

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

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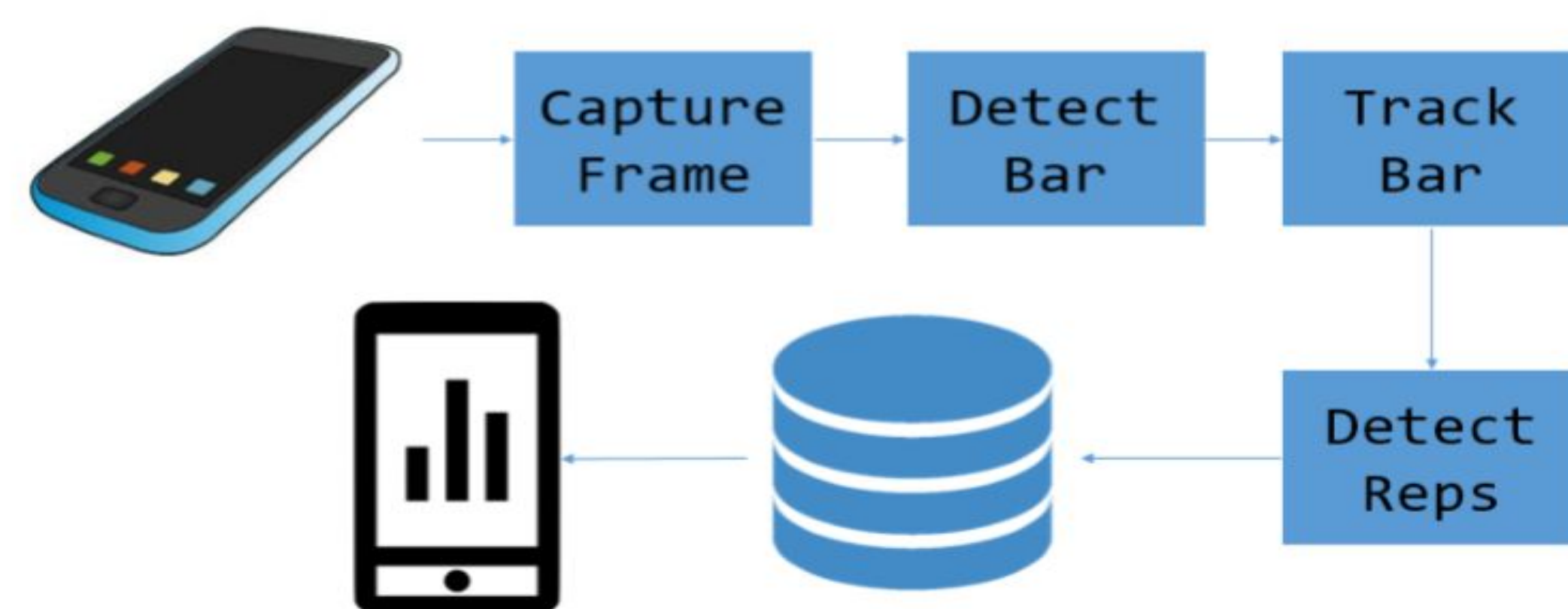
Introduction

Objective: An automated approach for monitoring exercise movements to help beginners improve their form and prevent injuries.

Background:

- ❑ The popularity of weight training exercises and related injuries have been on a rise.
- ❑ There is a lack of tools to assist users in monitoring their performance.

System Overview



- ❑ Provides real-time movement analysis and feedback.
- ❑ Designed to be easily accessible by relying only on a smartphone camera.
- ❑ Uses object detection techniques for detecting and tracking user's exercise equipment.
- ❑ Unlike existing approaches that use wearable sensors, MirrorMatch offers a cost-effective and scalable solution to make fine-grained movement tracking more accessible.

System Design

MirrorMatch generates the following metrics in real-time:

- ❑ Repetition count
- ❑ Time spent during lifting and lowering phases.
- ❑ Velocity of the bar movement during lifting and lowering phases.
- ❑ Range of movement for each rep.

REP 1 INFO:

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Range Of Motion (in pixels): 299 pixels
Lift time (s): 2.63333 seconds
Lower time (s): 2 seconds
Lifting velocity (p/s): 69.8734 p/s
Lowering velocity (p/s): 57.5 p/s
    
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Figure 1 A snapshot of MirrorMatch output statistics

Methodology

- ❑ Start of a workout session is indicated by a touch command to start capturing frames through the device camera
- ❑ For each captured frame, the user equipment (e.g. a barbell) is detected via a HAAR cascade classifier.
- ❑ Upon detection, the system tracks the bar to identify its position in each frame.
- ❑ A series of bar positions obtained during a rep exhibit peaks and troughs.
- ❑ 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 statistics associated with each rep are displayed to the user in real-time.

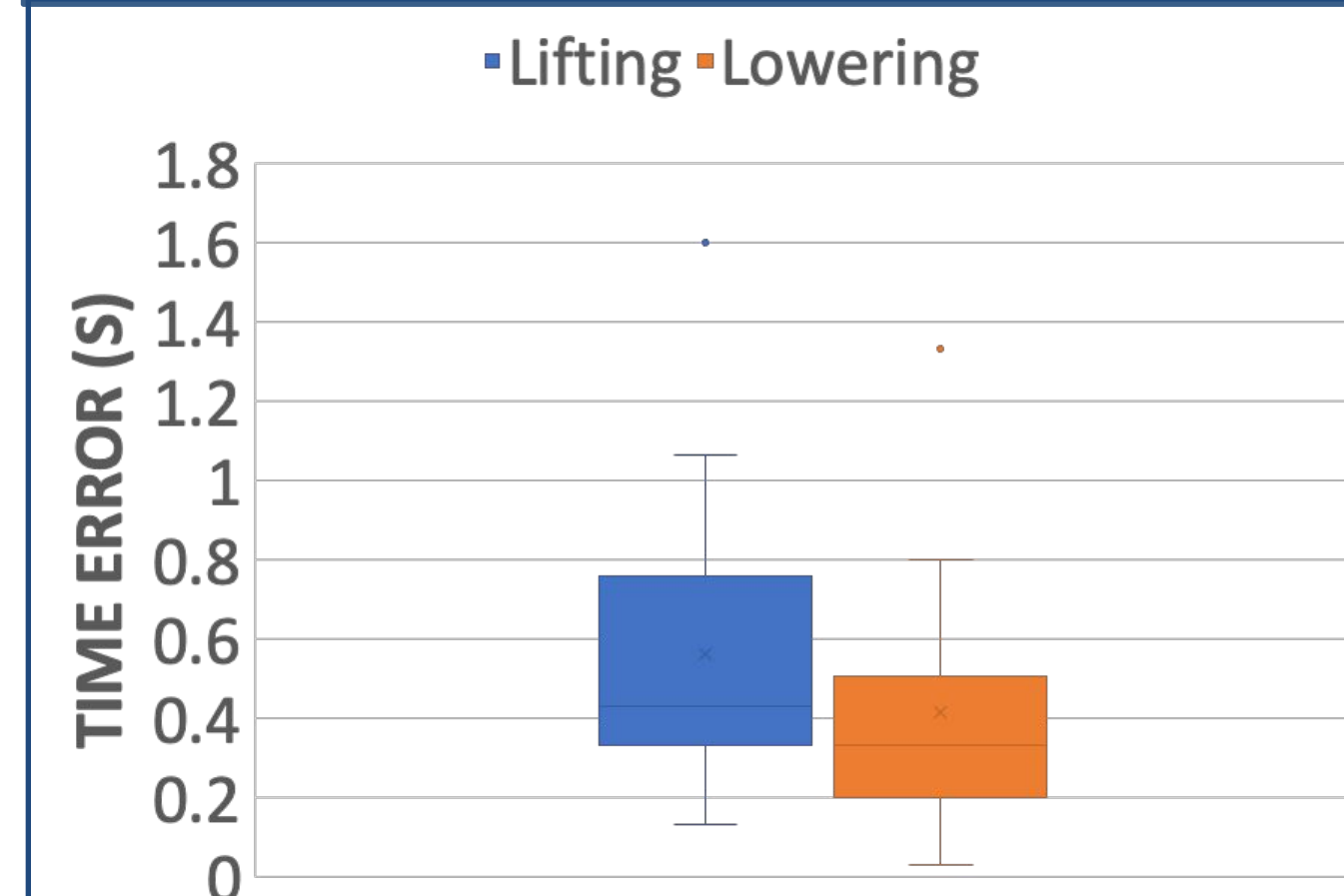
Experimental Design



We collected data from

- ❑ Four different individuals
- ❑ Two exercises: bicep curls and bent over rows
- ❑ Total of 50 reps

Results



- ❑ True Positive Rate for offline repetition detection: 100%
- ❑ Median error for lifting duration: 0.43 seconds
- ❑ Median error for lowering duration: 0.33 seconds
- ❑ Median error for range of motion: 70 pixels
- ❑ Median error for lifting velocity: 51.5 p/s
- ❑ Median error for lowering velocity: 45.1 p/s

Future Work

- ❑ Include a wider range of weight lifting exercises.
- ❑ Map pixels to real-world distance
- ❑ Voice-activated commands for start and stop of each set.
- ❑ Audio feedback, similar to a coach.
- ❑ Extend application scenario to physical therapy and rehabilitation.

Acknowledgements

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