Smart Wardrobe Organizer

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Abstract: Finding clothes is painful and can be time-consuming. An automated smart wardrobe system for clothing management, detection, and recommendation of garments using a simple mobile application can largely help people. This application utilizes machine learning algorithms and neural network-based techniques to detect and identify the type, colour, 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 deciding of what to wear. The proposed system incorporates IoT sensors and APIs to monitor the wardrobe's status.

1.0 Introduction

Technology has made our day-to-day life more convenient through smart systems integrating Internet of Things (IoT). IoT is the branch of universal computing that helps to identify and locate things in real-world environments. A Smart system has the ability to collect and analyse the data to make a decision with the help of sensors and actuators

1.1. Sensors and actuators

Sensors and actuators help a smart system to monitor the environment, gather the data automatically, and effect the changes to that environment where necessary. Usually, such systems minimize displeasure of users that are brought through manual systems.

1.2 Requirement of Smart Wardrobe Organizer

In today's world, the economic standard of a large number of people is high enough to possess an excessive amount of clothes, shoes, and accessories than their basic needs. Therefore, managing closets has been a headache to those stylish people who are always in a hurry in this competitive world. At present, most of the people manage their wardrobes manually and sometimes they end up wearing the same clothes repeatedly, whereas a significant portion of their clothes remains unused. Considering that, Smart Wardrobe Organizer incorporates IoT to our daily life, to bring more user satisfaction by reducing the workload of the users.

1.3 Use of Smart Wardrobe Organizer

Considering the hassle of users to manage clothing, an automated smart wardrobe app helps the users to see the list of all the wearable, finds the location of cloth inside the closet, suggests outfit based on weather and occasion, etc. using digital image processing.

1.4 Report design

This report outlines the design, development, and functionality of the Smart Wardrobe organizer application, highlighting its innovative capabilities in organizing, suggesting outfits, and managing clothing inventory efficiently

In this report,

- Section 2.0 sheds light on the related research.
- Section 3.0 includes revised needs statement & target specification.
- Section 4.0 explains the conceptual design of the proposed system briefly.
- In Section 5.0 The implementation detail of the smart wardrobe has been discussed.

2.0. Customer Needs Assessment

Wardrobe plays a vital role to detect the user profile from the fashion preferences. Now a days, RFID technology has earned vast popularity to assembled physical environment with the virtual world. Smart wardrobe organizer uses RFID technology to get the user's dressing events and generate the user profile automatically by the system. The RFID reader will scan repeatedly all the RFID tags attached to each clothes to detect the presence or absence of a clothing item inside the wardrobe. If a clothing item is absent from the closet for a certain time duration, the system will consider it as worn. It used a machine-learning algorithm to recommend users their daily outfits. An IoT based wardrobe along with a mobile application use RFID tag to detect presence of outfits inside the closet and suggests cloths according to user's choice of colours, style, emotion and material criteria in three ways. Mix and match algorithm, random number generator and user scheduler is used to serve these purposes. Case-Based Reasoning based on Semantic Data Analysis (CBR-SDA) model is used to develop an intelligent clothing and accessories management. This smart wardrobe is designed considering the user's routine, situation, weather, mood etc. to improve user's lifestyle. Smart wardrobe app has embedded sensors for detecting garments inside the wardrobe and to identify what is taken out or placed into the wardrobe. The wardrobe suggests suitable garment pairings for purchase through a web interface when a user has taken out a piece of garment. This application also suggests appropriate outfits based on current weather condition and occasions. Table I shows some an initial customer needs list and Table II show types of customer list obtained from interviews and observations.

Table 1. Initial Customer Needs List Obtained from Interviews and Observations

Convenience
Personalized Recommendations
Virtual Try-On
Outfit Inspiration
Wardrobe Organization
Style Advice
Shopping Assistance
Event-Based Outfits
Body Type Analysis
Clothing Care and Maintenance
Sustainability
Social Sharing
Personalized Feed
Expert Advice

Table 2. Hierarchal Customer Needs List

1. Convenience (0.9)
    1.1 Hassle-free option to manage wardrobe,
    1.2 Time optimization for organizing and planning outfits.
    1.3 Dress Location Detection
2. Personalized Recommendations (0.79)
    2.1 Personalized outfit suggestions based on style, preferences and body type.
3. Virtual Try-On (0.65)
    3.1 To be able to try on clothes virtually, without having to physically change clothes.
4. Outfit Inspiration (0.6)
    4.1 Inspiration for new outfits and ways to style existing clothes.
5. Wardrobe Organization (0.8)
    5.1 A digital inventory of clothes, with details like color, type, and occasion.
6. Style Advice (0.75)
    6.1 Expert style advice and guidance on how to improve fashion sense.
7. Shopping Assistance (0.68)
    7.1 Help finding similar items or brands when shopping online or in-store.
    7.2 The suggestion of suitable outfits and Clothing
8. Event-Based Outfits (0.6)
    8.1 Outfit suggestions for specific events or occasions, like weddings or job interviews.
9. Body Type Analysis (0.65)
    9.1 Analysis and recommendations based on individual body type and proportions.
    9.2 Clothing dimensional measurements, for instance, bust, waist, shoulder-to hem, etc
10. Clothing Care and Maintenance (0.6)
    10.1 Tips and reminders on how to care for clothes, like washing and dry cleaning.
    10.2 Storing actionable events, such as items out to be cleaned or repaired are tracked
11. Sustainability (0.7)
    11.1 To know the environmental and social impact of clothing choices.
    11.2 Suggests arrangements for unused clothes, such as donate, exchange or sell
12. Social Sharing (0.67)
    12.1 To share outfits and fashion choices with friends and social media.
    12.2 Recognizes and arranges photos of user’s clothes in the right categories.
13. Personalized Feed (0.8)
    13.1 A personalized feed showing new arrivals, fashion trends based on preferences.
14. Expert Advice (0.79)
    14.1 Access to fashion experts and stylists for personalized advice and guidance.

3.0 Revised Needs Statement and Target Specification

3.1 Needs Statement:

Develop an AI-powered Smart Wardrobe system that utilizes machine learning algorithms to provide personalized fashion recommendations, virtual try-on, and wardrobe organization, while also offering expert style advice, shopping assistance, and sustainable fashion guidance.

3.2 Target Specification:

3.2.1 Primary Targets:

- **Fashion-conscious individuals (ages 25-45)**
- **Busy professionals seeking style convenience**
- **Environmentally aware consumers**

3.2.2 Secondary Targets:

- **Fashion influencers and bloggers**
- **Style enthusiasts seeking inspiration**
- **Individuals seeking personalized shopping experiences**

4.0 External Search

4.1 Machine Learning Requirements:

4.1.1Computer vision for image recognition and analysis

4.1.2 Natural Language Processing (NLP) for chatbot and voice assistance

4.1.3 Collaborative filtering for personalized recommendations

4.1.4 Deep learning for virtual try-on and style prediction

4.2 System Requirements:

4.2.1 User profiling and data collection

4.2.2 AI-powered fashion recommendation engine

4.2.3 Virtual try-on and augmented reality integration

4.2.4 Sustainable fashion guidance and eco-friendly recommendations

4.2.5 User-friendly interface and chatbot assistance

4.2.6 Continuous learning and algorithm improvement

4.2.7 Personalized shopping assistance and styling advice

4.3 Performance Metrics:

4.3.1 User engagement and retention

4.3.2 Accuracy of fashion recommendations

4.3.3 User satisfaction with virtual try-on

4.3.4 Increase in sustainable fashion choices

4.3.5 Reduction in user effort and time spent on fashion decisions

5.0 Concept Generation

Considering the wastage of time while dress selection related tasks from the personal wardrobe in day-to-day life. Smart wardrobe which provides automated dress suggestion, dress location detection, shopping support and virtual fit on. In this proposed system.

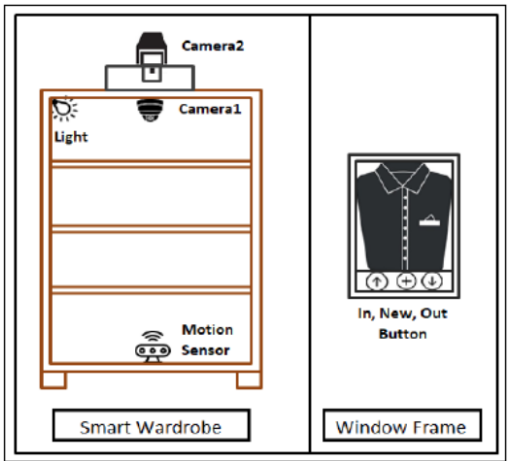

Figure 1:- Proposed Architecture of Smart Wardrobe Organizer

5.1 Conceptual Design:

The Smart wardrobe will be able to keep track of the clothes' location inside the closet using cameras. It will be possible to convert any ordinary wardrobe, irrespective of its size and structure, into a Smart wardrobe with the help of this concept. Installation of this system will make it very easy to keep track of clothes quickly, and thus day-to-day life will be easier on the user's part. The designed system will be both user-friendly and cost-effective. Besides

tracking the location of clothes, using the mobile application, user will also be able to keep the list of clothes according to prior categories, search for particular garments, see detailed information of each cloth and plan what to wear when. This application will also suggest user what to wear in what weather or for which occasion using AI.

5.2. Converting any Wardrobe into a Smart Wardrobe:

For converting any wardrobe into a Smart wardrobe, installer will fit one camera (Camera1) on the top of the wardrobe. Under Camera1, he will mark a particular area (by drawing a red border around that area) where the user will need to put his clothes before putting clothes inside the wardrobe or getting clothes out. Installer will have to mark the area, known as 'Photo Window', in such a way so that camera installed above it can get a clear picture of the clothes kept on it. Three buttons will be installed beside that 'Photo Window', regarded as - 'In', 'Out' and 'New'.There will be another camera along with motion sensor, installed on the upper edge of the wardrobe's door or in some place from where the closet is visible. Camera2 will take picture when the door opens as 'Previous State' (Image1) and whenever there will be some motion inside a specific range near the shelves as 'Current State'. The system will determine which clothing was kept into which shelf or partition of the closet by comparing Image1 to Image2. A light will be fitted inside the wardrobe to ensure good image qualities for both Camera1 and Camera2. It will be turned on whenever the wardrobe door opens. Using the mobile application user will be able to see up-dates of clothes kept in that wardrobe from his individual user account.

5.3 Working Procedure

The overall working procedure of the system [shown in Figure 2] has been delineated step by step below

Figure 2: Workflow diagram of Smart Wardrobe

5.3.1 Wardrobe Light:

The light inside the wardrobe will be turned on every time user opens the door of that wardrobe. It will remain on until the door is open and will turn off automatically as soon as the door closes.

5.3.2 Storing New Clothes:

Initially the user will need to list all his clothes along with their pictures in the mobile application. To store a new cloth he will have to put that clothe on 'Photo Window' after folding it correctly (with the collar of the cloth on the upper side of the folding). Then he will need to press the 'New' button. His press will trigger Camera1 and Camera1 will take a

picture of the cloth kept on the ‘Photo Window’. The system will send this image to the central database for further processing and a unique ‘Cloth ID’ will be assigned to that cloth. User can insert and edit further information (colour, price, cloth type, category) to regard that cloth using the mobile application for recording purpose.

5.3.3 Keeping Clothes Inside:

If the user wants to keep one of his listed clothes inside that wardrobe, he first needs to keep that piece of clothing on the ‘Photo Window’ and press the ‘In’ button. Camera1 will take pictures of that cloth and send it to the central database. By processing and comparing that image with the images of previously listed clothes, the system will find out the ‘Cloth ID’ of that clothing. When the user presses the ‘In’ button, Camera2 will also take a picture (Image1) of the wardrobe as Previous State’. The system will use this image to keep track of the cloth’s location. Camera2 will take a picture (Image2) when it will sense movement in the predefined range, known as ‘Current State’. The system will compare the image of ‘Previous State’ (Image1) and ‘Current State’ (Image2) to calculate the position of dissimilarity between these two images. This calculated position will be considered as the approximate location of the cloth which will be stored against that ‘Cloth ID’. When the user will click that cloth in the mobile application to know its position in the wardrobe, the application will show a red circle around that specific pixel location on the ‘Reference Wardrobe Image’. Apart from the location, the application will also show the date and time of keeping that cloth inside the wardrobe.

5.3.4 Taking Out Clothes:

The user will need to put a cloth on the ‘Photo Window’ before taking it out and press the ‘Out’ button in order to keep track of clothes that have been taken out of the wardrobe. Camera1 will take its picture and using the same image comparing procedure the system will figure out its ‘Cloth ID’. Then the system will update its location as ‘Outside the wardrobe’ and will also record the date and time of taking out that cloth.

6.0 Implementation Of Smart Wardrobe

The cardinal goal of the proposed blueprint design of the smart wardrobe is digitizing the overall process of finding attires and other clothing easily in any kind of wardrobe.
This system can easily be implemented by integrating some hardware devices with Image processing as described below:

6.1. Hardware Devices

The overall architectural design of the proposed smart wardrobe here consists of the following electronic devices:

- Two Raspberry Pi Camera Modules; one (Camera1) fitted vertically on top of 'Photo Window' and the other (Camera2) fitted in an angle with the wardrobe so that it can get a clear front view of that wardrobe.
- Three Raspberry Pi
- Three buttons fitted on the wooden window frame (In, Out, New)
- IR Motion Sensor (set up on the ground of wardrobe)
- 50 mA Light (As the current limit of Raspberry Pi is 50mA)

The functionality of the core electronic devices used in this system is depicted below:

6.1.1 Raspberry Pi and Raspberry Pi Camera Module:

Two Raspberry Pis are attached to both of the Raspberry Pi Camera Modules, and one is attached to the 'Photo Window'. The images captured by the Raspberry Pi Camera Module will be transmitted to the central server using the Raspberry Pi.

$$\Delta E_{yiq} = {}^{q}k_y(\Delta Y)^2 + k_i(\Delta I)^2 + k_q(\Delta Q)$$

In Equation 1, Y represents luma, I represent hue of colour, Q represents saturation of the colour, and k_y, k_i, k_q are regarded as the weighting coefficients which compensate for the proportioned inequality of Y, I and Q. The height and width of both of these images must be the same. This has been implemented in JavaScript language using Node.js library. This library can work with images in JPG/PNG format. The 'fs' module is included, which provides an API for interacting with the file system. Next 'pngjs' is included, which is a simple PNG encoder/decoder for Node.js, and it is used to create and modify png files. Using the 'pixel match' function of the Node.js library, the dissimilarity between the two images is calculated. The range of dissimilarity is between 0 to (height*width). 0 means no dissimilarity (in case of the same image) and value is maximum when the two images are completely different. In our system, the images were taken while keeping clothes inside or outside of the wardrobe and they won't be the same as the images stored in the database. The dress might be folded a bit differently or placed a bit differently in the Photo Frame. But if the images are of the same dress, the dissimilarity will be less than the threshold value 0.7 and the system will return the unique 'Cloth ID' of the similar dress. If dissimilarity is more than the threshold then the system detects them as images of different dresses.

6.1.2 Locating Position of Dress Inside Wardrobe:

In this approach, the images of 'Previous State' (Image1) and 'Current State' (Image2) are compared to each other and location of dissimilar pixels are stored. Dissimilarity is again calculated using Equation 1. Then it creates a new PNG image having the same width and height as the reference image and marks the dissimilar pixel with red color while the other pixels are almost white.

6.2. Mobile Application with Artificial Intelligence

A mobile application has been designed, keeping in mind all the features of the system. Figure 4 shows the homepage of the app where ‘My Wardrobe’ option shows the category wise division of clothes made by the user. Here ‘My Plan’ page is where user can plan what to wear which day on the calendar and ‘My Suggestion’ page will provide useful suggestions about what to wear depending on weather, occasion, and other circumstances. The scroll bar below provides the user with various options like cloth statistics, list of washed clothes, ironed clothes, clothes that are in laundry, calendar with dress plan notifications and dress suggestions for different weather.

6.3. Implemented System Evaluation

In this process, each pixel of one image is compared with another and squared YUV distance between colors at the pixel positions is calculated. If the color difference is above the maximum possible distance, an additional check is done to see if it is a real rendering difference or just anti-aliasing. Anti-aliasing is not counted as a difference. But if the color difference is less than the maximum possible difference, then the pixel will be considered as a similar one.

7.0 Comparision and Discussion

7.1. Advantages compared to Other Proposed Systems

The proposed system is cost-effective and user-friendly. By installing the system once, the user will be able to turn any wardrobe into a smart one. So he will not need to buy an expensive module of Smart Wardrobe. In the system proposed with RFID tags, the user has to purchase RFID tags and attach them to new clothes, but there will be no such further hassle in our proposed system. All the user will need to know is the functionality of ‘In’, ‘Out’, and ‘Store’ buttons. There are already some mobile applications in the market which keep lists of clothes, but neither can they locate the current position of clothes nor they can suggest clothes using AI. Our proposed system is a combination of all these features.

7.2 Limitations

Despite all these advantages, the system has it’s own limitations, such as:
1. Initially, the user will need to install the system as a whole, so it’s not free of cost.
2. Every time before keeping the dress inside or putting it outside, the user will need to keep the dress on the Photo Window and press ‘In’ or ‘out’ button, this might slow down the user.
3.As the system requires hardware parts, the user will need to replace or repair them if anything goes wrong.

7.3. Future Expansion

The system is still at the initial stage of development. In future, we plan to develop the whole system, analyze its accuracy, and test its user acceptability. Improving the system accuracy will be the primary goal as it is of utmost importance to track the location of dress correctly inside the wardrobe. To make the system more user-friendly, we plan to remove the concept of 'Photo Window' and track the location of the dress using video processing instead of image processing .

8.0 Concluding Remarks

In this digital age, technology is making all our works automated and much simpler. Our closets and wardrobes heretofore remain the same, and people still spend their valuable time in organizing and finding their clothes. Implementation of Smart wardrobe can save them from lots of hassles, and it can also be proved handy in the online clothing shops and markets. It is a cost-effective system which is easy to implement and use. This will make the process of storing and finding clothes fully automated, making our lives more comfortable and accelerated.

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