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MYO Armband and Leap Motion data fusion with OpenSim based Virtual Reality Environment

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Abstract In this paper, a novel method combining MYO Armband and Leap Motion is proposed to apply in Virtual Reality display tasks. With the proposed method, we address the Leap Motion's problem of lost detection and improve the Leap Motion's robustness. By integrating MYO and Leap Motion, we can obtain the user's palm's position with MYO, while Leap Motion fails to detect the user's hands. A rigorous analysis is also given in this paper. The validity of the proposed method is verified by simulations with OpenSim.

Keywords MYO · Leap Motion · OpenSim · Virtual Reality · Data Fusion

1 Introduction

Nowadays, with the development of the robot manipulators, robots are commonly working in complex and dangerous environments, such as space, operations. In some applications, it also require the operator to remote control robots. To obtain a better teleoperation performance, it is important to choose a suitable tool to capture the operator's operation sequence and transfer it precisely to the robot.

In some fields, many works have been done on human-robot teleoperation and cooperation, these works have made considerable progress on this topic. Among them, humans can share the same workspace with robots[1], in some applications, such as operations and some dangerous situations, humans can also use teleoperation technology to control the robot remotely[2]. However, these improvements also encountered some challenging problems, in some complex teleoperation tasks, such as surgery[3], in order to obtain a better performance, it is necessary to provide a visualization GUI to the operator. In these tasks,

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TouchX[4], Leap Motion, also Kinect are used to provide a better interaction experience for the operator while obtaining a better performance[5]. From a practical point of view, teleoperation is beneficial for the surgeon and makes ergonomic control of the surgical robot possible. Nevertheless, manipulating such robot are also limited by some restrictions that can trigger technical or medical problems which are sometimes neglected[6].

Besides, with the development of the Virtual Reality (VR) technology, The use of natural interfaces has considerably evolved recently[7]. By using this technology, it is possible to use motions of the body or gestures of hands during interaction tasks[8][9].

In this paper, in order to improve the accuracy and robustness of the Leap Motion's position tracking ability, we propose a method combing the MYO armband and Leap Motion, in which a fusion of MYO's position data and Leap Motion's data is made to obtain a better performance of the palm's position-tracking.

The main contributions of this paper are listed below.

(1) A novel palm position tracking method combining MYO Armband and Leap Motion is proposed to address the lost detection problem of Leap Motion.

(2) A Virtual Reality (VR) system based on OpenSim is built to provide a nature visualization interface for the users.

2 Related Works

Gesture motion is one of the most accurate and efficient communication factor in tooltips controlling tasks[10]. To address the hand pose capture and enhance the performance of teleoperation, many works have been done with Kinect, a body motion capture device developed by Microsoft. Nevertheless, designed for the whole body motion track, Kinect and other similar sensors do not have enough accuracy for hand or palm's position tracking. Different with Kinect, Leap Motion offers another way for tracking hand motions and has shown satisfactory results on this topic. Hernoux et al.[11] used the Leap Motion to trace one of the operator's finger to mimic the writting motion with a robot. In the human-robot cooperative surgery field. The work proposed in [12] used the Leap Motion to control surgical tools in a simulated environment.

Nevertheless, these works also highlighted the Leap Motion's lost detection problems, in some particular situations, the operator's hands will overlap over the Leap Motion, which means that the Leap Motion will lost the upside hand's position. This problem will effect the real time performance of the control system. What's more, the work proposed in [13] also used the Leap Motion and MYO Armband's data fusion to detect the operator's arm's movement.

We develop a novel method combining Leap Motion and MYO armband. With such method, we figure out a cheap solution for addressing the Leap Motion's lost detection problem.

3 Simulation System

In this paper, a human operator, a MYO Armband, a Leap Motion and a PC are included in the simulation system, as been shown in Fig.1. The Leap Motion is used to capture the palms' position information, the MYO Armband is used while the Leap Motion can not detect the operator's hand, and the computer with OpenSim is used to display the Virtual Reality environment.

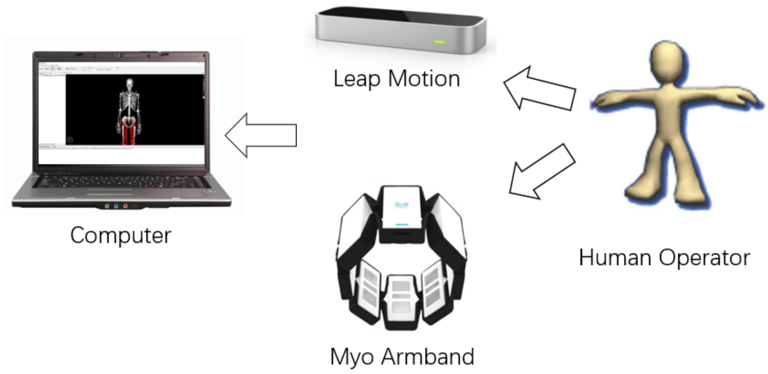

Fig. 1 The architecture of the simulation system

3.1 Leap Motion

In this simulation system, Leap Motion, as shown in Fig.2, is used to capture the human hand motion as well as the palm's position. Released by Magic Leap Company, Leap Motion is a miniaturized USB device using infrared LEDs and two cameras to trace the trail of hands as well as the fingers. Due to the patent protection, the algorithms and processing of Leap Motion is unknown yet[12].

The internal structure of the Leap Motion is shown as Fig.3.

3.2 MYO Armband

Developed by the company Thalmic Labs, the MYO armband is a device which can recognize hand gestures and movements. With the help of 8 electromyography (EMG) sensors, the MYO armband are able to recognize each gesture, basing on the electrical impulses generated by the arm muscles[15].

Fig. 2 The Leap Motion

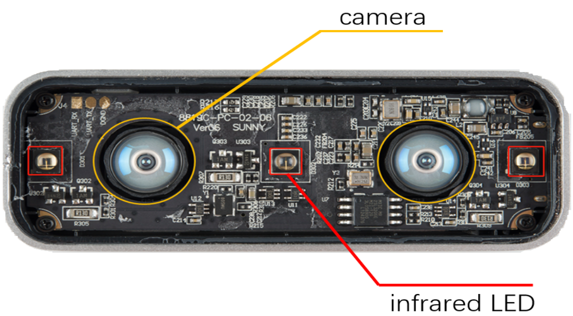

Fig. 3 Inside Leap Motion[14]

What's more, the MYO armband also has a nine axis inertial measurement unit (IMU), which allows the armband detecting the movement of arms. Besides, for transmitting feedback, MYO has a tactile sensor, it has three types of intervals (short, medium and long vibrations) to the user as making a correct movement timely.

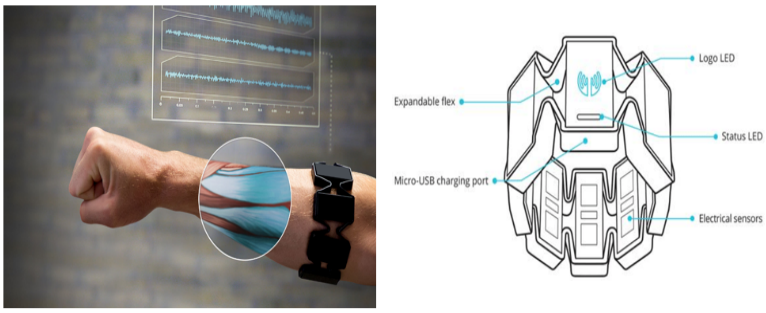

Fig. 4 MYO Armband reading electrical signals from muscles and the external units in the MYO Armband.[16][17]

Fig. 5 The MYO armband used in this project

3.3 OpenSim

OpenSim is an open-source software to model, simulate and analyse the neuromuscular skeletal systems[18], the screen shot of OpenSim is shown as Fig.6.

In this paper, we use OpenSim to build up a Virtual Reality (VR) environment and provide a simulations to verify the validity of the proposed method.

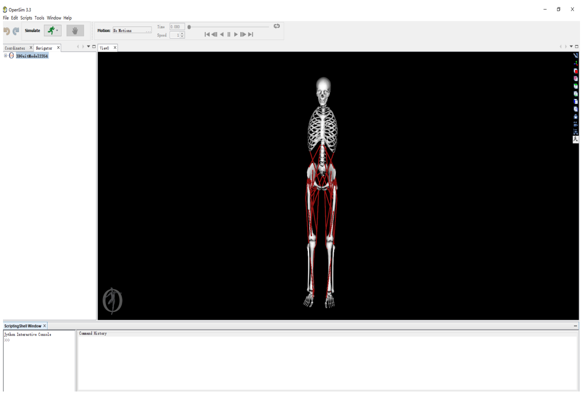

Fig. 6 The screen shot of OpenSim

4 Problem Formulation

This section mainly describes the development of the combination of MYO armband and Leap Motion to address the Leap Motion's lost detection problem.

As the discussions made in section 2.1, the operating principle of Leap Motion is that, by using infrared LEDs and two cameras to trace the trail of the hand as well as the fingers capture the human hand motion and the palm's position. Normally, this pattern can detect the hands effectively, nevertheless, when the hands are overlapping, the Leap Motion can only detect the downside hand, which is closer to the cameras, and lose the detection of the upside hand. Although this overlapping case only occurs in some particular situations, and it does not have much influence on the user experience, it is important for us to obtain the intact track of the hand in some tasks such as surgery.

4.1 The combination between MYO Armband and Leap Motion

To address this problem, we propose a novel method that combining MYO armband and Leap Motion to obtain a better tracing performance. The process of this method is shown in Fig.7.

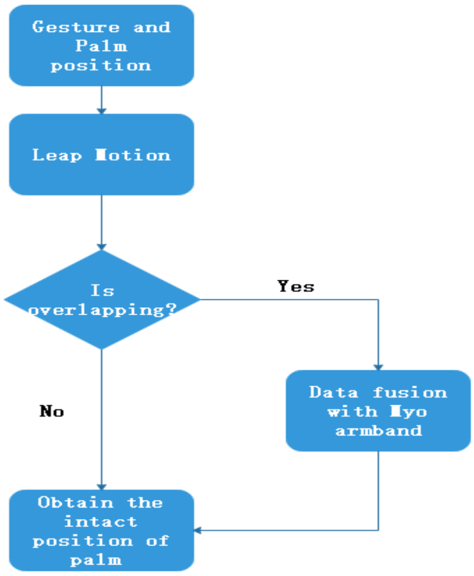

Fig. 7 The process of the combination of MYO armband and Leap Motion

Using the Leap Motion and MYO's SDK, the process of implementation is as follow:

(1) Using the Leap Motion to capture the operator's palm information.

(2) Using the Leap Motion's SDK function to estimate if the hands are overlapping or not.

(3) If the hands are overlapping, Call the MYO's IMU sensors to estimate the position of the hand upside.

(4) Fuse the palm position data obtained from Leap Motion and MYO to reconstruct the trajectory of the upside hand.

The real-time scenes and the hand model is integrated in OpenSim, it will be discussed in detail in the following section.

4.2 Space Vector transition

In this project, it is the key point to transfer the Leap Motion and MYO's coordination to the coordinates of the OpenSim, we develop a mapping algorithm to address this problem. Assuming that, at the initial point, the operator's palm coordinates of Leap Motion is $P_{LM}(x_0^{LM}, y_0^{LM}, z_0^{LM})$, at the same time, it's coordinates of MYO is $P_M(x_0^M, y_0^M, z_0^M)$, and the coordinates of OpenSim is $P_{OS}(x_0^{OS}, y_0^{OS}, z_0^{OS})$. At time t, the coordinates are $P_{LM}(x_t^{LM}, y_t^{LM}, z_t^{LM})$, $P_M(x_t^M, y_t^M, z_t^M)$, and $P_{OS}(x_t^{OS}, y_t^{OS}, z_t^{OS})$, respectively.

When the hands are in a normal position, rather than an overlapping position, the mapping relationship can be expressed as below:

$$\begin{cases} x_t^{OS} = x_0^{OS} + L_1(\Delta x_t^{LM}) \\ y_t^{OS} = y_0^{OS} + L_2(\Delta y_t^{LM}) \\ z_t^{OS} = z_0^{OS} + L_3(\Delta z_t^{LM}) \end{cases} \tag{1}$$

where $L = (L_1, L_2, L_3)$ are undetermined coefficients, $\Delta P_{LM}(\Delta x_t^{LM}, \Delta y_t^{LM}, \Delta z_t^{LM})$ are the change value of the palm position detected by the Leap Motion.

In this experiment, we set $L = (0.1, 0.1, 0.1)$.

In this paper, we are going to add the MYO's information when the hands are overlapped. The mapping relationship we made can be expressed as follow:

$$\begin{cases} x_t^{OS} = x_t^{LM} + k_1(\Delta x_t^M) \\ y_t^{OS} = y_t^{LM} + k_2(\Delta y_t^M) \\ z_t^{OS} = z_t^{LM} + k_3(\Delta z_t^M) \end{cases} \tag{2}$$

where $k = (k_1, k_2, k_3)$ are undetermined coefficients, $\Delta P_M(\Delta x_t^M, \Delta y_t^M, \Delta z_t^M)$ are the change value of the palm position detected by the MYO armband.

In this experiment, we set $k = (0.1, 0.1, 0.1)$.

5 Experimental Results

To verify the effectiveness of the method proposed above, we design a virtual reality system based on OpenSim. As shown in Fig.8, the Leap Motion is used to capture the position of the palms, and the MYO armband is equipped on the operator's right arm. With the help of OpenSim, the movements of the operator's arms can be shown by a skeleton model timely. In the first step of the experiment, we run the Leap Motion's SDK in Visual Studio 2017 to capture the positions of the palms, and prepare to send these data to the MATLAB

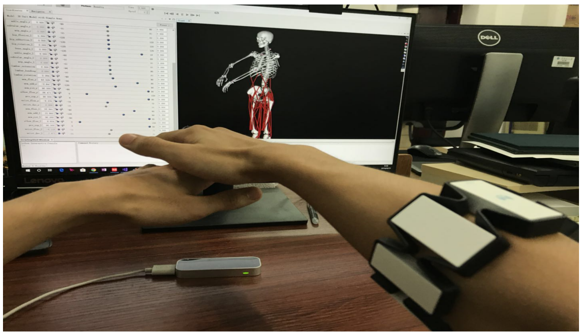

Fig. 8 The Combination of Leap Motion, MYO and OpenSim

program. Then, we can run the MATLAB program, with MATLAB 2016b, to receive these position data using UDP Socket and launch the visual interface.

In the experiments, we can observe that, in the situation of no wearing the MYO armband, when the operator's hands are overlapped (in our experiment, the left hand is downside), the skeleton model's right hand will stop moving because the Leap Motion has lost the position of the right for the blocking of the left hand.

In the situation that wearing the MYO armband, when the operator's hands are overlapping, the skeleton model can still obtain the position of the right with the help of the MYO armband.

The results of the experiment are shown as Fig.9.

6 Conclusion

In this paper, we mainly proposed a novel method for MYO armband and Leap Motion's data fusion, and created a virtual reality (VR) environment to visualize the process.

The experimental results have shown that the method proposed can address the Leap Motion's problem of losing detection when the hands were overlapping, and improve the Leap Motion's robustness. Besides, the virtual reality environment based on OpenSim can make the operations more visualized to the operator. The VR environment will be useful in some particular tasks, like using Leap Motion to Control a surgical robot, for offering a better manipulating experience to the operator.

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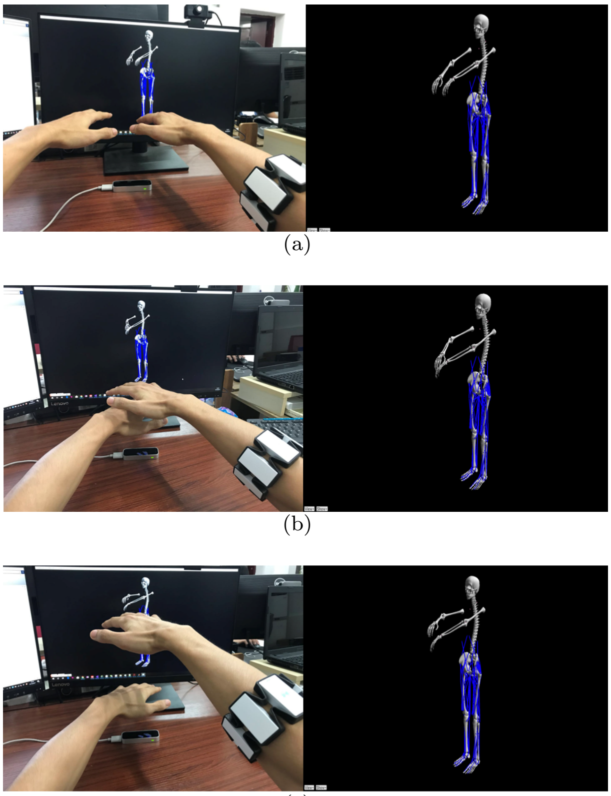

(a)

(b)

(c)

Fig. 9 (a) The initial positions of the hands; (b) the overlapping hands; and (c) reappear the hands' movement while they are overlapping.

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