Copycat hand

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1 Introduction

The goal of authors' research group is to develop the robot hand system which can learn dexterous motions of the human hands by watching. We have therefore attempted realtime estimation of posture using high-speed search of similar images from database. However, our previous method has a disadvantage that search time increases in proportion to expansion of data though estimating precision gets high. Moreover, the expansion of data may scatter the processing time if the database is not efficiently constituted for high-speed search.

The present study therefore classified all the data into classes by using joint angle information of hand and fingers to let self-organizing and adopted two- or multiple- step search utilizing typical characteristic quantity of the classes. In addition, numbers of data affiliated to each class were intended as uniform by adding the algorism of self-reproduction and self-annihilation to each class in self-organization. We propose a high-speed processing above 150 fps with high-precision without deviation of search time.

2 System configuration

Human hand images and joint angle data were acquired as a set for preparing database. The images were recorded by means of a monochromatic high-speed camera at resolution of 320*240 pixels laterally and vertically each in the state that a hand and fingers were viewed in the screen with a sufficient size. The elimination of background, change of resolution and extraction of contour were conducted, and the characteristics were calculated with respect to reference point and its vicinity with high-order local autocorrelational function.

Clustering was conducted by means of Self-Organizing Map in order to collect data with mutually similar joint angles. Prepared at first were the initial classes with typical angles, characteristic quantities, and information of vicinal classes. Then, by using data in the primary database, angular distances between the data and class were calculated and the class closest to respective data was selected. Concurrently, data with which the most vicinal class was defined were registered as those affiliated to the most vicinal class. After affiliated classes for all data were determined, some classes were duplicated with respect to what number of data affiliated to each class exceeded twice of ideal number of data. As for those with number of affiliated data being less than a quarter of ideal data number, relevant classes were eliminated.

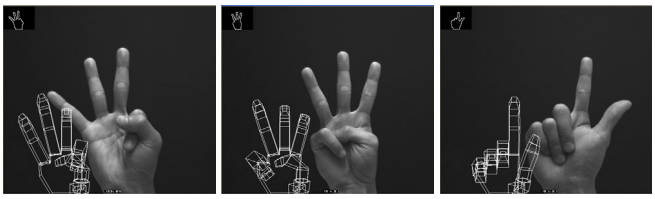

Figure 1: Examples of hand posture estimation.

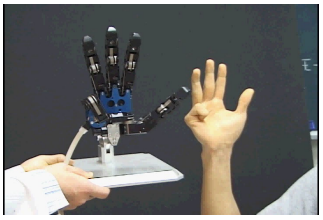

Figure 2: Mimicking with robot hand.

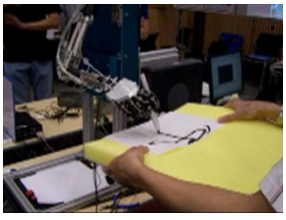

Figure 3: Writing.

3 Estimation of hand-finger angels

A test subject held up a hand at a position at roughly 1 m distance in front of the high-speed camera and moved fingers and hand freely. Hand motion in all directions was allowed as far as staying within the field angle of the camera.

Figure 1 shows examples of estimation. Estimated result plotted with wire frame model has been overdrawn on the real image of a hand. It is intuitively comprehensible that finger angles have possibly been estimated at a high precision when continuously moving hand and fingers. The system at this time operates faster than 150 fps. When the estimation results are transmitted to a humanoid robot hand, the dexterous hand can imitate your hand motions with high accuracy with the processing speed of 150 fps or over, as shown in Figure 2.

Our system can perform dexterous motions like those of the human beings by watching or mimicking. At our lab, he is now learning how to hold and handle a pen, and write characters with it by watching and mimicking the human behavior (Figure 3). In the near future, he will be able to create new dexterous motions to solve the problems in his environment by himself.

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