

# Paper Review: Postural Hand Synergies for Tool Use

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## 1 Paper Summary

This paper presents a study on postural hand synergies with data collected from human subject trials. The experiment asks each of the 5 subjects to imagine picking up some commonly seen objects when the posture of the hand grasp is recorded in the form of joint angles. A PCA analysis is then carried out across the joint angles on the hands, and it is found that most of the variances are contained in the first two principle components. It is also found that different grasps vary on a continuum of spectrum instead of clustered into discrete groups.

## 2 What I Learned

I learned that given that many degree of freedom a human hand has, the actual effective dimension is much lower due to correlation between different joint angles. It is also surprising that the study found no evidence of clustering occurs on the grasp of different objects. Intuitively, we make discrete grasp configuration for different object, but the study somehow shows that the posture varies on a continuous spectrum.

## 3 Opinions

### 3.1 Up Votes

- I like how this paper visualizes raw data in multiple ways. The correlation plot immediately reveals relations between different joints. It also verifies the fact that we don't have individual control over some of the finger joints.
- I also love the ray-cast rendering of the hand posture in the PCA analysis. It gives direct visual intuition on what are the dominant modes of hand postures.

### 3.2 Down Votes

Given most if not all of the joint angles are biologically constrained, it does not seem like the correlation among them is linear. PCA can only account for linear coordinate transformations, and therefore, has a limited capability of explaining the underlying dynamics between the fingers.

## 4 Evaluations

The goal of this paper is to study the postural hand synergies to

1. provide insights into how human plans for hand grasp configurations;
2. explore correlations between the different degree of freedom of a human hand;
3. find out whether hand postures can be clustered or classified for different object being grasped.

The overall analysis on the postural hand synergies is quite significant as it not only provides direct insights for planning robotic grasp configurations, but also hints that the control of grasp posture may be regulated independently of contact forces.

The overall quality of this paper is solid. The data is collected rigorously with specialized sensor equipment while the diversity of the data is ensured through having multiple subject, multiple trials, and multiple object grasps. The PCA analysis is definitely one of the simplest and most powerful techniques for studying feature correlations. The paper has also shown that the effective information of the human grasp can be compressed down to just 2 or 6 dimensions depending on the fineness of control. However, one slight shortcoming of this approach is the linear assumption that comes with PCA, which is almost certainly not true for the model of human finger control.

## 5 Questions

1. It seems like the orientation of the hand can be synergized with the overall posture of the hand, why not consider at least the wrist angle of the posture? It seems like the rendered hand postures all have the same top-grasp orientation.
2. How is the discrimination function computed and how is the confusion matrix (of posture-to-object) generated?