## Tactile and Visual Object Exploration



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## Learning by Exploration

A robot needs to be aware of the properties of objects to efficiently perform tasks with them. Currently, most robots are provided with this object information by a programmer. However, autonomous robots working in service industries and domestic settings will need to perform tasks with novel objects. Hence, relying on predefined object knowledge will not be an option.

Instead, robots will have to learn about objects by exploring their properties through physical interactions, such as pushing, stroking, and lifting. As random exploration is an inefficient approach, we develop methods for efficiently gathering information.



The fundamental knowledge learned about objects and primitive actions will later on form the basis for learning complex behaviors and predicting the properties of novel objects. By discovering accurate representations of objects, the robot will be able to plan and execute manipulations more precisely.

## Learning Tactile Sensing using Vision

The textures of object surfaces can be observed both by visual inspection and by sliding a dynamic tactile sensor across the surface. The robot can combine these types of sensor readings to determine which components of the data contain information pertaining to the texture. In particular, the robot can find the components that are maximally correlated between the two sensor modalities. Given the relevant data components, the robot can create a compact representation of object textures, which allows it to distinguish between surfaces more accurately.

## Active Learning of Object Properties

Learning about objects is not a passive perceptual process: its embodiment allows a robot to discover object properties by actively changing its point of view and by interacting with objects. At the same time, the robot observes the effect of its actions and learns how it can bring about desired effects.



To learn efficiently, the robot should select the exploratory actions that yields the highest information gain out of all possible actions. By efficiently exploring its environment, a robot develops object knowledge grounded in its sensorimotor experience.

The developed object knowledge can be used to manipulate previously unknown objects in unstructured environments. For example, the robot could teach itself to perform tasks in domestic environments.





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