A Robust and Accurate 3D Hand Posture Estimation Method for Interactive Systems

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ABSTRACT

In this paper, a new 3D hand posture estimation system using a single camera and 3 interactive systems are introduced. Existing hand gesture recognition systems estimate hand's 3D models based on image features such as contour or skin texture. However, it was difficult to estimate the wrist rotation because the contour and the texture data do not have enough information to distinguish hand's sides. To solve this problem, we propose a new 3D hand posture estimation system that uses data of nail positions. Nail positions are an important factor to recognize hand's sides. Using nail positions, it becomes possible to detect whether the camera is facing palm or dorsum. In addition, nail areas can be robustly extracted from a skin area by a simple image processing technique. Our Proposed system uses a database consists of data-sets of the hand's contour, the nail positions, and finger joint angles. To estimate the hand posture, the system first extracts the hand's contour and the nail positions from the captured image, and searches for a similar data-set from the database. The system then outputs the finger joint angles of the searched data-set. Our experimental results show high accuracy in the hand posture estimation with the wrist rotation.

Author Keywords

Hand gesture, interaction device, robot, tactile feedback.

ACM Classification Keywords

H5.2 User Interfaces: Interaction styles (e.g., commands, menu, forms, direct manipulation).

General Terms

Design.

INTRODUCTION

The hand posture estimation system can be used for various systems. It is important to estimate the hand posture with a single camera for the realization of the hand gesture input. If it is possible, user can manipulate the devices while doing other things, because the user does not have to sit at the desk or hold the mobile device in his/her hand for the manipulation.

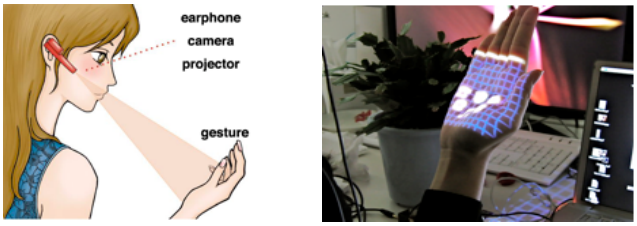

Figure 1. BrainyHand: An Ear-worn Gesture Interaction Device.

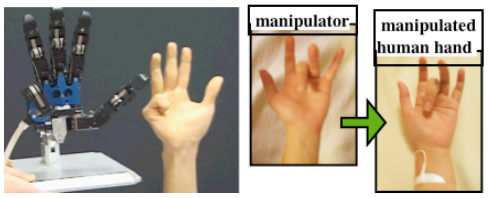

Figure 2. RobotHand manipulator.

Figure 3. PossessedHand: Human manipulator using electrical muscle stimulation(EMS).

The 3D hand posture estimation system using the single camera is expected for the interaction devices(Fig. 1, 2, 3) with the bare hands. A number of single camera approaches have been suggested for posture estimation. The most common approach[1] uses 2D contours of captured hand to estimate hand posture. This approach matches the captured hand contour with the contours of hand models or a database, to estimate hand posture with high-speed processing. However, this approach will failing to estimate the postures, when the captured contour data does not have enough information to distinguish hand's sides. Figure 2-(a) shows an example of the hand posture which is likely to fail.

To solve this problem, another approach which is considered inside line of hands[2] has been proposed. In this approach, it is easy to estimate hand posture as it is shown in Figure 4-(a). At the same time, this approach fails to estimate posture as shown Figure 4-(b), because this posture only has hands contour. By using previous result, the false recognition can be prevented. However, initial hand's posture becomes restricted.

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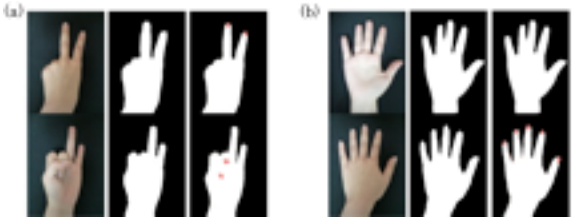

Figure 4. Examples of ambiguous hand postures. (left column) c (center column) contour. (right column) contour and nail.

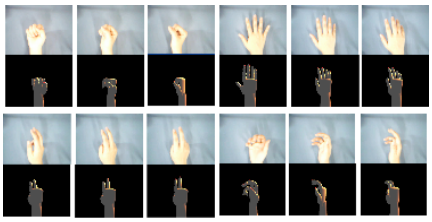

Figure 5. Results of 3D Hand Posture Estimations.

An approach using texture as crease in the hand besides hands contour and inside line is also suggested[3]. This approach estimates both hand postures on Figure 4-(a) and (b), although this is not consistently result in outcomes, because the textures of crease are easily effected by the lighting environments change. In addition to the approaches above, an estimation approach which uses shading of hands is proposed[4]. However, this approach can not recognize hand's sides in shade-less environments because of diffused lighting.

The key to prevent false estimation is to distinguish hand's sides correctly. The existing image-based approaches use texture and shading to distinguish hand's sides; these are effective approaches. Nevertheless, an extraction of texture and shading is not robust in some lighting environments. In short, hand posture estimation system needs a new extractable factor that can robustly distinguish hand's sides.

SYSTEM CONFIGURATION

Nail positions have information to distinguish hand's sides, as shown in Figure 4. Our proposed system(Fig. 6) uses a database, consisting three elements: data-sets of a hand contour, nail positions, and finger joint angles. The contour is digitalized by Higher-order Local AutoCorrelation (HLAC). The nail areas can be easily extracted from a skin area by simple image processing technique[5]. The technique can extracts the nail and skin areas except in blue lighting and intense lighting conditions. The finger joint angles are measured by the data glove of 18 degrees of freedom. To estimate the hand posture, system firstly extracts hands contour and nail positions from the captured image, secondly it searches for a similar data-set from the database. The system then outputs the finger joint angles of the searched data-set. To show the effectiveness of our system, we tested by comparative experiments

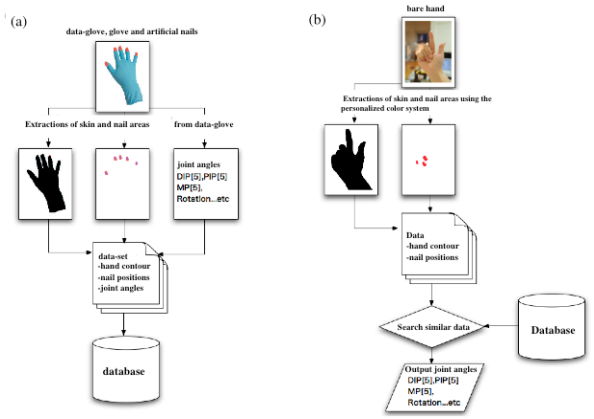

Figure 6. System outlines. (a)An construction of a database. (b)A hand gesture estimation.

between the data glove and our system. Then, we confirmed an accuracy of hand posture estimation with the wrist rotation.

Our experimental results show high accuracy in the hand posture estimation with the wrist rotation(Fig. 5). The finger joint angles estimation is approximately 7.23 degree of standard deviation of error. The processing time is within 10ms. The system works correctly except in blue lighting and intense lighting conditions

CONCLUSION

The 3D hand posture estimation system is proposed. Brainy Hand(Fig. 1), Robothand manipulator(Fig. 2), and Human manipulator(Fig. 3) are also suggested as the application examples by using the estimation system. RobotHand manipulator is nearly-completed system. On the other hand, BrainyHand and PossessedHand need more discussions for efficient interaction ideas.

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