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Workout Pose Correction System using KNIFT

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***Abstract*— This paper proposes a system to assist users in performing exercise workouts by implementing MediaPipe Keypoint Neural Invariant Feature Transform (KNIFT). Exercise requires proper directions to follow as improper movements during exercise can lead to injuries. Mediapipe KNIFT offers real time tracking of the user's movement as compared to only pose detection. Using the coordinates of the joints, the angle between joints and speed of movement can be calculated which can be used to guide to user to follow proper exercise movements. Pygame library was used to make a user friendly interface, along with voice recognition to enable hands free usage.**

***Keywords*— Computer Vision, KNIFT, Python, cv2, Media pipe, Pose Correction, gtts, SR.**

I. Introduction

"Computer vision and artificial intelligence has gained significant advancements and recognizing and tracking humans has been an esteemed field[3]. MediaPipe Keypoint Neural Invariant Feature Transform (KNIFT) has provided an efficient solution to tracking humans by dividing the human body into key points or landmarks[1]. In response to this need, we designed a comprehensive system designed to enhance workout sessions by capturing and analysing workout videos, detecting joint positions, and offering real-time feedback on exercise form[4]. The primary objective of system is to address the challenges associated with incorrect exercise form and help users achieve their fitness goals more effectively.

The workout system aims to provide correct guidance to its user to perform exercises. The user can stand in front of an inbuild or external camera and the video stream is pipelined to the system[5]. Using MediaPipe KNIFT, we extract all the landmarks or joints of the user and calculate the angle between the joints to guide the user if they are doing the exercise correctly [6]. The number of reptations is also calculated by defining start and end angle ranges[7]. Pygame library, along with OpenCV was used to create a user interface[1]. OpenCV provides many tools to draw on the video stream, which is used to show corrected poses to the user. Since user may be away from their computer, they can also operate the system using voice commands implemented using Speech Recognition(SR) and Google Text to Speech (Gtts) libraries[9].

This research focuses on methodology , including data capture, video analysis, joint detection using Mediapipe library, workout categorization, angle pair calculation, pose correction, and feedback mechanisms. By introducing this system as a novel approach to workout pose correction and guidance, this research paper aims to contribute to the field of computer vision in fitness training[10]. The system's comprehensive features and real-time feedback capabilities have the potential to revolutionize workout sessions, enabling individuals to optimize their training routines, minimize the risk of injuries, and achieve their fitness objectives more efficiently[11]."

II. LITERATURE SURVEY

In recent years, various systems have been developed to improve workout routines using computer vision, machine learning, and artificial intelligence. These systems aim to guide users in performing exercises correctly, reducing the chances of injury, and providing real-time feedback on posture[2].

1. AI-Based Workout Assistant Systems
An AI-based workout assistant developed by Gourangi Taware and Rohit Agarwal focuses on using artificial intelligence to assist users in achieving their fitness goals by monitoring and analyzing workout sessions. Their system integrates AI with human-computer interaction, using real-time video processing to detect incorrect postures and provide feedback, much like the KNIFT-based workout system used in this paper[2].

2. Virtual Fitness Trainers Neha and Dr. S.K. Manju Bargavi developed a virtual fitness trainer system that relies on artificial intelligence to track users' movements and provide customized feedback during exercises. Their system primarily focuses on user accessibility and injury prevention, integrating real-time feedback mechanisms[3].

3. Yoga Posture Detection Using Machine Learning
Another closely related system is presented by D. Mohan Kishore et al., which applies machine learning to detect and evaluate yoga postures. The system uses pose estimation to analyze body alignment during different yoga asanas, offering similar real-time corrective guidance as seen in our workout pose correction system using KNIFT[4].

4.Human Pose Detection Using Deep Learning
A study by Deepak Maurya and Grandel Dsouza utilized deep learning to track human pose detection in various fitness applications. This study also aims to ensure real-time posture correction, a critical element in fitness AI systems[7].

5.BlazePose and Machine Learning
Swapnil Dawange and Akash Chavan implemented Mediapipe BlazePose along with machine learning techniques to analyze workout movements, focusing on accuracy in detecting the angle and form of the body[8].

6.Human Pose Estimation for Action Recognition
Liangchen Song, Junsong Yuan, and Zicheng Liu provided a comprehensive survey on human pose estimation and its application in action recognition[20]. Their work emphasizes how pose estimation is used to identify actions and provide feedback on posture, a key aspect of fitness and workout systems. This study highlights the importance of real-time posture recognition, similar to the goals of the KNIFT-based workout system[20].

7. Hand Gesture Recognition Using Neural Networks
Shailaja Uke and Amol Zade explored human hand gesture recognition using neural networks and real-time video processing[1]. Their research in recognizing human movements through visual input is aligned with the present study, where KNIFT and Mediapipe are used to detect full-body joint movements. This shows how real-time recognition of human actions can be extended to fitness applications[5].

8.Gym Trainer Application Using Machine Learning
Sathvik K Gatti and Rohit P introduced a gym trainer application that uses machine learning for workout monitoring[6]. The system aims to guide users by detecting and correcting postures in real-time. It incorporates AI-based techniques to ensure accurate posture during various exercises, which directly aligns with the principles used in KNIFT-based workout correction[6].

9.Human Pose Estimation for Action Detection
Duc Thanh Nguyen and Wanqing Li presented a method for object detection using template matching for real-time applications[10]. Their approach to improving template matching through pose estimation and recognition is relevant to systems like KNIFT, which rely on real-time pose detection to guide users during workout sessions[10].

10.Yoga Pose Estimation and Feedback Using Deep Learning
Vivek Anand Thoutam's study focuses on yoga pose estimation and feedback generation using deep learning algorithms[14]. The system uses pose recognition to detect incorrect postures and generate feedback, a concept closely related to the KNIFT-based system used in this paper[14].

11.Sentiment Analysis in Videos Using Machine Learning
Shailaja Uke and colleagues explored video sentiment analysis using machine learning, which involves recognizing emotions and movements in videos[13]. The methodology of real-time video processing and sentiment analysis can be extended to pose estimation in fitness applications, such as correcting workout forms during real-time video capture[13].

12.Object Detection Using Feature-based Template Matching
Simone Bianco and Marco Buzzelli explored object detection using feature-based template matching for real-time applications[12]. Their method of using visual features for object recognition can be related to how human joints are detected in workout systems using MediaPipe and KNIFT[12].

13.Real-Time Fitness Monitoring Using Machine Learning
Sushma V and Kavya L implemented a fitness trainer application that uses machine learning to guide users through workout routines[15]. Their work includes real-time monitoring of posture and movements, similar to the KNIFT-based system used in this study. This reinforces the growing use of AI and machine learning in fitness technology[15].

14.Proximity Approach for Object Detection in Video,This paper discusses the importance of video surveillance for addressing social needs, especially with increasing concerns about crime and public safety[21]. The system described in this paper emphasizes the use of proximity in identifying whether an object is new or has disappeared, and the algorithm effectively tracks objects with varying shapes and colors under different environmental conditions[21].

These systems collectively represent significant advancements in integrating AI, computer vision, and fitness technology, providing foundational insights into how our system leverages KNIFT for workout correction.

III. METHODOLOGY

Figure 2 shows architectural view of proposed system along with figure 3 which depict overall flow of user interface[4].

Data Capture: The methodology begins with the data capture process, where workout videos are captured using the cv2 library in Python. This step allows MediaPipe to access the user's webcam or any other video input device to record the workout session continuously. By continuously capturing the video feed, the system ensures that there is a robust and consistent source of data for analysis and feedback.

Data Pre-processing: Before analysis, workout videos undergo several pre-processing steps to ensure optimal performance

- Resizing: Videos are resized to a standardized resolution to facilitate consistent processing across different input sources and devices.
- Normalization: Pixel intensity normalization is applied to enhance the contrast and visibility of key features, ensuring robust joint detection even in varying lighting conditions.
- Noise Reduction: Techniques such as Gaussian blurring or median filtering are employed to reduce noise and artifacts in the video frames, improving the accuracy of subsequent analysis.

Video Analysis: Once the workout video is captured, system performs video analysis to extract essential information about the user's exercise form. This analysis involves processing each frame of the video using the cv2 library. OpenCV library contains over 500 functions which can be used in above application areas. OpenCV has many powerful image processing functions [22]. By examining each frame, we can identify relevant features, movements, and joint positions. This frame-by-frame analysis provides detailed insights into the user's form and movement patterns throughout the entire workout session[2-4].

Joint Detection: The MediaPipe library plays a crucial role in the joint detection. This step involves using the KNIFT algorithm and pre-trained models to detect and track the positions of 33 joints within the user's body throughout the workout video as shown in figure 1. These joints include those in the arms, legs, torso, and other relevant body parts. By accurately estimating the joint positions and tracking their movements, it establishes a solid foundation for further analysis and feedback[19].

Menu Selection: A user interface along with Voice recognition libraries allows users to specify the type of workout they are performing, such as legs, chest, back, arms, etc. This categorization step is essential for providing targeted feedback and correction based on the specific exercise being performed. This approach ensures that users receive feedback and correction based on their specific workout routines[20].

Voice based control: GTTS enables us to convert voice to text or vice-versa. This allows us to process the user's inputs via voice and enable the user to control the system.SR is used to recognize to the input voice instructions from user and converts it into text easy to recognize by system[16].

Angle Pair Calculation: The next step in the system involves calculating angle pairs to analyze exercise form and provide appropriate feedback. For each exercise, two angle pairs are determined. These angle pairs capture the angles between relevant joints, providing the user's form and movement patterns. The change in these angles is recorded in order to count the number of repetitions of the exercise. In some cases, a third angle pair may be calculated if the exercise requires additional angles to accurately assess form.

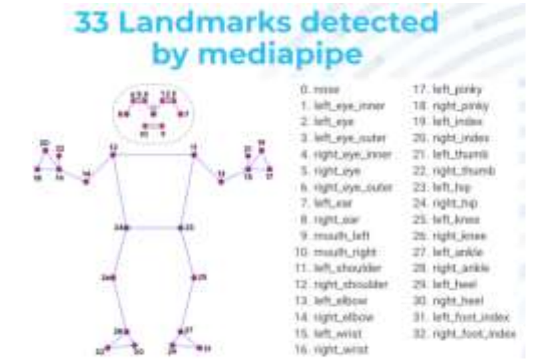

Figure 1. Landmarks detected by KNIFT from Mediapipe library.

Pose Correction: If incorrect exercise form is detected , it provides real-time notifications in voice form to guide users in making immediate corrections. These warnings alert the user of incorrect posture or movement, helping them adjust their form in real-time. Additionally, KNIFT visually marks the joints performing the incorrect exercise with different colors in the video feed, providing users with a clear visual cue regarding where adjustments are needed. This real-time feedback and correction mechanism aims to enhance exercise technique and minimize the risk of injuries.

Multithreading Integration: Multithreading is integrated to enable the user to use the workout system along with voice commands. Multithreading also allows for simultaneous video capture and analysis hence the user can access all the features without interruption.

We have used the multithreading for mainly 3 reasons:

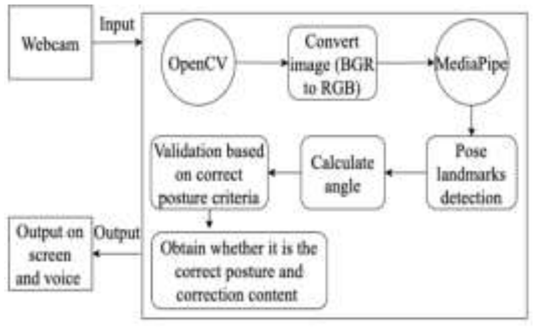

Figure 2. Block Diagram

1] Parallel processing of frames: Implement multithreading to process multiple frames of the workout video simultaneously. This approach can significantly improve the speed of video analysis, allowing the system to provide real-time feedback without significant delays.

2] Asynchronous Input Handling: Use multithreading to handle user inputs asynchronously while the video analysis is ongoing. This ensures that the system remains responsive to user interactions, such as pausing the workout session or switching between exercises, without interrupting the main processing pipeline.

3] Separate Thread for Voice-Based Input and Output:
Allocating a distinct thread for voice-based input and output functions in the system enables seamless interaction with users. This thread is dedicated to processing voice commands and delivering feedback audibly, ensuring uninterrupted communication while the main thread manages visual elements like menus through Pygame. By separating these tasks, the system optimizes user engagement, facilitating a smooth and intuitive workout experience.

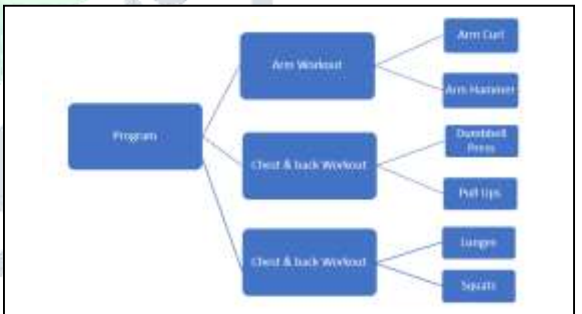

Figure 3. Project flow

Figure 3 is the actual UI flow of the developed system. It shows how we can communicate between different workout options and their domain fields.

IV. MATH

In this project the calculation angle function used in which 3 joint co-ordinates are provided and then the angle is calculated.

```
a = np.array(a) # First
b = np.array(b) # Mid
c = np.array(c) # End
radians = np.arctan2(c[1]-b[1], c[0]-b[0]) - np.arctan2(a[1] b[1], a[0]-b[0])
angle = np.abs(radians*180.0/np.pi)
if angle >180.0:
    angle = 360-angle
```

V. RESULTS AND DISCUSSIONS

The Figure 4 is the Mediapipe camera feed which represents the correct pose for workout, obtained using the OpenCV library, displays the workout session captured . In this feed, two angles are presented, one utilized for counting repetitions and the other for detecting correct pose. This visual feedback aids users in monitoring their exercise form and progress in real-time. Users can monitor exercise form and progress effectively, enhancing self-correction during exercises as instructed using voice commands.

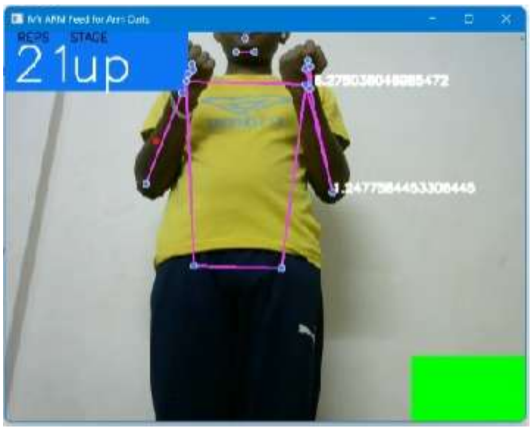

Figure 4. Correct pose detection

The Figure 5 is extension which shows the wrong pose for the workout. Actually, the arm elbow must be close to body while performing arm curl, whereas in feed it is away from body, it is calculated using 2^{nd} angle at elbow and shoulder. When wrong pose is detected the lower right rectangle on screen changes its colour from green to red and the voice command is also given as "You are performing the exercise wrongly move your arm closer to body". This voice command is different for the other exercises according to the reason for wrongly performed workout.

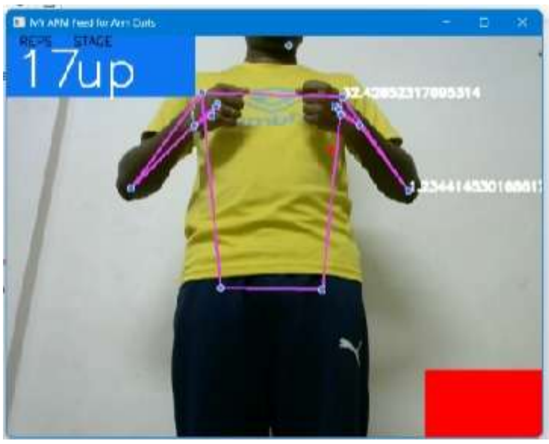

Figure 5. Wrong pose detection

Figure 6. Workout menu

The Figure 6 is the workout menu which is option with the voice menu. This has 3 type of workout.

Three types of workout are :

1) Leg Workout

2) Chest and back Workout

3) Arm Workout

We can end the menu display by using the Quit button in the interface. After we quit the menu the program will ask for whether to continue workout using menu based, voice based or end the program using the text to speech library and will also take voice inputs from users.

Figure 7. Arm Workout menu

The Figure 7 is the sub menu of Arm Workout from the Workout menu. This provides the different arm workouts which can be performed. Tailored to target specific muscle groups, such as the arms, it provides users with a variety of exercise choices. There are similar menus for Chest and Back Workout , Leg Workout also having the same template just the different exercise. Organizing workout options into intuitive categories simplifies exercise selection and customization for users.

In addition to its menu-based interface, a voice-based menu option is provided specifically to users with diverse accessibility needs. This feature enables users to interact with the system using oral commands, offering an alternative mode of interaction tailored to individuals who may encounter challenges with traditional menu-based interfaces. Similar to its menu-based counterpart, the voice-based menu allows users to navigate through workout options, select exercises, and control the system entirely through verbal instructions. By providing this alternative mode of interaction, the system enhances inclusivity and accessibility, ensuring that all users, regardless of their preferred mode of communication, can effectively engage with the system. This hands-free approach empowers individuals with mobility impairments or visual impairments to participate seamlessly in workout sessions, thereby fostering a more inclusive fitness training environment.

VI. CONCLUSION

In conclusion, the workout pose correction system, employing the KNIFT algorithm alongside OpenCV and Mediapipe, has demonstrated significant advancements in refining exercise postures. The core mathematical principles driving this progress involve trigonometry for angle calculations and distance measurements. These calculations, based on key joints detected in the pose estimation model, enable the system to precisely evaluate and correct body positions during various exercises[18].

VII. FUTURE SCOPE

This includes exploring advanced pose correction algorithms, integrating machine learning for personalized workout recommendations, extending support for multiple users, developing a mobile application for remote accessibility, and continually refining the system for enhanced accuracy and user experience[17]. Make It portable using the raspberry pi and the Touch screen display.

VIII. REFERENCES

[1] Uke, Shailaja N., and Amol Zade. "Optimal video processing and soft computing algorithms for human hand gesture recognition from real-time video." Multimedia Tools and Applications (2023): 1-23.

[2] Gourangi Taware, Rohit Agarwal, “AI-based Workout Assistant and Fitness guide,” International Journal of Engineering Research & Technology (IJERT)Vol. 10 Issue 11, November-2021.

[3] Neha ,Dr. S. K. Manju Bargavi”Virtual Fitness Trainer using Artificial Intelligence”.

International Journal for Research in Applied Science & Engineering Technology (IJRASET).Volume 11 Issue III Mar 2023.

[4] D.MohanKishore,S.Bindu,Nandi Krishnamurthy Manjunath,”Estimation of Yoga Postures Using Machine Learning Techniques”IJY-2022.

[5] Amol V. Zade ,et al. "An enhanced artificial neural network for hand gesture recognition using multi-modal features." Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization 11.6 (2023): 2278-2289.

[6] Sathvik K Gatti, Rohit P ”Gym Trainer Application using Machine Learning.”International Journal for Research in Applied Science & Engineering Technology (IJRASET)Volume 10 Issue VII July 2022.

[7] Deepak Maurya, Grandel Dsouza”Human Pose Detection using Deep Learning.”International Research Journal of Engineering and Technology (IRJET).Volume: 07 Issue: 03 | Mar 2020

[8] Swapnil Dawange, Akash Chavan”Workout Analysis Using Mediapipe BlazePose and Machine Learning”Volume 9, Issue 12 December 2021.

[9] Mayuresh Kaulwar ,et al. "Brain Tumor Detection Using Convolutional Neural Network." 2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA). IEEE, 2023.

[10] Duc Thanh Nguyen, Wanqing Li,”An Improved Template Matching Method for Object Detection”Research gate 2009.

[11] Soham S Nimale, et al. "Systems and Methods: Image Encryption Using Steganography and XOR Operations." 2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA). IEEE, 2023.

[12] Simone Bianco, Marco Buzzelli,”Object Detection Using Feature-based Template Matching” The International Society for Optical Engineering · March 2013.

[13] Nilesh Uke ,et al. "Efficient Method for Video Sentiment Analysis." International Conference on Computation Intelligence and Network Systems. Cham: Springer Nature Switzerland, 2023.

[14] Vivek Anand Thoutam“Yoga Pose Estimation and Feedback Generation Using Deep Learning ”Hindawi Computational Intelligence and NeuroscienceVolume 2022, Article ID 4311350, 12 pages

[15] SushmaV, KavyaL ”Fitness Trainer Application Using Artificial Intelligence” International Research Journal of Engineering and Technology (IRJET)Volume: 10 Issue: 05 | May 2023

[16] Ravindra Thool ,et al . "UML based modeling for data aggregation in secured wireless sensor network." Procedia Computer Science 78 (2016): 706-713.

[17] Chivate, Atharva Balasaheb, et al. "Comparative Analysis of Multiple ML Models and Real-Time Translation." 2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA). IEEE, 2023.

[18] Alexander Sibiryakov,”Fast and High-Performance Template Matching Method”IEEE Computer Society Conference on Computer Vision and Pattern Recognition · June 2011.

[19] Patil Gitesh, et al. "Chatbot for Medicine at Your Fingertips Using TextMining." 2023 IEEE 5th International Conference on Cybernetics, Cognition and Machine Learning Applications (ICCCMLA). IEEE, 2023.

[20] Liangchen Songa, Junsong Yuana, Zicheng Liuc,”Human Pose Estimation and Its Application to Action Recognition: A Survey” Journal of Visual Communication and Image Representation (2021)

[21] Shailaja Uke ,et al. "Proximity Approach for Object Detection in Video." International Journal of Control and Automation 13.2 (2020): 868-876.

[22] Nilesh J Uke, Ravindra C Thool and Shailaja Uke, "A Vision based Driver Support System for Road Sign Detection", International Journal on Recent Trends in Engineering & Technology, 2014.