The FreeMoCap Project:
A free-and-open-source, hardware-and-software-agnostic, research-grade, minimal-cost motion capture system and platform for decentralized scientific research, education, and training

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I. Background

The FreeMoCap Project (https://github.com/jonmatthis/freemocap) seeks to create a common framework for the recording and analysis of human, animal, and robotic movement in order to simultaneously advance the scientific frontier while creating a more accessible and equitable approach to research, training, and education.

II. The Free Motion Capture System

The Free Motion Capture (FreeMoCap) system leverages emerging markerless motion capture software (e.g. OpenPose, DeepLabCut, etc) to create a streamlined 'one-click' pipeline for 3D kinematic reconstruction. This project utilizes a Python back-end and will (eventually) be packaged into a custom build of Blender (a free 3d animation software) to provide a full GUI based system that does not require a installation or usage via Command Line Interface.

This system works with arbitrary camera hardware and provides methods for synchronous recording of wired cameras (e.g. USB webcams) as well as the post-hoc synchronization of independent cameras (e.g. GoPros).

Initial support is provided for OpenPose and DeepLab-Cut markerless tracking with an Anipose-based backend for camera calibration. Customizeable wrappers that will allow the seamless integration of any additional markerless tracking methods (e.g. AlphaPose, DeepPoseKit, DAANCE, etc).

Additional wrappers will reformat motion capture data from traditional optical (Vicon, Qualisys, etc) and IMU-based (Motion Shadow, Rokoko, etc) motion capture systems into a **common, human-readable data type** designed to facilitate research collaboration and sharing of analytical methods. Support for eye tracking data (e.g. Pupil Labs) is in development.

III. Scientific Goals

This project seeks to create a common framework with shared data-types to allow researchers from various fields to combine their findings and methodologies in service of broad and multi-faceted understanding of human and animal movement in the natural world.

The computer vision community is making tremendous advances in the field markerless motion capture software, but these advances are of limited utility to the scientific
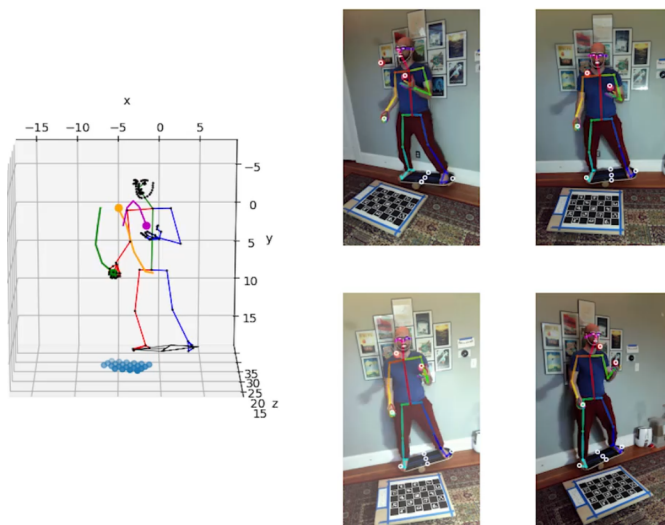
Fig. 1. This animation was made with approx. 100 USD worth of equipment. Skeleton tracked via OpenPose. Juggling balls and balance board tracked via custom network trained with DeepLabCut

community due to the disorganized nature of the related software. Often the installation and basic usage of the latest tracking software is difficult, requiring skills that are outside the scope of the researchers who stand to gain from them.

The FreeMoCap project emphasizes ***ease-of-use*** to allow specialized researchers to focus on their area of expertise when engaging in collaborative and interconnected multi-disciplinary research programs.

IV. Educational and training Goals

The eventual goal is to create a system that will allow a 14-year-old with no technical training and no outside assistance to recreate a research-grade motion capture system for less than 100 US Dollars. This will provide an immediate in-road for any person to engage with *real* scientific research and engage in self-directed, 'inside-out' exploration and training without the need for a physical or financial connection to a degree-granting institution. The Blender-based GUI system allows this project to piggyback on the vibrant community and high quality tutorial content associated with that program, and allows for the possible to complex technical interaction without the need for prior technical training.