Analysis of fingertip-based features during pick and grasp manipulation

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***Abstract*— This study is an exploration of fingertip-based features that can distinguish pick and grasp actions. We measured time-series data of fingertip force and acceleration from seven subjects grasping cylindrical urethane. The analysis results of support vector machine learning show that the three-dimensional feature obtained from fingertip force and acceleration is effective for discriminating the two operations.**

I. Introduction

The functions of the fingertips are diverse and have gained attention across the medical and mechanical fields. To understand fingertip operations, Cutkosky presented a hand-centric classification scheme [1]. Some studies have attempted to measure and analyze fingertip operations [2, 3], but the tactile sensation is impaired during measurement [2], or only single-finger operations have been analyzed [3]. As such, there is no research that measures natural multi-finger operations and analyzes the fingertip force.

This study explores fingertip-based features that can distinguish two multi-finger operations: pick and grasp. We define a pick to be an operation that does not bring the palm into contact with the object and a grasp to be an operation that brings the palm into contact with the object. We define multi-dimensional features that can be calculated from time-series data of fingertip force and acceleration and select features that are effective for discriminating the two operations.

II. Methods

To analyze human finger operations without impairing the tactile sensation, we aim to fulfill the three conditions adopted by the research of Nakao et al. [3]. To satisfy the three conditions, we used HapLog (Tec Gihan Co., Ltd., JAPAN) (Fig. 1). We obtained four measurement values—pressure p_t for the thumb and p_i for the index finger as well as the magnitude of acceleration a_t for the thumb and a_i for the index finger. We assumed that the difference between the pick and grasp appeared in the interval T from the time when the finger touched the object to the time when the finger pressure increases. Moreover, we assumed that the two operations can be classified by the features based on fingertip force and acceleration. Then, we evaluated 10 feature values. (Table I)

III. Experiments and Results

Experiments were conducted to obtain time-series data of fingertip force and acceleration from seven subjects picking and grasping cylindrical urethane. When performing the pick and grasp, each subject was instructed to touch the side or bottom of the object. Figure 1 shows the time series of p_t and a_t for one pick operation and grasp operation of subject 3. For each subject, we attempted to distinguish the two operations using the proposed 10 features. We used a support vector machine to calculate the recognition rate. We evaluated the recognition performance of each feature and selected the top five features of the recognition rate. We created a combination of 34 features that included the features of both fingers and confirmed the recognition rate for all sets.

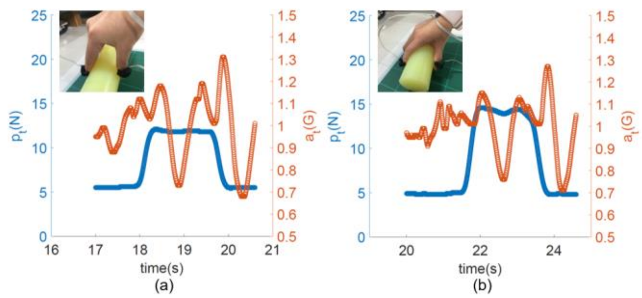

Figure 1. Measurement system and changes in pressure and magnitude of acceleration measured at the fingertip: (a) pick and (b) grasp.

Table I. 10 Feature values

Name	F1	F2	F3	F4	F5
Feature	$ave(p_t)$	$ave(a_t)$	$ave(p_i)$	$ave(a_i)$	$dif(a_t)$
Name	F6	F7	F8	F9	F10
Feature	$dif(a_i)$	$var(a_t)$	$var(a_i)$	F1/F3	F2/F4

The recognition rate is 78.2% for a three-dimensional feature consisting of F2, F3 and F9.

IV. Conclusion

This study analyzed features that can distinguish two operations. The recognition rate was 78.2% when using the three-dimensional feature; therefore, we conclude that pick and grasp operations were distinguishable in each subject.

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