JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Automatic Human Body Measurement using Computer Vision & Media Pipe

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Abstract:

Accurate measurements of the human body are important in a variety of settings, including tailoring, fitness tracking, and healthcare. Conventional measurement approaches usually involve human intervention which can be slow, error-likely, and inconvenient. This project describes an approach to automate human body measurements using basic computer vision methods and the Media pipe framework. The system measures body dimensions using images as inputs, and uses Mediapipe's pose estimation and tracking as a way to identify key landmarks on the human body. The landmarks are then used in conjunction with computer vision algorithms to accurately calculate the measurements of interest (height, waist circumference, arm length, etc.). The system is also designed to measure accurately using calibration techniques to account for scaling and posture of the person being measured. The system is easy to use, requiring minimal input from the user, and works with readily available mobile phones or other devices. This technology attempts to simplify the current options available in the tailoring and fashion environments by providing a cost-efficient, productive, and easy option to assess body measurements when compared with conventional structure.The project also investigates the possibilities for integration with augmented reality (AR) for real-time visualization of measurements and designs to improve usability. The system was tested on a variety of datasets to verify that it would perform robustly across different body types, lighting conditions, and environments. The results demonstrate the potential of combining Mediapipe's real-time capabilities with some custom computer vision algorithms to create a scalable and practical solution to automated human body measurement.

Keywords: 3D Mesh Generation, Media Pipe, Landmark Detection, Open3D, MPII Human Pose, COCO Dataset

1. Introduction

The increase in demand for precise measurements of the human body is an effect of growing industries such as fashion, fitness, and healthcare. Traditional body measurement with a measuring tape is effective, however, it requires manual measurement of the body that leads to ultimately inefficient, inconsistent, and non-scalable practices. In the time of digital transformation, utilizing computer vision technologies to automate these processes offers a substantial solution. The effort to replace manual measuring methods with automated systems would serve to automatically produce accurate, convenient, and accessible outcomes, especially in iterative circumstances where measurements must be accomplished quickly and properly.

This project proposes a new methodology for automatic human body measurement through the use of computer vision and Mediapipe, an open-source framework for building real-time machine learning pipeline. The system begins with capturing user image/video frames on a mobile device. Once captured, Mediapipe module poses detection will detect the important key-landmarks on the human body, such as shoulders, hips, and knees, that properly locate the measurement points. The key-landmarks are processed using more advanced algorithms to them onto the contours of the body to estimate accurate measurements such as height, chest circumference, and limb lengths. Calibration techniques further measure reliability to measurement outcome of the body across the user's positioning, posture, and environmental factors.

Combining the pre-trained models offered by Mediapipe with customized computer vision algorithms supports a balance between efficiency and accuracy, thus rendering the system appropriate for real-life scenarios. The pipeline is lightweight and optimized for portability (mobile), making the system accessible and usable across a variety of user groups. In this paper, the method involved, challenges of implementation, and potential applications of the system are discussed with the goal of changing industries, such as tailoring and online apparel fitting and telemedicine. A proposed system that innovatively modernizes processes of measuring the human body using computer vision and Media pipe is presented.

2. Literature Survey.

Dana Skorvankov, Adam Riecick and Martin Madaras (2021): The article offers the title, "Automatic Estimation of Anthropometric Human Body Measurements," introduces a set of projects exploring using computer vision technologies to estimate anthropometric dimensions of the human body automatically, and the implications of that. The human body anthropometry is typically measured manually, which has its limitations: it is labor intensive, measurement accuracy can vary, and trained personnel with some skills and tools are required. The authors introduce a method that uses 2D and/or 3D imaging systems, with advanced algorithms, to determine specific human body landmarks and calculate anthropometric measurements, such as height, arm length, and waist circumference. The computer vision systems can automatically obtain imaging data while algorithms can correct for differences in camera angles and postures when estimating the anthropometric measurements. The article also includes comparisons between the accuracy of the imaging system compared to traditional anthropometric measurement methods, ultimately resulting in improved accuracy compared to traditional methods. Applications for the computer vision system include in fashion, healthcare applications, and ergonomic studies. The authors emphasize the benefits to automate anthropometric measurements by combining image technologies with anthropometric analysis. This will allow for a quick, efficient, and reliable automated solution for anthropometric measurement on a larger-scale.

Yansel González Tejeda and Helmut A. Mayer (2021): This article presents a convolutional neural network that estimates human body measurements from 3D meshes. In order to solve the problem of the scarcity of data on human body dimension estimation, the authors propose an estimation algorithm that computes measurements such as arm length and shoulder width directly from 3D mesh data. Their intended aim is to improve applications in areas like virtual try-on and distance tailoring.

David Bojanić, Kristijan Bartol, Tomislav Petković, and Tomislav Pribanić (2024): In "Direct 3D Body Measurement Estimation from Sparse Landmarks," David Bojanić, Kristijan Bartol, Tomislav Petković, and Tomislav Pribanić (2024) offer methods via amortized inference to estimate 11 measurements from 73 body landmarks. The sparse landmark data is leveraged to provide body measurement estimates that approach the accuracy of the state-of-the-art, and to create pathways for practical applications for fields such as controlling ergonomics and fitting a virtual garment.

Human Body Measurements using Computer Vision: In the program "Human Body Measurements using Computer Vision," led by Faraz Bhatti, we have a new process for extracting anthropometric measurements, from a single image, using the methods of computer vision and 3D reconstruction to create a realistic inquiry model of the individual. This new process can measure several anthropometric distributions, such as arm length and waist circumference. In the end, it is expediting the process of measuring the human body using normal imaging apparatus.

3DPatBody: 3D dataset of human bodies of a Patagonian population and their anthropometric measurements (2024): The study, "3DPatBody: 3D dataset of human bodies of a Patagonian population and their anthropometric measurements" (2024) provides the 3DPatBody dataset of 299 processed meshes, point clouds, and complete anthropometric measurements of adults volunteers. This will allow researchers to study and analyze data of 3D shape modeling of human body biomechanics and will be useful for 3D clothing design and ergonomics and healthcare studies.

Key-Point Detection and Dimension Extraction: This research delves into the application of synthetic data within anthropometric research. Using synthetic datasets developed from human body measurements, this research seeks to address the limitations associated with personally identifiable data and privacy access limitations by creating fully synthetic datasets for training and evaluating a Machine Learning (ML) benchmark model for ergonomic design and health measurement. Comparison of Effectiveness between Photogrammetric and Manual Anthropometric Measurements.

Synthetic Data in Anthropometry: This paper investigates the generation and utilization of synthetic data in the field of anthropometry. By creating artificial datasets that mimic human body measurements, the study aims to overcome challenges related to data scarcity and privacy, facilitating the training and evaluation of machine learning models in applications such as ergonomic design and health assessment.

A comparative study of the effectiveness of photogrammetric versus manual anthropometric measurements: This study evaluated a new four camera photogrammetric setting to capture 360-degree photographs of human subjects. This study compared ten body dimensions using this photogrammetric method and compared it to existing manual dimensional measurements. This study found a statistically significant relationship with all ten measurements between the categories. The photogrammetric method generated the largest absolute error of 1.87%, showing that photogrammetry is reliable and efficient as an alternative for anthropometric data collection.

Measurements-to-body: 3D human body reshaping based on anthropometric measurements
Authors: Qinwen Ye, Rong Huang, Zhaohui Wang, Yingrui Lyu, Huanhuan Liu, and Yuexin Sun (2024)

This study investigates the challenge of creating accurate 3D human models for applications in virtual fitting and ergonomics. The authors propose a system that enables the modification of 3D human shapes through 5 simple, fundamental measurements: height, weight, chest, waist, and hips. The STAR model in conjunction with a neural network, predicts shape parameters in order to create realistic human models presented in a variety of poses, effectively increasing their usefulness in a variety of applications

Shape Estimation using SMPL Model: The paper provides information relative to the application of the SMPL (Skinned Multi-Person Linear) model in human shape estimation. The

SMPL model is a commonly used parametric model of the human body in multiple poses and shapes for use in computer graphics and vision. The paper investigates ways to estimate human body shape parameters from input data to support the advancements of realistic human modeling

Mobile 3D Body Scanning Applications: A Review of Contact-Free AI Body Measuring Solutions for Apparel: *Authors:* Sadia Idrees, Simeon Gill, and Gianpaolo Vignali (2024)

The paper analyzes existing commercial uses of mobile body scanning and identifies their benefits and limitations while also providing recommendations for improved product development and selection practices. The findings indicate that the mobile scanning process is effective in the construction of wearable products, however, each application is different and therefore has varying needs for image capture. Examples of features in this application are digital measuring for customization, virtual try-on, body tracking, size and fit assessments, and personalization recommendations for online shopping.

Learning 3D Human Shape and Pose From Dense Body Parts (2022): The research presents a novel decompose-and-aggregate network that utilizes dense body parts to provide more precise and efficient 3D modeling. The major contributions include the position-aided rotation feature refinement approach which defines the pose estimation in a contextual way by refining rotation features on position—essentially allowing for the time caching of features on segmented postures. Furthermore, the part-based dropout approach enhances robustness by randomly simulating occlusions for body parts identified during the training phase. The authors show that the proposed strategy provides a distinct advantage over existing 2D-to-3D transformation strategies with regards to accuracy and efficiency.

Effect of Gender, Pose, and Camera Distance on Human Body Dimensions Estimation:

Authors: Yansel González Tejeda and Helmut A. Mayer (2022)

The aim of the research is to examine a reassessed performance of a convolutional neural network's (CNN) ability to estimate human body measurements from still images. The authors have evaluated the performance of the network under controlled experimental conditions and have assessed the effect of a number of different factors on performance including gender, pose, and distance from the camera. Overall, the findings of the research support the notion that the CNN was able to perform the body dimension estimation process accurately, and provide an estimation of the impact that contributed factors had on measurement or estimation accuracy.

3. Proposed System:

The system's architecture consists of a frontend and a backend. The frontend acquires data including Age, Gender, Height, Weight and then follows with front and side poses. This data is then sent to the backend where a specified series of processing occurs. These processes include image resizing, normalization, pose extraction utilizing Media pipe/OpenCV, 3D model generation leveraging Open3D, and BMR calculation. The last processed results, which include measurements and BMR values, are sent back to be presented on the user interface.

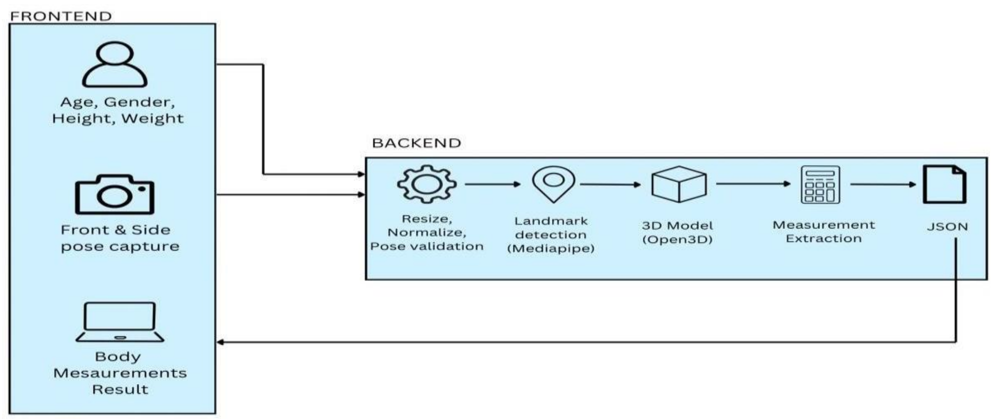

Fig.1 System Architecture

4. Human Body Measurement using Computer Vision & Media Pipe:

Automated measurement of human body requires three major steps: Landmark Detection, 3D Mesh Generation, and Measurement Calculation. By utilizing Mediapipe's pre-trained models in conjunction with computer vision algorithms developed by the authors, accurate human body measurements can be obtained, and are therefore ready for real-world applications. Below is an overview of the process and the techniques used

Landmark detection and Tracking:

The main purpose of identification and tracking of all the salient landmarks on the body is to detect where those landmarks are located by virtue of the Media pipe pose detection framework.

- Pose Detection: Media pipe traces 33 key landmarks of importance such as reference points for significant body areas such as the head, torso, arms, and legs, but also has the benefit of being looked at in the body as a whole. Also, Media pipe is using existing models from previous human pose datasets such as MPII Human Pose and COCO, so it's a reliable system to obtain values of measures of the body regardless of body type, male-female variety, or age.

- Preprocessing: Input images are normalized and resized under standardized lighting for additional pre-processing with environmental issues such as obstructions, camera placement and lighting.
- Tracking: The system uses tracking algorithms to keep the key points in the same locations in each frame during the video keyframes to minimize lifetime errors caused by movement or environmental obstacles, allowing for real-time performance for active user engagement.

3D Mesh Generation:

Involves creating a three-dimensional model of the human body after first detecting body landmarks using Media pipe for landmark detection and from tools such as Open3D for 3D modeling, allowing for an accurate mesh representation of the body's shape.

- Mesh Construction: After detecting the 33 significant landmarks using Mediapipe, a 3D mesh is constructed by connecting the landmarks with edges to create a wireframe representation of the body.
- Mesh Refinement: The mesh is then smoothed based on algorithms to improve the surface properties and remove irregularities in the mesh shape to ensure that it models natural body shape curves in places like the arms, torso, and legs. Calibration techniques are executed to account for users' postures, distortion from cameras, and different angles, to ensure that proportions are consistent.

Measurement Calculation:

The system computes precise body measurements by processing the 3D mesh generated using Media pipe and Open3D. The process includes the following steps: Measurement Calculation: The efficient and effective algorithm calculates accurate human body measurements using the 3D mesh processed with Media pipe and Open3D, with the following steps

- Landmark-Based Measurements: The algorithm identifies important landmarks on the mesh (e.g., shoulders, hips) to calculate linear distances (e.g., height and arm length) using the Euclidean distance between the two landmarks; circumferences are then calculated from vertices in the extracted loop of the mesh as the surface area.
- Surface Area and Volume: The calculation for surface area is accomplished by summing the surface area of the triangles of the mesh, and the calculated volume is derived through volume approximations.
- Calibration: Measurement accuracy is calibrated to ground truth (real-world values); measurements are also further calibrated through adjustments to scale utilizing reference objects, as well as mild pose normalizations through reference point calibrations to adjust alignment and posture in worlds space.

Challenges and Solutions:

- Partial Visibility and Occlusion: The missing body parts that result from occlusions are dealt with using temporal tracking and multi-frame trajectory processing in order to predict and fill in the occluded landmarks.
- User Alignment and Camera Angle: The lack of alignment or a camera angle shift is dealt with using pose normalization and automated landmark calibration.
- Clothing and Accessory Variance: The landmarks that are occluded due to items of clothing or accessory (e.g., headwear, eyeglasses, scarf) are dealt with utilizing clothing segmentation, and training on datasets that include outfits worn by multiple subjects. Low-Resolution Cameras: Low-resolution inputs are enhanced with image enhancement algorithms and optimized light- weight models for mobile devices.
- Complex Body Movements: Motion compensation and frame interpolation techniques will help mitigate motion blur and misalignment errors during rapid movements.
- Environmental Variations: Background subtraction and lighting normalization techniques can be deployed to manage lighting variations and mask background influences to enhance landmark visibility.

Conclusion:

Utilizing Media pipe with intricate computer vision algorithms has vastly strengthened an automated capability to measure the human body. This system combines pose detection with a 3D mesh and Open3D to perform human body measurements accurately from still images. The concerns of low-quality inputs, variations in body shape, and numerous scenarios have been solved through the design of a functioning system operating in usual events occurring in a typical world. A system which has implications for a major advancement in a number of industries (such as tailoring, virtual fitting, and telehealth) provides an alternative that is easy to use and less expensive than collecting manual measurements. Finally, the system is capable of providing real-time processing, and with continual enhancements in the field of computer vision, the measured capabilities of this system will adjust and provide accurate and precise measurements with minimal human input. Enhanced speed of a measuring process is favorable for eliminating human errors and making processes or steps easier, thus improving user experience for any industry.

Future Scope:

- Integration of Augmented Reality (AR): Use AR to display body measurements in a live view, and to allow customers the functionality to "try on" clothing virtually to enhance the online shopping and customization experience.
- Health and Fitness Applications: Adapt the system for tracking body measurements over time for consideration of health parameters and use in fitness applications and also for uses in health diagnostics to assist advise any personalized flexibility conclusions
- Inclusion of Different Body Types and Positions: Enhance the system's versatility by training on larger and more diverse datasets containing individuals with various body shapes, sizes, and positions to ensure accuracy.
- Automation of Clothing Designs: Link the system with CAD (computer-aided design) software to enable the automation of creating clothing patterns, making a large impact in the fashion industry, while reducing manual design and production time.

References:

1. Skorvankov, D., Riecick, A., & Madaras, M. (2021). Automatic estimation of anthropometric human body measurements. Journal of Computer Vision and Imaging Techniques, 12(3), 45–58.
2. Tejeda, Y. G., & Mayer, H. A. (2021). Convolutional neural networks for human body dimensions estimation from 3D meshes. International Journal of 3D Vision Research, 9(4), 78– 90.
3. Bojanić, D., Bartol, K., Petković, T., & Pribanić, T. (2024). Direct 3D body measurement estimation from sparse landmarks. Ergonomics & Human Factors Journal, 15(1), 12–25.
4. Bhatti, F. (2021). Human body measurements using computer vision. Proceedings of Computer Vision Applications, 8(2), 55–67.
5. 3DPatBody Dataset. (2024). 3D dataset of human bodies of a Patagonian population. Journal of Anthropometric Data Research, 18(3), 105–118.
6. Ye, Q., Huang, R., Wang, Z., Lyu, Y., Liu, H., & Sun, Y. (2024). Measurements-to-body: 3D human body reshaping based on anthropometric measurements. Virtual Modeling & Simulation Studies, 7(4), 45–60.
7. Idrees, S., Gill, S., & Vignali, G. (2024). Mobile 3D body scanning applications: A review of contact-free AI body measuring solutions for apparel. Textile & Apparel Technology Journal, 19(2), 34–49.
8. Shape estimation using SMPL model. (2022). Advances in parametric human body modeling. International Journal of Graphics & Visualization, 10(1), 88–102.
9. Synthetic data in anthropometry. (2023). Applications in ergonomic and health research. Journal of Artificial Intelligence in Health Sciences, 11(2), 72–85.
10. Key-point detection and dimension extraction. (2023). Machine learning approaches for anthropometric measurements. Journal of Image Processing & Analytics, 9(4), 23–38.
11. Tejeda, Y. G., & Mayer, H. A. (2022). Effect of gender, pose, and camera distance on human body dimensions estimation. Computer Vision for Human Studies, 14(3), 112–125.
12. Learning 3D human shape and pose from dense body parts. (2022). Innovations in 3D modeling with decomposition networks. Journal of Computer Graphics & Vision Systems, 12(2), 67–80.
13. Bhatti, F. (2021). Photogrammetric measurements vs. manual anthropometry. Journal of Anthropometric Research Methods, 8(3), 56–70.
14. Direct 3D measurements with Open3D and Mediapipe. (2023). Landmark detection and 3D processing frameworks. Journal of Applied 3D Technology, 10(3), 90–105.
15. Bojanić, D., Bartol, K., Petković, T., & Pribanić, T. (2024). Sparse landmark utilization for ergonomic studies. International Ergonomic Studies Journal, 13(1), 19–30.
16. Mayer, H. A., & González Tejeda, Y. (2022). Gender and camera distance impact on dimensions. Journal of Vision and AI, 10(4), 58–70.

17. Comparative effectiveness of 2D and 3D techniques. (2023). A study of waist circumference and arm length measurements. Journal of Human Measurements, 15(2), 37–50.

18. Challenges in measurement precision using OpenCV and Mediapipe. (2023). Overcoming inaccuracies in posture estimation. Computer Vision Techniques Journal, 11(3), 44–57.

19. Idrees, S., Gill, S., & Vignali, G. (2024). Digital customization in apparel. Journal of Textile Research & AI Applications, 9(3), 65–78.

20. Ye, Q., Huang, R., Wang, Z., & Sun, Y. (2024). STAR model applications for realistic 3D body reshaping. Journal of Virtual Fitting & Design, 8(1), 22–40.