

Estimation of 3D Finger Postures with wearable device measuring Skin Deformation on Back of Hand

Wakaba Kuno¹, Yuta Sugiura¹, Nao Asano¹, Wataru Kawai² and Maki Sugimoto¹

¹Keio University, Japan
²University of Tokyo, Japan

Abstract

We propose a method for reconstructing hand posture by measuring the deformation of the back of the hand with a wearable device. Our method constructs a regression model by using the data on hand posture captured by a depth camera and data on the skin deformation of the back of the hand captured by several photo-reflective sensors attached to the wearable device. By using this regression model, the posture of the hand is reconstructed from the data of the photo-reflective sensors in real-time. The posture of fingers can be estimated without hindering the natural movement of the fingers since the deformation of the back of the hand is measured without directly measuring the position of the fingers. In our demonstration, users can reflect his / her own finger posture in a virtual environment.

CCS Concepts

•Human-centered computing → Interaction devices;

1. Introduction

Measuring hand posture is important because it can be applied to virtual reality systems and user interfaces. There are two common methods: camera-based and glove-type. Camera-based methods enable hand posture to be recognized without limiting user movement because there is no need to wear a device [WP09]. However, there are restrictions regarding the place of use since cameras need to be installed and this method often has occlusion problems. Glove-type methods can recognize hand posture without occlusion, but the glove may limit hand movement [KJP02] [XNA17].

In contrast with these two methods that measure the hand itself, there are methods that indirectly measure hand posture. There have been many proposals for devices that are worn on the fingers [MCA99] [OSO12], those that wrap around the wrist [DP14] [FWG*11] [GYI16], and those that wrap around the forearm [TL17] [ZH15] [ZXH16]. These devices do not limit a user's movement and are robust against occlusion. However, they cannot recognize various gestures, and their position must be adjusted depending on the user.

In our previous study, we focused on the back of the hand [SNK*17] because the muscles and bones on the back of the hand are linked to the fingers and finger movements can be clearly observed. This area is less affected by the wearing of clothing compared with a device attached to the wrist or forearm.

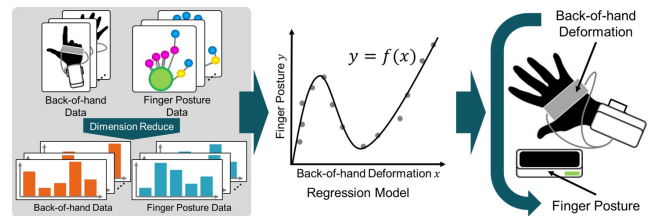


Figure 1: Proposed method of reconstructing hand posture using regression model.

2. Proposed method

We obtain the relationship between the deformation of the back of the hand and the finger posture by using a multivariate and multi-variable regression model to estimate the finger posture from the deformation of the back of the hand (Figure 1).

Our method has two phases: a learning phase and estimation phase. At the learning phase, we measure the deformation of the back of the hand and the finger posture simultaneously by using measurement devices. We reduce the dimension of the measured data. Then, the regression model learns the relationship between the deformation and the posture by using the dimensionally reduced data. At the estimation phase, we measure only the deformation of the back of the hand. After reducing the dimension of the sensor data, we can estimate the dimensionally compressed finger posture with the regression model. We use Leap Motion to measure finger postures

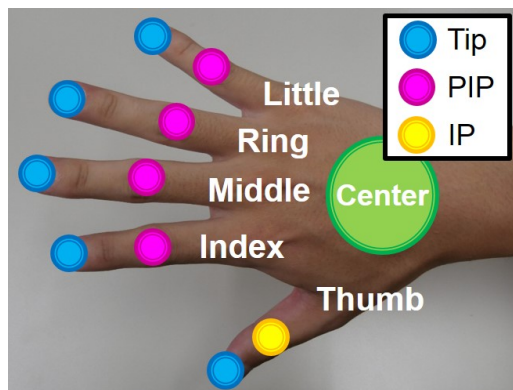


Figure 2: Hand labels defined in this research.

in the learning phase. We decided to use the position information of 10 joints: the fingertips of each finger, the interphalangeal (IP) joint of the thumb and the proximal interphalangeal (PIP) joints of from the index finger to the little finger (Figure 2). We measure the 3-dimensional relative position of these joints from the hand center to acquire 30-dimensional data. We measure the deformation of the back of the hand and acquire 13-dimensional data by using the wearable device developed in [SNK*17]. The device takes measurements with photo-reflective sensors that can measure distance with infrared rays. We filter the measured back-of-hand data and finger posture data with a low pass filter with an IIR filter (the cutoff frequency is 0.84 Hz for back-of-hand data and 1.78 Hz for finger posture data). We reduce the dimension of the back-of-hand data from the 13th to the 5th dimension and finger posture data from the 30th to the 5th dimension to convert them into data expressed by uncorrelated variables. We use principal component analysis (PCA) and reduce the dimensions. The regression model learns the relationship between the deformation of the back of the hand and the finger posture by using the dimensionally reduced data of the back-of-hand and the finger posture. We use random forest regression (RFR) with the highest coefficient of determination in the preliminary experiments.

3. Demo description

In our demonstration, we use Leap Motion as a finger posture measurement device, and the device developed by [SNK*17] as the device measuring the back of the hand. By attaching the device to the back of the hand, users can reflect his / her own finger posture in a virtual environment.

4. Conclusion

We proposed a method for reconstructing the finger posture from the deformation of the back of the hand by using the wearable device developed at [SNK*17]. We use a regression model to express the relationship between the deformation of the back of the hand and the finger posture with the training data, and we estimate the finger posture from the deformation by using the model. In our demonstration, users can reflect his / her own finger posture in a virtual environment by attaching the device to the back of the hand.

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