AI Physio

Machine Learning based Estimation and Evaluation of Human Pose for Physical Therapy Application.

Graduate

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Initial Situation: Physical therapy is a growing problem in an aging society. It tends to be expensive, unpleasant, and limited by the availability of physical therapists. This results in unsatisfied patients, incorrectly prescribed physical therapy, and eventually skyrocketing healthcare costs.

At the same time, the rapid development of deep learning solutions in recent years has lead to significant advancements in human pose estimation (HPE). HPE refers to the task of estimating the configuration of human body parts from images. It is applied to a variety of tasks, including human motion analysis.

This master's thesis presents a machine learning-based approach to physical therapy that can overcome traditional barriers, such as staff, scheduling, or compromises to patient experience.

Approach / Technology: Recent advances in deep learning-based HPE have revealed computationally efficient ConvNets, which allow realtime HPE at the edge. These research contributions fuel the idea of exercise monitoring algorithms integrated into embedded computer vision modules. As part of this thesis, such an efficient HPE neural network is trained, tested and deployed on an edge device.

Swiss startup VRMotion engineered a pose tracking system which is capable of performing 3D HPE in realtime. In other words, this system estimates a 3D kinematic body model of the person in the detection area. The tracking algorithm is run on a dedicated high-performance computer. Leveraging this pose tracking system, an algorithm is developed which assesses a person's movements by comparing it to some pre-recorded target movements. At the core of this assessment method is a robust stochastic model. This makes the algorithm comprehensible, sample efficient and easily extendable to all kinds of periodic movements. Such a lightweight evaluation algorithm suggests the following practical workflow:

The physical therapist instructs the patient in a series of exercises and the patient performs them under the therapist's supervision. Once the patient performs the exercise correctly, the statistical properties of the movements are extracted and stored. Thereafter, the patient can perform the exercise unassisted by simply following the pre-recorded reference sequence.

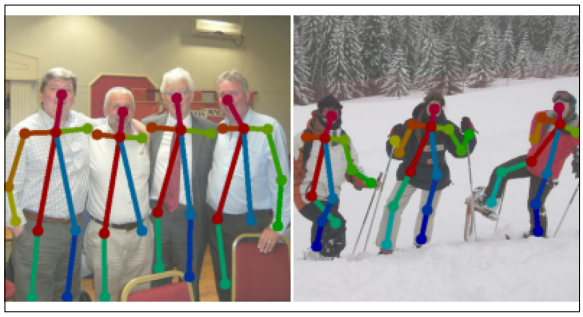
Result: This master's thesis comprises two main contributions.

First, a computationally efficient multi-person HPE neural network is trained and deployed on a low-cost embedded computing board. This marks a first step towards user-friendly AI assistance for physical therapy patients.

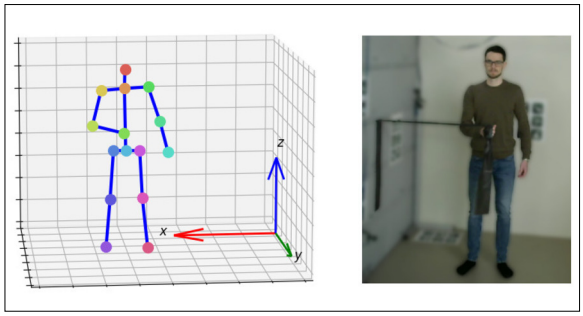
Second, an exercise evaluation algorithm is presented that is scalable to any exercise that can be performed within an three-meter cube. This algorithm is part of a system that accurately detects and assesses body movements performed by patients, all in realtime.

Before this thesis was even completed, it had already achieved considerable attention and success. Two awards in competitions and twice the top grade from the University of California, Berkeley speak for themselves.

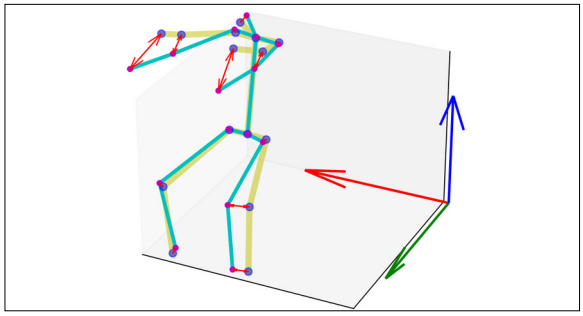
Two images validate the performance of a pose estimator. This in-house trained neural network runs on an edge device.
Validation images Microsoft COCO



The pose tracking system estimates a 3D kinematic body model (left) of the person in the detection area (right).
Own presentment



An evaluation algorithm determines the deviation of the user's current pose (cyan) from the target pose (yellow).
Own presentment



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Subject Area
Software and Systems