Demo Abstract: MirrorMatch: Real-Time Detection of Repetitive Movements using Smartphone Camera

Noah Jennings
Computer Science Department
Old Dominion University
Norfolk, United States
njenn001@odu.edu

Shubham Jain
Computer Science Department
Old Dominion University
Norfolk, United States
jain@cs.odu.edu

ABSTRACT

MirrorMatch is a motion tracking system that provides real-time movement analysis with the use of a mobile camera. It allows the user to evaluate their own exercises over time and gauge their progress at a lower cost than traditional methods. MirrorMatch is built upon commercial off-the-shelf smartphone cameras and image processing techniques. Unlike existing approaches that use wearable sensors, MirrorMatch offers a cost-effective and scalable solution to make fine-grained movement tracking more accessible.

KEYWORDS

Motion tracking, Computer Vision, Fitness monitoring, Mobile sensing

I INTRODUCTION

Until recent years, fitness enthusiasts have relied on themselves, and those around them, to assess the correctness and precision of their movements. However, this practice leaves room for errors in monitoring and can potentially lead to workout related injuries. Personal trainers and coaches can be helpful in such assessment, but are often costly and cannot be afforded by non-athletes. An automated approach to monitor exercise movements can help beginners improve their form and prevent injuries. Such a technique would not only reduce the number of injuries caused by improper form, but also accelerate rehabilitation in therapy patients [4]. Existing systems require additional equipment other than just a mobile device, including, but not limited to wearable inertial sensors [2], [3]. Not only do these additional sensors cost more, but they also add to the user's cognitive load who must remember to carry and charge an additional device.

We present MirrorMatch, a smartphone camera based technique to monitor exercise movements and compute performance metrics in real-time. Our system attempts to bridge the gap between usability and cost by being tailored towards the needs of the user. It provides exercise analysis using only the user's smartphone. It is a low-cost scalable solution for users to track their motion in any environment or setting.

II DESIGN & IMPLEMENTATION

A. Algorithm design

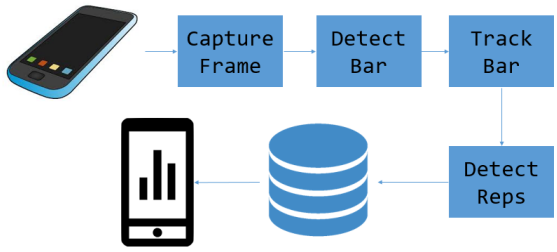

Figure 1. MirrorMatch Overview

Figure 1 presents an overview of MirrorMatch. Once the user indicates the start of a workout through a simple touch command, the camera starts capturing frames. For each captured frame, we detect the location of the user's workout equipment, e.g. a barbell or dumbbell. Once it is detected, the application tracks the equipment and recognizes repetitive motion from the captured data. The repetitions are detected and displayed in real-time. At the end of the workout, the stats computed for each rep are added to a database under that specific workout. The application then presents a graphical analysis of the entire workout.

B. Implementation

The logic behind MirrorMatch has been implemented into an Android application. To prevent user distraction, the interface for MirrorMatch is designed to look sleek and simple, with clear access to workout start and stop options. The application also provides a camera preview to allow the user to make sure that their movement is in the camera's field of view. We integrated OpenCV, an open-source computer vision library [1], [5], into the application to process camera frames in real-time. We use an object detection classifier to detect the barbell in each frame [6]. This bar is then detected in subsequent frames and the positions of the bar are recorded. A series of bar positions obtained during a rep exhibit peaks and troughs. Peaks are essentially where the user begins to lower the equipment, and troughs appear where the user begins to lift the equipment. These are essential in rep detection as each

trough represents the end of a previous rep and the beginning of the next one. Each peak represents the halfway mark for a rep. The time between each pair of troughs dictates the duration of each rep, and once the second trough in each pair is detected the rep is said to be complete. The distance in pixels between a trough and the following peak is used to compute the range of motion (ROM) for that rep. As each of these variables are computed they are displayed on the screen to the user, starting with their ROM, the rep duration, and rep count once the second trough is found.

III DEMO DESCRIPTION

To demo our system, MirrorMatch will be loaded on an Android mobile phone. A user will hold a mock bar and perform exercise-like movements to complete a workout. As the user works out, MirrorMatch will automatically detect each repetition and display the information related to that rep, i.e, the rep number, its duration, and its ROM. Once we finish a few reps, we will end the session, return to the workout analysis for that session, and examine a table depicting the workout and a detailed review of its reps respectively.

IV CONCLUSION & FUTURE WORK

MirrorMatch is a low-cost scalable system that relies on commercial off-the-shelf smartphones to allow users to gather and visualize workout analytics. In hopes of preventing injury and aiding in therapeutic exercise, MirrorMatch allows the user to access all of their movements, along with a detailed analysis of the workout down to each of its reps.

In the near future, MirrorMatch will extend to a large number of workouts for the user to record and analyze. We plan on refining the data analysis and detection algorithm to improve rep detection for a variety of exercises. MirrorMatch will eventually give the user the ability to share selected sessions along with the session's analysis. Eventually, MirrorMatch will incorporate voice assistants that provide audio feedback to the user - much like a personal trainer. We hope to see MirrorMatch being used not only by athletes, but also in physical therapy. Improving such an application could help users enhance their performance over time and potentially prevent injuries.

References

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