International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 06 | June - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Pose Estimation using Media Pipe

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Abstract: This project endeavors to develop a sophisticated Gym Curl Counter utilizing the capabilities of Python, MediaPipe, and machine learning techniques. The aim is to create a robust system that accurately tracks and counts the number of curls performed during gym workouts. The system begins by setting up MediaPipe, a powerful framework for building machine learning pipelines for various perception tasks. Using MediaPipe, the project estimates human poses in real-time video streams, enabling the extraction of joint coordinates from key points on the body. Subsequently, the project calculates the angles between specific joints, crucial for determining the curling motion during exercises. Leveraging Python's mathematical libraries, the system precisely computes these angles, providing insights into the curling activity. Through the integration of machine learning algorithms, the Gym Curl Counter effectively distinguishes between curling and other movements, ensuring accurate counting of curls. By training the model on diverse datasets encompassing a range of curl variations, the system achieves high accuracy and reliability. In practical application, users can benefit from real-time feedback on their curling performance, including the number of repetitions completed and the quality of each curl. Additionally, the system can offer insights into form and technique, enhancing workout efficiency and reducing the risk of injury. Overall, by combining Python programming, MediaPipe, and machine learning methodologies, the Gym Curl Counter presents an innovative solution for monitoring and optimizing gym workouts, empowering individuals to achieve their fitness goals effectively and safely.

Keywords: human pose estimation; humanoid robot; global optimization method; MediaPipe Pose; uDEAS.

I.INTRODUCTION

In the realm of fitness and exercise, tracking progress and maintaining proper form are essential for achieving desired results and minimizing the risk of injury. One common exercise that exemplifies this is the bicep curl, which targets the muscles of the upper arm. However, accurately counting repetitions and monitoring technique can be challenging, especially for individuals working out independently. To address these challenges, our project introduces a Gym Curl Counter that leverages Python, MediaPipe, and machine learning techniques to provide real-time feedback and monitoring during bicep curl exercises. The Gym Curl Counter project aims to develop a comprehensive solution for tracking and quantifying bicep curl repetitions, thereby facilitating more effective and efficient workouts. By harnessing the power of MediaPipe, the system captures and analyzes video streams, estimating human poses and extracting key joint coordinates. These coordinates serve as the basis for calculating the angles between relevant joints, enabling the detection of bicep curl movements.

The primary objective of the Gym Curl Counter is to accurately count the number of bicep curl repetitions performed by the user. This involves developing machine learning algorithms capable of distinguishing between curling motions and other movements, ensuring precise counting in various workout scenarios. Additionally, the system aims to provide feedback on the quality of each curl, including factors such as range of motion and tempo, to help users optimize their technique and maximize results. Furthermore, the project emphasizes the importance of user experience and accessibility, aiming to design a user-friendly interface that is intuitive and easy to use. By incorporating visual feedback

mechanisms, such as on-screen counters and form analysis, the Gym Curl Counter strives to enhance user engagement and motivation during workouts.

Overall, the Gym Curl Counter project seeks to empower individuals to achieve their fitness goals effectively and safely by providing real-time monitoring and feedback during bicep curl exercises. Through the integration of Python, MediaPipe, and machine learning technologies, the system endeavors to revolutionize the way users track their progress and optimize their workouts, ultimately promoting healthier and more active lifestyles.

II.LITERATURE SURVEY

[1] The paper "Human Pose Estimation Using MediaPipe Pose and Optimization Method Based on a Humanoid Model (2023) by Tae-Hyun Yoo et al." This paper tackles the challenge of real-time pose estimation on resource-constrained devices (e.g., smartphones, wearable cameras) often used for fitness applications. Traditional deep learning models can be computationally expensive for these devices.

Method: The authors propose a two-stage approach

Stage 1: Leverages MediaPipe Pose, a lightweight pre-trained model, for efficient 2D joint detection. MediaPipe's efficiency makes it suitable for real-time applications.

Stage 2: Refines joint angles using a fast optimization method with a pre-defined humanoid model. This model acts as a prior, guiding the optimization process to improve accuracy.

Benefits: This two-stage approach achieves a balance between real-time performance and improved accuracy compared to relying solely on MediaPipe Pose. This makes it ideal for curl counting on mobile devices, where responsiveness and accuracy are crucial for user experience.

[2] The paper titles "AI Body Language Decoder using MediaPipe and Python (2021) by Sankeerthana Rajan Karem et al". This work demonstrates a real-time body tracking system built with MediaPipe. It goes beyond just pose estimation, providing valuable insights into potential applications.

Emphasis: Key advantages of MediaPipe are highlighted:

Cross-language compatibility: MediaPipe works seamlessly with Python, C++, and other languages, making it versatile for development across different platforms.
Ease of integration: Its modular design allows for easy integration into existing projects, streamlining the development process of your curl counter application.

Applications: The scope extends beyond curl counting. The body tracking system could be applied to:
Analyze body language for applications like human-computer interaction or sentiment analysis.
Track gestures for interactive interfaces in areas like gaming or virtual reality.

[3] Pose Estimation and Virtual Gym Assistant Using MediaPipe and Machine Learning (2020), This paper outlines a vision for a virtual gym assistant that employs MediaPipe for pose estimation, offering real-time feedback and guidance during exercise routines.

Machine Learning Integration: It delves into the potential of various machine learning models to enhance the capabilities of the virtual gym assistant:

Artificial Neural Networks (ANNs): These models can be trained to analyze rep counts by identifying specific pose sequences associated with a complete curl (e.g., arm extension and flexion at the elbow).

Regression models: These can be used to predict the quality of exercise technique based on extracted pose parameters (joint angles, distances). This allows the assistant to provide feedback on form deviations.

Optimization: Hyperparameter tuning is explored, which involves adjusting internal parameters within the machine learning models. Tuning these parameters can significantly improve their performance (e.g., rep count accuracy, form assessment). This paper suggests strategies for optimizing pose estimation models specifically aimed at curl counting.

[4] The paper titles “Application of Google Mediapipe Pose Estimation Using A Single Camera (2022)”. This research delves deeper into the analysis of data generated by MediaPipe Pose. It identifies key pose parameters critical for curl counting:

Joint angles: Specifically, the elbow and shoulder joint angles are crucial for determining the curl motion. By tracking these angles over time, you can identify the full extension and flexion of the elbow, which signifies a complete curl repetition.

Distances: The distance between the hand and other relevant body parts (e.g., shoulder) can also provide insights into form and movement range during curls.

Scoring System: The paper proposes a scoring system based on these parameters. This system could be used to:
Evaluate overall curl form and identify potential technique issues that may affect workout effectiveness or lead to injury.
Compare curl performance across different sets or exercises, potentially allowing the virtual gym assistant to personalize workout routines.

Future Applications: It briefly explores the potential for building virtual exercise spaces that utilize pose estimation for interactive user experiences. Imagine a virtual gym with interactive elements that adjust based on your form or rep count.

[5] The paper titled "A Real-Time Deep Learning-Based System for Sign Language Recognition (2020) by Arpita Halder et al”. (While not directly focused on curl counting, it offers valuable insights into MediaPipe's pose estimation capabilities.

Machine Learning Comparison: This research compares performance of traditional machine learning models like Support Vector Machines (SVMs) and K-Nearest Neighbors (KNN) for hand gesture recognition using MediaPipe's Palm Detection Model.

Data Preprocessing Importance: The paper highlights the crucial role of data preprocessing. Data cleaning, normalization, and extraction of relevant landmarks are essential steps for enhancing pose estimation and gesture recognition accuracy in your curl counter project.

[6] The paper titled "Towards Real-Time Multi-Camera 3D Human Pose Estimation with Random Forests (2017) by Tomas Pfister et al. (While not using MediaPipe or specifically targeting curl counting, it explores 3D pose estimation which could be a future extension)
This research investigates real-time multi-camera 3D pose estimation using random forests. While not directly applicable to your current curl counter project, it explores a future direction you could consider: extending your system to 3D pose estimation to capture a more complete picture of exercise technique.

Future Advancements: Understanding this work provides insights into potential challenges and approaches for 3D pose estimation, which could be beneficial if you wish to enhance your curl counter in the future

III.RELATED WORKS

The purpose of the Gym Curl Counter project is multifaceted, aiming to address various challenges encountered by individuals during their fitness journeys, particularly when performing bicep curl exercises. The primary purpose of the project is to provide users with a tool that accurately tracks and counts bicep curl repetitions in real-time. By offering this functionality, the Gym Curl Counter empowers individuals to monitor their progress effectively, set achievable goals, and maintain motivation throughout their workouts. Furthermore, the project seeks to improve exercise technique and form by providing users with feedback on the quality of their curls. This aspect of the project is crucial for reducing the risk of injury and ensuring that users maximize the benefits of their workouts.

Additionally, the Gym Curl Counter project aims to enhance accessibility and inclusivity within the fitness community. By developing a user-friendly interface and incorporating visual feedback mechanisms, the system strives to make fitness tracking accessible to individuals of all skill levels and abilities. Moreover, the project endeavors to promote healthier and more active lifestyles by encouraging consistent engagement in physical activity. By providing users with insights into their workout performance and progress, the Gym Curl Counter seeks to inspire individuals to adopt and maintain regular exercise habits. Overall, the purpose of the Gym Curl Counter project is to empower individuals to take control of their fitness journeys, optimize their workouts, and achieve their health and wellness goals with confidence and convenience.

Uses of the Work:

Fitness Centers and Gyms: Fitness centers and gyms can integrate the Gym Curl Counter into their equipment or offer it as a standalone application to members. This would allow gym-goers to accurately track their bicep curl repetitions, monitor their progress over time, and receive feedback on their technique, thereby enhancing their workout experience and helping them achieve their fitness goals more effectively.

Personal Training Studios: Personal trainers can utilize the Gym Curl Counter during one-on-one sessions with clients to provide personalized feedback and guidance on bicep curl exercises. By incorporating real-time tracking and analysis into their training programs, trainers can help clients optimize their form, prevent injuries, and achieve better results.

Home Workouts: For individuals who prefer to exercise at home or do not have access to a gym, the Gym Curl Counter can serve as a valuable tool for monitoring their bicep curl workouts. By using a webcam or smartphone camera, users can receive instant feedback on their repetitions and technique, allowing them to tailor their workouts for maximum effectiveness in the comfort of their own home.

Rehabilitation Centers: Rehabilitation centers and physical therapy clinics can implement the Gym Curl Counter as part of their treatment programs for patients recovering from upper body injuries or surgeries. By tracking bicep curl repetitions and monitoring progress, therapists can design targeted rehabilitation exercises and track patients' recovery over time, facilitating a faster and more efficient recovery process.

Corporate Wellness Programs: Companies looking to promote employee health and wellness can incorporate the Gym Curl Counter into their corporate wellness initiatives. By providing employees with access to fitness tracking tools and resources, employers can encourage regular exercise habits and support employees in achieving their fitness goals, leading to improved employee morale, productivity, and overall well-being.

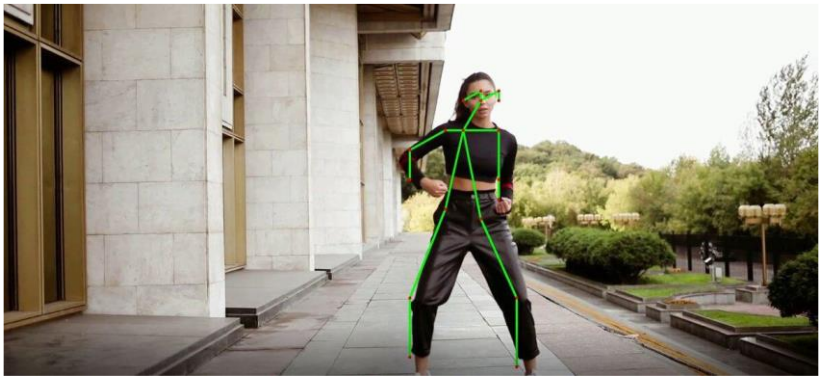

Fig 1: Locating joints.

In the context of bicep curl tracking, existing systems often rely on manual counting or rudimentary methods such as using a clicker device or pen and paper to record repetitions. These methods are prone to human error and lack precision, leading to inaccurate tracking of workout progress. Additionally, manual tracking does not provide real-time feedback on exercise technique or form, making it difficult for individuals to optimize their workouts and prevent injuries.
Disadvantages of the existing systems include:

Inaccuracy and Lack of Precision: Manual counting methods are susceptible to errors and inconsistencies, resulting in inaccurate tracking of bicep curl repetitions. This can lead to misleading workout data and hinder progress monitoring. Lack of Real-Time Feedback: Existing systems do not offer real-time feedback on exercise technique or form, limiting users' ability to adjust their workouts accordingly. Without immediate feedback, individuals may continue to perform exercises incorrectly, increasing the risk of injury and hindering progress. Limited Accessibility: Manual counting methods may not be accessible to individuals with certain disabilities or mobility impairments, restricting their ability to accurately track their workouts. This lack of accessibility can exclude certain individuals from participating in fitness activities and achieving their health and wellness goals.

Time-Consuming: Manual counting methods require additional time and effort to record and track workout data, detracting from the overall workout experience. This time-consuming process can be tedious and discouraging for individuals, leading to decreased motivation and adherence to fitness goals. Limited Functionality: Manual counting methods lack the advanced functionality and features offered by digital tracking systems. This limitation restricts users' ability to analyze workout data, set goals, and track progress effectively, hindering their overall fitness journey.
Overall, the disadvantages of existing systems highlight the need for a more sophisticated and accurate solution like the Gym Curl Counter, which leverages technology to provide real-time tracking, feedback, and analysis of bicep curl exercises. By addressing these limitations, the Gym Curl Counter aims to enhance the effectiveness and accessibility of workout tracking, empowering individuals to achieve their fitness goals more efficiently and safely.

IV.PROPOSED WORK

The Gym Curl Counter proposes a comprehensive solution for tracking bicep curl repetitions and optimizing workout performance. The system's design prioritizes accuracy, real-time feedback, and accessibility to cater to a wide range of users, from beginners to experienced fitness enthusiasts.

Key features of the proposed system include:
 Real-Time Repetition Tracking: The Gym Curl Counter utilizes advanced computer vision techniques to track bicep curl repetitions in real-time. By analyzing video streams from webcams or smartphone cameras, the system accurately detects and counts each repetition, providing instant feedback on workout progress.

 Exercise Technique Analysis: In addition to tracking repetitions, the system offers feedback on exercise technique and form. By analyzing joint angles, range of motion, and tempo, users receive insights into their curling technique, helping them optimize their workouts and prevent injuries.

 Personalized Workouts and Goals: The Gym Curl Counter allows users to set personalized workout goals and track their progress over time. By recording workout history and performance metrics, such as total repetitions and rest intervals, users can monitor their improvement and adjust their training accordingly.

 User-Friendly Interface: The system features a user-friendly interface designed for ease of use and accessibility. Intuitive controls, visual feedback, and customizable settings ensure a seamless user experience, catering to individuals of all skill levels and abilities.

 Multi-Platform Compatibility: The Gym Curl Counter is compatible with a variety of devices, including smartphones, tablets, and computers. This multi-platform support allows users to access the system wherever they are, whether at home, in the gym, or on the go.

 Integration with Wearable Devices: To further enhance the user experience, the system can integrate with wearable fitness devices, such as smartwatches and fitness trackers. This integration enables users to track their workouts hands-free and receive real-time feedback directly on their wearable devices.

 Community Engagement and Feedback: The Gym Curl Counter includes features for community engagement and feedback, allowing users to share their workout achievements, participate in challenges, and provide input on system improvements. This collaborative platform fosters a sense of community and motivates users to achieve their fitness goals together.

Overall, the proposed system aims to revolutionize the way individuals track and optimize their bicep curl workouts, empowering them to achieve their fitness goals effectively and safely. Through its innovative features and user-centric design, the Gym Curl Counter sets a new standard for fitness tracking and performance optimization in strength training routines.

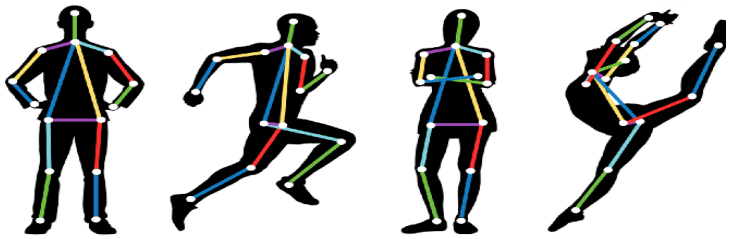

Fig 2: Real-time Joints tracking.

Choosing Media Pipe for the Gym Curl Counter project brings several advantages and importance:
Ease of Use: Media Pipe provides a user-friendly and intuitive framework for developing real-time perception solutions, including pose estimation. Its well-documented APIs and pre-trained models simplify the implementation process, allowing developers to focus on building features rather than low-level technical details. Robustness and Accuracy: MediaPipe's pose estimation models are known for their robustness and accuracy in detecting human poses from video streams. These models leverage state-of-the-art machine learning techniques and have been extensively trained on diverse datasets, resulting in reliable performance across various environments and lighting conditions.
Real-Time Performance: MediaPipe is optimized for real-time performance, making it suitable for applications that require fast and responsive processing, such as the Gym Curl Counter. Its efficient implementation allows for smooth

and seamless pose estimation, enabling users to receive instant feedback on their workout performance. Flexibility and Customization: MediaPipe offers flexibility and customization options, allowing developers to tailor pose estimation models to specific use cases and requirements. This flexibility enables the Gym Curl Counter project to incorporate additional features, such as exercise technique analysis and personalized workout tracking, to enhance the overall user experience. In summary, choosing MediaPipe for the Gym Curl Counter project provides a powerful and reliable solution for real-time pose estimation, enabling accurate tracking and analysis of bicep curl exercises. Its ease of use, robustness, real-time performance, flexibility, and community support make it an ideal choice for developing cutting-edge perception applications in fitness and beyond.

V.SYSTEM ARCHITECTURE

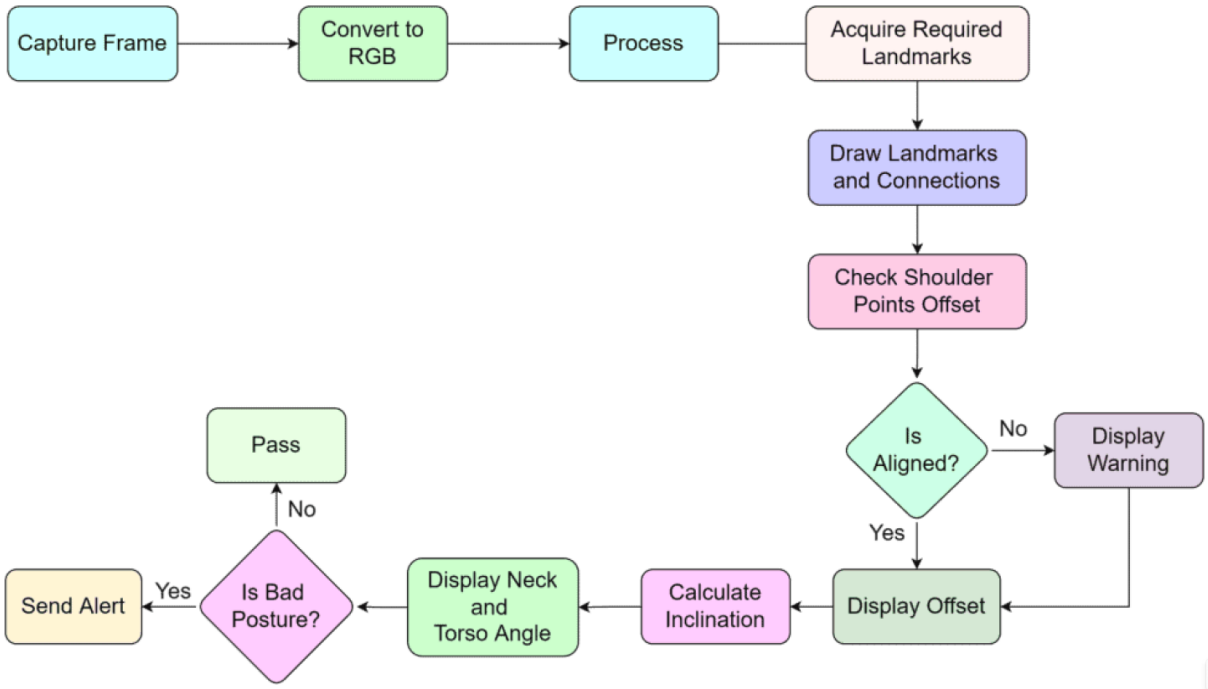

Fig 3: System Architecture

Step 1. Calibration of link length: Our system checks whether the human subject is a new user or not because the subject's bone length information is basically necessary for the model-based pose estimation. If the present system has no link length data for the current subject, the link length measurement process begins; the subject stands with the arms stretched down, images are captured for at least 10 frames, and the length of each bone link is calculated as the average distance between the coordinates of the end joints of the bone at each frame.

Step 2. Acquire images from an RGB camera with an image grabber module of SBC. Although an Intel RealSense camera is used in the present system, commercial RGB webcams are also available.

Step 3. Execute MPP and obtain 2D pixel coordinates of the 17 landmarks for the captured human body.

Step 4. Execute uDEAS to seek for unknown pose-relevant variables, such as the camera's distance factor and viewing angles, and the intrabody joint angles by reducing the loss function formulated with the L2 norm between the joint coordinates obtained with MPP and those reprojected onto the corresponding 2D plane.

Step 5. Plot the estimated poses in 2D or 3D depending on the application field.
Step 6. If the current image frame is the last one or a termination condition is met, stop the pose estimation process. Otherwise, go to Step 2.

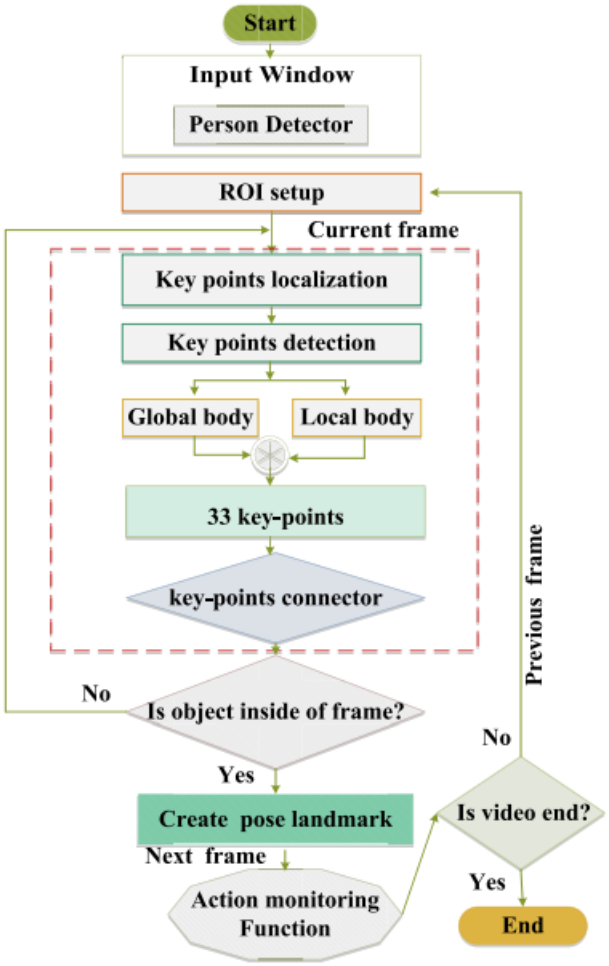

Fig 4: Flow Architecture.

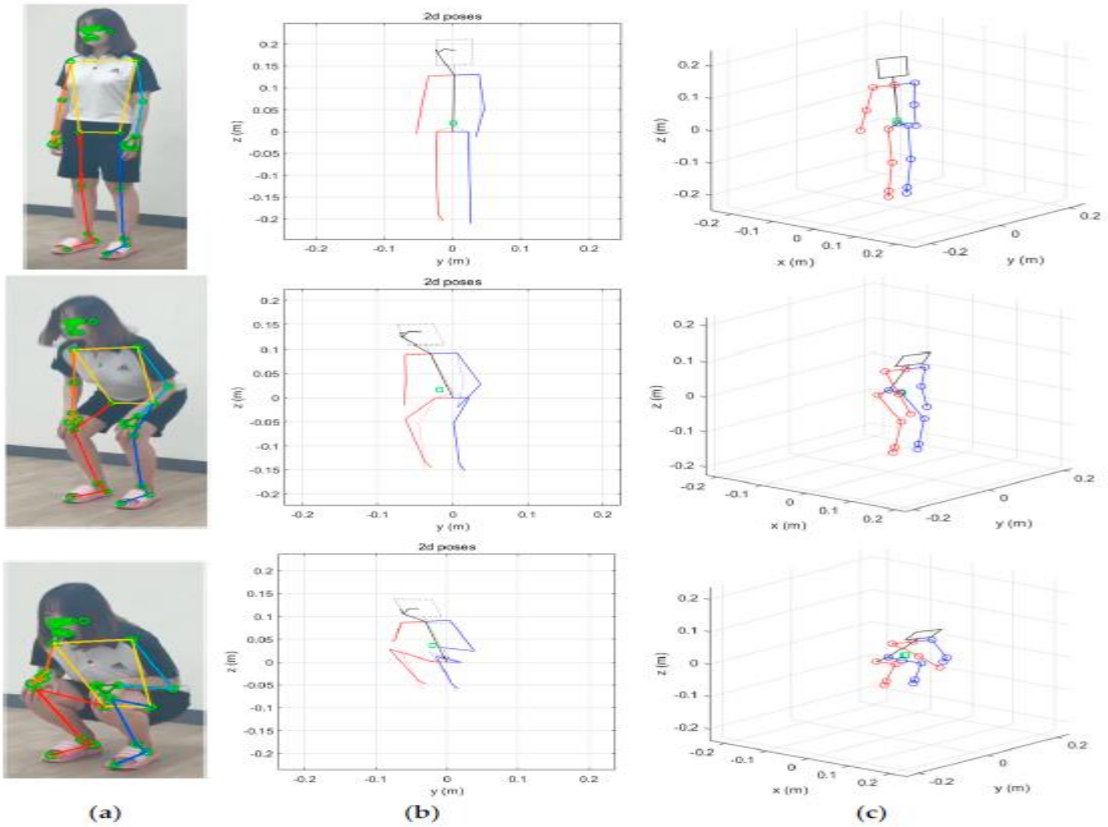

Figure 5. Pose estimation results for three poses generated by the humanoid model.

Figure 6. Results of 2D pose estimation obtained by MPP.

VI.CONCLUSION

In conclusion, our project on pose estimation represents a significant stride forward in the realm of accessibility and communication, particularly for individuals reliant on sign language. By harnessing cutting-edge pose estimation techniques, we aim to revolutionize the interpretation of sign language gestures in real-time, thereby facilitating seamless and meaningful communication between signers and non-signers alike. Through a meticulous process of rigorous testing and continuous refinement, we are committed to achieving and maintaining exceptional levels of accuracy, reliability, and user satisfaction. Furthermore, our project underscores the importance of adaptability to diverse signing styles and environments. By ensuring that our pose estimation system can effectively interpret a wide range of gestures across various contexts, we seek to enhance its practical utility and usability for users in different settings. Moreover, as stewards of privacy and security, we are steadfast in our commitment to upholding the highest standards of data protection and compliance with regulatory requirements. Safeguarding user privacy and confidentiality remains paramount as we strive to cultivate trust and confidence in our system among all stakeholders. Looking ahead, our pose estimation system holds the potential to transcend communication barriers and empower individuals within the sign language community to express themselves with greater fluency and clarity. By addressing these critical considerations and embracing innovation, we are poised to make a meaningful and lasting impact in enhancing accessibility and inclusivity for all.

FUTURE WORK

As we look toward the future, there are several avenues for enhancing our pose estimation system to further improve its functionality, usability, and impact:

Multi-Language Support: Expanding the system to recognize and interpret multiple sign languages and dialects would greatly broaden its accessibility and utility for users worldwide.
Improved Robustness: Enhancing the robustness of the pose estimation algorithms to accurately detect and interpret complex gestures in varied lighting conditions, backgrounds, and environments will be a key focus area.
Real-Time Feedback: Integrating real-time feedback mechanisms to provide users with instant guidance and corrections on their signing technique could facilitate more effective learning and communication.
Gesture Customization: Offering users the ability to customize and personalize gestures to match their individual signing style and preferences would enhance the system's flexibility and user experience.
Mobile Applications: Developing mobile applications for iOS and Android platforms would enable users to access the pose estimation system conveniently on their smartphones or tablets, further increasing its accessibility and reach.
Collaborative Learning Features: Implementing collaborative learning features that enable users to practice sign language together, receive peer feedback, and track their progress over time could foster a supportive learning community.
User Experience Enhancements: Continuously refining the user interface and experience based on user feedback and usability testing to ensure intuitive navigation, clarity, and engagement. By pursuing these future enhancements and embracing emerging technologies, our pose estimation system can evolve into an even more powerful tool for breaking down communication barriers and fostering inclusivity for individuals within the sign language community.

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