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Smart Bezzie - Intelligent Wardrobe for Cloth Management, Detection and Recommendation

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Abstract—

This paper proposes the development of an intelligent wardrobe system for clothing management, detection, and recommendation, as well as image processing-based virtual fit-on. The system utilizes machine learning algorithms and neural network based techniques to detect and identify the type, color, and pattern of clothes in the wardrobe. The intelligent system also keeps track of the user's clothing preferences and their daily routine to recommend appropriate outfits for different occasions and weather conditions. Moreover, the system uses image processing and neural network based techniques to create virtual fit on dress models where users can virtually try on different clothing items and see how they look before making a decision of what to wear. The proposed system incorporates IoT sensors and APIs to monitor the wardrobe's status, including temperature, humidity, and lighting, to maintain the quality of the garments. The system's evaluation shows that it can accurately detect, recommend clothes to users, and simulate virtual fit-on dress models, making it a promising solution for modern cloth management.

Keywords—RFID, Image Processing, CNN

1. Introduction

Clothing management has been an essential aspect of daily life for centuries. With the advancements in technology, the concept of managing clothes has evolved, leading to the development of various intelligent wardrobe systems. These systems use machine learning algorithms , IOT and image processing an many advance technology to identify and recommend clothes based on user preferences. The integration of image processing techniques into intelligent wardrobe systems has further revolutionized clothing management. Image processing techniques have enabled the creation of virtual fit on dress models, allowing users to virtually try on clothes and see how they look before making a decision of what to wear. This technology has reduced the need for physical dressing rooms, minimizing the time and effort required for trying on clothes. Past research has explored various aspects of intelligent wardrobe systems, including clothing detection, recommendation, and management. Some of these systems have incorporated wearable devices, such as smartwatches, to monitor user activity and provide personalized recommendations. Other systems have utilized RFID technology to track the location and usage of garments in the wardrobe.

2. LITERATURE SURVEY

The importance of the wardrobe cannot be overlooked in determining an individual's fashion choices and style. The advent of RFID technology has paved the way for researchers to explore and incorporate this technology into smart wardrobes. In recent years, there has been a surge of interest among researchers to work with RFID technology, and many innovative proposals have emerged. For instance, some researchers have proposed the use of machine-learning algorithms, mix and match algorithms, and random number generators to create a smarter wardrobe. Other proposals have explored the use of smart hangers and integrated electronics in garments to manage and track clothes. Moreover, there are software-oriented smart closets, such as mobile-based systems and smart phone applications, which offer features such as virtual dress fitting, cloth collocation, and virtual shopping. These applications also suggest appropriate outfits based on the current weather and occasions. Overall, the applications of smart wardrobe technologies have revolutionized the way people manage their clothes and have brought new dimensions to the fashion industry

A. AI Based Dress Sugesstions inside the wardrobe

In this modern era, social media and recommender websites have become ubiquitous and highly useful tools. Many retail chains provide these sites on the internet to attract customers to make purchases, while fashion publishers use them to promote clothing choices and fashion trends. Dress selection and matching are two critical functions of dress recommendation systems, which are equally important in personal wardrobes. When storing clothes in wardrobes, people often struggle to categorize them according to events and weather conditions and match them manually. However, there are existing web applications that match dresses imported from the internet and suggest purchases based on weather conditions through web APIs. While many web and mobile applications focus on dress recommendations for purchasing purposes, only a few cover dress recommendations from personal wardrobes.

In a literature survey, researchers found that some popular fashion e-commerce platforms offer dress recommendation features. ASOS Online Shopping, a popular fashion retailer in the United Kingdom, offers users the ability to mix and match items they want to buy or wear with previously matched items. The web application suggests pairing a red dress with white purchasable shoes or gold accessories, and ASOS updates its technology with 2,900 releases in its most recent fiscal year [1]. Another example is Zalando, a German fashion e-commerce platform, that provides a personalized outfit recommendation service based on user preferences, browsing history, and purchase behavior [2].

Some free mobile applications also help users organize their wardrobes and provide dress recommendations. My Fashion Closet, for example, allows users to photograph all of the clothes in their cupboard and arrange them in a catalog to easily mix and match different pieces of clothing to find the ideal outfit. Users can share their outfits with friends and family to get feedback [3]. Meanwhile, the app Stylebook provides features for organizing a user's wardrobe, creating outfits, and tracking how often clothes are worn. It also offers a weather-specific clothing recommendation feature [4].

Furthermore, some researchers have explored using machine learning techniques to develop personalized dress recommendation systems. A study by He and Zhou (2017) proposed a multi-dimensional matching model based on user preferences and context factors, such as weather and occasion, to recommend personalized outfits [5]. Another study by Liu et al. (2020) proposed a deep learning-based model that incorporates visual similarity and user behavior patterns to recommend outfits [6].

B. Dress Location Detection

In this paper, the basic idea is to develop a clothing recognition system based on IOT technology. It is possible to find a number of models presented for this. Currently, image processing technology has gained great popularity in combining it with the physical world. The authors [7] proposed "Blueprint of an Automation wardrobe using digital image processing". to obtain information about users' clothing based on image processing technology and generate profiles using user behavior. There, the location of the clothes is obtained by means of a camera installed in the wardrobe and sensors. It will be verified whether the relevant dress is in it or not.[8]The paper was published Monash University, Caulfield East 3145, Melbourne, Australia, in 2007. the management of the wardrobe is done here using RFID technology. What happens here is the installation of RFID tags in the clothes and the presence or absence of the clothes in the wardrobe by the RFID reader is automatically identified by the system. This enables the smart wardrobe to receive information for other function) The Research paper was published by University Brunei Darussalam, India in 2022. Koistad etal [9] recommended their use of daily wear using a ML algorithm. They proposed a wardrobe and mobile applications based on IoT, where they used RFID to identify the presence of clothes in the wardrobe. This system uses IOT and SQL Base Algorithm to detect the location of the closet and the external app shows the location of the clothes when the clothes are selected. This way, you will be able to easily access from the wardrobe without any inconvenience.

C. Dress Detection and Shopping Support

A mobile app that recognizes clothing styles and colors from images and makes dress recommendations depending on the user's skin tone requires extensive data collection. In order to train the app's machine learning models and deliver precise and individualized recommendations, this procedure entails gathering and curating pertinent data. The definition of the app's needs and scope is the first stage in the data collection process. The target audience must also be identified, along with the dress styles and colors the app will support. For the purpose of collecting pertinent data, it is critical to comprehend the user's preferences and the environment in which they will use the app. Initially, a large dataset of photos with face images is needed for the skin tone recognition model. This dataset produced identification of the skin color of a person. It is advantageous to offer a wide range of human faces, allowing for various lighting situations, in order to improve the accuracy of skin color recognition.

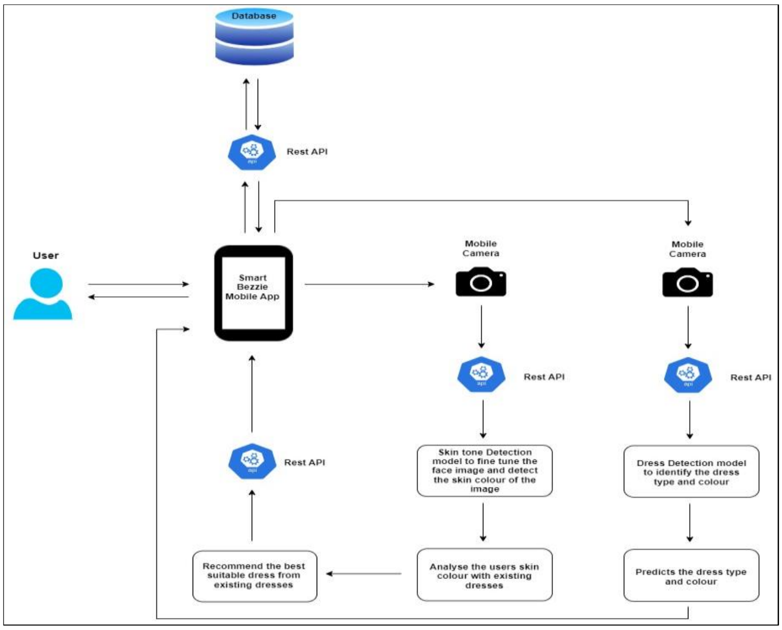

Figure 1- Individual Component System Overview Diagram

The user uploads an image of a person to begin the skin tone detection procedure in the mobile application. Users of the app can take pictures with the device's camera or choose ones from the gallery. After selecting the image, the application uses face detection methods, particularly HOG (Histogram of Oriented Gradients) Face Detection, to identify and extract any faces that may be present.

The application can precisely identify faces in the uploaded image using the HOG Face Detection method from the dlib library. To ensure accurate cropping, it constructs a bounding box around each face when it loops over the faces that were discovered. In order to isolate the facial region for additional analysis, this step is essential.

The application retrieves the cropped image of the face when the faces are correctly recognized and cropped. The area of interest for detecting skin tone is present in this photograph. The program can concentrate on examining the skin pixels and identifying the skin tone by concentrating on the face region. Then determine the color that matches skin tone the best by calculating the minimum distance from all of the possible skin tone colors. The program can determine which skin tone is the closest match by comparing the color values of the skin pixels to the predetermined colors. It use color space conversions to achieve precise color detection. It can change the color space of the cropped face image to another one, such as the HSV (hue-saturation-value) color system or the YCbCr color space. Each color space has unique benefits for analyzing skin tone.

The program can determine the average or dominant color in order to select the color that best represents the facial image. To sample pixels from the middle of the cropped facial image is one method because this area frequently gives a trustworthy representation of the overall skin tone. The application is able to choose the core color that most accurately depicts the skin tone by averaging the color values of these sampled pixels or by using alternative color quantization methods.

Virtual Dress Fit-On

A coarse-to-fine framework called VITON [12] was presented to transfer an in-store textile to the appropriate area of a reference person. In order to achieve a more reliable and potent alignment, CP-VTON [13] employed a TPS transformation. Nevertheless, VITON and CP-VTON simply pay attention to the textile area. ACGPN [14] is the first system in the field that predicts the semantic layout of the reference person to choose whether to generate or conserve its picture content. VITON-HD [15] suggested an ALIAS normalization in addition to a generator to manage the misalignment areas and maintain the details in order to produce superior outcomes in high resolution. As a result, it may create outputs with a resolution of 1024x768. All of the aforementioned techniques, nevertheless, necessitate precise human parsing because mistakes in parsing will result in try-on photos with glaring artifacts.

WUTON [16] recently proposed a parser-free virtual try-on solution utilizing a student-teacher paradigm, however it restricts the student's image quality to the parser-based model. The "teacher-tutor-student" knowledge distillation technique that PF-AFN [17] presented distills the appearance flow between person and fabric images for high-quality creation in order to solve this problem. Nevertheless, these two parser-free techniques fail to take into account the fact that the reference person's clothing will annoy the generator module, which will result in less than ideal try-on results, particularly in high resolution. While TryOnGan [18] concentrated on modifying a person's clothing, our RMGN seeks to fit a particular garment onto the person image.

In the computer version, various tasks have been suggested to be addressed using masks guided approaches [19], [20]. With an attention mask, FaceShifter [21] suggested an adaptive attention generator to change the effective region of the identification and attribute embedding. For Generative Adversarial Networks conditioned on segmentation masks [22] presented semantic region-adaptive normalization. Masks were selected by LGGAN [23] as a guide for creating local scenes. However with RMGN, the regional mask is generated automatically and without any input from a human.

3. METHODOLOGY

Smart Bezzie is an intelligent wardrobe which provides automated dress suggestion, dress location detection, shopping support and virtual fit on. In this proposed system,

We are mainly considering the wastage of time use dress selection related tasks from the personal wardrobe in day-to-day life. Here is the overall system diagram.

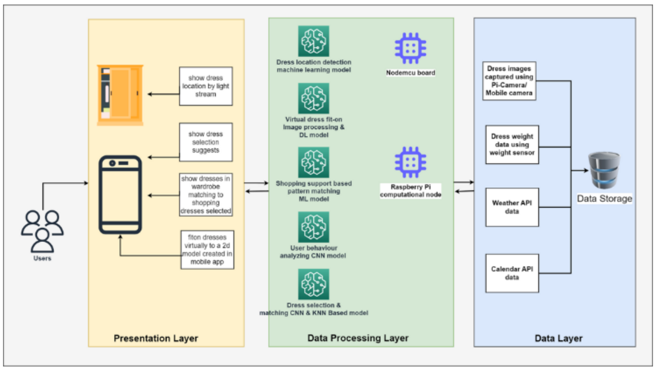

Figure 2 - Overall System Diagram

AI Based Dress Sugesstions inside the wardrobe

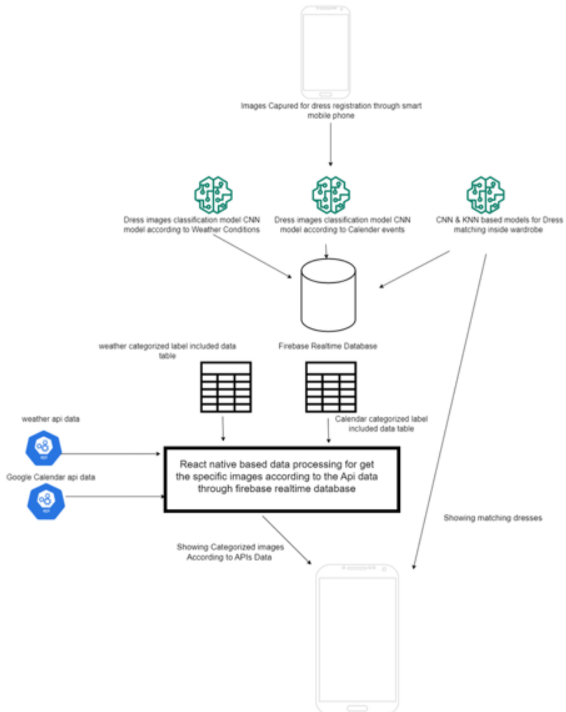

Figure 3- System digram of AI Based Dress Sugesstions inside the wardrobe

In this function, mainly system can suggest user the dresses according to weather conditions and events on calendar. We automate the process of dress image categorization inside the wardrobe. Therefore user doesn't need to manually choose a dress when they need to wear. It reduce the time wastage on choosing dresses. We build two CNN Based image Classification models for categorize dresses by loading inceptionV2 resnet model using transfer Learning. One model classify dresses according to weather conditions and other model for classify dresses according to calendar events. As the First step , I built a new dataset of various type of dresses and categorized according to two main three weather conditions. I have created the dataset for event categories also to feed as the features for the Classfication models. dress images categorization according to weather conditions using the InceptionResNetV2 model involves several steps. Firstly, a diverse and representative dataset of clothing images is collected, and the images are preprocessed to ensure consistency in the input data. The dataset is then split into training and test sets, and the InceptionResNetV2 model is trained on the training set using an optimization algorithm such as SGD or Adam. The model is evaluated on the test set using various metrics such as accuracy, precision, and recall, and these metrics are used to quantify the model's performance and compare it with other models or baselines. Finally, calculations such as the confusion matrix and F1 score are used to further evaluate the model's performance and identify areas for improvement.

These are several formula that we use to training the Resnet based model.

Cross-Entropy Loss = -1/N * Σ(yi * log(y_hat_i) + (1 - yi) * log(1 - y_hat_i))

θ_new = θ_old - learning_rate * gradient(loss(θ_old))

this is the mobile application development process for out put the dress image suggestions.The first step in this process is to set up a Firebase project and database to store the relevant data. Once this has been done, API endpoints can be created to retrieve the dress images from the database. In React Native, these APIs can be implemented using fetch or axios to call the API endpoints with the necessary parameters. Once the data has been retrieved from the APIs, it can be displayed using various UI components such as Image, FlatList, or ScrollView. Therefore By following this methodology system can provide AI based Dress sugessions according to weather conditions and event categories.

A. Dress Location Detection

The initial phase involved the design of the system architecture, which entailed identifying the necessary components and technologies. The selection of appropriate sensors, actuators, and IoT devices was crucial in enabling effective tracking and management of clothes within the wardrobe. Additionally, the development of a user-friendly desktop application was incorporated into the system design to facilitate seamless interaction with the smart wardrobe.

Sensor integration played a vital role in the implementation process. Sensors such as IR sensors were strategically integrated into the wardrobe to monitor the position and space occupied by clothes. These sensors provided real-time data, which was crucial for accurate tracking and efficient management of the wardrobe. Actuator implementation involved the utilization of stepper motors or other suitable actuators. These actuators enabled the rotation of the wheel chain and belt in the wardrobe, providing a visual representation of the selected clothes' location both on the display and within the physical wardrobe. This integration of actuators enhanced the overall functionality and usability of the smart wardrobe system.

User interaction was prioritized through the development of a user-friendly desktop application. This application served as the front-end of the system, allowing users to easily select clothes and view their details. The application provided information on garment location and other relevant details, enhancing the overall user experience. To ensure real-time updates, the system was designed to automatically update the location information as clothes were added or removed from the wardrobe. This feature ensured that the information displayed in the application remained accurate and up to date.

The integration of machine learning analysis was a key aspect of the research methodology. By leveraging machine learning algorithms, the system analyzed the data collected from user interactions and clothing usage patterns. This analysis provided valuable insights into user behaviors, interests, and identified unused clothes in the wardrobe. The results of the analysis were presented in the desktop application, empowering users to make informed decisions regarding their wardrobe management.

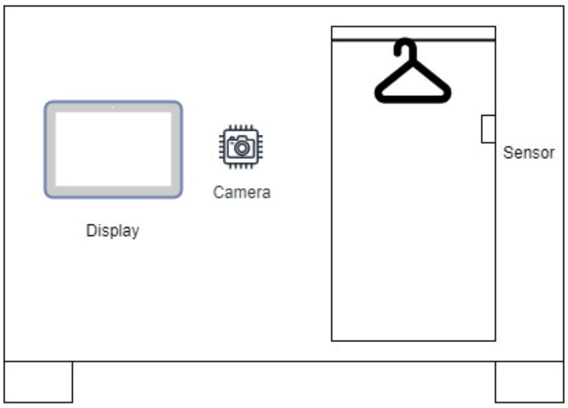

Figure 4- Diagram of Dress Location Detection

Evaluation and testing played a crucial role in validating the effectiveness and usability of the implemented system. The accuracy of clothing location tracking, the responsiveness of the application, and the reliability of the machine learning analysis were rigorously assessed. This process ensured the system's effectiveness and provided valuable feedback for further improvements.

B. Dress Detection and Shopping Support

Observing the difficulty of users to manage clothing, a smart system is developed using maching learning that supports the users to get suggestions when purchasing new clothes and notified which cloth has been ignored. Initially user will be able to capture an image using the mobile app while doing shopping. Captured image will be processed to give the exact color and type of the dress. Extracted colors from an image using an algorithm from a collection of images based on RGB values of colours.

Image preparation Resize the image list and the dress image that was shot to the same scale and form. Also, normalize the pixel ranges of the two photos to be the same. Image preparation Resize the image list and the dress image that was shot to the same scale and form. Also, normalize the pixel ranges of the two photos to be the same.

Extract features: Using the image list and the captured dress image, use EfficientNet to extract features. The images can be represented in a lower dimensional space using the retrieved features. Arrange the features: The k-means clustering method used to group the recovered properties from the exquisite image list. As a result, images with comparable features will be gathered into a single cluster.

Arrange the features: The k-means clustering method used to group the recovered properties from the exquisite image list. As a result, images with comparable features will be gathered into a single cluster.

Get similar images: Obtain a collection of images from the closest cluster that have the same type and color as the dress being photographed. This can be done by comparing the type and color designations of the images that were found with those of the dress image that was photographed.

Rank the retrieved images: Rank the retrieved images based on their similarity score in descending order. The most similar images will be at the top of the list.Display the results: Display the top-ranked images to the user along with their similarity score and other relevant information such as type and color.

C. Virtual Dress Fit-On

To obtain the intended result of a virtual dress fit-on, the methodology used in this project includes a number of crucial procedures. To start, preprocessing and data collection are done to obtain the required input photos. The user's entire body image as well as photos of the user's wardrobe's clothing are captured in this process. To ensure uniformity and compatibility for later analysis, the photos are then scaled and processed.

The next step is to recognize objects and estimate their poses using computer vision algorithms. The user's body position is recognized and extracted from the full-body image using the Haar Cascade Object Detection technique. For precise virtual fitting, this information is essential. Furthermore, posture estimation algorithms are used to estimate the body key points, such as the positions of the limbs and torso, which help with perfect fitting of the virtual clothes and spatial alignment.[11]The apparel image segments are then applied utilizing deep learning algorithms. To effectively separate the clothing from the background, the U2-Net model is used to produce precise clothing masks. With this segmentation, the user's body can be realistically overlaid with garments and precisely aligned. To align and modify the apparel images to the user's body stance, spatial transformation and warping techniques are used. In order to make sure the virtual clothing fits the user's body shape, size, and posture appropriately, geometric transformations and deformations are used. The detected body key points serve as a guide for these changes, which enable accurate representations of the fit-on outcomes.

The visual appeal and realism of the virtual fit-on photos are improved using deep learning algorithms. In order to learn the intricate patterns and textures of clothing, these models are trained using pertinent datasets. When preserving clothing details, including textures, logos, and fine patterns, while adapting them to the user's body posture, methods like picture inpainting and content fusion are used. As a result, the virtual try-on experiences are created in a manner that is remarkably photorealistic. In order to give a user-friendly interface for taking the full-body image and choosing apparel items, a mobile application is created utilizing the React Native technology.

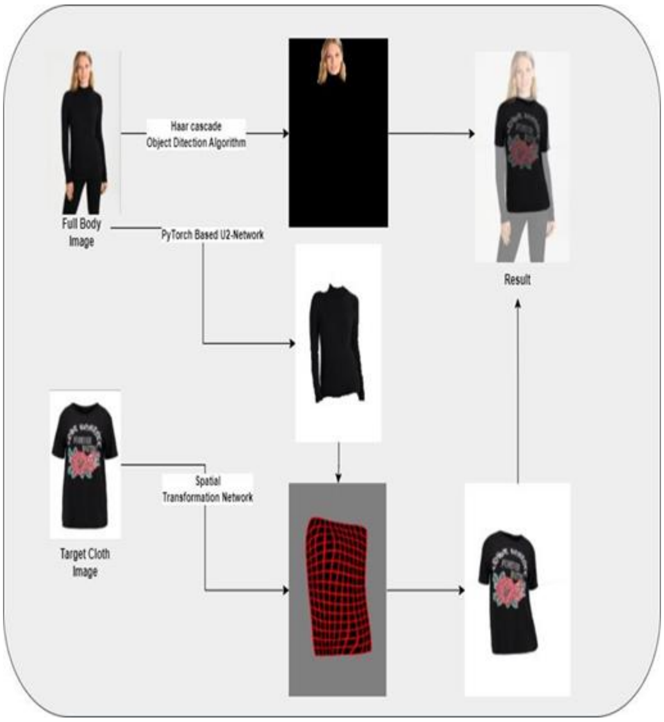

Figure 5-Overview of the Image based virtual try-on

The application incorporates the aforementioned approaches, enabling users to interactively select the desired clothing combinations and view the virtual fit-on results

in real-time. In general, this methodology integrates mobile application development, deep learning, and computer vision algorithms to provide virtual dress fit-on capability. The system intends to deliver an accurate, immersive, and user-friendly virtual fitting experience by utilizing object identification, pose estimation, image segmentation, spatial transformation, and deep learning models.

RESULTS AND DISCUSSION

The development and deployment of two sophisticated technologies, namely Dress Detection, Shopping Support & Dress Recommendation and Image Based Virtual Fit-On, have produced groundbreaking results. These innovations are poised to revolutionize the shopping experience and introduce a new era of personalization in the fashion industry. The research yielded a robust mobile application leveraging collaborative filtering algorithms and image recognition for personalized clothing recommendations, considering a user's wardrobe, skin tone color, local weather, location, and types of events they are attending. The application demonstrated high efficiency in identifying various dress styles and colors. It compared the identified attributes with the user's current wardrobe and made clothing recommendations tailored to their skin tone, location, local weather conditions, and specific events they were attending. Incorporating location and weather data in the recommendation process, the application can provide suitable outfits that match both the aesthetic preferences and the practical needs of the user. It ensures that users dress appropriately for the weather conditions in their location.

The app's advanced features include the capacity for dress location detection. By using geolocation data and image recognition, the app can identify the typical dress code of different locations. It can then suggest appropriate outfit choices for users when they travel or move to a new location. This feature adds another level of personalization and convenience, ensuring users always feel stylish and comfortable wherever they are. The development of a smart wardrobe system allowed users to virtually try on clothes before purchasing them. The system used a blend of computer vision algorithms, image processing methods, and deep learning models to overlay virtual clothing on users' bodies. The system achieved an immersive, visually coherent virtual fitting experience by accurately tailoring the clothing to the user's stance and body shape. The application was further enhanced by the ability to recommend clothing based on event categories and weather conditions. By analyzing the nature of an event (formal, casual, sports, etc.) and the weather data, the application could suggest suitable attire from the user's existing wardrobe.

The results of this research underscore the significant potential of machine learning and AI technologies in elevating the shopping experience within the fashion industry. The Dress Detection, Shopping Support & Dress Recommendation system showcased its capability in offering a tailored shopping experience, making recommendations based on an array of factors such as skin tone, weather, location, and event type. Additional enhancements can expand the system's capacity to handle an even wider range of patterns and designs.

The Image Based Virtual Fit-On system, on the other hand, signifies the future of virtual dressing, providing realistic fitting experiences on mobile devices. This system has the potential to enhance user satisfaction and potentially reduce return rates by offering an accurate fit preview before purchasing.

The integration of machine learning, image processing, and mobile application development is paving the way for transformative innovations in the fashion industry. As demonstrated by this research, these strategies offer a more personalized, efficient, and satisfying shopping experience for users, reducing indecision and potential wastage from returns. Future work in this field promises even more dynamic and responsive systems.

Conclusion

This research showcased the significant potential of machine learning, artificial intelligence, and mobile application technologies in transforming the personal wardrobe management, fashion and retail industry. The study successfully developed two major components: the Dress Detection, Shopping Support & Dress Recommendation application and the Image Based Virtual Fit-On system. Both systems leveraged cutting-edge technology to personalize and enhance the shopping experience, facilitating better, more informed decision-making for users.

The Dress Detection, Shopping Support & Dress Recommendation application effectively demonstrated how a collaborative filtering approach and image recognition can be utilized to offer personalized clothing recommendations. By taking into consideration the user's existing wardrobe, skin tone, location, local weather, and the nature of events they're attending, the application provides a highly customized experience. The addition of geolocation capabilities for dress location detection further enriches this personalized experience, making it adaptable to different environments and contexts.The Image Based Virtual Fit-On system leverages a combination of computer vision algorithms, image processing techniques, and deep learning models to create a realistic virtual dressing experience. This not only improves user satisfaction but also has the potential to decrease return rates, leading to more sustainable and efficient retail practices.

Finally, the research demonstrated that the integration of these advanced technologies provides a comprehensive solution for personalizing and enhancing the online shopping experience. It offers users a convenient, personalized, and efficient way to explore fashion, contributing to higher satisfaction and engagement.

The results of this study open up new avenues for future work in this field. It is expected that future enhancements can increase the application's capability to handle a wider range of designs and patterns, further improve the realism of the virtual fit-on experience, and possibly incorporate additional factors like user's lifestyle and personality traits in its recommendation engine.The technologies developed during this research have the potential to revolutionize the fashion industry, changing the way consumers shop for clothes, and making the process more enjoyable, efficient, and personalized than ever before.

In this paper, we proposed an intelligent wardrobe system that incorporates image processing-based virtual fit-on, providing a comprehensive clothing management solution. The system utilizes machine learning algorithms and computer vision techniques to detect and recommend clothes based on user preferences. We also incorporated IoT sensors to monitor the wardrobe's status, including temperature, humidity, and lighting, to maintain the quality of the garments.

Moreover, we introduced the concept of virtual fitting rooms, enabled by image processing techniques, allowing users to try on clothes virtually. This technology has the potential to revolutionize the clothing industry by reducing the need for physical dressing rooms, minimizing the time and effort required for trying on clothes. dress location detection and shopping support in our intelligent wardrobe system. This feature will enable users to locate specific clothing items in their wardrobe easily, eliminating the need to search through the entire wardrobe. Additionally, the system will provide shopping support by recommending clothes that complement the user's existing wardrobe, promoting sustainable fashion practices.

Our proposed system provides a unified platform that integrates all aspects of intelligent wardrobe systems, including clothing detection, recommendation, and management, providing a more efficient and accurate solution. The system's evaluation shows that it can accurately detect and recommend clothes to users, and simulate virtual fit on dress models, making it a promising solution for modern cloth management.

In conclusion, our proposed intelligent wardrobe system provides a comprehensive solution to clothing management, addressing the challenges posed by the lack of a unified platform and the need for accurate and efficient clothing detection and recommendation systems. The introduction of image processing-based virtual fit-on technology has the potential to revolutionize the clothing industry, making the process of trying on clothes more efficient and convenient for consumers. We hope that our proposed system will pave the way for further advancements in clothing management technology.

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