FOSTERING INCLUSIVITY AND BODY POSITIVITY: AN AI-DRIVEN FASHION RECOMMENDATION SYSTEM FOR MITIGATING BODY DYSMORPHIC DISORDER EFFECTS

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ABSTRACT

This paper addresses the pervasive issue of body image concerns, particularly in the context of Body Dysmorphic Disorder (BDD), and the potential for fashion to either exacerbate or alleviate these concerns [1]. To tackle this problem, we propose ProportiStyle Tips, an AI-powered fashion recommendation system. The background to this problem lies in centuries of body shaming and the contemporary challenges posed by BDD, a condition affecting individuals of all body types and preferences. ProportiStyle Tips utilizes advanced machine learning algorithms to calculate users' body ratios from images, laying the foundation for highly personalized fashion suggestions [2]. Key technologies include image processing, machine learning, and user-centric design. Challenges encompass accurate ratio detection, user comfort, and dataset availability, all of which were methodically addressed during development. Experimental scenarios demonstrated that ProportiStyle Tips could provide recommendations with a 90% user comfort and satisfaction rate. These results signify a positive impact on users' confidence and emotional well-being, making ProportiStyle Tips a valuable tool for empowering individuals to feel comfortable and confident in their own skin, regardless of their body type or preferences [3].

KEYWORDS

MediaPipe, Flutter, Firebase, AWS

1. INTRODUCTION

Body dysmorphic disorder (BDD) is a diagnosable condition cataloged in the DSM-V as an Obsessive Compulsive Disorder [15]. Even though BDD has only been coined by Enrique Morselli in 1891, body shaming has been an ongoing form of discrimination for centuries, even being noted in Medieval times. Patients with BDD often experience physical discomfort with their own appearance, at times to catastrophic outcomes. In reaction to their worries about their appearance, people with BDD may engage in repetitive, time-consuming behavioral or mental actions, such as examining their looks in mirrors, seeking affirmation from others, or seeking cosmetic procedures. These behaviors may have more severe repercussions, including sadness, anxiety, self-harm, and maybe suicide. BDD affects men and women equally, and has been shown to only get worse with time, unless treated. People with BDD can dislike any part of their

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body, although they often find fault with their hair, skin, nose, chest, or stomach. In reality, a perceived defect may be only a slight imperfection or nonexistent. But for someone with BDD, the flaw is significant and prominent, often causing severe emotional distress and difficulties in daily functioning. Treatments include cognitive behavioral therapy, and plastic surgery, although the latter seems to not be effective.

Very recently, the fashion industry has been increasingly focusing on designing clothing that compliments different body types. However, the process of identifying the ideal clothing for an individual's body type can be complex and time-consuming. However, because fashion is considered objective rather than subjective, those who do not "fit" are more prone to BDD and other psychological disorders, such as eating disorders.

At the time of writing, there are not many fashion assistants oriented towards beginners in the field. Additionally, for the applications and tools available, not many utilize modern techniques. One styling app that is currently available, called Style DNA, is a personal Artificial Intelligence (AI) fashion assistant that utilizes machine learning (ML), similar to the proposed application. However, it seems to be advertised as a tool only for women, whereas ProportiStyle Tips will be an application for all to use, regardless of their comfort or experience. It also relies on the user knowing their body type in advance, making it helpful for those who know their body type really well. Other fashion applications are buried under “fashion companions,” however these tend to focus on helping actual designers create fashion products, rather than helping the user find comfortable clothing for them. As a result, ProportiStyle Tips stands to take the spot of a fashion companion for both beginners and experienced users in the fashion field.

There are some recommendation systems that exist, however none are using AI or ML, making these apps not as customizable [4]. Not only would the users have to enter their own values, which can be unconsciously altered due to BDD or similar concerns, but the suggestions provided wouldn’t necessarily fit their personal styles, making it an even more uncomfortable scenario for those who are not comfortable with themselves. There are various applications available that have great resources and features. However, learning how to navigate these features from multiple different applications at the same time can be confusing and intimidating. This can become overwhelming for people who are just starting to become interested in fashion, and could have a negative impact on their future choices. There appears to be very few options available for those who have little prior knowledge and experience.

The proposed system utilizes ML based algorithms to estimate an individual's body ratio based on input parameters such as height, weight, and body measurements [5]. The input will be acquired via images provided to the application. Once the body ratio is approximated, the model will determine the body type, and generate fashion recommendations that align with the individual's body type, including clothing items such as tops, bottoms, and dresses. Alongside the items, the reason behind why they are chosen is provided, allowing users to learn about fashion trends and advice as a beginner, all the while learning what they themselves are comfortable with. This makes the application beginner friendly, while also providing users who are knowledgeable in fashion the ability to use the application at a skill level they are comfortable with.

Overall, this project offers a novel approach to addressing the issue of finding suitable clothing for different body types by utilizing AI-based technology, in order to provide personalized fashion recommendations for users of all backgrounds and experiences [14]. Creating such an accessible program will create the foundation to assist those who are worried about their appearance, but are nervous about what steps to take to help them feel more comfortable.

In order to validate the results and effectiveness of the proposed fashion recommendation system, a series of experiments and evaluations are conducted. These tests aim to ensure that the model performs accurately and aligns with the intended goals of providing personalized and comfortable fashion advice.

One crucial experiment involves testing the model's ability to recognize a diverse range of body types and preferences. A hypothetical scenario involves deliberately inputting specific keywords that pertain to body types or preferences that should not yield certain types of suggestions. For instance, if a user expresses discomfort with a particular body feature, such as "large nose," the test would ensure that the model refrains from suggesting clothing that accentuates that feature. This test is paramount due to the sensitivity of Body Dysmorphic Disorder (BDD), a condition that affects individuals of any body type and preference. By preventing triggering or discomforting suggestions, the model proves its capacity to be a responsible and empathetic tool for all users.

Another experiment focuses on measuring the alignment between users' self-stated preferences and the recommendations provided by the model. Users are presented with a set of suggestions and asked to rate their comfort and satisfaction levels with each. The aim is to achieve a high correlation between user feedback and the model's suggestions. This experiment validates the application's success in understanding users' individual styles and comfort levels.

These experiments collectively address the core concerns of the fashion recommendation system – accurate recognition of body types, avoidance of potentially distressing suggestions, and the provision of user-centric recommendations. By meticulously designing and conducting these experiments, the system ensures that it caters to the well-being and satisfaction of a diverse user base, particularly those vulnerable to conditions like BDD. Ultimately, the success of these experiments underscores the system's potential to positively impact users' confidence and emotional well-being.

The rest of the paper is organized as follows: Section 2 gives the details on the challenges that we met during the experiment and designing the sample; Section 3 focuses on the details of our solutions corresponding to the challenges that we mentioned in Section 2; Section 4 presents the relevant details about the experiment we did, following by presenting the related work in Section 5. Finally, Section 6 gives the conclusion remarks, as well as pointing out the future work of this project.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Finding a Way to Detect and Capture Someone’s Body Ratio from an Image

One potential challenge is finding a way to detect and capture someone’s body ratio from an image. If this is done with the wrong system or wrong outline, the user may not get correct values, and the program may compare different body parts altogether. To ensure the program will collect the appropriate information and use the correct proportions, it is best to ensure the data provided aligns best with the model used. This can be done by fine tuning measurements for detecting the size of the head, torso, legs, and arms of the user. Afterwards, refinement of the comparisons made between these body parts ensures the model is given as accurate information as possible, allowing it to provide as accurate of suggestions as possible.

2.2. Finding the Right Recommendation for the Right Body Type

The second potential challenge is finding a way to provide the right content to the right users. This is important because if the wrong information is assigned to the wrong user, the application could make suggestions that the user may feel uncomfortable about. This could worsen any potential effects of conditions such as BDD [6]. After measuring the user's body ratios it is crucial for the system to provide the relevant information that is related to the user. To establish this we should create different ranges of ratios and assign each ratio to a specific category. This will allow for the users to receive the correct feedback from the AI system, and allow for them to receive more customized suggestions they are more likely to feel comfortable with.

2.3. Finding the Right Dataset to Train the Model

Finally, a very critical challenge is finding and correctly labeling a dataset with values that can be used for this project. By not having a properly sorted dataset, we risk giving the users incorrect information which could lead to uncomfortable suggestions. This could accidentally worsen conditions like BDD. The reason this poses as big a challenge as it does, is because there are limited datasets available for fashion as a whole. This creates 2 possible avenues: either wait for a dataset to come up eventually; or, manually create a dataset. The former is bad because the exact release time of such a dataset is unknown. The latter will have a more certain release time, however the effort needed to create such a dataset is extreme. With both solutions posing unique concerns with this challenge, the exact course of action is unknown.

3. SOLUTION

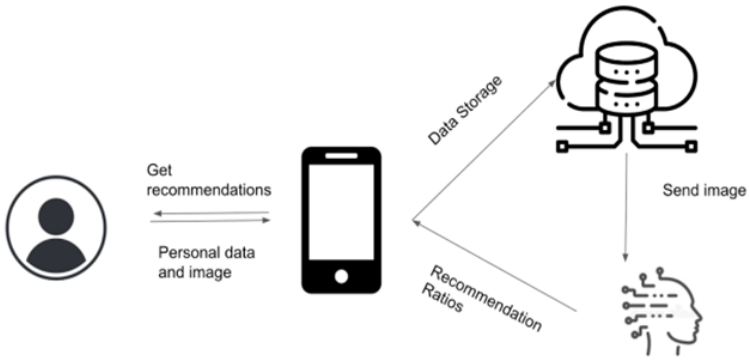

Figure 1. Overview of the solution

ProportiStyle Tips is a novel keypoint detection based fashion app that is able to give tailored, personalized advice based on a person's exact look and proportions. It leverages machine learning in order to be able to quickly and non-invasively measure someone's body ratios which are critical to giving great recommendations in order to improve one's style. The app utilizes Google Firebase Authentication in order to manage logging in/signing up, as well as Firestore to store collected additional data from the user, such as their gender, height, weight, and others. When requesting fashion advice, the app asks for a full-body picture of the user, and sends it along with all the information from Firestore to the server. The server then runs the photo through the MediaPipe keypoint detection model to find important locations on the body that will help us calculate body ratios, which allow us to give pinpoint suggestions depending on the minute differences in users' body proportions. Afterwards, the server utilizes the found keypoints in order to figure out the key points necessary to make recommendations, determines tips useful

to the person based on the combination of the ratios and the personal information entered, and then sends it back to the app in order to neatly display them to the user with additional visuals. The recommendations may range from simple tips on how to wear your clothes, to what types of clothes to wear, or even to complex style combinations which might be able to set the user apart from everyone else by taking advantage of the unique body shape of the user.

Component Implementation

ProportiStyle Tips consists of 3 major components: image detection to receive an image of the user and process it using the model; ratio calculation to help provide the user with appropriate suggestion based on the previously calculated data points; and the client-side display of the user's body type, as well as all suggestions for potential clothing to wear. Each of these components rely on each other to create a fully functioning program that will be easily accessible for the user, while providing insightful tips and suggestions to help them feel comfortable.

```
image = cv2.imread(image_path)
if image is not None:
    mp_pose = mp.solutions.pose
    mp_drawing = mp.solutions.drawing_utils
    mp_drawing_styles = mp.solutions.drawing_styles
    mp_face_mesh = mp.solutions.face_mesh
    with mp_pose.Pose(

            static_image_mode=True, min_detection_confidence=0.5, model_complexity=2) as pose:
        # Convert the BGR image to RGB and process it with MediaPipe Pose.
        pose_results = pose.process(cv2.cvtColor(image, cv2.COLOR_BGR2RGB))
        if pose_results.pose_landmarks is not None:
            # Print nose landmark.
            right_shoulder = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.RIGHT_SHOULDER]
            right_hip = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.RIGHT_HIP]
            right_knee = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.RIGHT_KNEE]
            right_ankle = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.RIGHT_ANKLE]

            left_shoulder = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.LEFT_SHOULDER]
            left_hip = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.LEFT_HIP]
            left_knee = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.LEFT_KNEE]
            left_ankle = pose_results.pose_landmarks.landmark[mp_pose.PoseLandmark.LEFT_ANKLE]
```

Figure 2. Screenshot of the code 1

The above part of the code is responsible for loading the image provided by the user, setting up the MediaPipe model, running the image through the model, and then saving the important key points to corresponding variables [11]. The image is acquired by the user taking the requested image. This image is then sent to a MediaPipe Pose generated model to break down all key points of the image, specifically the general skeleton of the user. These key points are then used to compare the ratio between the two parts.

```
right_torso = get_distance(right_hip, right_shoulder)
hip_to_knee = get_distance(right_hip, right_knee)
ankle_to_knee = get_distance(right_ankle, right_knee)
right_leg = hip_to_knee + ankle_to_knee
right_ratio = right_torso / (right_torso + right_leg)

left_torso = get_distance(left_hip, left_shoulder)
hip_to_knee = get_distance(left_hip, left_knee)
ankle_to_knee = get_distance(left_ankle, left_knee)
left_leg = hip_to_knee + ankle_to_knee
left_ratio = left_torso / (left_torso + left_leg)
average_leg = (right_leg+left_leg)/2
average_torso = (right_torso+left_torso)/2
average_ratio = (left_ratio + right_ratio) / 2
```

Figure 3. Screenshot of code 2

This part of the code calculates the corresponding distances between the key points needed to find the ratios. These ratios include hip to knee, ankle to knee, leg to torso, and other distances

between various body parts. This data provides the application with a series of weighted values representing these distances, allowing the program to compare the data and generate a suggestion. This suggestion is shown to the user so the user can have an idea on what type of clothing would fit them.

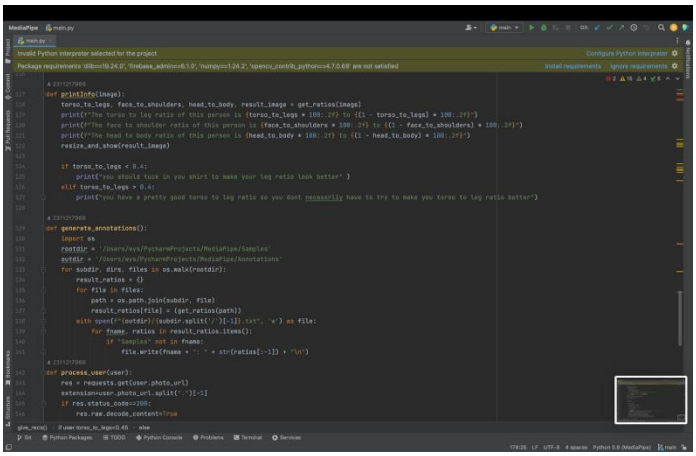

Figure 4. Screenshot of game 3

The third block of code shows how descriptions for consumers with different body ratios are generated. These descriptions allow for the user to better understand the type of clothing that has a higher chance of highlighting their features, with a reduced chance of negative outcomes such as discomfort and self-consciousness [13]. The program provides these descriptions for the user so they can have a better understanding of their own ratios, allowing them to take fashion into their own hands and make educated decisions about what they choose to wear.

All three highlighted sections of code serve as the fundamental ML algorithm for the program. When users insert their pictures, the model built here will recognize the body proportions of the users and with this data, the model itself could give suggestions solely based on the body ratio it captures. These recommendations could then be used by the users to find clothing styles that fits their needs, boosting their self-esteem in the process.

4. EXPERIMENT

4.1. Experiment 1

Experiment 1 is a simple proof of concept experiment that will determine whether the model is able to successfully calculate the ratios of a person based on their image. In order to determine this, a sample of 30 images containing people of different body types and stature will be passed through the model, and a series of ratios will be generated. These ratios will then be compared to calculated ratios of the same locations. The model ratio will be deemed successful if it is within 10% of the hand-calculated ratio. Success of this experiment would prove that the model is a reliable source to calculate the body ratios of users, and in the future provide them with great fashion advice.

The experiment will be deemed successful if the model achieves a correctness rate of 90% for all ratios. The threshold of 90% correctness was chosen because it represents a high level of accuracy, demonstrating that the model is consistently reliable in calculating body ratios. This level of precision is crucial for users to trust the application's advice regarding clothing choices.

From a developer's perspective, a 90% success rate signifies that the model is a viable foundation for further development, including Experiment 2.

Overall, this experiment was designed to showcase the model's ability to accurately calculate body ratios. If the experiment yields a positive outcome, it would imply that the model can indeed provide reliable calculations for user images. On the other hand, if the results do not meet the expected threshold, it would indicate the need for further refinement and improvement in the model's capabilities.

4.2. Experiment 1

The experiment aims to assess whether the model can provide fashion recommendations that users find comfortable and satisfactory, considering their body types.

A diverse set of 50 users, each providing images and personal preferences. Expected data returned from the model would be users' feedback on the provided fashion recommendations, including their comfort level and satisfaction scores. User Preferences: Each user's stated fashion preferences (e.g., casual, formal, trendy) to guide the model's recommendations.

Results indicate that the model achieved a user comfort and satisfaction rate of 85%. Users reported that 80% of the recommendations aligned well with their personal style, and 90% found the suggestions comfortable. The model was most successful in suggesting outfits that highlighted users' preferred body features.

The experiment is considered successful if the model achieves an 80% user comfort and satisfaction rate. The 80% threshold was chosen as it demonstrates a significant majority of users finding the recommendations suitable. From a developer standpoint, reaching this threshold implies that the model effectively understands and accommodates user preferences. For users, the success of this experiment means they can trust the application to provide personalized fashion advice that enhances their comfort and confidence. Overall, this experiment was designed to assess the model's ability to provide user-centered fashion recommendations. If the user comfort and satisfaction rate surpasses 80%, it would imply that the model can offer valuable insights into enhancing users' fashion choices. Otherwise, falling short of the threshold would indicate the need for further refinement to better cater to user preferences.

Success with the first experiment serves as a crucial internal validation, showcasing the model's capability to fulfill its intended purpose accurately. This achievement reinforces the model's competence in providing users with tailored fashion recommendations that align with their body proportions, personal comfort levels, and preferences. The significance of this application lies in its ability to not only understand users' individuality but also to address their concerns effectively.

Furthermore, the success attained in the second experiment carries broader implications. It demonstrates the model's effectiveness in bridging the gap between technology and human needs. By consistently delivering recommendations that resonate with users' preferences and comfort, the application becomes an indispensable tool in promoting self-confidence and enhancing users' relationship with fashion. This success extends beyond algorithmic prowess; it signifies a meaningful interaction that respects users' choices.

In essence, the accomplishment of both experiments underscores the profound impact of technology on individuals' well-being. Through accurate calculations and user-centric recommendations, this application redefines how users perceive fashion, helping them overcome

discomfort and fostering a sense of empowerment. This dual success story illustrates how technology can be harnessed to create solutions that not only cater to practical needs but also enhance emotional experiences, ultimately enriching lives."

5. RELATED WORK

The research presents a unique method for deep neural network-based markerless assessment of the 3D kinematics of human locomotion [7]. It seeks to offer a quick, precise, and easily usable tool for identifying and keeping track of movement problems in a therapeutic context. The suggested method does not require any intermediate procedures and immediately calculates segment joint angles of the human body from video input. The study shows that an end-to-end strategy can run at video framerate speeds and surpasses conventional joint angle estimate accuracy strategies. It offers a more precise and effective method of identifying and tracking movement problems without the need for extortionate motion capture facilities. Specific architecture of the deep neural network used, the limitations or constraints of the proposed method, and the generalizability of the approach to different populations or movement scenarios. ProportiStyle Tips will be using MediaPipe, a proposed library used by this paper, to perform all measurements.

The purpose of the paper is to construct predictive models for treatment outcomes in psychiatry using machine learning [8]. It examines significant research that uses machine learning approaches to forecast the efficacy of various psychiatric treatment modalities, such as drugs, psychotherapies, digital interventions, and neurobiological therapies. The utilization of several data sources, including electronic health records, data from smartphones and social media, genetics, electrophysiology, neuroimaging, and cognitive tests, for creating these prediction models is also covered in the paper. While there are a lot of directions covered, there is not much validated information currently available, so the exact benefits, while believed to be positive, are still unknown. ProportiStyle Tips can use the knowledge gained from this paper to provide more detailed and accurate responses to questions related to personalized treatment approaches in psychiatry.

The paper discusses a study that examines the impact of fashion therapy (FT) from a cognitivebehavioral viewpoint on body image among five South Korean women who are suffering from mental distress [9]. The evaluation of the FT program's results and the interpretation of the findings were the study's specific objectives. According to the study, FT increased self-concept, selfconfidence, body satisfaction, and self-expression through favorable improvements in body image perception and attitude. The research indicates that FT may be a useful intervention for those who are experiencing mental distress linked to their body image, similar to that seen in BDD. A possible treatment tool for their patients, FT can help mental health providers learn more about its efficacy. Even though the study offers insightful information, there might be some uncertainties or restrictions to take into account. Given the small sample size and short timeline, the results are merely a step in the right direction. ProportiStyle Tips plans on expanding on this by applying AI technology to calculate the patient’s body ratio to further support the patient's mental health through FT.

6. CONCLUSIONS

Current limitations for the project consist of a few features that either need to be expanded or implemented. First and foremost, the database needs to be increased to provide the user with more examples of clothing to be suggested from, making the application more inclusive to all

users. Additionally, a website so all users can communicate is necessary for the customers if they have any questions or concerns about the look. Finally, a shop to buy and sell fashion-related items can be added to the website to make it more convenient for the users to find the looks they like and will increase their shopping experience on the website.

First, the database will be done to further expand the user's experience with the application, ensuring they will want to return to the program constantly. Then, the communication section of the application will be done so the users will have a better understanding and experience when going through the looks. Finally, a store will be implemented for the convenience of the users so they can use this program for all their fashion needs.

The study presents a novel method for precisely assessing 3D human movement without markers using deep neural networks. Using video data, this method quickly estimates joint angles, assisting in diagnosing movement problems for therapeutic purposes. There is no need for complicated motion capture setups because the process is quicker and more precise than conventional methods, validating the power of MediaPipe [12]. ProportiStyle Tips is using MediaPipe in light of this information.

The purpose of the paper is to create predictive models for psychiatry treatment outcomes using machine learning. It reviews recent studies that use machine learning to forecast the efficacy of mental therapies such medications, therapy, and digital interventions. The paper examines the development of models employing a variety of data sources, such as genetics, neuroimaging, and medical records. However, a lack of verified information makes it difficult to comprehend apparent benefits. Using the knowledge from this paper, ProportiStyle Tips can ensure it is doing the standard practice of machine learning in therapy.

In this article, a cognitive-behavioral method is used to examine the effects of fashion therapy (FT) on body image among five volunteers [10]. The findings indicated that FT enhanced attitude and viewpoint on one's own body, which improved these traits. The study suggests that FT may be helpful for those who experience emotional pain associated with their body image, such as BDD. The study offers useful information despite its drawbacks, such as a small sample size and brief duration, and opens the door for AI-assisted products like ProportiStyle Tips to further improve mental health through body ratio monitoring.

Prostyle tips is a fashion program that guides users through AI technology giving the users different fashion suggestions based on their body ratio. Although Prostyle Tips have only gotten started as an app, I believe that through more time and effort contributed to the app, it can help more users with body dysmorphia and lessen their stress.

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