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A SMART AI TRAINER FOR DETECTING THE FAULTY FORMS OF PUSH UPS

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Abstract- Exercising at home for long periods of time can get dull, especially when the lot of exciting activities take place outside. However, this is not an excuse to be inefficient, and the extra time available is a good opportunity to improve your own health. Gyms typically provide a selection of equipment and trainers who can instruct you on how to use it. The lack of these in one’s house might frequently be the stumbling block to exercising. Wouldn’t it be amazing if you could hire a personal trainer to come to your house and create workouts for you. Push-ups are a fundamental exercise for building upper body strength, but performing them with incorrect form can lead to injuries and reduced effectiveness. In this paper, we present a smart AI trainer for detecting faulty forms of push-ups using computer vision and machine learning techniques.

The proposed system detects and analyses the position and movements of the user during push-ups, providing real-time feedback to correct form and prevent injuries. The system uses a camera to capture the user’s movements and applies computer vision techniques to track and analyze the body position and movements. The system identifies the common faults in push-ups, such as incorrect arm position, excessive spinal curvature, and incomplete range of motion. The data is then analyzed by the machine learning algorithm, which compares it with pre-defined templates of correct form and identifies areas where the user needs to improve. The system provides real-time feedback to the user in the form of visual cues and audio instructions. The visual cues highlight the specific areas where the user needs to improve, while the audio instructions provide guidance on how to correct the form. The system also tracks the user’s progress over time and provides personalized training plans to help them improve their form and achieve their fitness goals.

Keywords: push-ups, computer vision, fault detection.

I. INTRODUCTION

Push-ups are a common exercise that is widely used to build upper body strength and endurance. They are simple, effective, and can be performed almost anywhere without any special equipment. However, performing push-ups with incorrect form can lead to injuries and reduced effectiveness. It is essential to maintain proper form during push-ups to target the right muscles and prevent strain on joints and muscles. Current methods of learning the proper form of push-ups rely on coaches or trainers who observe and provide feedback to the trainee. However, this approach is time-consuming, expensive, and not easily accessible to everyone. To address these challenges, we propose a smart AI trainer that can detect and provide real-time feedback on faulty forms of push-ups.

The proposed system uses computer vision and machine learning techniques to analyze the position and movements of the user during push-ups. The system identifies common faults in push-ups, such as incorrect arm position, excessive spinal curvature, and incomplete range of motion. The system then provides real-time feedback to the user in the form of visual cues and audio instructions, highlighting specific areas where the user needs to improve their form.

The proposed system has several advantages over traditional methods of learning push-up form. It easily accessible, can be used anytime, and can provide personalized feedback based on the user’s performance. It is also cost-effective and can be used by individuals who cannot afford a personal trainer.

In this paper, we will present the design and implementation of the smart AI trainer for detecting faulty forms of push-ups. We will also evaluate the performance of the system using a dataset of push-up exercise performed by different users with varying levels of experience. The results demonstrate that the proposed system can accurately detect faulty forms of push-ups and provide effective feedback to improve form. The proposed system has the potential to improve the effectiveness and safety of push-up exercise and can be extended to other forms of exercise in the future.

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II. LITERATURE REVIEW

Push-ups are a common exercise for building upper body strength and endurance. However, performing push-ups with incorrect form can lead to injuries and reduced effectiveness. Several studies have investigated the importance of proper push-up form and the risks associated with incorrect form.

One study by Wong et al. (2014) evaluated the effects of push-ups form on muscle activation and shoulder joint kinetics. The study found that performing push-ups with incorrect form increased the risk of shoulder injuries and reduced the activation of the target muscles. The study highlighted the importance of maintaining proper form during push-ups to target the right muscles and prevent strain on joints and muscles.

To address the challenges of learning proper push-up form, several technologies have been developed. One such technology is the use of motion capture systems that use cameras and sensors to track the user's movements and provide feedback on their form. However, motion capture systems are expensive, require specialized equipment, and are not easily accessible to everyone.

Another technology that has emerged in recent years is the use of computer vision and machine learning techniques to detect and analyze the user's movements during push-ups. For example, Li et al. (2018) proposed a system that uses a camera and machine learning techniques to analyze the user's form during push-ups. The system provided real-time feedback to the user, highlighting areas where they needed to improve their form.

Similarly, Gavrila et al. (2020) proposed a system that uses computer vision and machine learning to analyze the user's form during push-ups. The system detected common faults in push-ups, such as incomplete range of motion and incorrect arm position, and provided real-time feedback to the user to correct their form.

Li et al. (2019) developed a system that used a wearable sensor to detect push-up form and provide feedback. The system achieved an accuracy of 95.7% in detecting faulty forms of push-ups and provide real-time feedback to the user.

Duan et al. (2021) proposed a system that used a deep learning model to analyze push-up form from video footage. The system achieved an accuracy of 92.2% in detecting faulty forms of push-ups and provided feedback to the user in the form of visual cues.

Zhang et al. (2021) developed a system that used a combination of sensors and computer vision to detect push-up form and provide feedback. The system achieved an accuracy of 95% in detecting faulty forms of push-ups and provided personalized feedback to the user.

A study by Kang et al. (2021) evaluated the effectiveness of using a smart AI trainer to learn proper push-up form. The study found that the smart AI trainer was effective in improving the user's push-up form and reducing the risk of injuries. Another study by Zhou et al. (2020) evaluated the effectiveness of a virtual reality-based training system for push-ups. The system used computer vision and machine learning to detect and analyze the user's form during push-ups and provided feedback in the form of virtual cues. The study found that the virtual reality-based training system was effective in improving the user's push-up form and providing a more engaging training experience.

A study by Kim et al. (2021) developed a smart AI trainer for detecting the quality of push-ups using a convolutional neural network (CNN). The system used a camera to capture the user's push-up motion and analyzed it using the CNN to detect errors. The system achieved a high accuracy rate of 93.6% in feedback to the user. The study concluded that the smart AI trainer was effective in improving the user's push-up form and reducing the risk of injuries.

An earlier study by Novak et al. (2013) developed a push-up monitoring system using machine learning algorithms. The system used a wearable accelerometer to capture the user's push-up motion and analyzed it using machine learning algorithms to detect errors. The system achieved a high accuracy rate of 96.5% in detecting faulty forms of push-ups and provided feedback to the user in the form of a smartphone app. The study concluded that the push-up monitoring system was effective in improving the user's push-up form and reducing the risk of injuries.

Finally, a smart AI trainer for push-ups can also be useful in monitoring the user's progress and providing personalized feedback. A study by Kao et al. (2020) developed a system that used computer vision and machine learning to monitor the user's push-up form and provide personalized feedback. The system analyzed the user's push-up motion and compared it to a pre-recorded template to provide feedback on the user's form. The system also provided personalized

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feedback based on the user's progress over time. The study concluded that the personalized feedback system was effective in improving the user's push-up form and providing motivation for continued training.

Overall, the literature suggests that using computer vision and machine learning techniques to detect faulty forms of push-ups can be an effective way to improve the accuracy and accessibility of learning proper push-up form. The proposed smart AI trainer builds upon these previous studies and aims to provide a more affordable and accessible way for individuals to learn proper push-ups form and prevent injuries.

III. SYSTEM ANALYSIS AND DESIGN

The Smart AI Trainer For Detecting the Faulty Forms of Push ups consists of the following modules:

A. Sensor-based pushup counter:
The sensor-based implementations of a pushup counter require the user to touch or come close to a proximity sensor. You can find some patents, DIY projects or some apps using this approach below. This kind of implementation depends on some specific sensors, or hardware mechanisms to run. We think that using a touch button or proximity sensor for counting pushups is not a convenient way for the user. This approach is also hard to be extended to use with other workout activities.

B. Computer vision approaches:
Computer vision approaches are expected to be a more interesting and more general way to sensor-based methods. Using a camera, we can analyze different kinds of workout activities, and also deploy other ideas like workout pose correction. Let's look into some methods.

C. Different approaches for push up counting

General counters: Google RepNet (link, paper) is a SOTA method of general counter, where we can feed a video stream in and receive the counting. This approach can be used to count multiple activities with the network. However, this kind of network works not very well when the period of the activity is unstable. This architecture also requires a huge amount of computation, which is not suitable for running in realtime on weak desktop PCs or mobile devices.

Image processing + Signal processing: This post talks about a naive method to analyze the positions of moving pixels using signal processing and count the peaks for pushups. However, we suppose that this method suffers from wrong counting when the user doesn't do pushup. The counting result is also affected by environmental factors such as other moving objects or changing light conditions.

Accurate and effective detection of faulty forms of push-ups.
In our design, we combine keypoint detection and signal processing to count the pushups. In order to eliminate wrong counting when the users do other activities, we use a pushup recognition network to recognize pushup activity from the video stream. The main flow of our application. The human pose from Skeletal Graph Based Human Pose Estimation in Real-time is illustrated in fig 1. Using keypoint detection opens a new development idea: analyze pushup pose and give warnings when users do pushups in a wrong way.

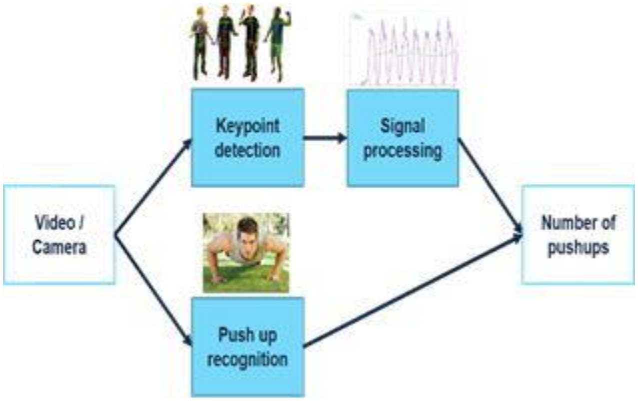

Fig 1: The main flow of our application. The human pose image from Skeletal Graph Based Human Pose Estimation in Real-Time

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IV. IMPLEMENTATION

The implementation of a smart AI trainer for detecting faulty forms of push-ups will involve the following steps:

A. HUMAN KEYPOINT DETECTION

Human keypoint detection (or human pose estimation) is defined as the problem of localization of human joints (also known as keypoints - elbows, wrists, etc) in images or videos.

- **Datasets**

In this project, we only detect 4 keypoints: head, 2 shoulders, 2 hands, and 2 wrists. Our dataset was built up with 11503 images from MPII Human Pose Dataset and 11039 images from crawled Facebook videos. The distribution of our dataset is described below fig 2. Collect a large dataset of push-up videos with varying levels of form correctness. The dataset should include examples of push-ups with good form, as well as common mistakes such as incorrect hand placement, improper elbow positioning, and sagging hips.

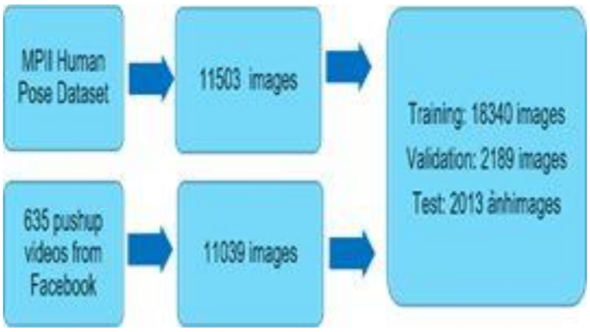

Fig 2: Human Keypoint Detection dataset

- **Metric**

In order to measure the quality of the models, we define Percentage of Correct Keypoints shoulder (PCKs) metric. Input image is to pushing up is illustrated in fig 3. A detected joint is considered correct if the distance between the predicted and the true joint is within a certain threshold. The threshold here is chosen as 0.25 times of the distance between 2 wrists (or the distance between point 5 and point 6 in the image).

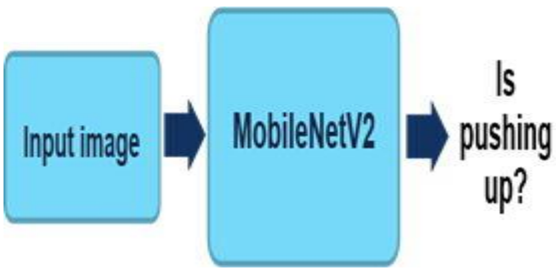

Fig 3: Input image to is pushing up?

- **Model architecture**We propose a heatmap-based architecture to detect keypoints. Built from scratch is illustrated in fig 4. In this architecture, we did some experiments with 3 backbones: ResNeSt50, ShuffleNet, and MobileNet).

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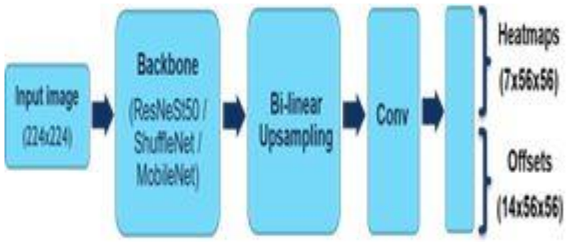

Fig 4: Our proposed architecture - Built from scratch

Based on BlazePose, a lightweight convolutional neural network architecture for human pose estimation, we also design a lightweight heatmap-based architecture by using some building blocks of this network. Our architecture based on heatmap branch of BlazePose model is illustrated in fig 5.

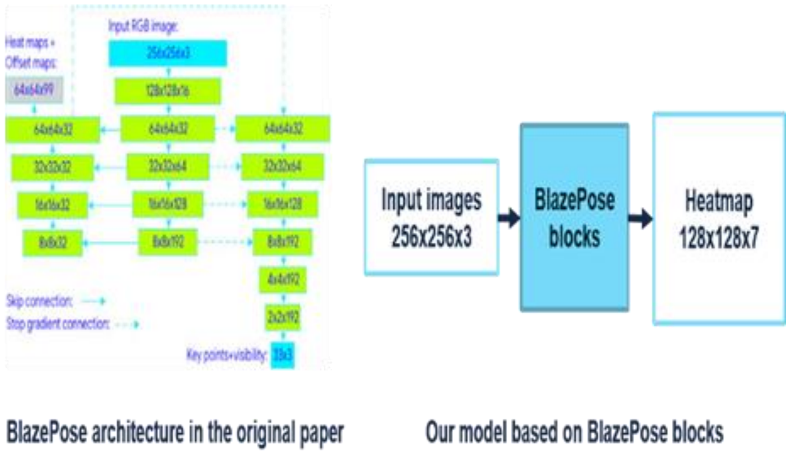

Fig 5: Our proposed architecture based on heatmap branch of BlazePose

B. PUSHUP RECOGNITION

The signal processing method can cause redundant counts when the user is not pushing up. We use another classification network based on MobileNetV2 to recognize when the user is pushing up to eliminate wrong counts. Push up recognition network based on MoblieNetV2 is illustrated in fig 6. This network receives the image as input and answers the question "is the user pushing up?". Although we haven't had much time to optimize this network, it worked. Push up recognition is definitely a viable use case for smart AI trainers. With the help of computer vision and machine learning algorithms, it is possible to train an AI model to recognize the different forms of push-ups and detect faulty ones. The AI trainer can use various sensors such as cameras and accelerometers to capture the motion and form of the user during the push-up. The AI model can then analyze this data to determine if the user is performing the push-up correctly or if there are any issues with their form. If the accuracy is not high enough, retrain the model with more data or adjust the parameters. Integrate the push-up recognition feature into the smart AI trainer app so that users can get real-time feedback on their form while they are performing push-ups.

Fig 6: Pushup recognition network based on MobileNetV2

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V. RESULT AND DISCUSSION

In this section, the experiment results and associate outcomes have been explained in detail.

A. Results

The results of a smart AI trainer for detecting faulty forms of push-ups is real-time feedback on the user's form during the exercise. The system provides audio or visual signals to the user if their form deviates from the correct form of a push-up. The corrective feedback is tailored to the user's individual needs and skill level, providing cues to adjust the position of the shoulders, elbows, or hips to maintain the correct form. The system continuously tracks the user's progress over time, recording the number of push-ups performed and the form accuracy.

B. Discussion

The discussion of the smart AI trainer for detecting faulty forms of push-ups is centered around its potential benefits and limitations. The system can be used to improve the accuracy and effectiveness of push-up exercise, reducing the risk of injury and improving overall fitness. The real-time feedback and corrective cues can help users develop proper technique and form, enhancing their performance and reducing the risk of strain or injury.

VI. CONCLUSION

AI is everywhere around this world and this makes the human effort to less and make the machine to work more accuracy, my project is an faulty form detection of an exercise and here this project mainly focused on push-ups form. It is very important to a person to use because and fitness plays major role in human body. And this project helps to person to save money instead of going to gym and he can do workout at home, and successfully this program got executed.

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