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Development of a drone-based evaluation tool for motion analysis in athletics long jump

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List of acronyms

AI Artificial Intelligence

CPU Central Processing Unit

FPV First Person View

GPU Graphical Processing Unit

GUI Graphical User Interface

1 Introduction

Long jump is an athletic discipline that is renowned for its technical complexity and the precise movement patterns it demands from athletes. Even apparently small technical inaccuracies can significantly impact an athlete's performance. Therefore it is crucial to understand and continuously improve these movement patterns in training. However, taken the high approach velocity[1] into account, this can quickly become a difficult task. Especially the take-off phase can be very short and therefore hard to analyze.

Professional athletes often employ expensive high speed camera systems in combination with body pose markers to capture and analyze every single step they make.
Yet, this approach comes with some limitations. Due to their stationary installation, such camera systems are restricted to a fixed location. Moreover, they often combine multiple cameras in order to be able to capture the whole movement from the beginning of the approach until the landing. This leads to complex post-processing software requirements. Additionally, fixed markers need to be attached to an athletes body to be able to track their body position.

While these methods provide exact and reliable results, they are usually not accessible for hobby- and semi professional athletes.
In recent years however the advances in Artificial Intelligence (AI) and especially within the area of deep neural network paved the way for analyzing methods that require less complex setups. As of 2023 deep neural networks trained for body pose detection are even used in medical applications like gait analysis [1]. Because of the already extremely high and continuously improving accuracy, its application within the area of motion analysis in long jump is treated in the scope of this work.
A semi-autonomous drone based evaluation tool is newly developed. It is supposed to offer a portable alternative to address the lack of existing opportunities in analyzing long jump performances in training. For this purpose, the drone should autonomously fly next to the athlete throughout the whole jump, capturing their motion and therefore allow for a complete jump analysis. The drone itself is based on First Person View (FPV) drone

[1] around 10 m/s in male semi professional long jump

hardware. It is build from scratch using an on board single-board computer as flight control unit responsible for capturing the video. Additionally, a ground station software is developed to allow for a convenient jump analysis regarding the overall body pose as well as a fixed set of important parameters, i.e. knee angles, arm angles, hip position. The project's source code is available under `https://github.com/JF631/FLYJUMP`.

2 Methodology

The following chapter provides an overview over the relevant development components that are used within this project. Therefore, the used software packages are introduced before a short outline of the utilized drone hardware is given.

2.1 Software fundamentals

As the main part of this project's software will run on a portable remote computer allowing for not only to control the drone but also to perform the long jump analysis on video inputs, every software component is chosen to demand as little hardware requirements as possible. Especially no Graphical Processing Unit (GPU) is required to run the software. All image processing is performed using the Central Processing Unit (CPU) only. Furthermore, the software is designed to run platform independent.

2.1.1 Programming Language and why Python

2.1.2 Mediapipe for detecting body poses

One of the software's main tasks is to perform a human body pose detection in videos. Because this part runs on the remote computer only, it can also handle pre-recorded videos that should be evaluated.
The evaluation itself is performed using the mediapipe framework. It uses a pre-trained neural network that is able to detect 33 key points in body poses. The network can also be fine-tuned to improve its' accuracy. Even if this so called *transfer-training* method requires significantly less training data than training a neural network from scratch, it is not applied within this project as first test runs already showed accurate results.
Furthermore the mediapipe framework does not require any hardware acceleration and is renown for it's precise output. Hii et al. even showed in [1] that the framework can be applied in medical gait analysis applications to replace marker based approaches.
Mediapipe can deal with multiple input types including videos and live streams which is ideal for this project.

Different detection approaches

Literatur

[1] Chang Soon Tony Hii et al. “Marker Free Gait Analysis using Pose Estimation Model”. In: *2022 IEEE 20th Student Conference on Research and Development (SCOReD)*. 2022, pp. 109–113. DOI: 10.1109/SCOReD57082.2022.9974096.