Hand Tracking With Leap Motion Controller

Lin Shao
lins2@stanford.edu

Abstract

The novel device Leap Motion Controller provides an informative representation of hands. We utilize tracking data through the API of Leap Motion Controller to recognize hand movement and gestures. Our experiment shows that our method based on Leap Motion Controller tracking data can recognize hand gesture accurately when no occlusion happens.

Introduction

Gesturing is a natural part of human communication and becomes more and more important in AR/VR interaction. The Leap Motion Controller(LMC) is a new device developed for gesture interaction by Leap Motion (`https://www.leapmotion.com/`). The device has a small dimension of 0.5x1.2x3 inches. To use the Leap Motion Controller, the user need to connect it to a computer by USB. Then the users put hands on top of the Leap Motion Controller. Figure 1 gives an example of how to use the Leap Motion Controller.

Figure 1: Leap Motion Usage. The small object in the middle is Leap Motion Controller connecting to the Mac on the right. Hand on top of the Leap Motion is tracked and interacted with virtual objects. Picture source:`https://www.leapmotion.com/product/desktop?lang=en`

Tracking data from LMC

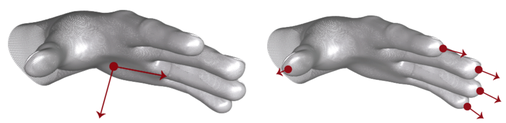

Figure 2: Example of tracking data with red color. Left: palm data. Right: fingers data. Figure source `https://www.leapmotion.com/`

Tracking data from Leap Motion Controller API is access by a Frame Object. Figure 2 highlights tracking data we used to build hand gesture features.
Palm positionP_{pos}, normal P_N and velocityP_v. Hand direction P_D.
Fingertips position F^i_{pos}, direction F^i_D and velocity F^i_v where i starts from 0 to 4 representing thumb, index, middle,ring and pinky respectively.

Designed Features

Features are based on geometry information of hand.

Static Gesture

Features for static gestures are mainly built based on palm and fingers relative distances. Distances between fingertips F^i_{pos} and palm center P_{pos}. Distance between thumb F^0_{pos} and index F^1_{pos}. Distance between index F^1_{pos} and F^2_{pos}.

Translation Feature

Translation Feature indicates fingers and palm are moving together straightly without rotation. We calculate the cross correlation of velocity vectors between fingers F^i_v and palm P_v.

Hand Rotation Feature

Palm Rotation Features contains two parts. One is the difference of current palm normal P^t_N and previous palm normal P^{t-1}_N defined by DP_N. The other parts is the angle between difference of current palm DP_N and hand direction P_D.

Index Tapping Features

Index Tapping Features contains two parts. One is the magnitude of index velocity F^1_1. The other is the angle between index velocity F^1_1 and hand direction P_D

Index Circle Direction Features

Index Circle Direction features are detecting whether the index circle is clockwise or counter clockwise.

Gesture Navigation

We choose three different gestures to represent moving forward/backward, turn left/right, roll clockwise/counter-clockwise.

Experiment Result

We implemented the demo based on unity5 and used skeleton hands as the output. Figure 3 gives several examples of static gestures our method could effectively recognized.

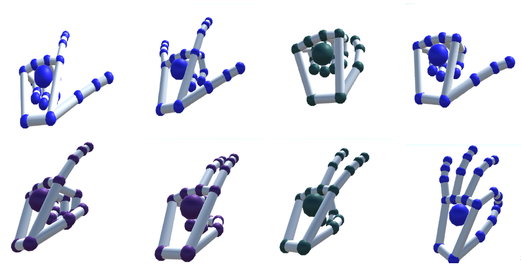

Figure 3: Examples of static gestures

Failure Case Analysis

We also analysis the failure cases to find out factors leading to misclassification.

Self-Occlusion

abstractname The Leap Motion Controller use IR to gather hand information in the space. When important fingers or regions are self-occluded by other hand parts, tracking data quality will greatly reduced.

Detection Region

Currently the detection region for Leap Motion Controller is still small. Hand tracking data becomes unstable when hands are near the detection region boundaries.

Parameters

In the above feature descriptors, some parameters are associated with real hand sizes. If the hand sizes and corresponding parameters are not matching, failure cases happens.

Error accumulation

For hand movement gestures, we also use first order differences. These values are less accurate and less robust due to error accumulation

Conclusion and Question

- Leap motion provides detailed descriptions of hand position and velocity which could be used for hand gesture recognition.
- The hand gesture recognition results also depends on other factors such as occlusion which sometimes lead to misclassification.

References

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