Shaking eases Object Category Acquisition

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Abstract
Acquisition of object category structure shared within the human society is a prerequisite for lexicon acquisition and is considered an important research issue of language acquisition. However, due to the difficulty of formalizing the task, endless discussion have been made on how the infants acquire such categories. In this study, we give some preliminary results from a robot experiment which shows that shaking behaviors, frequently observed from the early stage of infancy, can play an important role in acquiring such categories. By shaking objects with several contact conditions and utilizing the amplitude spectrum of the sound from the objects, the agent can acquire object categories independent of size, shape, and contact conditions.

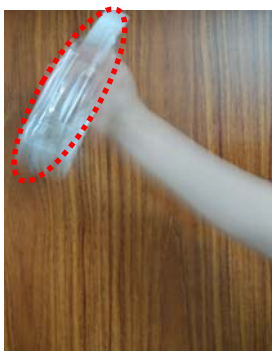
Problem Statement

How can humanoid robots acquire humanlike object categories which can be utilized for natural communication with the users?

Hypothesis

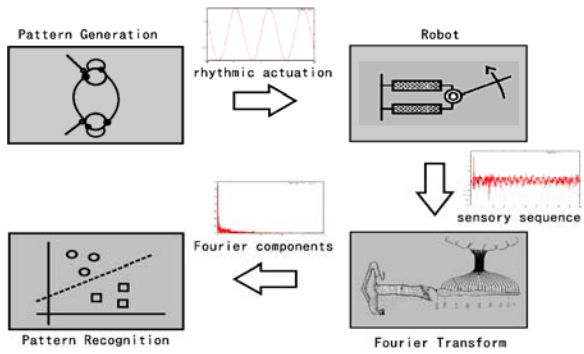
Infants are known to acquire multi-modal object categories by active touch. We assume that their explorative behaviors play an essential role.

Categorization by Shaking



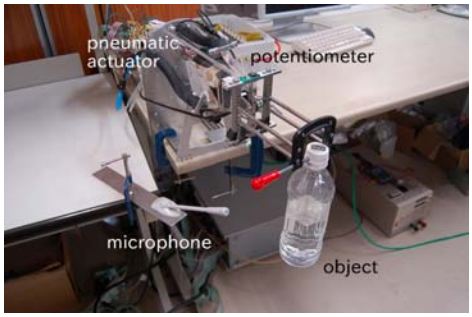
We focus on shaking, a behavior frequently observed in infancy. Shaking enables the agent to obtain information of the whole body of the object, which eases the acquisition of object categories independent of size, shape, and contact condition.

Model of information processing



The agent shakes the object with rhythmic actuation to obtain stable sensory data by virtue of entrainment. The amplitude spectrum of the auditory data is utilized as a feature vector for categorization. The objects are shook with several contact condition to obtain categories independent of size and shape.

Experiment setup



A robot arm with McKibben pneumatic actuators was utilized to show the ability of obtaining stable sensory data under poor control. Auditory data was obtained from a microphone.

Task design

(a) Rigid objects

(b) Paper materials

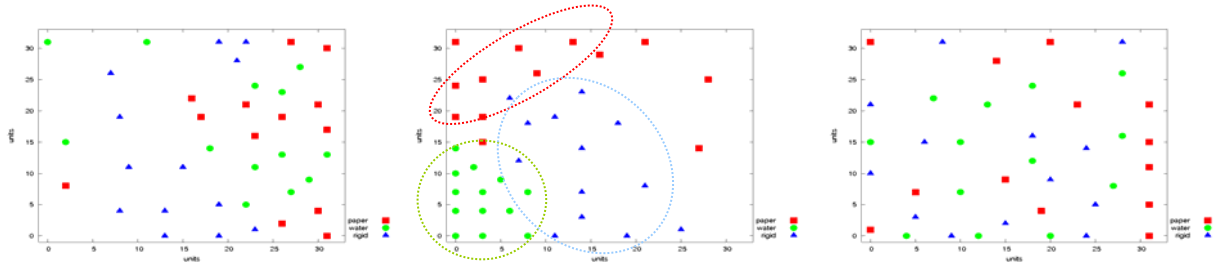
(c) PET bottle with water

The task was to acquire three object categories, namely rigid objects, paper materials, and PET bottle with water. The object in the left side was shook with several contact condition to learn the category. Then, the other objects was utilized to test the success rate of categorization.

Results

# of contact condition in teaching	rigid	paper	PET bottle
1	70%	10%	70%
2	100%	100%	60%
3	100%	100%	80%

The success rate of categorization for different # of contact conditions in the teaching phase is given in the table above. By shaking objects with several contact condition, the robot was able to obtain object categories independent of size, shape, and contact condition.



(a) Raw data (b) Amplitude spectrum (c) Phase spectrum

Results of SOM analysis are also given. We observe that Fourier transform extracts information of object category independent of size, shape, and contact condition as amplitude spectrums.

Conclusion and future work

The results of the experiment show that an agent with poor control ability can acquire object categories independent of size, shape, and contact condition by shaking objects with several contact conditions and utilizing the amplitude spectrum of audio sensory data. The difficulties of categorization faced in the current experiment are similar to those that infants face, and thus, indicates the possible role of infants' shaking behavior in object category acquisition. As for future work, we plan to modify the robot arm by adding more degree of freedom and an artificial skin to the hand to investigate the role of tactile sensory data in categorization. We also plan to run observation experiments with infants to learn the policy of changing the shaking behavior according to the objects.