Open-Source Hand Model Configuration Tool (HMCT)

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I. Introduction

To provide presence and a sense of embodiment in virtual reality (VR), it is essential to have a self-avatar, that accurately follows the user's movements [1]. Haptic gloves, e.g. Dexmo [2], however, mimic those movements heuristically with a *fixed* virtual hand model. We propose a tool that uses a camera image and a few manual annotations to determine the dimensions of the user's hand and automatically generate the configuration for an adaptive hand model that subsequently can be deployed in VR.

II. Methods

The configuration of the hand model[1] (based on the Pisa hand [3]) requires the users to place their palm on a glass surface inside a designated area, while fully extending all fingers and applying slight pressure to the surface. Below the surface, a camera and light are mounted. Upon running the utility, the camera captures an image of the hand to be measured and launches a user interface, where several *keypoints* can be added and dragged around (see Fig. 1). Once the user is done adjusting the keypoints, a yaml configuration with the measurements and scaling factors of the original model meshes is generated and can be provided to the hand model as an override to the default values. A user-specific hand model configuration only has to be generated once, as the measured properties of the hand are not expected to change.

The calibration tool is developed in python and uses the computer vision library OpenCV [4] for image processing and the interactive GUI. By previously having calibrated the camera with OpenCVs native camera calibration utility, the tool transforms pixel-space coordinates to real-world coordinates, i.e., measure the distances between annotations in meters. The first two keypoints are on both sides of the wrist in order to define the x-axis in hand model coordinates, i.e., the axis orthogonal to the fingers. Further keypoints are the joint positions. Visualizing the connections between the annotations and the optional visualization of the distances also help check the measurements' plausibility.

The source code of the calibration tool is publicly available[2].

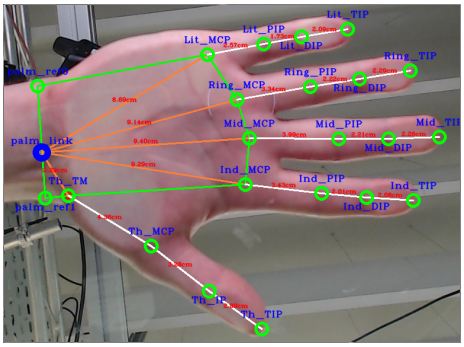

Fig. 1. Tool UI for keypoint placement that displays relative measures.

III. Evaluation

There were 13 participants (8 male, 5 female) with a total hand length from palm to middle finger from 170 to 210 mm. For each participant, the distances between the keypoints were measured once manually with a caliper and two times with the HMCT. Creating a hand model manually took $5\,min\,19\,s$ on average ($SD = 1\,min\,5\,s$). On average, using HMCT to measure and generate a model configuration took $1\,min\,4\,s$ ($SD = 19\,s$) in the first run and $55\,s$ ($SD = 8\,s$) in the second run. The mean absolute deviation between two HMCT measures of one participant was $1.9\,mm$ ($SD = 2.6\,mm$).

IV. Discussion

The evaluation showed that creating a hand model with the HMCT is faster compared to manual measurements and sufficiently consistent. As future work, we aim at integrating this tool in our VR workflow. Furthermore, we will record images with annotations to train ML models in order to enable automatic hand model creation based on images with known pixel-to-world-space transforms.

References

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[1]https://github.com/DavidPL1/human_arm/tree/haptic-control

[2]https://github.com/DavidPL1/human_hand_calibration