ON HUMAN HAND CONFIGURATIONS

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Introduction

The “Leap Motion” is a sensor that detects human hand configurations (poses)using infrared light. We use this device to record hand poses systematically, in order to better understand the space of possible hand configurations. Understanding the healthy pose space allows us to detect musculoskeletal diseases such as rheumatoid arthritis (RA) early.

We use a kinematic model of a hand that encodes 20 rotations of joints. Our model currently allows for adduction/abduction and flexion of the metacarpophalangeal joints, and it only allows for flexion of other joints.

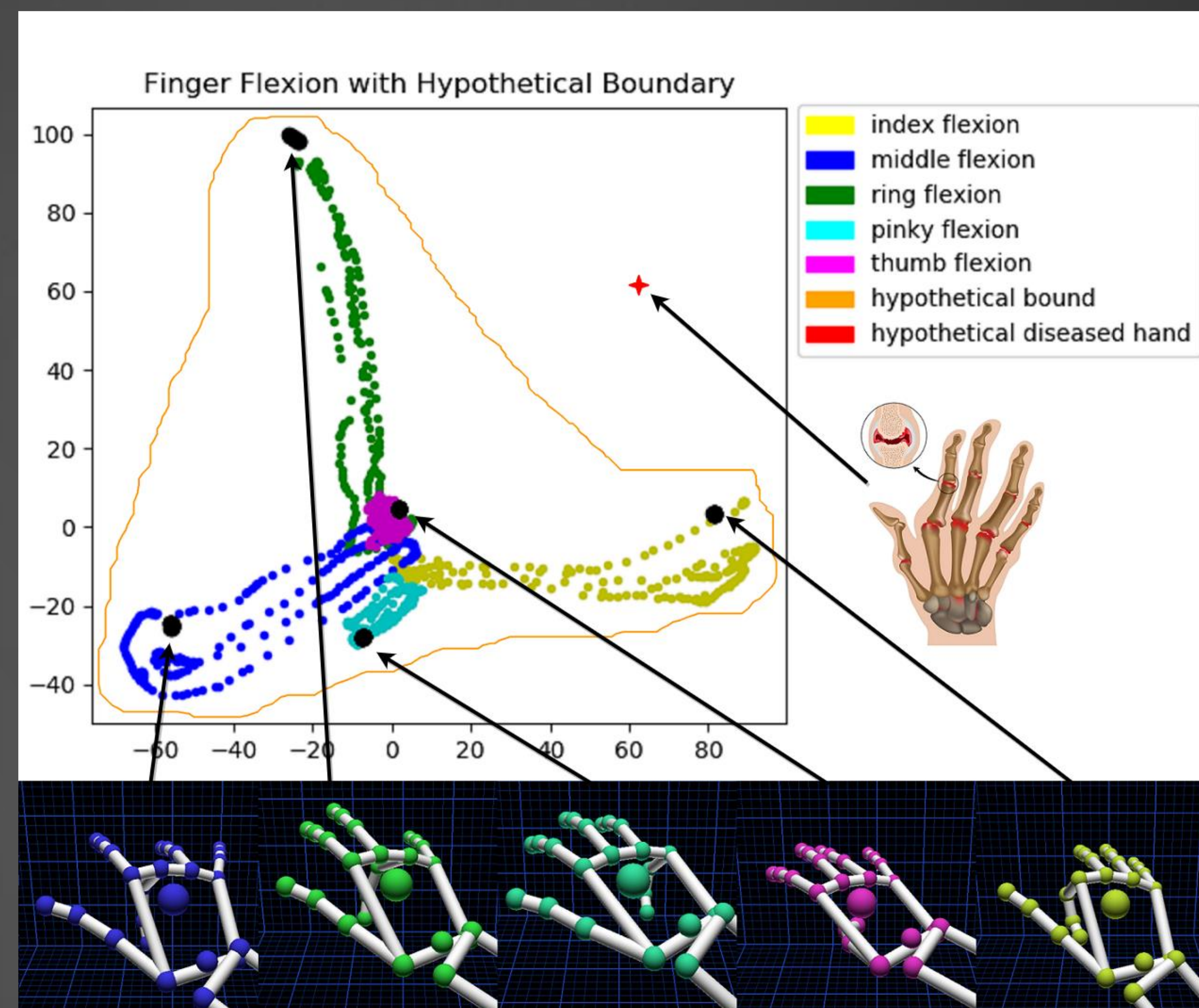
Methods

We use dimensionality reduction techniques to map 20-dimensional data points corresponding to healthy hand configurations down to two coordinates, where x is the first principal component and y is the second principal component (See Figure).

In this preliminary work, we used Principal Component Analysis (PCA) to perform dimensionality reduction. The data points were systematically collected by flexing each finger independently. We hypothesize that multiple fingers flexed simultaneously will be a non-linear combination of independent fingers.

Visualization

This data contains hand poses acquired by independently moving fingers, then using PCA to map those poses to 2D space.



Data Analysis

In orange, we show a hypothetical boundary of natural hand configurations. In order to determine the true boundary, we must gather data from human subjects with RA, which we leave for future work.

Shown as a red cross is a hypothetical diseased hand.

Points outside the bound will be candidates for diseases/disorders that deform the hand.

Limitations

PCA is linear and cannot separate data perfectly. We must test other dimensionality reduction techniques to find a better alternative.

The Leap Motion uses light to detect hands, meaning that certain poses cannot be read due to occlusion of the fingers.

Currently, our 20 degree of freedom hand model only allows 1 or 2 degrees of freedom per joint. Moving forward, this must be corrected in order to encode irregular hand configurations..

Conclusions/Future Directions

Moving forward, we will develop machine learning techniques to estimate a boundary for healthy hand configurations. This boundary will then be used as a baseline for identification of diseases and disorders that result in irregular hand configurations.

Rheumatoid Arthritis image obtained from pngguru.com: (https://www.pngguru.com/free-transparent-background-png-clipart-fbkzd)