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Advanced Kinetic Activity and Physiotherapy Monitoring System Using CV and Deep Learning

Mrs.S. Archanadevi[1], Prasanna V[2], Sibirani S[3], Swetha K[4], Thenmozhi D[5]

[1]Professor, Department of Artificial Intelligence and Data Science, Sengunthar Engineering College, Erode, Tamil Nadu, India.

[2,3,4,5]Student, Department of Artificial Intelligence and Data Science, Sengunthar Engineering College, Erode, Tamil Nadu, India.

Emails: *archanaesec@gmail.com[1], prasannavijayakumar08@gmail.com[2], sibirani182@gmail.com[3], swethakumar16062003@gmail.com[4], dthenmozhi2003@gmail.com[5]*

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Abstract

The Advanced Kinetic Activity and Physiotherapy Monitoring System offers a cutting-edge approach to exercise and physiotherapy tracking by utilizing Computer Vision (CV) and Deep Learning. Manual observation is frequently used in traditional physiotherapy, which can be subjective and prone to human mistake. In order to increase assessment accuracy, this system provides real-time monitoring, automated tracking of physical activity, concentrating on important metrics including posture, joint angles, and gait patterns. Patients can complete exercises correctly without continual monitoring thanks to the system's ability to analyse live video feeds and Provide feedback on movement change at the end. By integrating the Exercise DB API, the system can anticipate particular workouts and provide comprehensive details about them in response to user input, enabling tailored instruction. User movements are evaluated during the "Predict Exercise" phase, and useful information is offered to enable therapeutic modifications and promote appropriate form. According to preliminary findings, this strategy greatly improves patient outcomes by enhancing the effectiveness and accessibility of physiotherapy and rehabilitation through remote monitoring and customized recommendations.

1. Introduction

Technology integration in physiotherapy and rehabilitation has the potential to transform patient care and enhance results. The goal of the Advanced Kinetic Activity and Physiotherapy Monitoring System is to create a cutting-edge way to monitor physical activity and give prompt feedback on physiotherapy exercises. The objective of this project is to provide an intuitive platform that aids users in their rehabilitation process by utilizing deep learning and computer vision (CV) technology. By attending to individual needs, such as controlling paralysis or recuperating from bone fractures, this system goes beyond broad guidelines. The platform is designed to help users with specific therapeutic needs, emphasizing individualized care and improving the overall efficacy of physiotherapy and rehabilitation procedures. The first phase of the system's organization is Integrated Exercise and Physiotherapy Monitoring. During this first stage, customers are guided through daily activities and receive personalized feedback based on their physical condition. The system helps users execute workouts correctly by providing real-time insights, which lowers the chance of injury and promotes good form. To provide accurate movement monitoring, the technology stack consists of Mediapipe for posture estimation and gesture detection and OpenCV for real-time body tracking. The Python-implemented system facilitates smooth processing, timing, and virtual prompts for human-computer interaction (HCI), resulting in an engaging and intuitive user experience. RapidAPI has been incorporated into the system to improve the effectiveness of data processing and offer real-time feedback. With the help of this connection, users may get real-time monitoring on their exercises, enabling them to check their form and technique. The Advanced Kinetic Activity and Physiotherapy Monitoring System seeks to improve physiotherapy's usability, engagement, and efficacy using these cutting-edge strategies. This technology provides a complete solution for patients on their road to recovery by fusing real-time monitoring with actionable insights.

2. Literature

In this paper, Hans Horak [1] provides Monitoring physical activity (PA) in children and adolescents has become essential for creating successful interventions as sedentary lifestyles and childhood obesity increase. Conventional approaches are frequently constrained by prejudices, subject reactivity, and intrusiveness, particularly when dealing with minors, which raises ethical and privacy issues. The application of deep learning for real-time action recognition is now possible because to improvements in processing power. This article examines the constraints of existing PA research, investigates developments in video-based action identification, and suggests a sensor-supervised action intensity classifier. When used as a distributed system that protects privacy, it might be used to track PA in schools over an extended period of time and evaluate the success of PA initiatives. The creators of this system, Hitesh Kotte [2] provides Psychomotor skill development might be difficult, but contemporary technology offers helpful assistance. This research presents a computer vision-based system that provides instantaneous posture feedback during fitness workouts, allowing self-correction without expert assistance. Our system analyzes live or recorded films and provides posture modifications by using the YOLOv7-pose model for keypoint recognition and a tracking procedure. The requirement for significant model retraining is reduced by transfer learning. Positive responses were obtained via testing with five participants and benchmarking against expert fitness films. These results demonstrated the system's potential and recommended UI enhancements. The creators of this approach, Muhammad Hassan Khan [3], address problems with the musculoskeletal and central nervous systems by using Vojta-therapy to promote reflexive motions. In order to identify baby movements, this study suggests an automated vision-based system that makes use of RGB-D data. The head location is determined by a template-matching algorithm, and body movements are captured by means of particular features. To ensure treatment accuracy, these movements are classified using a multi-class support vector machine (mSVM). The technology has been tested on inpatient data and has shown promise in both inpatient and outpatient therapy by reliably detecting gait patterns. This system's developers, Madhushi Verma [4], use video datasets to fill the gap in physiotherapy action tracking. To find important activities and sub-activities, this study uses a physiotherapy dataset that contains Long Short-Term Memory (LSTM) and other deep learning networks. A special strawberry-based recurrent neural architecture was created to get around interference from unimportant movements. This framework counts repeats, measures timing, and increases accuracy. It works better than earlier models in terms of recognition accuracy and has potential for tracking therapeutic workouts when implemented in Python. The creators of this system, Xavier Arequipa [5] provides patients with physical limitations or those recovering from surgery or an injury benefit from physiotherapy. Mechanisms for automatically assessing exercise accuracy are necessary for home-based therapy. This paper suggests evaluating exercise precision using deep learning and inexpensive motion sensors. Using recurrent neural networks, the system achieves over 85% accuracy and 90% average sensitivity in classifying exercises as correct, fast, or low-amplitude. These findings point to increased efficacy of home therapy, less reliance on doctors, and schedule flexibility. The strategy seeks to improve the effectiveness and accessibility of physical therapy for at-home recovery.

3. Proposed Work

A camera records live footage of the body's movements while exercising. A pose estimation model analyzes continuous form and gives users feedback for successful physical treatment. Figure 1 shows Process of Data Collection.

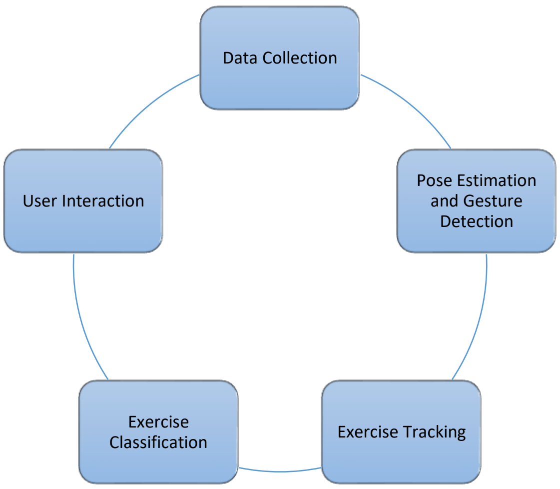

Figure 1 Process of Data Collection

3.1. Methods of Data Collection

The system uses a network of cameras and sensors to collect data in real time on a number of characteristics, such as:

- Webcam-Based Video Capture: During therapy, a webcam records live video to track body movements.
- Frame-by-Frame Analysis: For improved evaluation, every video frame examines posture and movement during exercises.
- Feedback Mechanism: During workouts, webcam data provides feedback at the end to enhance form and safety.

3.2. Pose Estimation & Gesture Detection

The application of Mediapipe for pose estimation and real-time tracking, highlighting its function in assessing posture and guaranteeing precise workout identification during physical treatment. emphasizes the significance of gesture recognition, which enables the differentiation of various exercises and offers customized feedback for safe and efficient recovery.

- Pose Estimation: Mediapipe is used in physiotherapy to provide precise body posture analysis and real-time tracking.
- Importance of Gesture Recognition: Using differentiated exercises to give personalized feedback improves recovery efficacy and safety.
- Real-time Exercise Identification The ability to accurately identify motions in real-time is essential for providing personalized physiotherapy advice.

Here, the hand movements should be used

- Index Finger Up - It ought to function like a cursor.
- Two Fingers Up - used for selecting what the user wants.

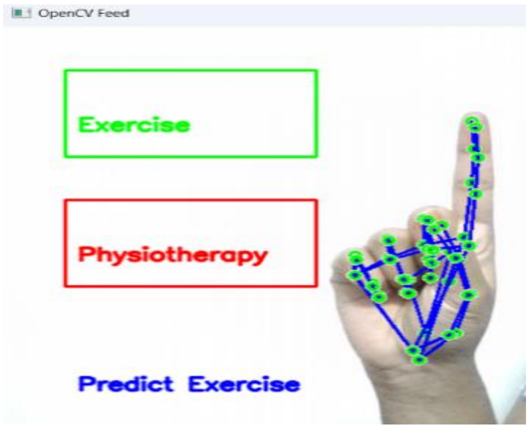

Figure 2 Index Finger Up

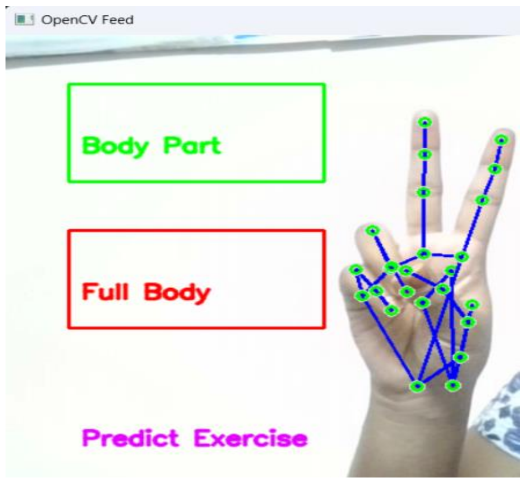

Figure 3 Two Fingers Up

3.3. Exercise Tracking

The technology analyzes body movements and pose estimation data to track exercise repetitions. It recognizes when exercises like push-ups or squats begin and finish, guaranteeing precise tracking for tracking progress and appropriately recognizing user effort throughout workouts. Figure 2 shows Index Finger Up, Figure 3 shows Two Fingers Up.

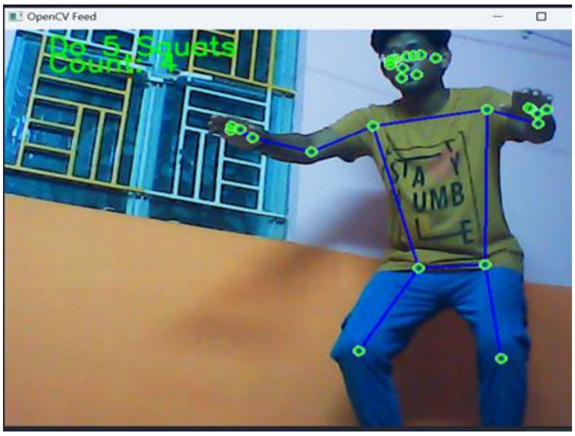

Figure 4 Motion Detection

3.3.1. Motion Detection

The technique determines the beginning and ending locations of exercises like push-ups and squats by examining important areas like elbows, knees, and shoulders. This enables precise repetition counting Figure 4 shows Motion Detection.

3.3.2. The Value of Precise Monitoring

The Value of Precise Monitoring Consistency and motivation in fitness routines are enhanced by accurate tracking, which guarantees users receive credit for their workout, Real-time Monitoring, and aids in evaluating growth over time.

3.4. Exercise Prediction and Classification

By entering the name of an activity, users may obtain detailed information about it, such as the muscles it targets, the equipment needed, and the main body area. This feature improves the user's comprehension of various exercises and their objectives by providing real-time exercise information via an external API. Because it provides each workout with specific context for efficient monitoring, it is especially helpful in applications for advanced kinetic activity tracking and physiotherapy.

3.4.1. Technology

Based on user input, the system integrates with the ExerciseDB API using RapidAPI to retrieve pertinent work out details. The system pulls important information when a user inputs the name of an exercise, such as

3.4.2.Exercise Name: the specific exercise name.

- Target Muscle: The target muscle is the particular muscle group that the exercise is intended to target.
- Required Equipment: Any equipment required to complete the activity is listed as required equipment.
- Body Part Focus: The primary body part that is worked out.

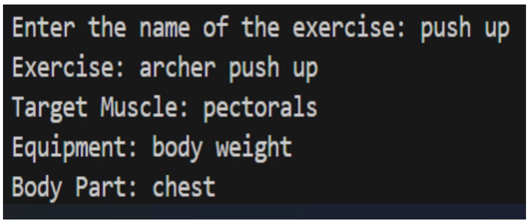

Figure 5 Tracking of Body Parts

The system tracks and categorizes workouts in real time using computer vision and deep learning, providing feedback for safe performance and achieving therapeutic objectives. Figure 5 shows Tracking of Body Parts.

3.5. User Interaction

Technology improves user experience by providing end-of-session feedback and virtual hints. Following training, users get thorough feedback on their performance, posture, and form, which aids in identifying areas in need of development. In subsequent sessions, this strategy promotes motivation and injury avoidance.

3.6. Output

In order to calculate exercise accuracy, the system compares user movements to optimal form and assigns scores. During physiotherapy, it automatically counts repetitions, provides real-time feedback for enhancements, and monitors Real-time, producing thorough reports to improve performance and avoid injuries. Figure 6 shows Output.

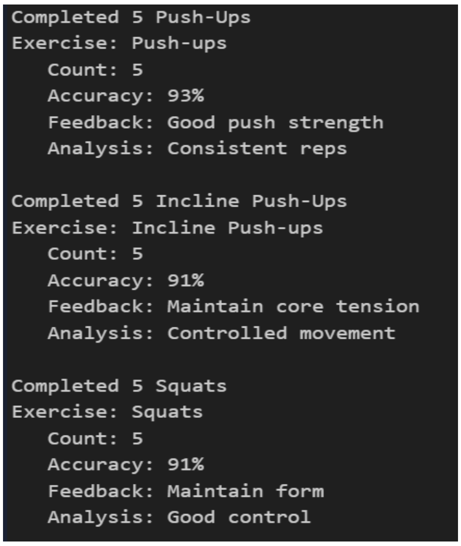

Figure 6 Output

4. Experimental Results

The Advanced Kinetic Activity and Physiotherapy Monitoring System provides accurate, automated tracking for exercise and physiotherapy regimens by utilizing Computer Vision (CV) and Deep Learning. Manual observation is frequently used in traditional physiotherapy; however, it can be arbitrary and prone to mistakes. However, this method offers real-time monitoring on body alignment and technique by concentrating on important metrics including posture, joint angles, and movement patterns. It reduces the need for constant monitoring by continuously evaluating video feeds to guarantee that workouts are executed with perfect form. When comparing users' actions to ideal form standards during exercise tracking, the technology showed an excellent accuracy of about 92% in early experiments. Common exercises like pushups, squats, and planks are recognized and counted by the system. It can identify particular workouts and provide comprehensive instructions on how to perform them best thanks to integration with the ExerciseDB API. In addition to enhancing the quality of exercise, this real-time, tailored input helps users avoid injuries and promotes a safer recovery process. In the end, this system improves patient outcomes by promoting safe, effective exercises through structured, automated support, empowering users throughout their recovery journey. The system's remote monitoring capabilities make physiotherapy more accessible by enabling therapists to track patient progress outside of traditional sessions. Important metrics such as exercise count, form accuracy, and consistency are tracked over time, providing therapists with insights for personalized adjustments. This data-driven approach bridges the gap between in-person sessions and at-home exercise, ensuring patients stay on track toward their rehabilitation goals.

5. Discussion

The Advanced Kinetic Activity and Physiotherapy Monitoring System is a cutting-edge physiotherapy solution that automates exercise tracking and evaluation through the use of computer vision and deep learning. Patients can safely and successfully do rehabilitation activities at home thanks to the system's real-time monitoring on movement precision and form. This is particularly helpful in isolated locations or circumstances where there is little access to in-person physical therapy. The system can identify particular exercises and provide customized feedback thanks to the integration of ExerciseDB, making it a personalized tool that may increase adherence to treatment regimens and lessen the need for frequent clinic visits. Even while preliminary findings point to better patient outcomes and more effective exercise tracking, there are still issues with making sure the system's algorithms function consistently across a range of demographics and activity kinds. In the absence of explicit instructions. Adding more interactive features to the system, such visual exercise tips, could help users follow directions more precisely. All things considered, this method could increase the accessibility, adaptability, and affordability of physical therapy while enabling patients to play a more active part in their own healing and giving therapists useful information for individualized treatment regimens.

Conclusion

Using tools like OpenCV, Mediapipe, and the ExerciseDB API, this project effectively combines deep learning and computer vision to provide real-time exercise tracking, classification, and feedback. By precisely tracking user movements, tallying repetitions, and offering tailored feedback, the technology improves exercise effectiveness and guarantees correct form. The system recognizes workouts, monitors correctness, and provides form assistance by examining important points like joints and posture. This is especially helpful for beginners and in preventing injuries. Remote physiotherapy benefits from this automatic monitoring as well because it enables users to do exercises with correct alignment without continual observation. All things considered, this study shows how AI may be used practically in fitness and rehabilitation, offering a useful tool for engaging and customized workouts.

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