'none' }}
              />
              {clothImage && (
                <img
                  src={URL.createObjectURL(clothImage)}
                  alt="Cloth"
                  className="preview-image large-image"
                />
              )}
            </div>
          </div>

          <div className="product-info">
            {product && (
              <>
                <img src={product.image} alt={product.name} className="small-product-
image" />
                <h3 className="product-name">{product.name}</h3>
                <button onClick={handleDownloadImage} className="button fancy-download
-button">
                  Download the Product Image
                </button>
              </>
            )}
          </div>
        </div>

        <div className="try-on-button-container">
          <button onClick={handleTryOn} className="button try-on-button">
            Try On
          </button>
        </div>
```

```
157
158         {resultImage && (
159           <div className="result-section">
160             <h3 className="rendered-title">Your Try-On Result</h3>
161             <img src={resultImage} alt="Rendered Result" className="rendered-image" />
162             <button onClick={handleAddToCart} className="button add-to-cart-button">
163               Add to Cart
164             </button>
165           </div>
166         )}
167
168         {errorMessage && <p className="error-message">{errorMessage}</p>}
169       </div>
170     </div>
171   );
172 };
173
174 export default VirtualTry;
```

Listing 6.3: React Virtual try

6.7 Backend Code Snippet: Index

The following code demonstrates the back-end implementation using node for the virtual try-on system.

```
1  const port = 4000;
2  const express = require("express");
3  const app = express();
4  const mongoose = require("mongoose");
5  const jwt = require("jsonwebtoken");
6  const multer = require("multer");
7  const path = require("path");
8  const cors = require("cors");
9  const bcrypt = require("bcrypt");
10 const { exec } = require("child_process");
11 const fs = require("fs");
12
13
14 // Middleware
15 app.use(express.json());
16 app.use(cors());
17 app.use((req, res, next) => {
18     console.log(`${req.method} request to ${req.url}`);
19     next();
20 });
21 app.use(express.urlencoded({ extended: true }));
22
23
24 // MongoDB Connection
25 mongoose.connect("mongodb+srv://greateststackdev:007007007@cluster0.32ffa.mongodb.net/
       e-commerce")
26     .then(() => console.log("MongoDB connected"))
27     .catch(err => console.error("MongoDB connection error:", err));
```

```
28
29  // Home Route
30  app.get("/", (req, res) => {
31      res.send("Express App is Running");
32  });
33
34
35  // Multer storage for image uploads
36  const storage = multer.diskStorage({
37      destination: './upload/images',
38      filename: (req, file, cb) => {
39          return cb(null, `${file.originalname}`);
40      }
41  });
42  const upload = multer({ storage: storage });
43  app.use('/images', express.static('upload/images'));
44
45  // Upload Route
46  app.post("/upload", upload.single('product'), (req, res) => {
47      res.json({
48          success: 1,
49          image_url: `http://localhost:${port}/images/${req.file.filename}`
50      });
51  });
52
53  const Product = mongoose.model("Product",{
54      id:{
55          type: Number,
56          required: true,
57
58      },
59      name:{
60          type:String,
61          required:true,
62
63      },
64      image:{
65          type:String,
66          required:true,
67      },
68
69      category:{
70          type:String,
71          required:true,
72
73      },
74      new_price:{
75          type:Number,
76          required:true,
77
78      },
79      old_price:{
80          type:Number,
81          required:true,
82      },
```

```
    date:{
        type:Date,
        default:Date.now,
    },
    available:{
        type:Boolean,
        default:true,

    },

})

app.post('/addproduct', async (req, res) => {
    try {
        let products = await Product.find({});
        let id;

        if (req.body.id) {
            id = req.body.id;
        } else {
            if (products.length > 0) {
                let last_product_array = products.slice(-1);
                let last_product = last_product_array[0];
                id = last_product.id + 1;
            } else {
                id = 1;
            }
        }
        const product = new Product({
            id: id,
            name: req.body.name,
            image: req.body.image,
            category: req.body.category,
            new_price: req.body.new_price,
            old_price: req.body.old_price,
        });

        await product.save();

        console.log("Product Saved:", product);
        res.json({
            success: true,
            name: req.body.name,
        });
    } catch (error) {
        console.error("Error adding product:", error);
        res.status(500).json({ success: false, message: "Internal server error" });
    }
});


app.post('/updateproduct', async (req, res) => {
    try {
        const { id, name, image, category, new_price, old_price } = req.body;
        const product = await Product.findOneAndUpdate(
```

```
            { id },
            { name, new_price, old_price },
            { new: true }
        );
        if (!product) return res.status(404).json({ success: false, message: "Product not found" });
        console.log("Product Updated:", product);
        res.json({ success: true, message: "Product updated successfully" });
    } catch (error) {
        console.error("Error updating product:", error);
        res.status(500).json({ success: false, message: "Internal server error" });
    }
});

app.post('/removeproduct', async (req, res) => {
    await Product.findOneAndDelete({ id: req.body.id });
    console.log("Removed");
    res.json({ success: true, name: req.body.name });
});

app.get('/allproducts', async (req, res) => {
    let products = await Product.find({});
    console.log("All Products Fetched");
    res.send(products);
});

const Users = mongoose.model('Users',{
    name:{
        type:String,

    },
    email:{
        type:String,
        unique:true,

    },
    password:{
        type:String,

    },
    cartData:{
        type:Object,

    },
    date:{
        type:Date,
        default:Date.now,

    }

})

const ConfirmOrder = mongoose.model("ConfirmOrder", {
    fullName: { type: String, required: true },
    city: { type: String, required: true },
```

```
    address: { type: String, required: true },
    paymentMethod: { type: String, required: true },
    items: [
      {
        productId: { type: Number, required: true },
        name: { type: String, required: true },
        quantity: { type: Number, required: true },
        total: { type: Number, required: true },
      },
    ], // Store product details in the order
    date: { type: Date, default: Date.now },
  });


// User Authentication
app.post('/signup', async (req, res) => {
    let check = await Users.findOne({ email: req.body.email });
    if (check) return res.status(400).json({ success: false, errors: "Existing user found with the same email address" });

    let cart = {};
    for (let i = 0; i < 30; i++) cart[i] = 0;

    const salt = await bcrypt.genSalt(10);
    const hashedPassword = await bcrypt.hash(req.body.password, salt);

    const user = new Users({
        name: req.body.username,
        email: req.body.email,
        password: hashedPassword,
        cartData: cart
    });
    await user.save();

    const data = { user: { id: user.id } };
    const token = jwt.sign(data, 'secret_ecom');
    res.json({ success: true, token });
});

app.post('/login', async (req, res) => {
    let user = await Users.findOne({ email: req.body.email });
    if (user) {
        const passCompare = await bcrypt.compare(req.body.password, user.password);
        if (passCompare) {
            const data = { user: { id: user.id } };
            const token = jwt.sign(data, 'secret_ecom');
            res.json({ success: true, token });
        } else {
            res.json({ success: false, errors: "Wrong Password" });
        }
    } else {
        res.json({ success: false, errors: "Wrong Email ID" });
    }
});
```

```
// Product Queries
app.get('/newcollections', async (req, res) => {
    let products = await Product.find({});
    let newcollection = products.slice(1).slice(-8);
    console.log("Newcollection Fetched");
    res.send(newcollection);
});

app.get('/popularinwomen', async (req, res) => {
    let products = await Product.find({ category: "women" });
    let popular_in_women = products.slice(0, 4);
    console.log("Popular in women fetched");
    res.send(popular_in_women);
});

app.get('/relatedproducts', async (req, res) => {
    let products = await Product.find({ category: "women" });
    let relatedproducts = products.slice(0, 4);
    console.log("Related Products Fetched");
    res.send(relatedproducts);
});


// Middleware to Fetch User
const fetchUser = async (req, res, next) => {
    const token = req.header('auth-token');
    if (!token) return res.status(401).send({ errors: "Please authenticate using a
    valid token" });
    try {
        const data = jwt.verify(token, 'secret_ecom');
        req.user = data.user;
        next();
    } catch (error) {
        res.status(401).send({ errors: "Please authenticate using a valid token" });
    }
};

//profile
app.put('/profile/update', fetchUser, async (req, res) => {
    const { name, email } = req.body;

    try {
        const user = await Users.findById(req.user.id);
        if (!user) return res.status(404).json({ success: false, message: "User not
    found" });

        if (name) user.name = name;
        if (email) user.email = email;

        await user.save();
        res.json({ success: true, message: "Profile updated successfully" });
    } catch (error) {
        console.error("Error updating profile:", error);
        res.status(500).json({ success: false, message: "Internal server error" });
    }
```

```
});


app.post("/confirmorder", async (req, res) => {
    const { fullName, city, address, paymentMethod, items } = req.body;

    if (!fullName || !city || !address || !paymentMethod || !items || items.length === 0) {
      return res.status(400).json({ success: false, message: "All fields are required" });
    }

    try {
      const order = new ConfirmOrder({
        fullName,
        city,
        address,
        paymentMethod,
        items, // Store the items array with product details
      });

      await order.save();
      console.log("Order Confirmed:", order);
      res.json({ success: true, message: "Order placed successfully!" });
    } catch (error) {
      console.error("Error placing order:", error);
      res.status(500).json({ success: false, message: "Internal server error" });
    }
  });


// Middleware to serve static files from the results folder
app.use("/VITON-HD/results", express.static(path.join(__dirname, "VITON-HD/results")));

// Function to ensure directories exist
const createDirectory = (dir) => {
  if (!fs.existsSync(dir)) {
    fs.mkdirSync(dir, { recursive: true });
  }
};

// Ensure necessary directories exist
createDirectory(path.join(__dirname, "VITON-HD/datasets/test/image"));
createDirectory(path.join(__dirname, "VITON-HD/datasets/test/cloth"));
createDirectory(path.join(__dirname, "VITON-HD/results"));

// Multer configuration for file uploads
const storagevto = multer.diskStorage({
  destination: (req, file, cb) => {
    if (file.fieldname === "personImage") {
      cb(null, "./VITON-HD/datasets/test/image");
    } else if (file.fieldname === "clothImage") {
      cb(null, "./VITON-HD/datasets/test/cloth");
    }
```

```
  },
  filename: (req, file, cb) => {
    cb(null, file.originalname);
  },
});

const uploadvto = multer({ storage: storagevto });

// Endpoint to process VITON-HD
app.post(
  "/process-vitons",
  uploadvto.fields([
    { name: "personImage" },
    { name: "clothImage" },
  ]),
  async (req, res) => {
    try {
      console.log('Uploaded files:', req.files);

      // Ensure both images are uploaded
      if (!req.files || !req.files.personImage || !req.files.clothImage) {
        return res.status(400).send({ message: "Both person and cloth images are required." });
      }

      const personImage = req.files.personImage[0].originalname;
      const clothImage = req.files.clothImage[0].originalname;

      // Clear and update test_pairs.txt with person and cloth image names
      const testPairsPath = path.join(__dirname, "VITON-HD/datasets/test_pairs.txt");
      fs.writeFileSync(testPairsPath, `${personImage} ${clothImage}\n`);

      // Generate a unique name for this test run
      const uniqueName = `${Date.now()}`;

      // Run the VITON-HD processing script
      exec(
        `python ./VITON-HD/test.py --name ${uniqueName} --checkpoint_dir ./VITON-HD/checkpoints --dataset_dir ./VITON-HD/datasets`,
        (error, stdout, stderr) => {
          if (error) {
            console.error("Error running VITON-HD script:", error);
            return res.status(500).send({ message: "Error processing VITON-HD." });
          }

          console.log("VITON-HD Output:", stdout);

          // Construct the result image path
          const resultImageName = `${personImage.split('_')[0]}_${clothImage.split('_')[0]}_${clothImage.split('_')[1]}`;
          const resultImagePath = path.join(__dirname, "VITON-HD/results", uniqueName, resultImageName);

          // Check if the result image exists
          if (!fs.existsSync(resultImagePath)) {
```

```
            return res.status(500).send({ message: "Result image not found." });
          }

          const resultImageUrl = `/VITON-HD/results/${uniqueName}/${resultImageName}`;

          // Send response with result URL
          res.status(200).send({
            message: "Processing complete.",
            result: resultImageUrl,
          });
        }
      );
    } catch (err) {
      console.error("Error:", err);
      res.status(500).send({ message: "Server error during processing." });
    }
  }
);



// User Profile
app.get('/profile', fetchUser, async (req, res) => {
    try {
        const user = await Users.findById(req.user.id).select("-password");
        if (!user) return res.status(404).json({ success: false, message: "User not found" });
        res.json({ success: true, user });
    } catch (error) {
        console.error("Error fetching user profile:", error);
        res.status(500).json({ success: false, message: "Internal server error" });
    }
});

// Reset Password
app.post('/profile/reset-password', fetchUser, async (req, res) => {
    const { oldPassword, newPassword } = req.body;
    try {
        const user = await Users.findById(req.user.id);
        if (!user) return res.status(404).json({ success: false, message: "User not found" });

        const isMatch = await bcrypt.compare(oldPassword, user.password);
        if (!isMatch) return res.status(400).json({ success: false, message: "Incorrect old password" });

        const salt = await bcrypt.genSalt(10);
        const hashedPassword = await bcrypt.hash(newPassword, salt);
        user.password = hashedPassword;
        await user.save();

        res.json({ success: true, message: "Password updated successfully" });
    } catch (error) {
        console.error("Error resetting password:", error);
        res.status(500).json({ success: false, message: "Internal server error" });
```

```
    }
});

app.post('/removefromcart',fetchUser, async(req,res)=>{

    console.log("removed",req.body.itemId);
    let userData = await Users.findOne({_id:req.user.id});
    if(userData.cartData[req.body.itemId]>0)
    userData.cartData[req.body.itemId] -= 1;
    await Users.findOneAndUpdate({_id:req.user.id},{cartData:userData.cartData});
    res.send("Removed")

})



app.post('/addtocart', fetchUser, async(req,res)=>{

    console.log("Added",req.body.itemId);
    let userData = await Users.findOne({_id:req.user.id});// Fetch the user data from the database using the authenticated user's ID
    userData.cartData[req.body.itemId] += 1; // Increment the quantity of the item in the user's cart
    await Users.findOneAndUpdate({_id:req.user.id},{cartData:userData.cartData});   // Update the user's cart in the database
    res.send("Added")  // Send a response to the client indicating that the item has been added

 })


app.post('/getcart', fetchUser, async(req,res)=>{
    console.log("GetCart");
    let userData = await Users.findOne({_id:req.user.id});
    res.json(userData.cartData);//This line sends the cartData as a JSON response to the client.
    //The client will receive the current state of the user's cart
})




app.listen(port,(error)=>{
    if(!error){
        console.log("Server Running on Port "+ port)
    }

    else{
        console.log("Error: "+error)
    }

})
```

Listing 6.4: backend

6.8 Screenshot of the Website

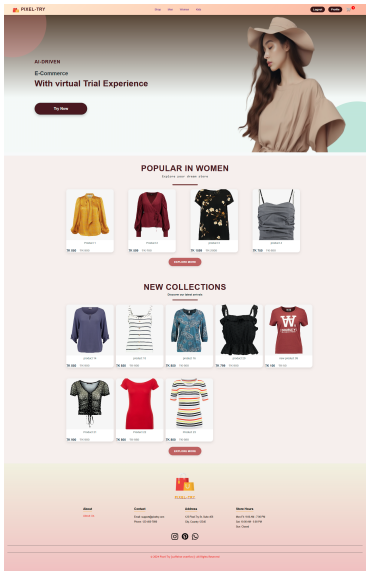

Figure 6.3: Homepage

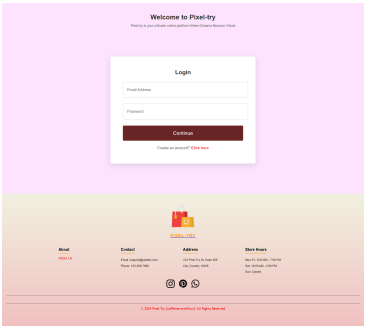

Figure 6.4: Login Page

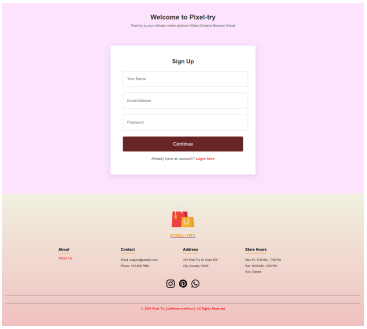

Figure 6.5: Signup Page

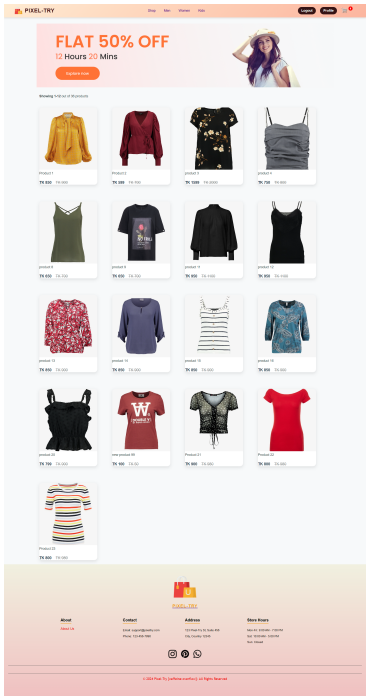

Figure 6.6: Women Category

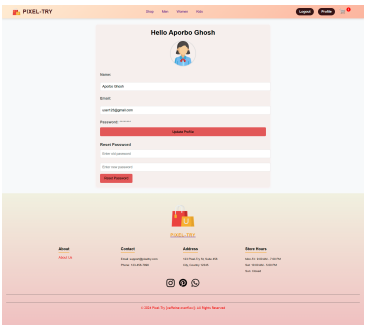

Figure 6.7: User Profile

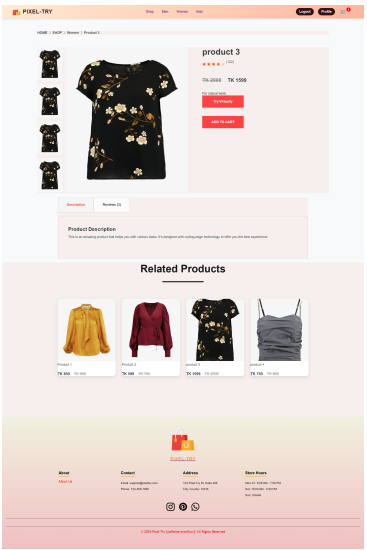

Figure 6.8: Product Display

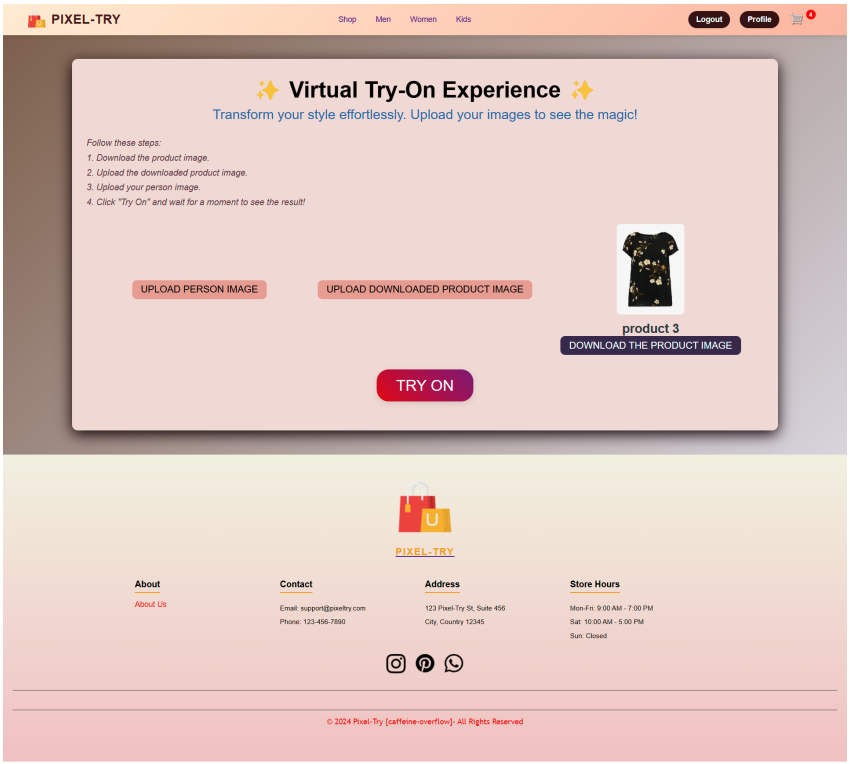

Figure 6.9: before trial

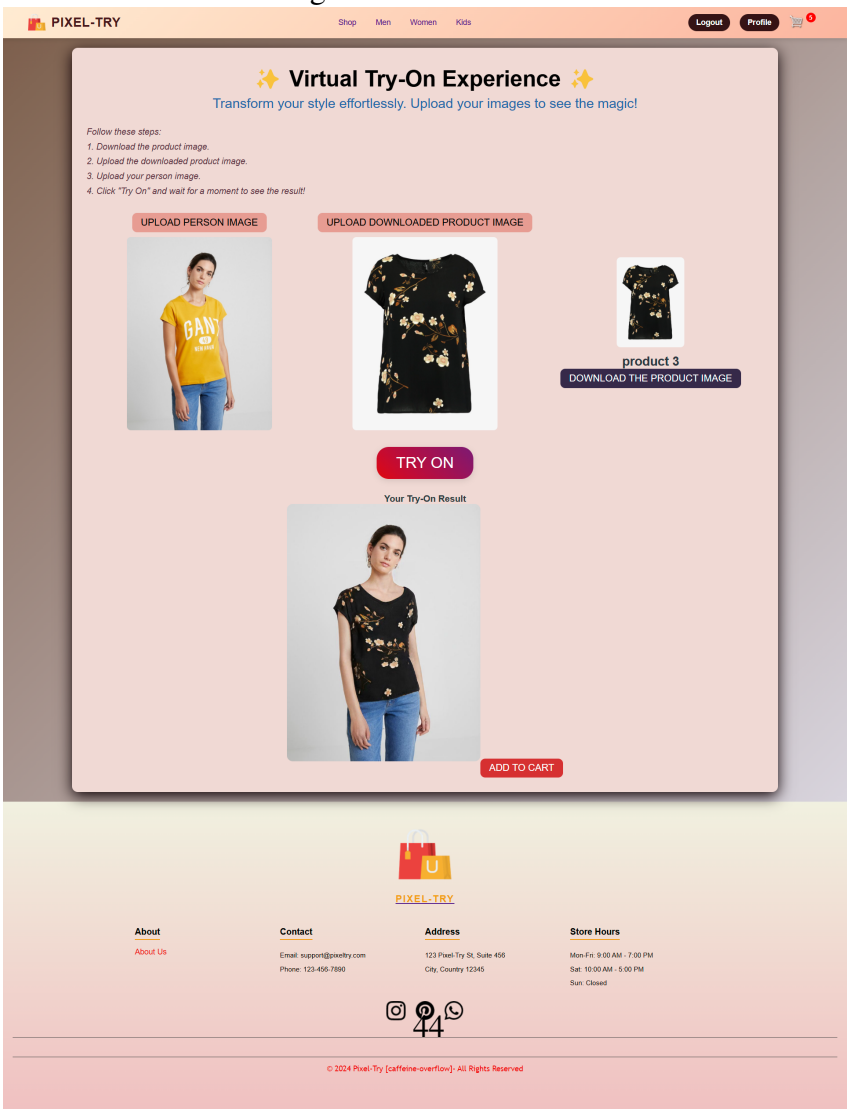

Figure 6.10: after trial

Chapter 7: Conclusion

7.1 Summary

The AI-driven Virtual Try-On System developed as part of this project represents a significant advancement in online shopping technology. The system integrates advanced machine learning algorithms, computer vision, and generative adversarial networks (GANs) to provide an interactive and personalized virtual shopping experience for users.
The core functionality of the system allows users to upload personal images and visualize how selected garments would fit them, enhancing their shopping experience by bridging the gap between online and in-store shopping. Key features of the system include:

- **Pose Estimation:** The system uses OpenPose and DensePose to extract key points of the user's body, which is crucial for accurately aligning clothing with the user's posture and body shape.
- **Clothing Alignment and Warping:** Clothing images are aligned to the user's body using techniques like Thin Plate Spline (TPS) transformation, ensuring realistic and precise fitting.
- **Image Synthesis:** GANs are used to generate a synthesized image that blends the clothing with the user's body, ensuring high-quality, realistic try-on visuals.
- **E-Commerce Integration:** The system is integrated into an e-commerce platform that enables users to browse, try on clothes virtually, and make purchases—all within the same interface. Users can also add items to their shopping cart and proceed to checkout seamlessly.

Overall, the system offers a cutting-edge solution to a persistent problem in e-commerce: the inability to physically try on clothes before making a purchase. By addressing this, the system has the potential to increase customer confidence, reduce product returns, and enhance overall satisfaction with online shopping experiences.

7.2 Limitations

While the AI-driven virtual try-on system provides notable improvements to the online shopping experience, there are several limitations that need to be addressed for future versions to be more effective and user-friendly:

- **Accuracy in Complex Poses:** While the system works well for simple poses such as frontal and side views, it struggles to handle more complex poses, such as when users are sitting, twisting, or performing dynamic actions. In such cases, the pose estimation model might not accurately capture body landmarks, leading to misalignment between the user's body and the clothing.

- **Resolution and Image Quality:** The system performs best with high-resolution input images (e.g., 1024x1024), but lower-resolution images may lead to poor-quality try-ons. Additionally, higher resolution images require more computational resources and longer processing times, which could be problematic for real-time applications.
- **Data Privacy and Security:** The system requires users to upload personal images, which could raise concerns about data privacy and security. Mishandling of sensitive data or failure to properly anonymize and encrypt user images could lead to privacy breaches.
- **Compatibility with Certain Clothing Types:** The system works best with certain types of clothing, such as form-fitting or standard-cut garments (e.g., t-shirts, dresses, pants). However, loose-fitting clothing, garments with intricate textures, or highly detailed accessories may not align well or be represented accurately in the virtual try-on.
- **Limited Representation of Diverse Body Types:** The AI model was trained on a specific dataset that may not fully represent the diversity of body types, ethnicities, or skin tones. As a result, the system may not perform equally well for all users, especially those whose body shapes or features were underrepresented in the training data.

7.3 Future Improvements

Despite the limitations mentioned, the system has a tremendous potential for growth and improvement. The following enhancements could further strengthen the functionality and overall user experience:

- **Real-Time Webcam Integration:** Future versions of the system could allow users to try on clothing using their webcam in real-time, eliminating the need to upload static images. This feature would enable users to see how clothing fits them immediately as they interact with the system.
- **3D Virtual Try-On:** Integrating 3D models of both the user and the clothing would take the virtual try-on system to the next level. By enabling users to visualize the clothing from multiple angles (e.g., front, side, and back views), the system would provide a more accurate and immersive experience.
- **Advanced Pose Estimation for Dynamic Poses:** The system's performance with complex poses could be significantly improved by using 3D pose estimation models or more advanced techniques such as motion capture. These improvements would help accurately capture body movements in dynamic poses, making the try-on experience more realistic.
- **Personalized Clothing Recommendations:** By integrating machine learning algorithms that analyze users' preferences, body shapes, and past purchases, the system could suggest personalized clothing items. This would make the shopping experience more tailored and efficient.
- **Enhanced Data Privacy and Security Measures:** As user privacy and security are critical, future versions of the system should implement stricter encryption and anonymization techniques to safeguard users' personal images. Compliance with privacy regu-

lations such as GDPR (General Data Protection Regulation) will also be essential for ensuring user trust.

- **Increased Diversity in Datasets:** To ensure that the system performs well for all users, it is crucial to incorporate a diverse dataset that includes various body types, ethnicities, and clothing types. This would help the system align better with a wider range of users and provide more accurate virtual try-ons.
- **Integration with Augmented Reality (AR):** Future implementations could include Augmented Reality (AR), allowing users to visualize how garments would look in real time through their mobile phones or AR glasses. This would create an immersive experience where users could see the clothing on themselves as if they were physically trying it on.
- **Cross-Platform Support and Globalization:** Expanding the platform to support multiple devices (e.g., mobile, desktop, AR glasses) and languages would increase accessibility for a global audience. Support for different sizing standards and cultural variations in fashion would also be important for international users.

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