Soft Morphological Processing of Tactile Stimuli for Autonomous Category Formation

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Motivation & Hypothesis

Objects → Morphological Processing → Autonomous Category Formation

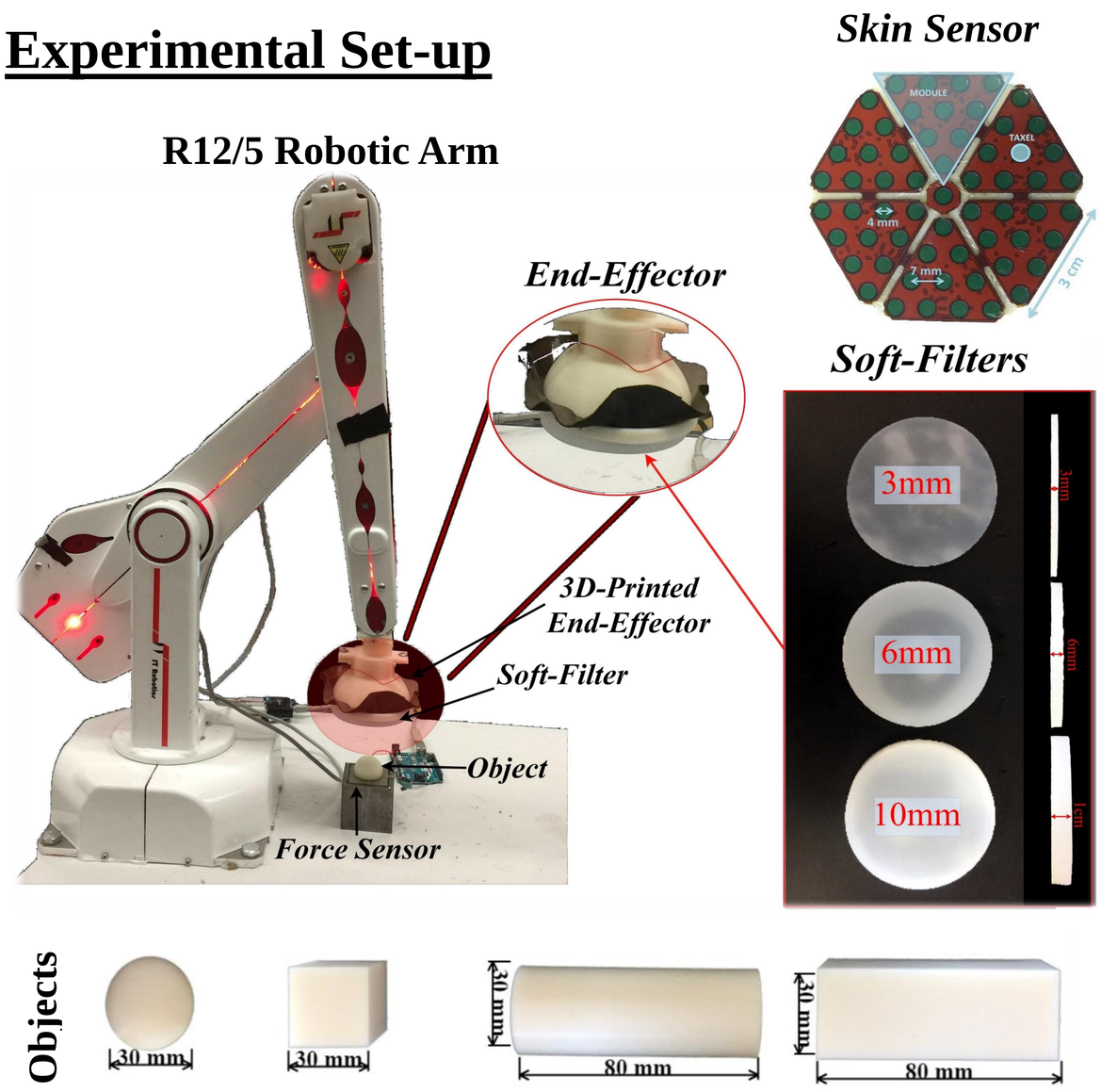
- Morphology affects tactile sensor response, pre-processing stimuli before inference can be done. It is fundamental we understand how the influence can change the robot perception of its surroundings.
- Through morphology, wish to influence the sensor response to retrieve tactile information which simplifies a predetermined, tactile, object discrimination task.

Discrimination Tasks

- 4 3D-printed objects with two varying properties.
- 7 possible discrimination tasks, from the combinations of different objects.
- Task 5 and 6 based on edge detection and elongation respectively.

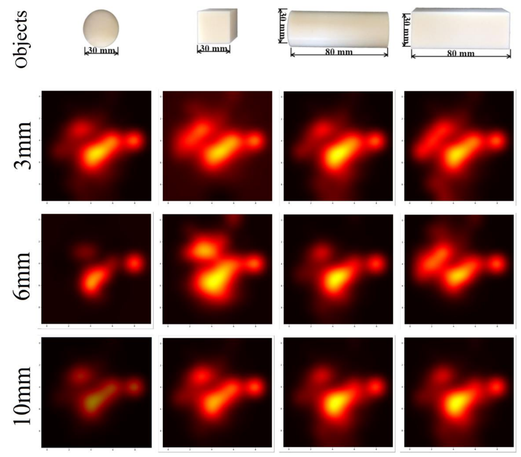
Task Table	Cluster 1	Cluster 2
Task 1	○	□ ⬭ ▭
Task 2	□	○ ⬭ ▭
Task 3	⬭	○ □ ▭
Task 4	▭	⬭ ○ □
Task 5	○ ⬭	▭ □
Task 6	▭ ⬭	○ □
Task 7	○ ▭	⬭ □

Experimental Set-up



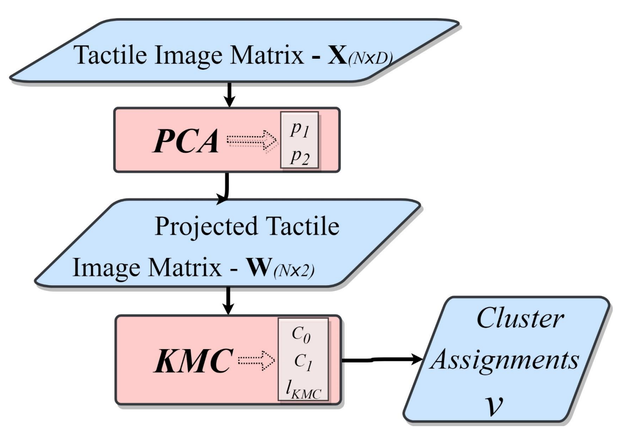
Dimensionality Reduction & Clustering

Raw Tactile Images



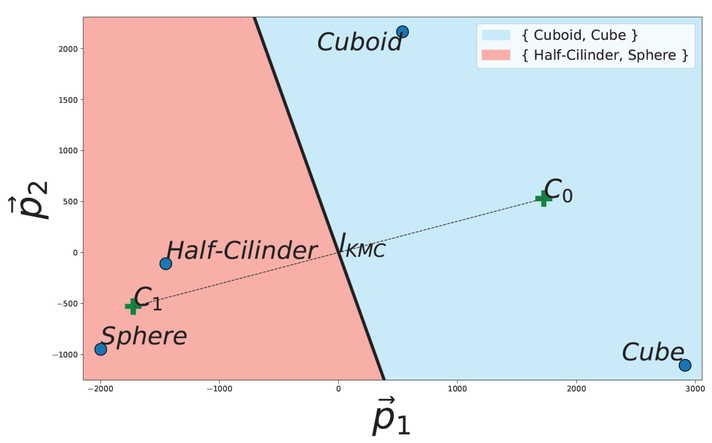
- Raw tactile images retrieved when probing each object in turn vertically.
- Hotter areas correspond to tactile taxels detecting a higher pressure.

Dimensionality Reduction & Clustering



- From the Raw tactile images, the tactile matrix X is formed.
- PCA re-encodes objects in 2 dimensions.
- K-Means Clustering is used to divide the objects into 2 groups.

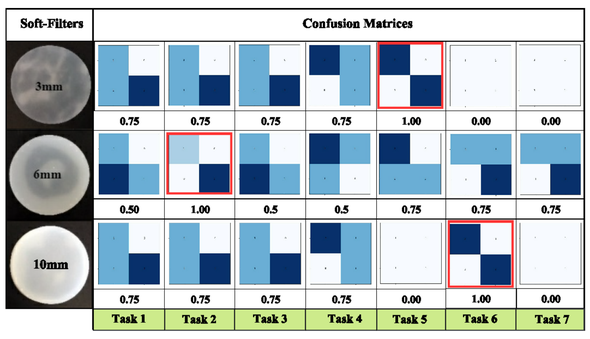
Clusters in PCA subspace



- Projected, 2-dimensional encoding of each probed object and the corresponding cluster guess.

Results

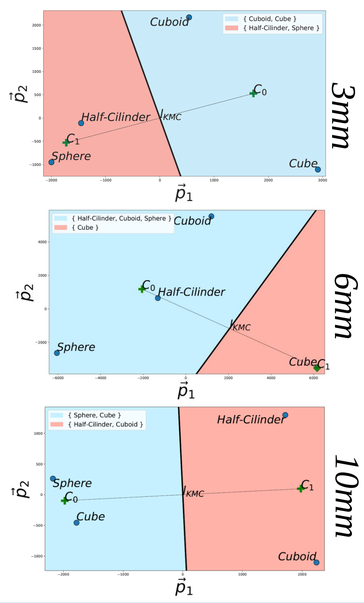
Task Optimization



- Depending on the used soft filter (morphology), the Autonomous Category Formation process forms qualitatively different clusters (optimized for different tasks).

Autonomous Category Formation Variations

- The projected tactile change position according to the soft filter.
- 3 mm filter draws close in space objects with sharp edges (edge detection).
- 6mm soft filter induces clusters based on object elongation.



Spatial Resolution Influence

- Performing the experiments over different number of taxels shows the need of a high spatial resolution tactile sensor.

References

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- Shimojo, M. (1997). Mechanical filtering effect of elastic cover for tactile sensor. IEEE Transactions on Robotics and Automation, 13(1), 128-132.

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EPSRC Engineering and Physical Sciences Research Council