An AI-Based Intelligent Fashion System For Virtual Try-On And Explainable Personalized Recommendation

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Abstract- *In this paper, we introduce a new Virtual Try-On System with the addition of an Explainable Suitability Analysis framework. Our Virtual Try-On System allows users to virtually try on clothes with images using a seven-stage pipeline. Our approach differs from existing Virtual Try-On Systems in its use of a neuro-symbolic approach to analyze the suitability of an outfit based on different occasions. We have used visual features like color, texture, and silhouette to analyze the suitability of an outfit with the help of a rule-based engine. Our approach combines image generation with intelligent decision- making.*

Keywords: Virtual Try-On, Computer Vision, Explainable AI (XAI), Neuro-Symbolic AI, Thin Plate Spline (TPS), Human Pose Estimation, Image Segmentation, Deep Learning, Feature Extraction, Rule-Based System, Fashion Recommendation, Cat VTON, Local Binary Patterns (LBP), Shannon Entropy, Fast API, Stream lit.

I. INTRODUCTION

The rapid expansion of e-commerce has fundamentally altered the fashion industry, enabling consumers to browse and buy fashion items via the internet. However, a significant hurdle in this sector is the lack of physical interaction with products prior to purchase, which leads to uncertainty and a rise in product returns.

Virtual Try-On (VTON) has come up as an effective solution in addressing this challenge by enabling users to virtually try on products by superimposing them onto their images. Current methods have mainly concentrated on creating realistic images using computer vision and deep learning. Nevertheless, they fail to offer meaningful insights regarding the suitability of the outfit. The proposed solution is based on an innovative Virtual Try-On System with Explainable Suitability Analysis. The system is based on an integrated solution involving geometric warping, neural rendering, and symbolic reasoning.

A seven-stage pipeline is adopted in this system, including pose estimation, segmentation, garment analysis, warping, rendering, feature extraction, and rule-based expert system analysis. The proposed solution provides an effective bridge between computer vision and intelligent decision-making, thus creating an informative and user-centric solution in the domain of digital fashion.

II. LITERATUREREVIEW

The advancement in Virtual Try-On (VTON) systems has attracted considerable attention in recent years, especially with the proliferation of online fashion retail. Initially, simple image overlay and 2D transformations were used for VTON, resulting in unrealistic results due to the inability to account for body pose and deformation. To overcome these limitations, advanced methods such as VITON and VITON-HD have incorporated deep learning for image-based virtual try-on. These methods focus on preserving details in garments and improving realism in output images. Recently, pose estimation models such as Media Pipe and Open Pose have been incorporated for accurate determination of body landmarks.

In addition, human parsing models such as SCHP (Self- Correction Human Parsing) have also been adopted for improving accuracy in layering. Geometric transformations such as Thin Plate Spline (TPS) have also been commonly used for addressing non-rigid transformations between flat garments and curved bodies. Generative models such as GANs and diffusion models such as Cat VTON have also greatly improved realism in output images.

Despite such improvements, most existing methods focus only on output appearance and lack decision capabilities. On the other hand, Explainable Artificial Intelligence (XAI) has also come to the forefront in recent years as an essential research area. Explainable AI focuses on ensuring explainability in decision- making processes. Techniques such as feature extraction using Local Binary

Patterns (LBP), Shannon Entropy, and clustering using K Means have been adopted for feature analysis in images. Despite such advancements in decision-making, limited research has been conducted on incorporating VTON systems with decision frameworks.

The proposed project aims to bridge this gap by incorporating computer vision, generative models, and rule-based expert systems for intelligent fashion recommendation systems. The proposed system is a significant advancement in intelligent fashion recommendation systems.

III. PROBLEM STATEMENT

The rapid rise of online fashion retailers has fueled the demand for more interactive and personalized online shopping experiences. However, current online shopping platforms do not offer adequate solutions for users to visualize how a garment would look on their body before purchasing. This has led to uncertainty in decision-making, user satisfaction, and a high rate of returns.

Existing Virtual Try-On (VTON) solutions, although trying to solve this problem by employing computer vision and deep learning technologies, mainly emphasize realistic image synthesis. These solutions, however, do not offer valuable insights on whether a chosen outfit is suitable for certain events, such as interviews, formal events, or casual events. Therefore, users are left in a dilemma when it comes to choosing suitable outfits.

In addition, existing solutions do not offer explanations on how a decision is made, leaving users in a dilemma. Therefore, there is a pressing need for a system that, in addition to realistic image synthesis, can evaluate how suitable a garment is for a given event, based on interpretable features. The problem is, therefore, how to design and develop an intelligent Virtual Try-On system that can offer realistic image synthesis and decision-making, allowing users to make confident fashion-related decisions.

OBJECTIVE

The main objective of this project is to develop an intelligent system for Virtual Try-On, where users can virtually try on clothes over their images and receive appropriate feedback regarding outfit suitability.

- Developing a multi-stage pipeline for pose estimation, human segmentation, and garment alignment for accurate virtual try-on.
- Implementing geometric warping methods such as Thin Plate Spline (TPS) for realistic transformations of garments onto human body shapes.
- Improving the quality of output through neural rendering methods for realistic try-on results.
- Extracting key visual features such as color, texture, contrast, and silhouette from garments using computer vision methods.
- Developing an intelligent system for outfit suitability using rule-based expert systems and fashion rules for various occasions.
- Integrating Explainable AI (XAI) concepts for providing appropriate feedback to users.
- Developing an efficient backend using Fast API for effective execution and an interactive frontend using Stream lit

EXISTING SYSTEM

Existing Virtual Try-On (VTON) systems are widely used in online fashion platforms to offer a digital preview of clothing for users. Early VTON systems used simple image overlay techniques, where images of clothing are simply overlaid on user images. These techniques were not very accurate in overlaying images and did not account for body pose and clothing shape.

With advancements in computer vision and deep learning techniques, newer systems like VITON and VITON-HD offer more realistic try-on experiences by incorporating techniques like pose estimation and image synthesis. Human parsing techniques are also used in these systems for better layering of clothing. These systems offer more realistic try-on experiences than earlier systems.

Existing systems, including VITON and VITON-HD, are mainly focused on offering a realistic try-on experience. They do not offer any evaluation of outfits. These systems do not offer any evaluation of outfits in terms of context, such as occasion or user preferences. These systems do not offer any explanations for try- on, thus failing to provide explanations for try-on. Thus, existing systems are limited to offering try-on experiences and do not offer intelligent decision-making.

IV. PROPOSED SYSTEM

The proposed system includes an advanced "Virtual Try-On" feature along with "Explainable Suitability Analysis" that aims to overcome the limitations of existing systems. The proposed system is different from existing systems since it does not only rely on visualization techniques for virtual try-

on but also includes computer vision and deep learning techniques for more realistic results and meaningful analysis.

System Overview

The proposed system includes a multi-layered architecture with the following components:

- Data Layer
- Processing (Module) Layer
- API Layer (Fast API)
- Frontend Layer (Stream lit)

The user has to input their image along with a garment image and a choice of occasion. The proposed system processes these inputs according to a structured processing pipeline and produces a try-on image along with a verdict of suitability and a confidence score.

Seven-Stage Processing Pipeline

The proposed system includes a seven-stage processing pipeline for more precise results:

- Pose Detection – This module is for the detection of body landmarks through pose estimation.
- Segmentation – This module is for the segmentation of the body to detect the clothing area.
- Garment Analysis – This module is for the analysis of the features of the garment.
- Geometric Warping – This module is for the warping of the garment through the Thin Plate Spline (TPS) technique.
- Cloth Composition – This module is for the composition of the cloth and the user image.
- Neural Rendering – This module is for the enhancement of the image through the use of the diffusion-based neural model.
- Suitability Analysis – This module is for the analysis of the appropriateness of the outfit through.

Feature Extraction Module

The system identifies the following key visual features of the garment:

- Color (using K Means Clustering in HSV color space)
- Texture (using Local Binary Patterns and Entropy)
- Contrast and Brightness
- Silhouette (shape and fit analysis)

These features serve as the basis for intelligent decision- making.

Rule-Based Expert System

One of the major contributions of the proposed system is the inclusion of the rule-based expert system.

It includes a set of pre-defined fashion rules (40+) that assess the suitability of the outfit for events like interviews, parties, and casual gatherings.

The system produces the following results:

- Suitability Verdict (Suitable/Not Suitable)
- Confidence Score
- Reasons for the decision.

Asynchronous Backend Processing

The system utilizes the Fast API framework, along with asynchronous processing, for backend computations.

A job-based system will be implemented for handling the request, including the following states:

- Queued
- Running
- Completed

This will ensure the smooth functioning of the system without any delays in the user interactions.

User Interface

The frontend will be implemented using the Stream lit framework, providing the users with an interactive interface for:

- Uploading the image
- Tracking the progress
- Viewing the results and analysis

Key Advantages of Proposed System

- Incorporates visual generation + intelligent decision-making
- Delivers Explainable AI (XAI) results
- Employs Neuro-Symbolic approach (AI + Rules)
- Boosts user confidence in online shopping

V. METHODOLOGY

The system proposed here is based on a structured approach that combines computer vision, deep learning, and rule-based reasoning. The methodology is broken down into several stages as follows:

1. Input Acquisition

The system starts by acquiring the user inputs, which include the person image, garment image, and the selected occasion type. The user inputs form the basis of the system. The user inputs include the person image, garment image, and the selected occasion type, which can be interview, party, or casual, among others.

2. Pose Detection

The person image uploaded by the user is then subjected to pose detection using a pose estimation model. The pose detection model detects the key landmarks of the human body, such as the shoulders, hips, and torso. The landmarks form the basis of the correct alignment of the garment with the human body structure.

3. Human Segmentation

The system then performs human segmentation, which involves segmenting the human body into different parts. The system then segments the human body into different parts, with the upper region of the human body being the target region. The system then retains the arm region.

4. Garment Feature Extraction

The image of the garment is processed to obtain the essential visual features:

- Color features through clustering
- Texture features through Local Binary Pattern (LBP)
- Brightness and contrast
- Shape features

These features would be required for the suitability analysis.

5. Geometric Warping

The flat image of the garment is mapped to the human body by applying the Thin Plate Spline (TPS) transformation to the image of the garment.

6. Cloth Composition

The image of the garment is composited onto the image of the user by the masking method. Smooth transitions of the images are ensured by refining the edges, followed by the overlaying of the original body parts such as the arms.

7. Neural Rendering

The deep learning-based rendering model smoothes the image in terms of texture, light, and shadow. This is an important aspect of creating a realistic image for virtual try-on.

8. Suitability Analysis

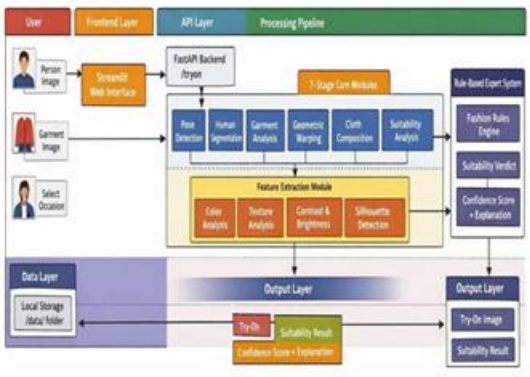
The extracted features are then analyzed by the proposed rule- based expert system. The proposed system analyzes the suitability of the outfit for a particular occasion using predefined rules and produces the results along with confidence values.

9. Result Generation

Finally, the proposed system produces the following results:

- Virtual Try-On Image
- Verdict for Suitability
- Confidence Values
- Explainable feedback

VI. SYSTEM ARCHITECTURE



VII. RESULT AND DISCUSSION

The developed Virtual Try-On System with Explainable Suitability Analysis was implemented and tested via the web interface. The system shows the efficient integration of frontend, backend, and intelligent analysis. The

results obtained from the different modules are presented in the following discussion:

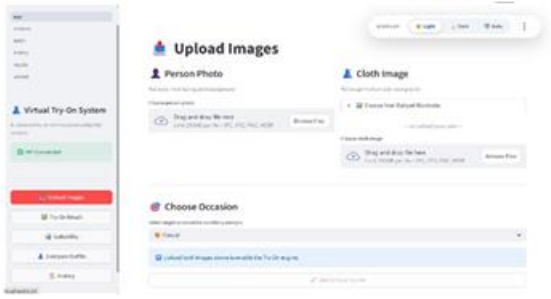


Fig.1 Upload Interface (Input Module)

The system also provides a feature of a user interface wherein the image of a person and the image of a garment can be uploaded along with the occasion. There is also a feature of a dataset-based selection of a garment and a feature of a drag and drop functionality. The system validates the input correctly.

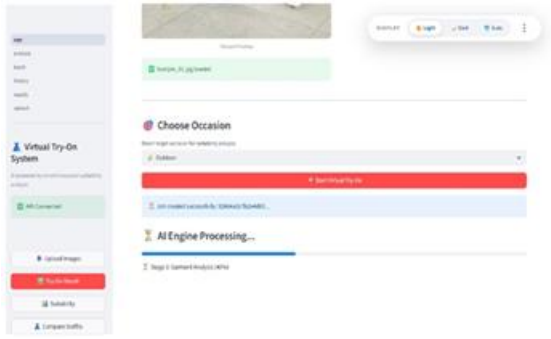


Fig. 2 Try-On Execution Processing

After the provision of the inputs, the execution of the try-on process is carried out through the backend API. A new job ID is generated for the process, and the system undergoes several stages such as garment analysis, warping, and rendering. The progress bar represents the stages of the processing pipeline, which is a clear indication of the effectiveness of the asynchronous job handling.

Fig. 3 Virtual Try-On Output

The system provides a comparison view of "before" and "after" for the user, allowing them to clearly see the original image and the result of the try-on operation. The results show a realistic alignment of the garments, scaling, and blending with the user's body. This verifies the success of pose detection, segmentation, and geometric warping techniques applied in the process.

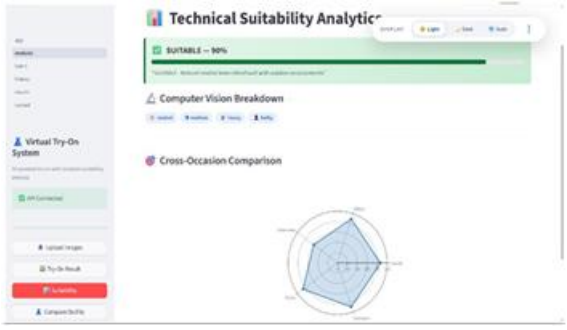


Fig. 4 Suitability Analysis Output

The system provides a clear output for suitability analysis, which includes the following components:

- Suitability Verdict (for example: Suitable)
- Confidence Score (for example: 90%)
- Occasion-specific evaluation
- Explanation based on extracted features

This is supplemented by a computer vision analysis, which includes components such as color tone, texture level, and silhouette. This is a demonstration of the AI explanation rather than a simple visual output.

Another page is designed for displaying the results of the suitability analysis in a structured way with progress indicators and informative messages. This page is useful for effectively communicating the complex results of feature extraction to human users.

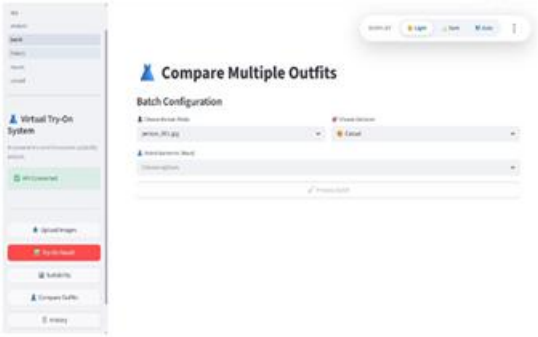


Fig. 5 Batch Processing (Compare Outfits Module)

The system supports the comparison of multiple garments for a single user image. This feature is useful for

users as it enables the comparison of various outfit options at once, thus making the system highly applicable and practical in real-life scenarios.

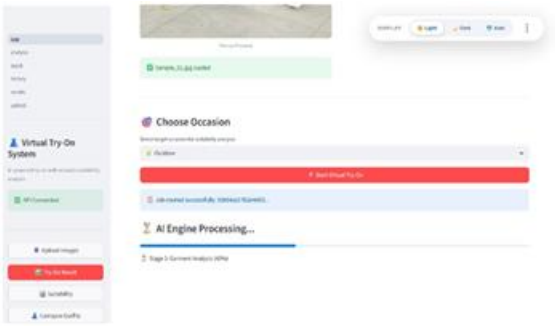


Fig. 6 Backend Performance and Workflow

The backend performance using Fast API is efficient in managing requests through an asynchronous job system. The lifecycle of the jobs, which includes Queued, Running, and Completed, helps in the smooth execution of computationally expensive tasks. The use of the polling mechanism between the frontend and backend helps in the real-time update.

The results demonstrate that the proposed system effectively combines computer vision and rule-based intelligence to deliver both realistic visualization and meaningful analysis. The try-on outputs are visually convincing, while the suitability analysis provides valuable decision support. Compared to traditional systems, this approach enhances user experience by integrating explainability.

However, minor limitations were observed in handling complex poses and variations in lighting conditions, which may affect accuracy. Despite these challenges, the system performs reliably under standard conditions and proves to be a significant advancement in intelligent fashion recommendation systems.

VIII. EVALUATION

The performance of the proposed Virtual Try-On System will be evaluated and validated with respect to the quality of images, the performance of the system itself, and Suitability Analysis. Test cases will be performed with respect to the images of the users in various occasions.

a. Evaluation Metrics

The performance of the proposed system will be validated with respect to the following parameters:

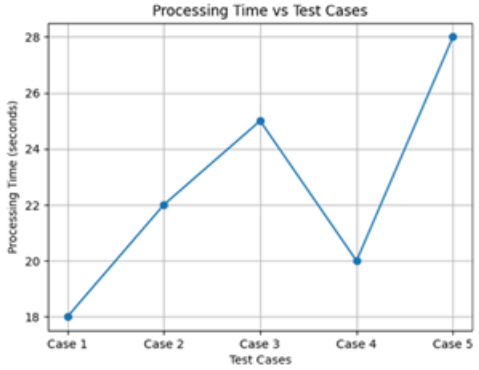
- Visual Realism - Quality of Images
- Alignment Accuracy - Accuracy of Garments' Fitting
- Processing Time - Time required to execute the system completely
- Suitability Accuracy - Accuracy of the verdict

User Experience - Experience of the users while interacting with the system

b. Experimental Results Table

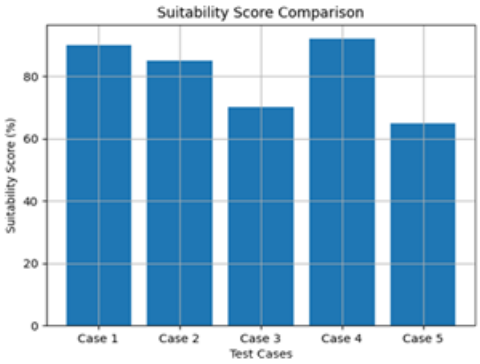
Test Case	Processing Time (sec)	Visual Quality	Alignment Accuracy	Suitability Score (%)	Verdict
Case 1	18	High	Accurate	90	Suitable
Case 2	22	High	Slight Variation	85	Suitable
Case 3	25	Medium	Moderate	70	Acceptable
Case 4	20	High	Accurate	92	Suitable
Case 5	28	Medium	Slight Misalignment	65	Not Suitable

c. Performance Analysis



Processing Time vs Test Cases

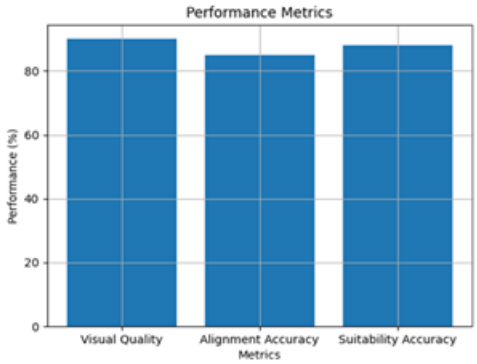
- The system was able to attain high visual realism except for a few instances by the application of warping and rendering.
- The system was able to attain high accuracy for the alignment of images, especially for frontal poses. However, the accuracy of the system for complex poses is slightly low.
- The average processing time of the system varied from 18 to 28 seconds.
- The performance of the rule-based analysis of suitability is satisfactory.



Suitability Score Comparison

d. Sample Graph Description

To compare the suitability scores of different test cases, a bar graph has been created. It has been found from the results that the system is performing well with a consistency of scores higher than 80%. A line graph showing the processing times has also been created.



Performance Metrics Bar Chart

IX. ADVANTAGES

- Realistic Virtual Try-On Experience

The system gives a realistic try-on experience to the user by generating images using computer vision.

- Explainable AI Integration (XAI)

Unlike other AI models, it gives an explanation for the suitability of the outfit for the user.

- Neuro-Symbolic Approach

The system combines a deep learning model with a rule- based expert system for decision-making.

- Accurate Garment Alignment

The use of Thin Plate Spline (TPS) for outfit alignment gives a perfect fit for all body types.

- Feature-Based Analysis

The system gives a scientific analysis of the suitability of the outfit by analyzing features.

- Occasion-Based Recommendation

The system gives recommendations to the user based on different occasions, such as interviews, parties, and hangouts.

- User-Friendly Interface

The use of Stream lit for interface development gives a user-friendly interface.

- Efficient Backend Processing

The use of Fast API gives a fast and efficient backend for processing user requests without any hindrance.

- Scalability of the System

The system is highly scalable, providing ease of adding new features.

- Supports Multiple Outfit Comparison

The system gives options for comparing multiple outfits for better decision-making by the user.

X. CONCLUSION

This project was based on the development of a novel Virtual Try-On System, along with the integration of Explainable Suitability Analysis, to overcome the limitations faced by the current fashion visualization tools. The proposed system was able to successfully incorporate computer vision, geometric warping, and neural rendering for generating try-on images. In addition, the system also provides outfit suitability analysis using rule-based expert systems, based on the features identified, such as color, texture, and silhouette.

The development of the seven-stage processing pipeline was able to ensure accurate garment alignment, along with image synthesis. The Explainable AI (XAI) incorporated into the system also provides the necessary feedback, such as the suitability verdict, to the users. The experimental results obtained for the system showed its effectiveness in the field, based on the visual realism, accuracy, and reliability.

The asynchronous backend, along with the interactive frontend, also helped the system deliver a smooth user experience. The proposed system was able to bridge the gap between image synthesis and intelligent fashion recommendation, thus providing an overall comprehensive solution for the current digital retail industry. The development provides a strong foundation for the advancement of AI-based fashion technology in the future.

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