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Product Recommendations Using Body Measurement

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Abstract: In the present age, accurate body measurement and product recommendations are becoming increasingly vital. In our project we are elaborating the benefits of leveraging advanced technologies to convey personalized experiences for customers. Accurate body measurement is crucial for ensuring the perfect fit of clothing and other personalized products. The body measurement of various individuals will be varied and has a wide area of measurement. Traditional methods often lack precision, leading to unsatisfactory experiences for customers. By leveraging advanced technologies like 3D scanning and computer vision, we can obtain precise measurements and provide tailored recommendations. We use Human Motion Recognition (HMR) which is used to analyse human behaviours. It can be used in fields like human-computer interaction and virtual reality. This not only enhances customer satisfaction but also reduces returns and improves overall efficiency. Product recommendations based on individual body measurements enable customers to find products that fit their unique preferences and body types.

By analysing data such as body shape, size, and style preferences, we can offer personalized suggestions that enhance the shopping experience. This level of personalization not only increases customer satisfaction but also drives sales and fosters long-term customer loyalty.

Our project aims to deliver a world of benefits through optimized body measurement. It also provides improved customer experiences, reduced returns, enhanced product development, and personalized solutions. We are utilizing the power of optimization to transform the way of measurement and interaction with the human body. Leveraging advanced technologies for precise body measurement and product recommendations is essential in today's competitive market. By enhancing precision and personalization, we can deliver superior customer experiences, reduce returns, and drive business growth. Embracing these advancements will position us to be committed to meeting customer needs. This finally helps in delivering accurate measurements and to recommend products to the users.

Keywords: Computer Vision, Human Motion Recognition (HMR)

I. INTRODUCTION

The domain of body measurements involves the quantitative assessment of the physical dimensions and proportions of the human body. This encompasses measurements such as height, weight, circumferences, and specific anatomical dimensions. It is useful to understand and accurately recording body measurements play a crucial role in numerous industries, including fashion, health and fitness, ergonomics, and medical diagnostics. Historically, body measurements have been essential for tailoring, sizing, and designing products that interact with the human body.

Accurate body measurements contribute to the development of personalized products and services, leading to enhanced user experiences. In healthcare, precise body measurements are vital for diagnostics, treatment planning, and monitoring patient progress. Stakeholders include fashion designers, healthcare professionals, fitness trainers, researchers, and anyone involved in the design and development of products tailored to the human body. The primary audience consists of professionals seeking advanced and efficient solutions for body measurement processes.

The traditional paradigm of sizing in the retail industry is based on static charts that categorize individuals into predetermined size categories. Consequently, customers frequently receive products that do not align with their unique body shapes, leading to dissatisfaction, increased return rates, and a subsequent impact on the financial viability of retailers. Moreover, existing recommendation systems often lack the granularity required to provide truly personalized suggestions. These systems, while effective to a certain extent, tend to overlook the critical factor of individual body measurements, resulting in recommendations that may not suit the customer's size and shape preferences. Bridging the gap between body measurements and product recommendations represents a pivotal opportunity to transform the online shopping experience.

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II. RELATED WORK

A. *Nataniel Ruizy, Miriam Bellver, Timo Bolkart, Ambuj Arora, Ming C. Lin, Javier Romero explained a Human Body Measurement Estimation With Adversarial Augmentation.*

The paper begins by highlighting the significance of reconstructing 3D human body shapes from images, emphasizing the lack of research on directly estimating body measurements from images. It discusses the importance of body measurements in various fields such as healthcare and the fashion industry, where metrics like waist girth serve as crucial indicators. The authors note that while previous work has successfully mapped a few body measurements to a 3D body mesh in a reference pose, the direct estimation of body measurements from images has been relatively unexplored.

1) *Advantages*

Direct Prediction of Body Measurements:
The proposed method directly predicts body measurements from images, addressing the lack of research in this specific area. This is a significant advantage as it eliminates the need for mapping measurements to a 3D body mesh, which can introduce limitations in resolution and accuracy.
Inclusion of Height and Weight: By incorporating height and weight as additional inputs, the method helps resolve scale ambiguity, enhancing the accuracy of body measurement predictions.

2) *Disadvantages*

Limited Discussion on Computational Complexity: The paper does not extensively discuss the computational complexity of the proposed method. The efficiency of the model, especially in real-time applications, could be a potential concern that is not thoroughly addressed.
Dependency on Synthetic Data: While the ABS is introduced to address the scarcity of real human measurement datasets, the reliance on synthetic data for training may raise concerns about the generalization of the model to real-world scenarios.

B. *Dongjun Gu, Youngsik Yun, Thai Thanh Tuan, And Heejune Ahn. Dense-Pose2smpl explained a 3d Human Body Shape Estimation from A Single and Multiple Images and Its Performance Study.*

This paper proposes a 2D image-based human body estimation method for accurate body shape and size measurement, with applications in human behaviour analysis, sports and medical analysis, and virtual reality. The method utilizes the Skinned Multi-Person Linear model (SMPL) and Dense-Pose network, referred to as Dense-Pose2SMPL. Unlike previous SMPL parameter estimation methods that rely on sparse joint correspondences, Dense-Pose2SMPL minimizes re-projection error by leveraging rich correspondences between pixels in the human image and 3D surface points in SMPL.

1) *Advantages*

Improved Measurement Accuracy: The Dense-Pose2SMPL method demonstrates significant improvements in body measurement accuracy, particularly in circumference estimation. This is crucial for applications in human behaviour analysis, sports, medical analysis, and virtual reality.
Rich Correspondences for Reprojection Error Minimization: Unlike previous methods relying on sparse joint correspondences, Dense-Pose2SMPL leverages rich correspondences between pixels in the human image and 3D surface points in SMPL. This helps minimize re-projection error and enhances accuracy in body shape and size estimation.

2) *Disadvantages*

Dependency on Dense-Pose Network: The method relies on the Dense-Pose network, and its performance may be influenced by the quality and diversity of the training data. Limitations or biases in the Dense-Pose network could impact the overall accuracy of the proposed method.
Application-Specific Evaluation: While the paper highlights improvements in specific scenarios (e.g., circumference estimation), the generalization of Dense-Pose2SMPL across a wide range of applications and body types may need further investigation.

C. Min Dong, Xianyi Zeng, Ludovic Koehl, Junjie Zhang an Interactive Knowledge explained a Based Recommender System For Fashion Product Design In The Big Data Environment.

This paper introduces an Interactive Knowledge-Based Design Recommender System (IKDRS) for personalized fashion product design. The system incorporates iterative interactions between virtual product demonstrations and a designer's professional knowledge to identify optimal design solutions. Key components include the acquisition of anthropometric data and designer perceptions through 3D body scanning and sensory evaluation. Technical fabric parameters are measured, and design knowledge is gathered through instrumental and sensory experiments. Fuzzy techniques classify body shapes and model relationships between human bodies, fashion themes, and design factors.

1) Advantages

Personalized Fashion Design: The Interactive Knowledge-Based Design Recommender System (IKDRS) is designed for personalized fashion product design. By incorporating iterative interactions and designer knowledge, it aims to identify optimal design solutions tailored to individual preferences.

Validation through Real Design Cases: The validation of the system through successful real design cases indicates its practical applicability and effectiveness in generating designs that meet user expectations.

2) Disadvantages

Complexity and Learning Curve: The implementation of an ontology-based design knowledge base and the use of fuzzy techniques may introduce complexity to the system. Designers may require time and training to fully understand and utilize these features effectively.

Dependency on Technical Fabric Parameters: While the consideration of technical fabric parameters is beneficial, the system's effectiveness may depend on the availability and accuracy of data regarding these parameters. Limited data or inaccuracies could impact the reliability of fabric-related recommendations.

D. Yui Shigeki, Fumio Okura1, Ikuhisa Mitsugami and Yasushi Yagi explained an Estimating 3d Human Shape Under Clothing from a Single Rgb Image

This paper introduces a novel approach for estimating naked human 3D pose and shape, including non-skeletal information like musculature and fat distribution, from a single RGB image. The primary motivation lies in applications such as virtual try-on, where accurately visualizing clothing fit to the actual body shape is crucial.

1) Advantages

Single RGB Image Input: The method optimizes Skinned Multi-Person Linear (SMPL) pose and shape parameters using only a single RGB image as input. This simplifies the data acquisition process and makes the approach more practical and accessible, especially compared to methods relying on multi-view images or 3D scanners.

Extension of SMPLify Method: The approach extends the SMPLify method by incorporating clothing category information and statistical displacement models. This extension allows for a more comprehensive and accurate estimation of human shape under clothing, improving the realism of virtual try-on scenarios.

2) Disadvantages

Dependence on Clothing Category Information: The accuracy of the method may be influenced by the availability and reliability of clothing category information. In scenarios where clothing details are complex or diverse, the method's performance might be challenged.

Modelling Displacement Challenges: While the approach addresses challenges in obtaining image pairs of clothed and naked people, the accuracy of displacement modelling using a clothing simulator may have limitations, especially when dealing with various clothing styles and fabrics.

E. Kamrul Hasan Foysal, Hyo-Jung (Julie) Chang, Francine Bruess and Jo-Woon Chong.Body Size Measurement Using a Smartphone

Measuring body sizes accurately and rapidly is a critical challenge for fashion retailers, particularly in the context of apparel e-commerce where providing correct-fitting products is essential. Current methods often rely on cumbersome 3D reconstruction-based approaches. This paper introduces a novel smartphone-based body size measurement method, aiming to address the need for digital and convenient ways to obtain accurate body measurements for online garment fit detection.

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1) Advantages

Convenience and Accessibility: The proposed smartphone-based body size measurement method offers a convenient and accessible solution. Leveraging smartphones, which are widely used in daily life, provides a user-friendly and familiar tool for obtaining accurate body measurements.

No Need for Reference Objects: Unlike some existing methods, the proposed approach does not require additional objects of a known size as a reference during the body image acquisition process. This simplifies the measurement process, making it more practical for users.

2) Disadvantages

Limited Scope: The paper focuses on specific body sizes like waist, lower hip, and thigh circumferences for selecting well-fitted pants. The method's applicability to measuring other body dimensions may not be explicitly discussed, limiting its scope in providing a comprehensive solution for all types of garments.

Dependency on Smartphone Technology: While smartphones offer convenience, the method's success depends on the capabilities of the smartphone camera and the accuracy of image processing algorithms. Older or low-quality smartphones may not yield accurate results.

F. Erich Stark, Oto Haffner and Erik Kucera explained a Low-Cost Method For 3d Body Measurement Based on Photogrammetry Using Smartphone.

This paper explores the potential of data collection through photogrammetry methods, leveraging smartphone cameras and post-processing techniques. The focus is on harnessing the evolving technologies embedded in smartphones for efficient and versatile data collection. The paper presents a low-cost method for 3D body measurement, aiming to overcome shortcomings identified in similar solutions.

1) Advantages

Utilization of Smartphone Cameras: The paper leverages the widespread availability and evolving technologies of smartphone cameras for data collection. This approach capitalizes on the convenience and ubiquity of smartphones, making data collection accessible to a large user base.

Low-Cost Method for 3D Body Measurement: The proposed method offers a low-cost solution for 3D body measurement. This can be particularly beneficial for scenarios where budget constraints limit the adoption of more expensive technologies.

2) Disadvantages

Applicability to Specific Body Parts: The paper may not explicitly discuss the applicability of the proposed method to measuring specific body parts or regions. Certain body areas may pose challenges in terms of visibility or accuracy.

Data Security and Privacy Considerations: The paper does not address potential concerns related to data security and privacy. Collecting 3D body measurements using smartphones may raise privacy issues that need careful consideration.

G. Zhong Lia, Lele Chenb, Celong Liua, Fuyao Zhanga, Zekun Lia explained an Animated 3d Human Avatars from A Single Image With Gan-Based Texture Inference.

This paper introduces a system for generating animated 3D human avatars from a single image using GAN-based texture inference. The key components involve segmentation of body shape and the utilization of the SMPL model for generating front and back geometry. The report highlights the system's capabilities, particularly its handling of partial occlusion cases and identifies limitations related to manual intervention in certain scenarios.

1) Advantages

Utilization of SMPL Model: The use of the Skinned Multi-Person Linear (SMPL) model for representing the geometry of the human body enhances the realism of the generated avatars. This model provides a detailed and anatomically accurate representation of body shapes.

GAN-Based Texture Inference: The employment of Generative Adversarial Networks (GANs) for texture inference contributes to the lifelike appearance of the generated 3D avatars. GANs enable the system to generate textures consistent with the input image, enhancing realism.

2) Disadvantages

Challenges with Intersecting Body Parts: While the system addresses partial occlusion, challenges may arise when body parts intersect. The paper suggests that additional steps beyond the system's capabilities are required to handle intersecting body parts, potentially introducing complexity.

Potential Sensitivity to Image Quality: The performance of the system may be sensitive to the quality of the input image. Low-resolution or noisy images may impact the accuracy and realism of the generated avatars.

H. Daud Ibrahim Dewan, Bikal Chapain, Manishankar Prasad Jaiswal explained an Estimating Human Body Measurement From 2d Images Using Computer Vision.

The paper explores the application of computer vision techniques, specifically pose estimation, for predicting the configuration of the human body from images. The report discusses the observed impact on model accuracy, highlighting variations in performance between linear and circular measurements.

1) Advantages

Higher Accuracy for Linear Measurements: The study reports higher accuracy levels for linear measurements, indicating relatively successful predictions of distances or lengths on the human body. This suggests that computer vision techniques, particularly pose estimation, can effectively estimate linear dimensions, providing valuable information for tasks such as body height or segment lengths.

Identification of Challenges for Circular Measurements: The research identifies challenges in achieving comparable accuracy for circular measurements. The diminished accuracy for parameters like circumference or diameter highlights potential limitations in applying computer vision techniques, especially pose estimation, for tasks involving circular measurements.

2) Disadvantages

Drop in Model Accuracy: The research notes a noticeable drop in the accuracy of the model when utilizing computer vision techniques for predicting body configuration. This drop in accuracy may pose challenges in the practical application of such models, especially in scenarios where precision is crucial.

Potential Complexity in Optimization: Achieving optimal performance in computer vision models, especially for tasks involving circular measurements, may be a complex process. Addressing the identified challenges and improving accuracy may require sophisticated algorithms, additional data, or enhanced training approaches.

I. Hajer Ghodhbani, Mohamed Neji, Imran Razzak, Adel M. Alimi explained a You Can Try Without Visiting: A Comprehensive Survey on Virtually Try-On Outfits.

The paper introduces the application of a Contextualized Convolutional Neural Network (CNN) for human pose estimation, specifically utilizing 2D images. The model is implemented and evaluated on the Leeds Sports Pose (LSP) dataset, aiming to predict human poses without relying on 3D models. The report discusses the model's performance and highlights challenges related to the edge detection of humans, leading to inconsistencies and errors.

1) Advantages

Contextualized Convolutional Neural Network: The paper introduces the application of a Contextualized Convolutional Neural Network (CNN) for human pose estimation. This type of neural network is designed to consider contextual information surrounding each data point, potentially enhancing the model's understanding of complex relationships in pose estimation.

Utilization of Deep Learning: The study leverages the capabilities of deep learning, particularly a Contextualized CNN, for human pose estimation. Deep learning models can automatically learn hierarchical representations of features, allowing for more effective and nuanced understanding of complex patterns in images.

2) Disadvantages

Challenges in Edge Detection: The paper notes challenges related to edge detection in human poses, leading to inconsistencies and errors in the estimated poses. Inconsistencies in edge detection can impact the accuracy of the model, particularly in scenarios where clear delineation of human body parts is crucial.

Potential Impact on Model Performance: The mentioned challenges in edge detection may have a direct impact on the overall performance of the Contextualized CNN. Inaccuracies in estimating poses could limit the reliability of the model, especially in situations where precise pose information is critical.

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J. Seyed Omid Mohammadi, Ahmad Kalhor explained a Smart Fashion: A Review of AI Applications in Virtual Try-On & Fashion Synthesis.

This paper provides a comprehensive survey of the use of artificial intelligence (AI) in the fashion industry, specifically in virtual try-on.

1) Advantages

Insight into AI Applications in Fashion: The survey offers insights into the application of AI in the fashion industry, particularly in the context of virtual try-on. This can be valuable for researchers, industry professionals, and stakeholders interested in understanding the current landscape and potential future developments.

2) Disadvantages

Potential Lack of Practical Implementation Insights: While the survey may provide an overview of academic research, it might not delve into practical implementation insights or real-world applications of AI in virtual try-on within the fashion industry. This limitation could impact the transferability of research findings to industry practices.

III. PROPOSED SYSTEM

The proposed system consists of using the SMPL model which comprises of realistic 3D model of the human body and blends shapes which is learned from thousands of 3D body scans. We also plan to implement the EKF model which is the Extended Kalman Filter which is used for the rigid body pose estimation of the human body. It offers an improvement in accuracy of the rigid body pose estimation by having linearized measurement which is derived.

1) *Body Measurement Extraction:* Advanced computer vision algorithms will be employed for precise facial landmark detection and body pose estimation. Deep learning models will be integrated to analyse single images, providing accurate and comprehensive body measurement. Users will have the option to submit front and side images for a more detailed measurement analysis.
2) *Virtual Try-On Feature:* Augmented reality (AR) technologies, including ARCore and ARKit, will be leveraged to create a realistic virtual try-on experience. Users can visualize recommended clothing items on their virtual avatars, allowing adjustments for fit, style, and customization. Interactive features, such as rotation, zooming, and detailed assessment of clothing items during virtual try-on, will enhance user engagement.
3) *Clothing Recommendation Engine:* Machine learning algorithms, encompassing collaborative filtering and deep learning models, will analyse user preferences, historical data, and current fashion trends. Personalized recommendations will consider individual style preferences, color choices, and seasonal trends. Users will have the ability to customize recommendations based on specific occasions, preferences, or wardrobe needs.
4) *User Profiles and Authentication:* Secure user authentication mechanisms will be implemented to protect user data. Users can create profiles to save preferences, track order history, and receive personalized recommendations. Convenient login options, including social media authentication, will be provided for user ease.
5) *E-commerce Integration:* Integration with popular e-commerce platforms through APIs will provide real-time access to diverse clothing catalogues. Seamless links to external websites will allow users to directly purchase recommended item. Pricing, availability, and additional details will be displayed directly within the system.
6) *Privacy and Security Measures:* Robust encryption protocols will secure the transmission and storage of user data. Users will have control over privacy settings and explicit consent for data usage. Adherence to industry standards and regulations, such as GDPR, will ensure user data protection.
7) *User Interaction and Feedback:* Interactive features will facilitate user feedback on recommendations and virtual try-on experiences. Analytics tools will gather insights into user behaviour, preferences, and popular trends. Continuous feedback loops will be implemented to enhance the recommendation engine based on user input.
8) *Customization Options:* Users will be able to customize clothing items during virtual try-on, adjusting colour, pattern, and style preferences. A feature-rich customization interface will be implemented to enhance user engagement.

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IV. DESIGN GOALS

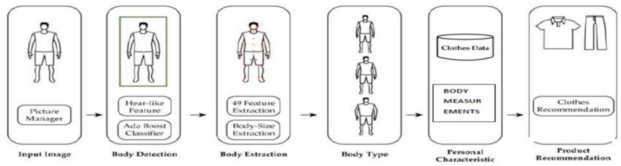

Fig 5.1 System Architecture

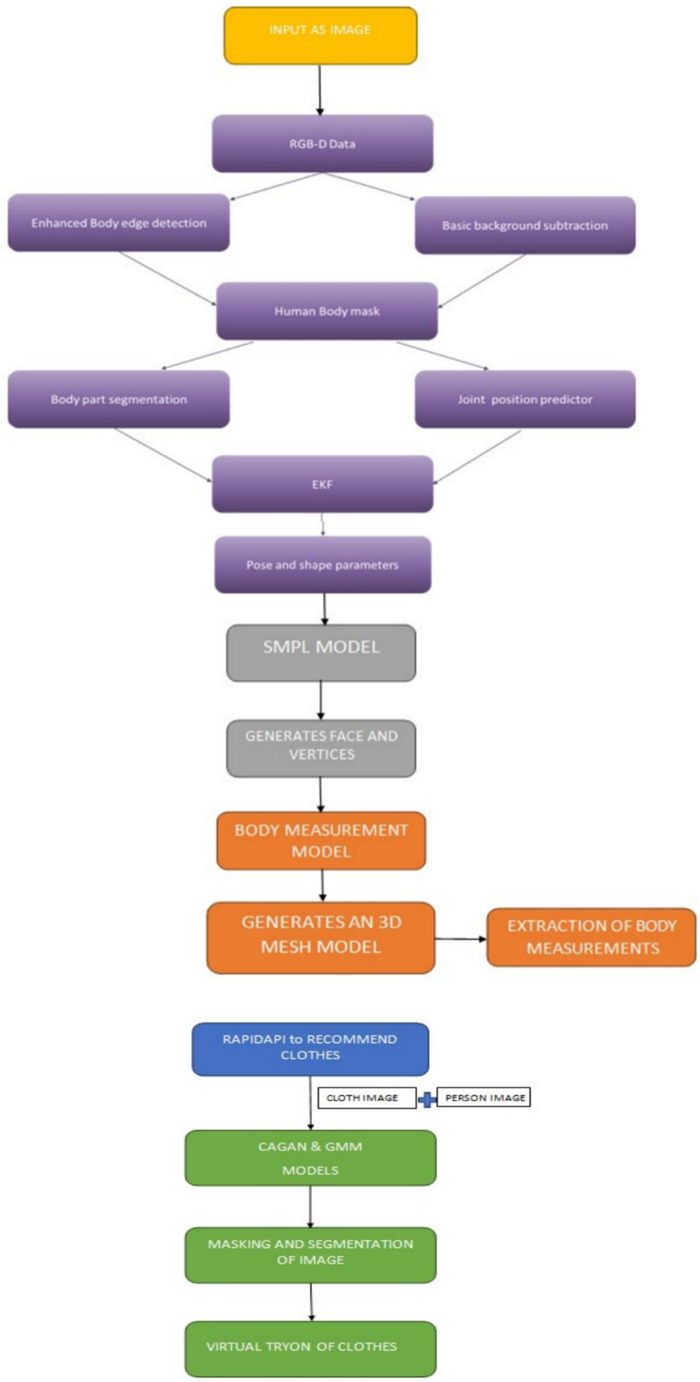

Fig 5.2 Data Flow Diagram

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A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted.

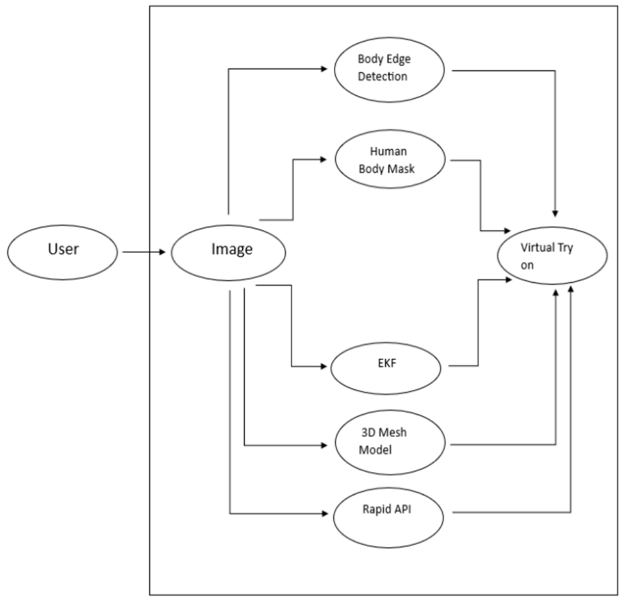

Fig 5.3: Use case diagram

In software engineering a class diagram in the Unified Modelling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.

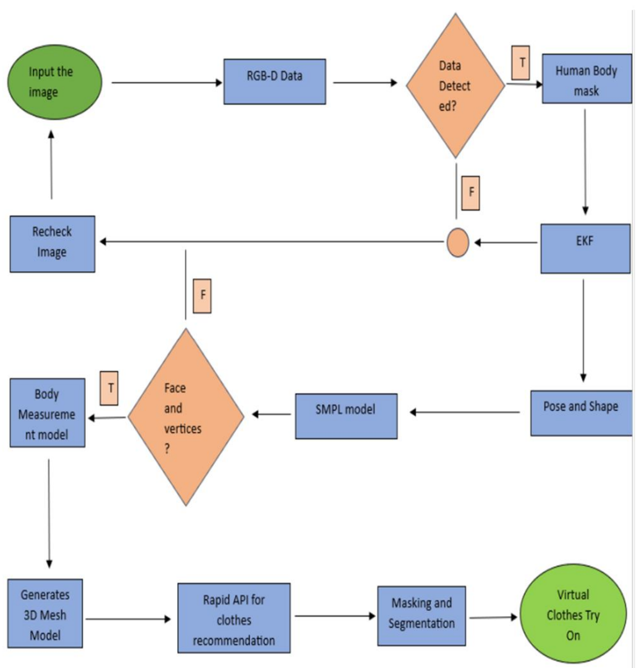

Fig 5.5 Sequence Diagram

The process starts with the input of RGB-D data, which is then used to detect a human body mask. If a body mask is detected, the body measurements and model vertices are measured.

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Next, a 3D mesh model is generated using either the body measurements or the SMPL model, which is a statistical model of human body shape and pose. The pose and shape of the model are then used to recommend virtual clothes that would fit the person well.

V. CONCLUSION

In conclusion, the "Body Measurement and Product Recommendation" project stands as a groundbreaking exploration at the convergence of cutting-edge technologies and the fashion retail industry. The successful integration of advanced image analysis, machine learning, and ecommerce technologies has not only achieved the primary objectives of precise body measurement extraction but has also introduced innovative features such as a virtual try-on experience and personalized product recommendations. The incorporation of virtual try-on features, facilitated by augmented reality (AR) technologies like ARCore and ARKit, represents a significant stride towards creating an immersive and interactive user experience. Users can now visualize and evaluate the fit and style of recommended clothing items in a dynamic virtual environment, enhancing their confidence in making informed fashion choices. The recommendation engine, powered by sophisticated machine learning models, goes beyond generic suggestions. It considers individual style preferences, seasonal trends, and even allows users to customize clothing items during the virtual try-on, fostering a truly personalized and enjoyable shopping experience. The project's commitment to size inclusivity ensures that the system caters to a diverse range of body shapes and sizes, promoting a sense of inclusiveness in the fashion landscape. Furthermore, the seamless integration with e-commerce APIs enables users to not only explore but also conveniently purchase the recommended clothing items directly through the platform. This fusion of virtual try-on and immediate access to the latest fashion catalogs creates a comprehensive and streamlined shopping journey for users. Looking ahead, the project opens avenues for further refinement and innovation. Continuous enhancements in machine learning models, expanded collaborations with fashion brands, and the integration of emerging technologies will contribute to the system's evolution. User feedback mechanisms and analytics tools will play a pivotal role in iteratively improving the recommendation engine and virtual try-on features, ensuring they align closely with user preferences and the dynamic nature of fashion trends. In essence, the "Body Measurement and Product Recommendation" project not only achieves its core objectives but also pioneers a new paradigm in personalized fashion experiences. By seamlessly combining body measurements, virtual try-on, and intelligent product recommendations, the project stands at the forefront of technological innovation in the fashion domain, setting the stage for future advancements and redefining the landscape of online fashion retail. This conclusion places a stronger emphasis on the virtual try-on feature and personalized product recommendations, highlighting their transformative impact on the user experience and the broader implications for the fashion retail industry.

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