

Affordances and Robots

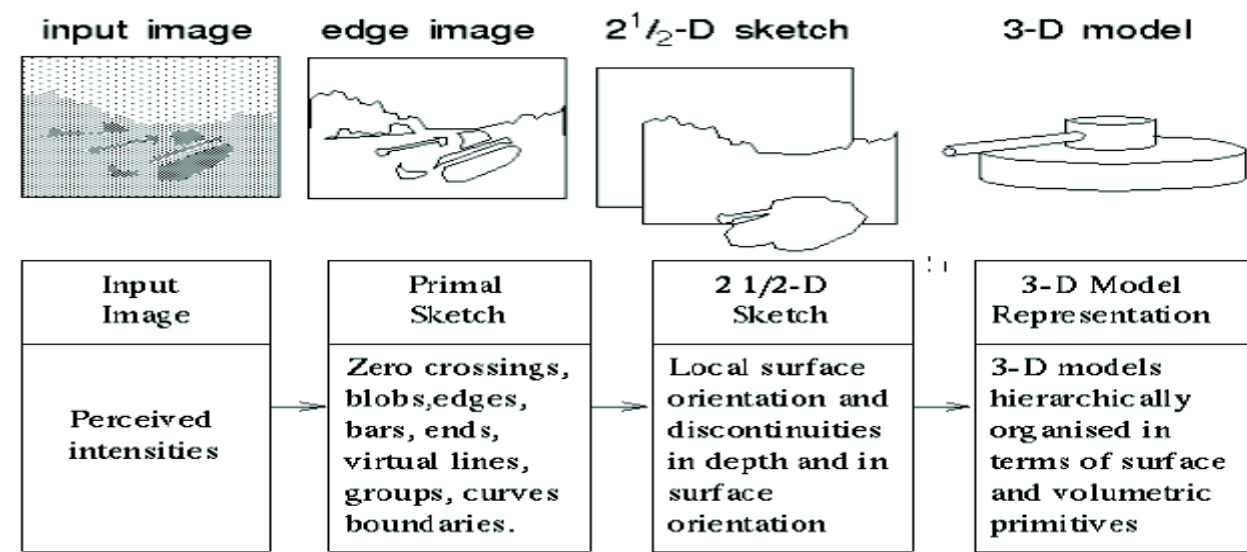
(The prescriptive way)

Contents

- ▶ Affordances from Ecological Psychology
- ▶ Affordances in Robotics

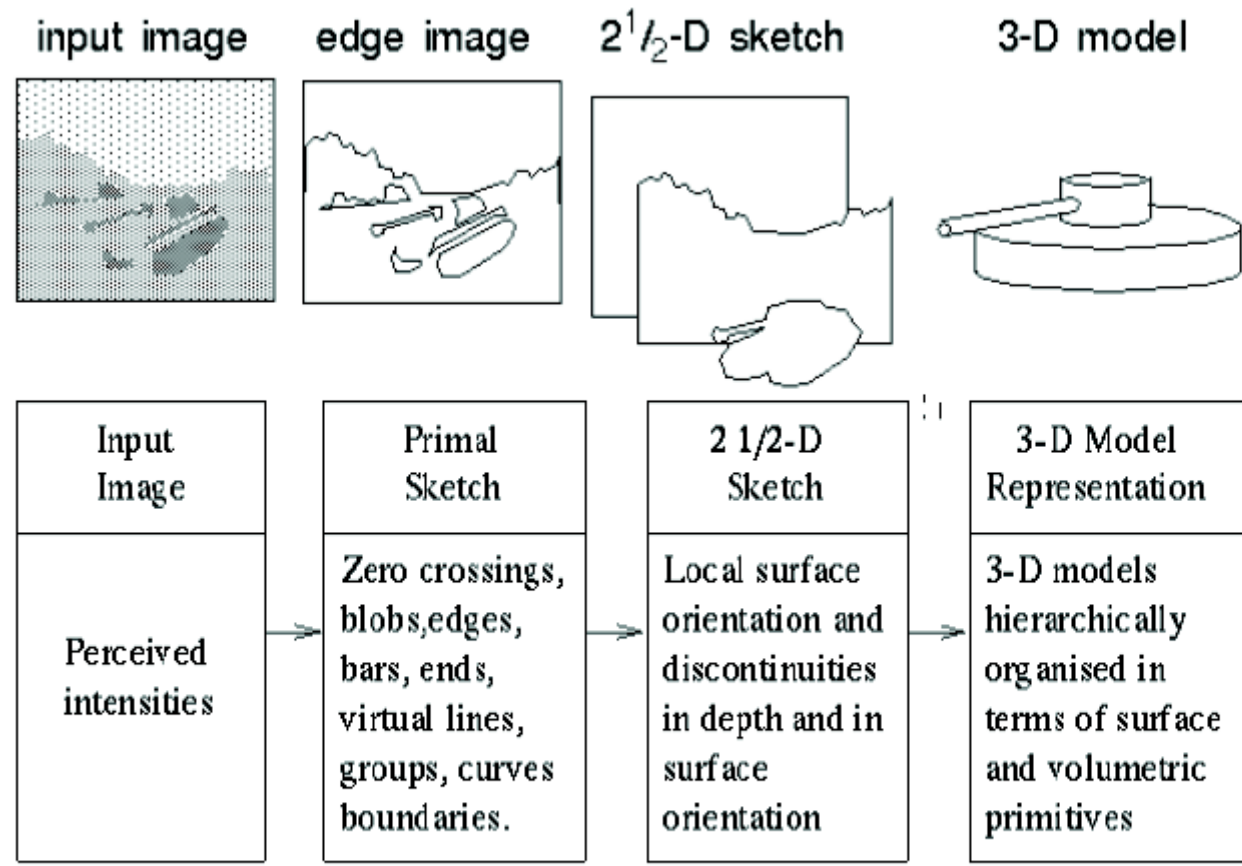
Traditional approach to visual perception in 70's

- ▶ Starting point of perception is the static pattern of light intensity on the retina
- ▶ Perception is indirect and mediated by other processes
- ▶ The outcome of the perception is the formation of an internal representation of objects in the environment



Stages of Visual Representation, David Marr, 1970s

Traditional approach to visual perception in 70's



Stages of Visual Representation, David Marr, 1970s

Traditional approach to visual perception in 70's

- ▶ In order to grasp a mug
 - ▶ Reconstruct the 3D model of the object from the retinal image
 - ▶ Recognize the object as a mug
 - ▶ Infer that the object is graspable thanks to the internal representations

A radical approach

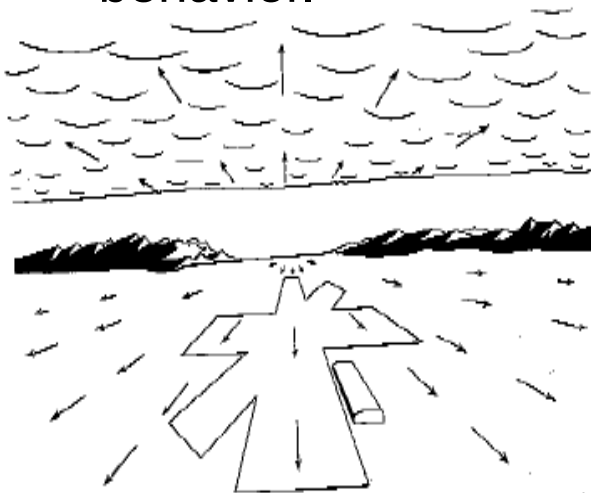
Each thing says what it is ... a fruit says “Eat me”; water says “Drink me”; thunder says “Fear me”; and woman says “Love me”. (Koffka, 1935)

► Mug says “grasp me”

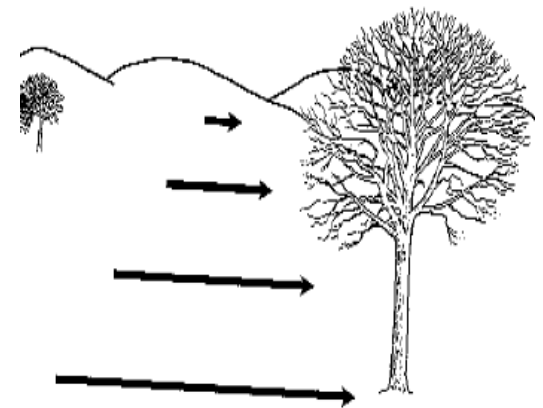
Optical variables/invariants



- ▶ **James Gibson**, During World War II, U.S. Army Air Force's Aviation Psychology Program.
- ▶ Visual aptitude tests for screening out pilot applicants
 - ▶ Tests in static images, e.g. depth perception
 - ▶ Perception of properties related to flying and landing
- ▶ Optical variables in the perceptual data that are meaningful.
- ▶ The optical center of expansion of the pilot's visual field. This center of expansion, indicates the direction of the glide and helping him to adjust landing behavior.

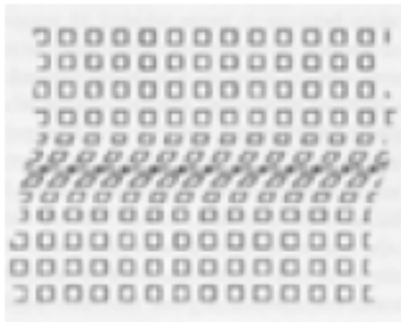


Transformational invariants

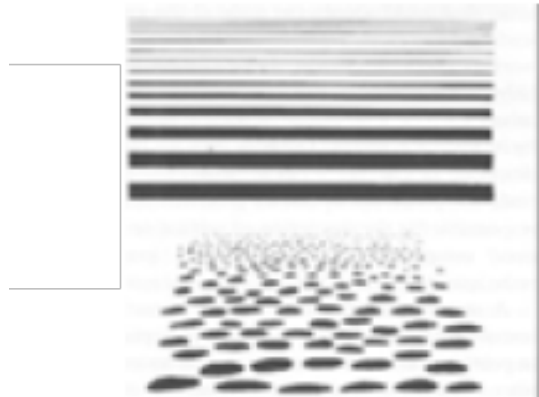


Optical variables/invariants

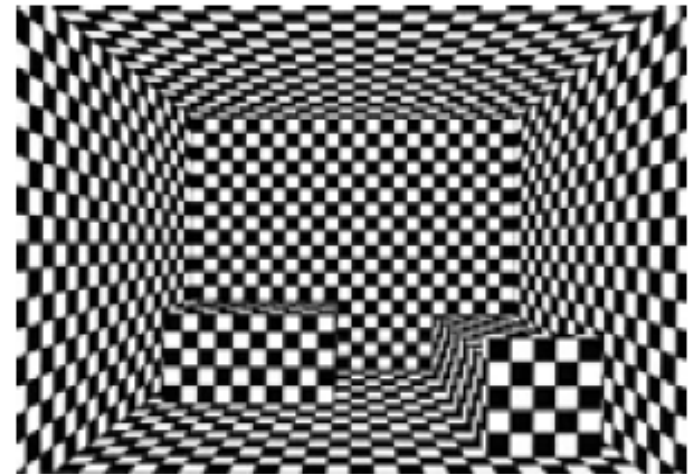
- ▶ Structured light carries information
 - ▶ e.g. light structured by texture



about shape



information about distance



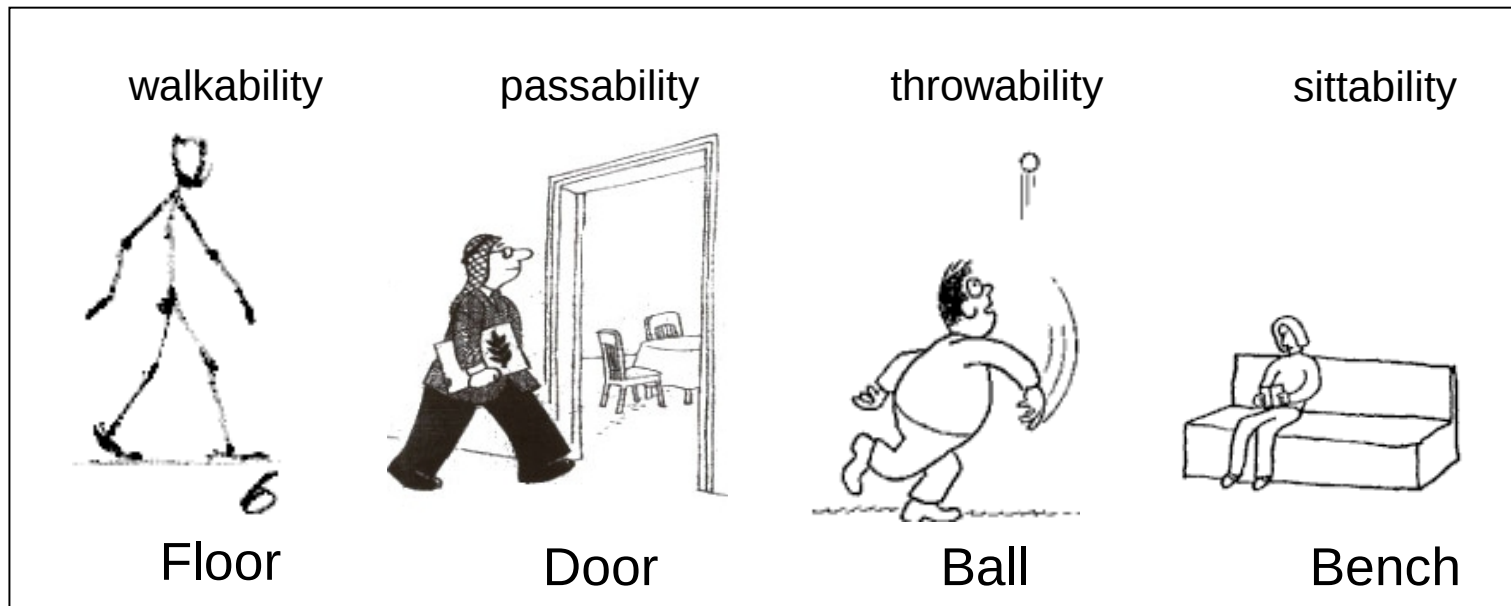
and general layout of objects in the environment

What is an affordance?



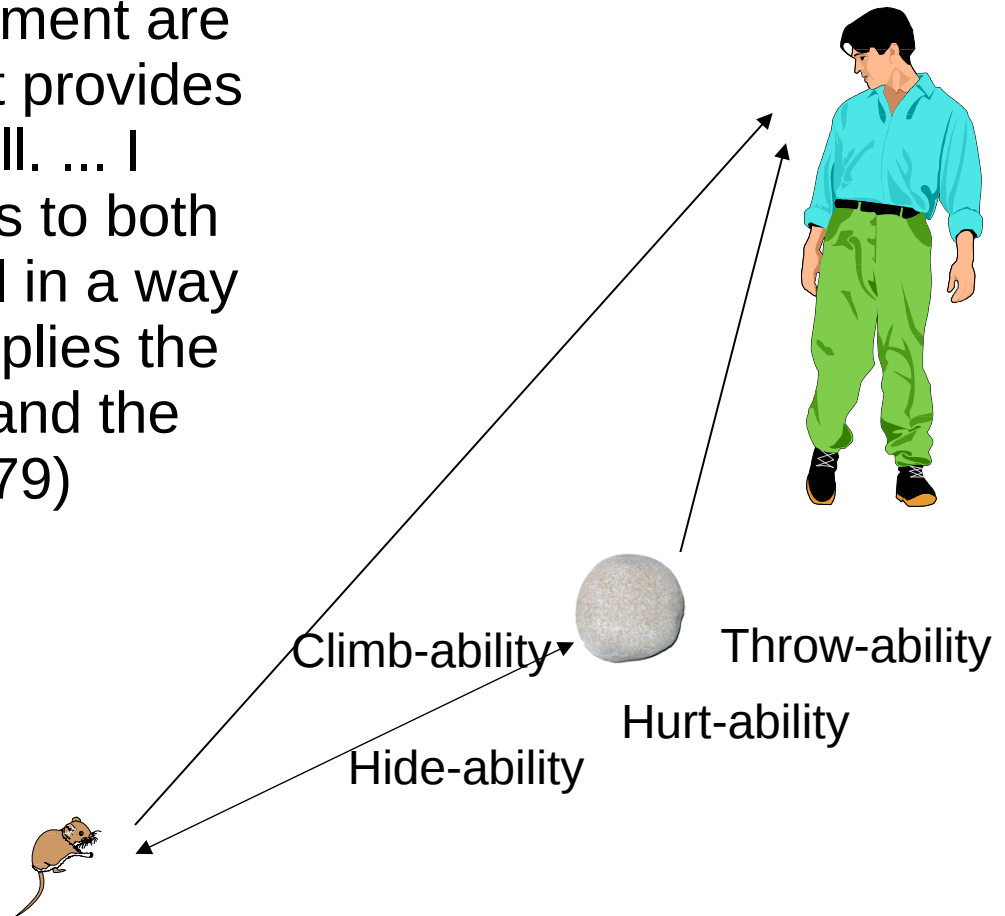
J.J. Gibson (1904–1979)

- ▶ “Affordances are action possibilities that the environment offers to an animal interacting with it”
- ▶ The organisms do not need to recognize the objects in order to act on them.
 - ▶ Direct perception.

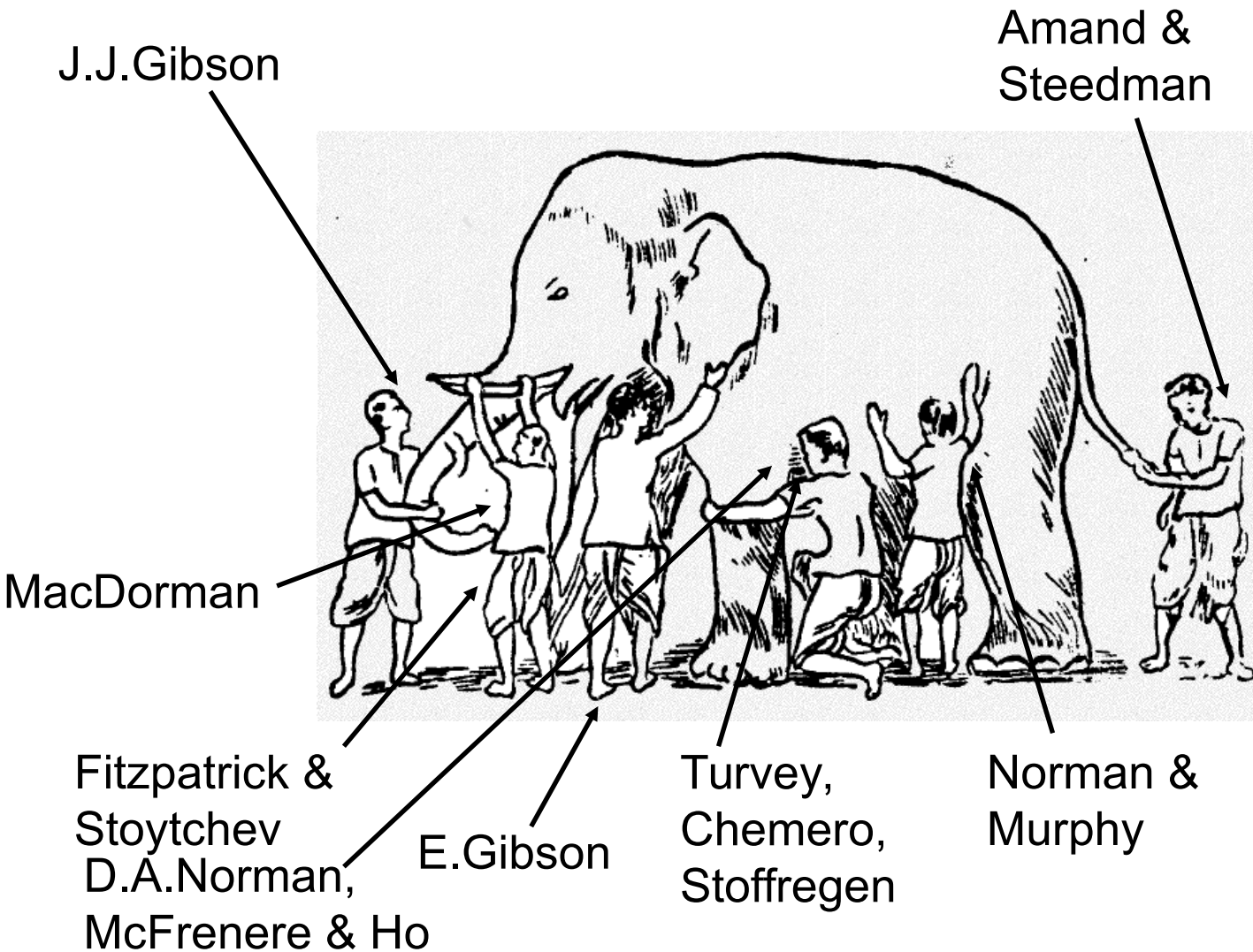


Affordances are defined in animal-environment system

“The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. ... I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment.” (J. J. Gibson, 1979)



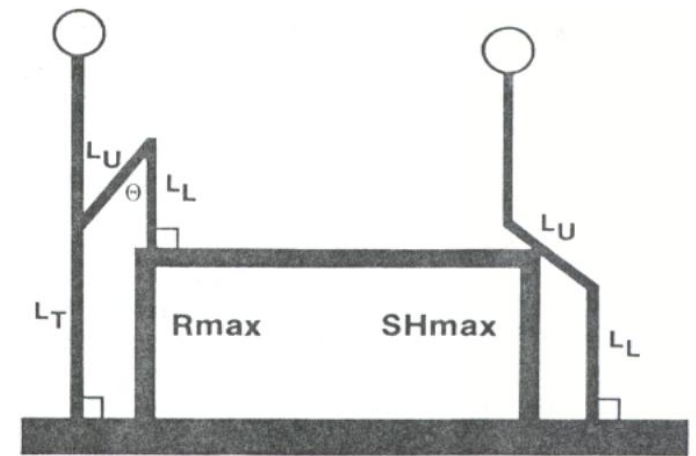
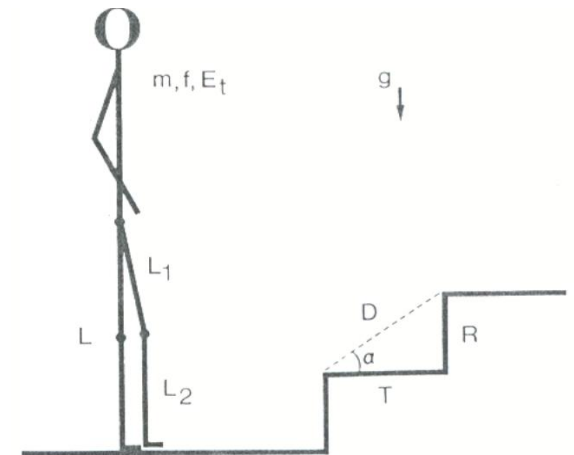
Affordances as an elephant



- ▶ expressed in verbose descriptions.
- ▶ evolved over time
- ▶ in contrast to the background of contemporary ideas.
- ▶ were often blended with his work on visual perception

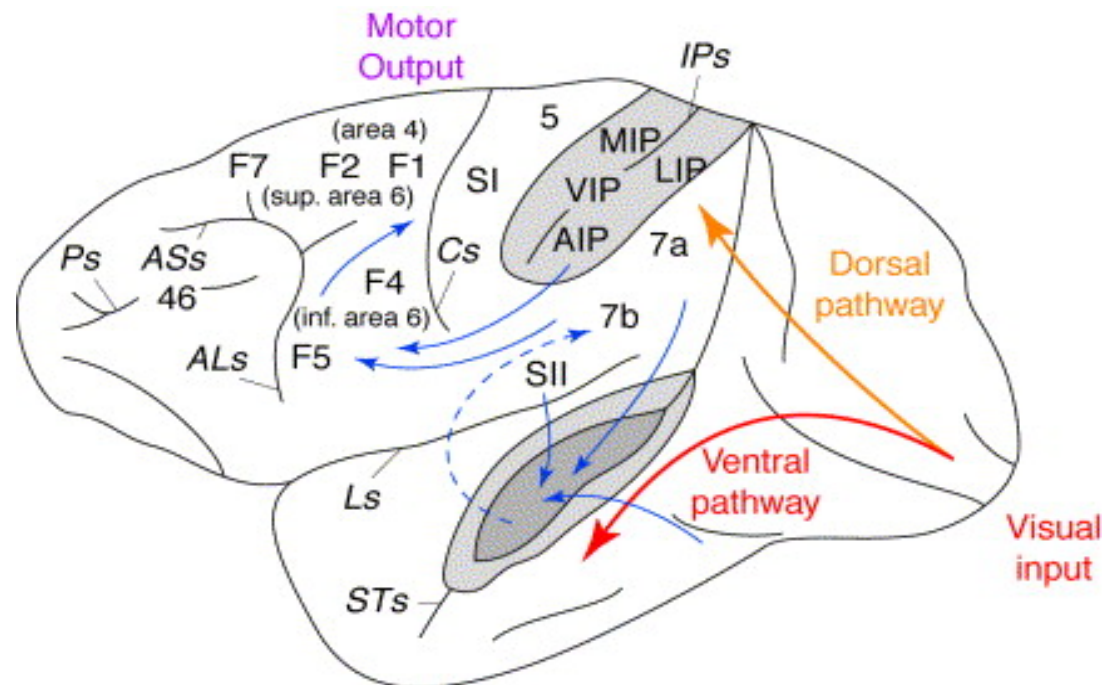
Experiments in Ecological Psychology

- ▶ Affordance ratios
- ▶ Warren's (1984) stair-climbing experiments
 - ▶ Claims that affordances are perceived in terms of intrinsic or body-scaled metrics
 - ▶ Identified critical points and optimal points which are perceivable, constant dimensionless ratios, called π
- ▶ Intrinsic nature of affordance perception: eyeheight
 - ▶ Walking through aperture (Warren and Whang; 1987)
 - ▶ Sitting and climbing to various surfaces (Mark; 1987)



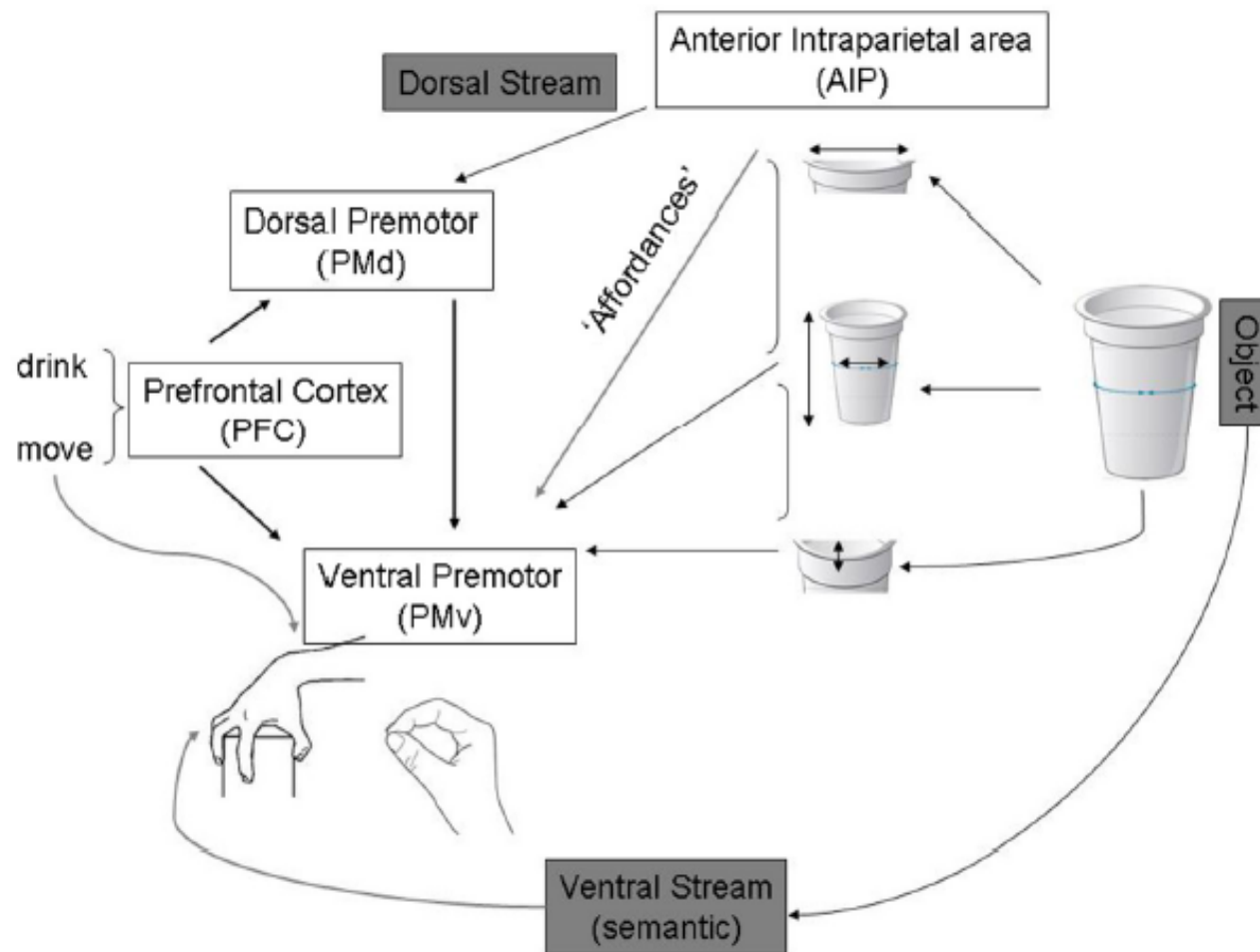
Evidence from Neurophysiology

- ▶ Dorsal system for information pickup -- AFFORDANCE
- ▶ Ventral system for high-level tasks like identification.
- ▶ The patient without a ventral system is able to successfully avoid from the obstacles or insert mails into slots in correct orientation.
- ▶ However the same patient does not recognize those objects.



Evidence from Neurophysiology

- ▶ A computational model

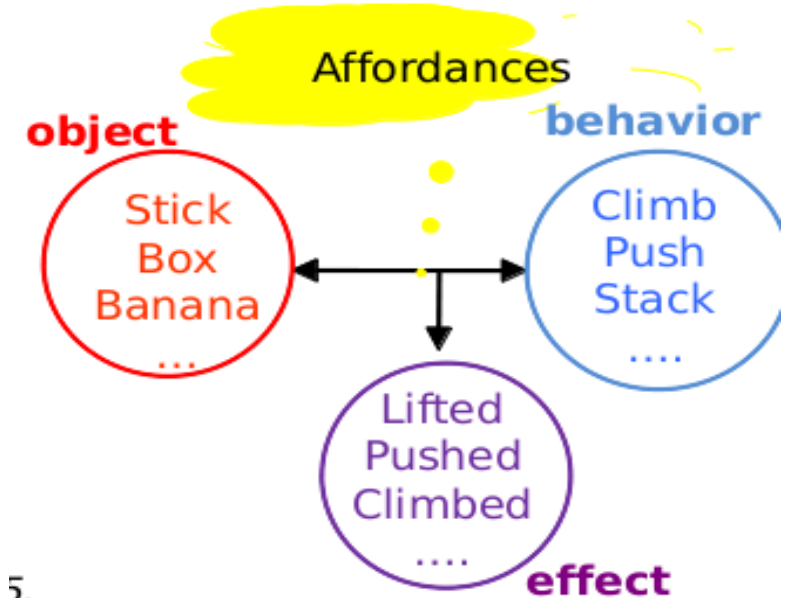


Formalize affordances for robot control



W. Kohler. *The mentality of Apes*. Routledge, 1925.

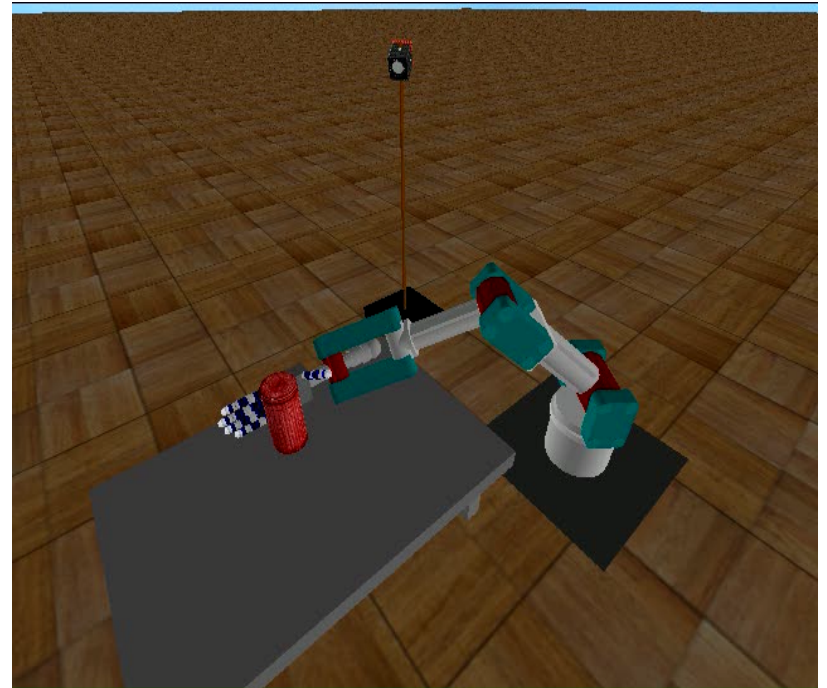
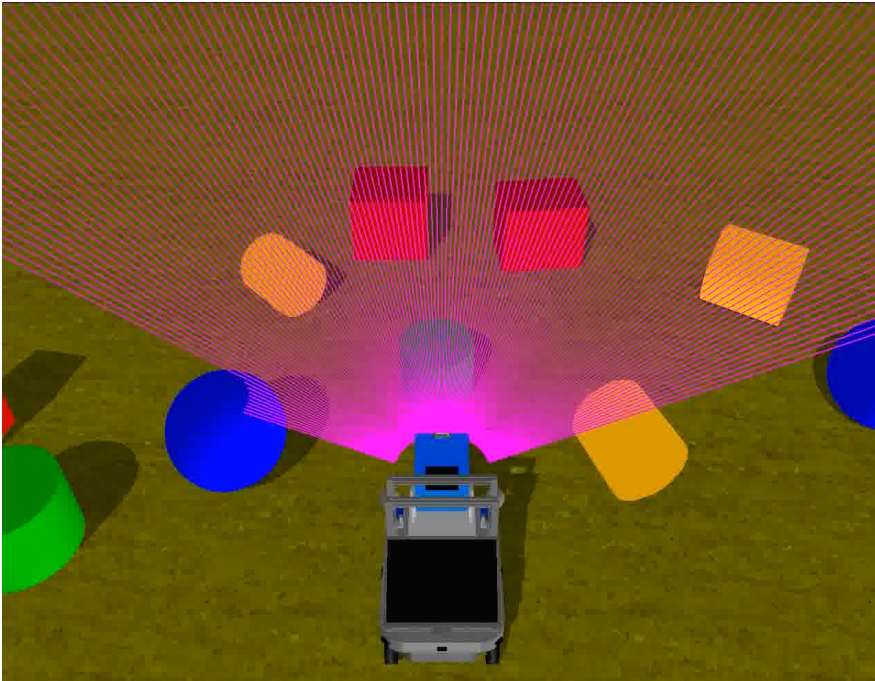
Learning (effect, (object, behavior)) relations



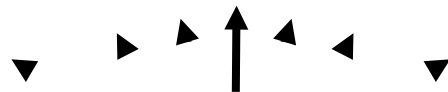
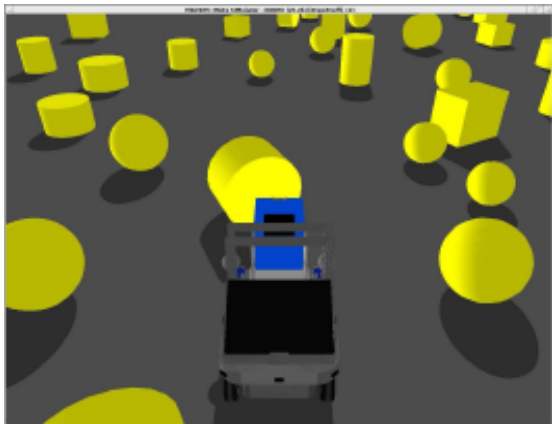
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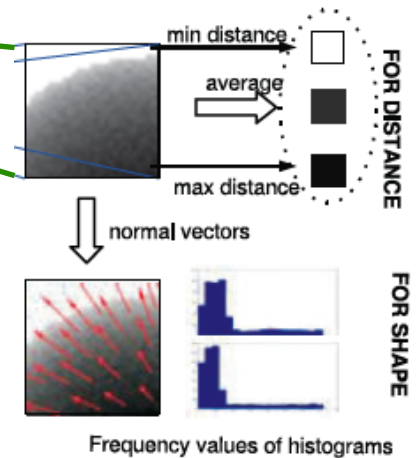
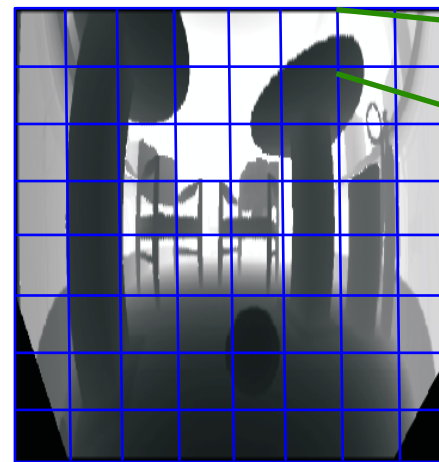
Learning of navigation and manipulation affordances in robots



Traversability affordances



Behaviors: Go-forward, go-left, go-right



No object detection!
(Robot's percept is combination of shape/ distance features from grids)

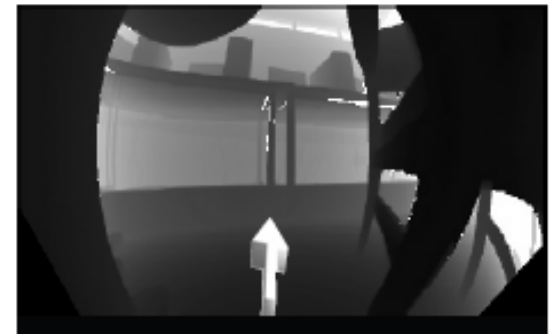
Affordances are perceived directly



(a)



(b)



(c)



(d)



(e)

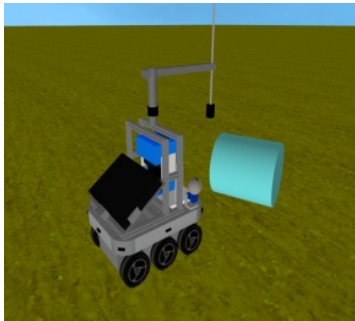


(f)

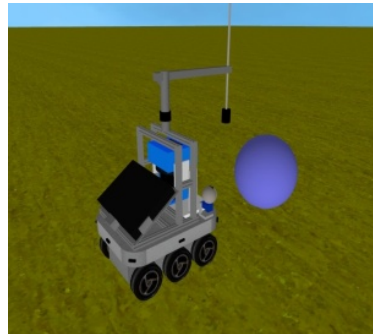
- ▶ The robot directly perceives traversability affordances without perceiving chairs, tables or walls in the environment.

Predict affordances of novel objects

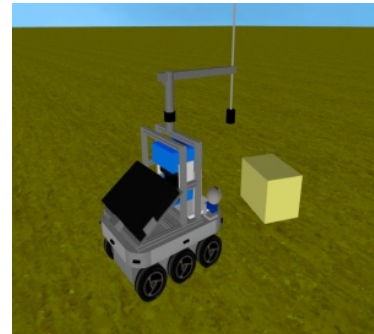
Learn



Test with unknown objects



%83.8



%100

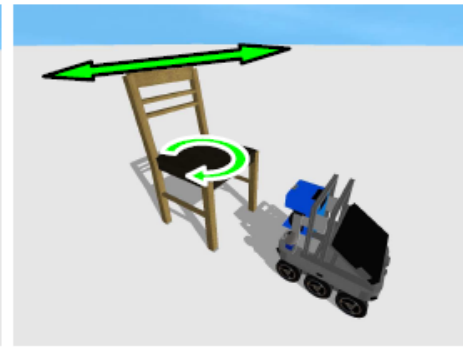
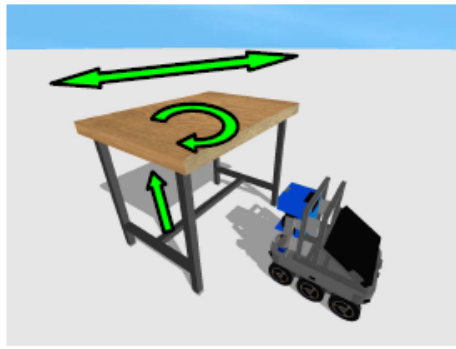
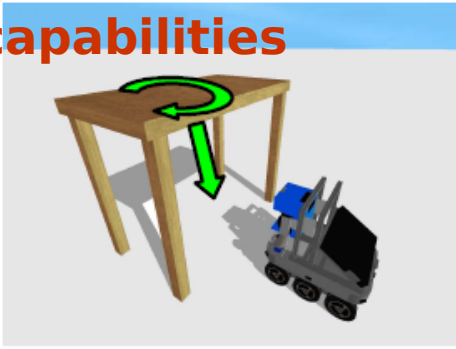


%100

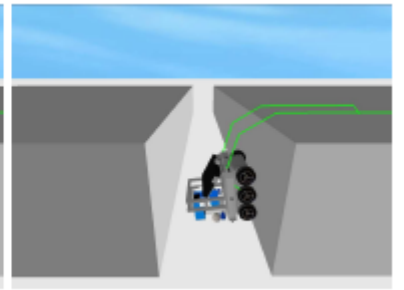
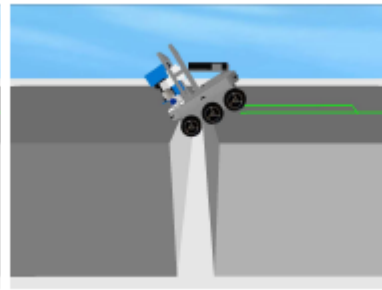
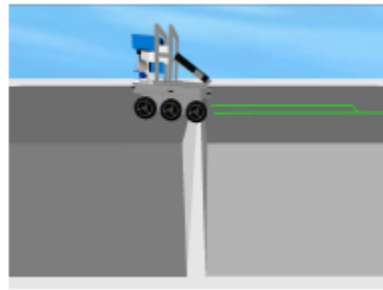
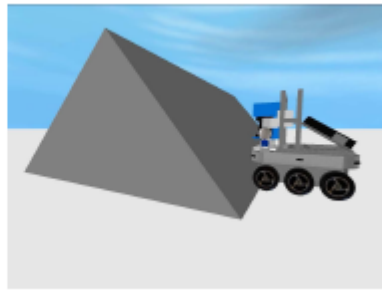
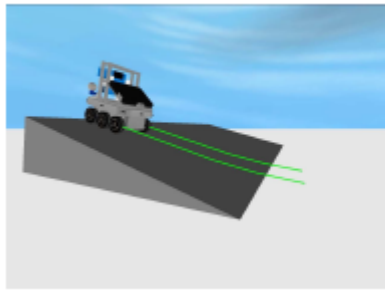
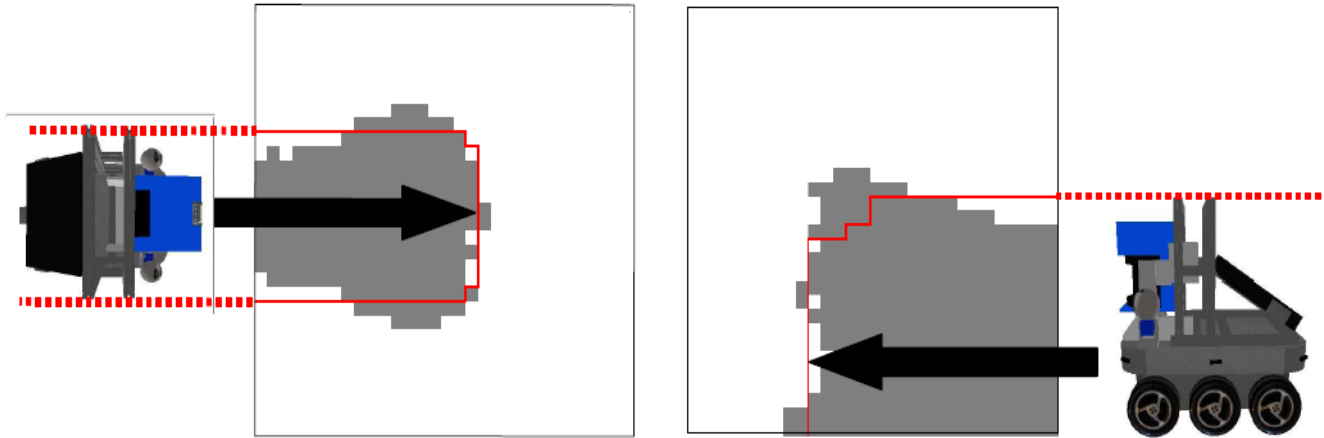
Learning and detecting affordances based on invariant properties enables generalization.

Predict affordances of novel objects

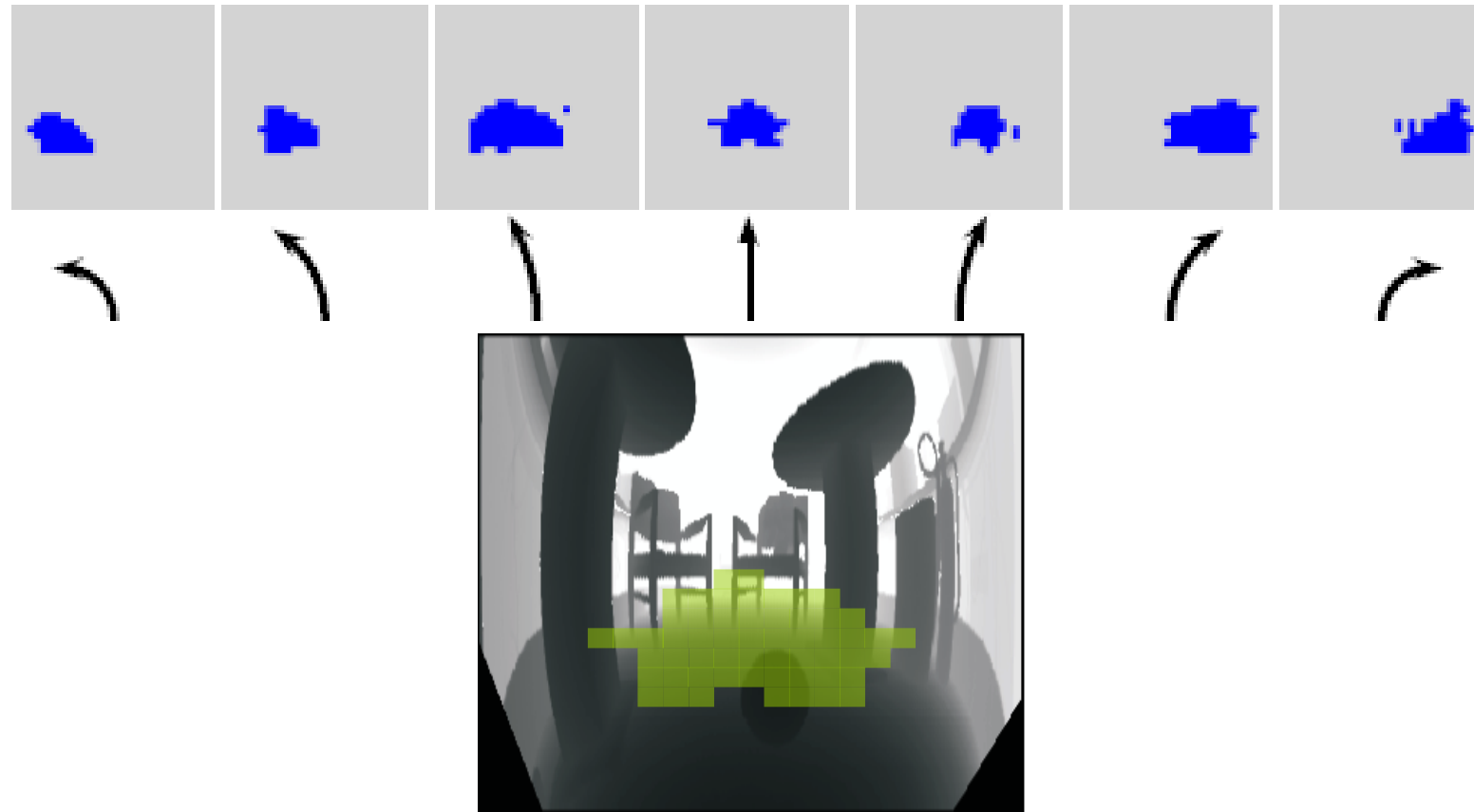
**Generalization
capabilities**



Robot automatically learned body-size related affordances

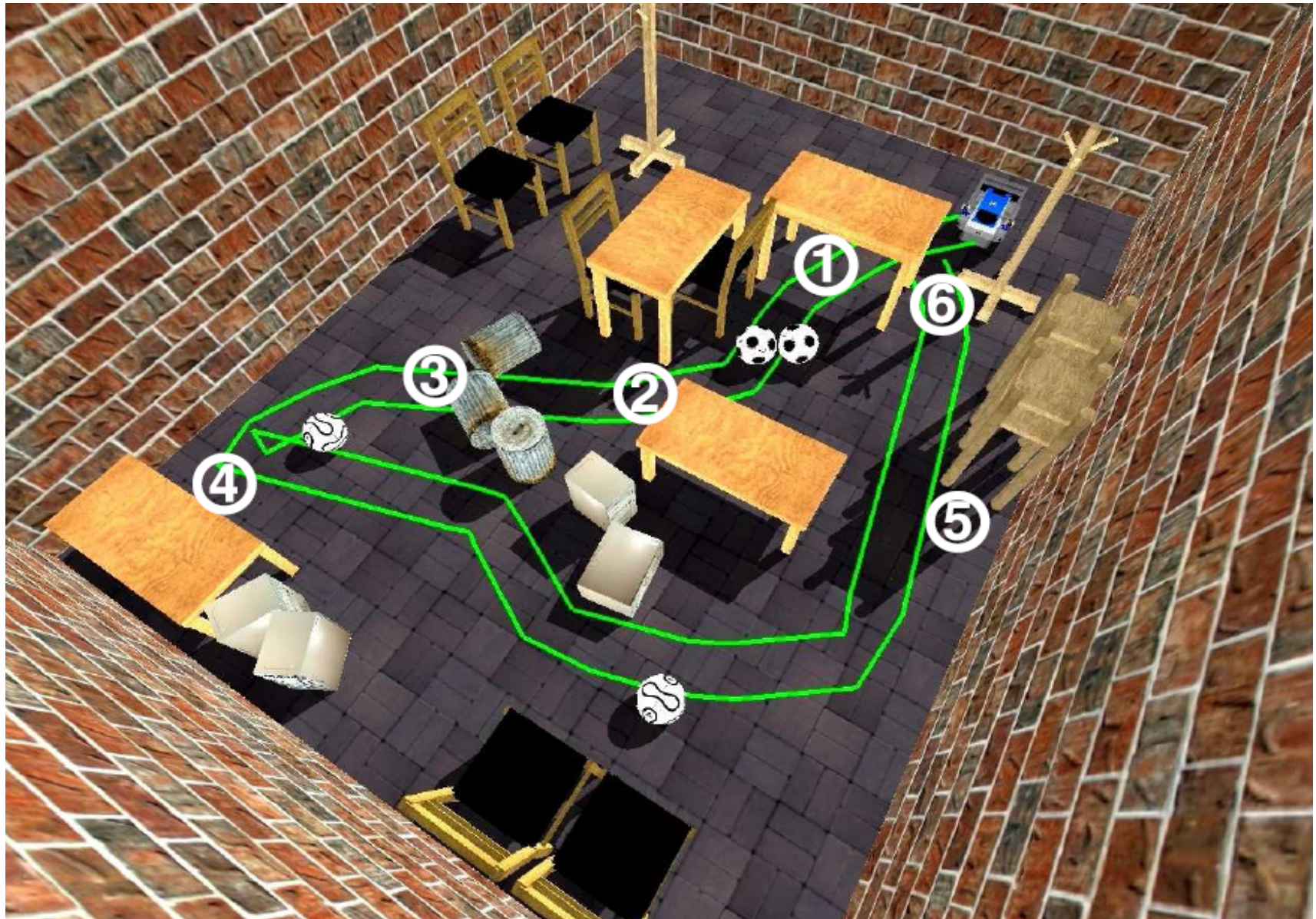


Affordances provide perceptual economy

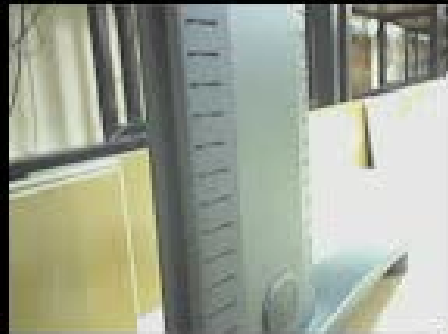


The robot discovers that only part of the image is sufficient to perceive traversability affordances.

Robot execution in the simulator



The table is '*drive-under-able*'
Aperture between legs is '*pass-through-able*'



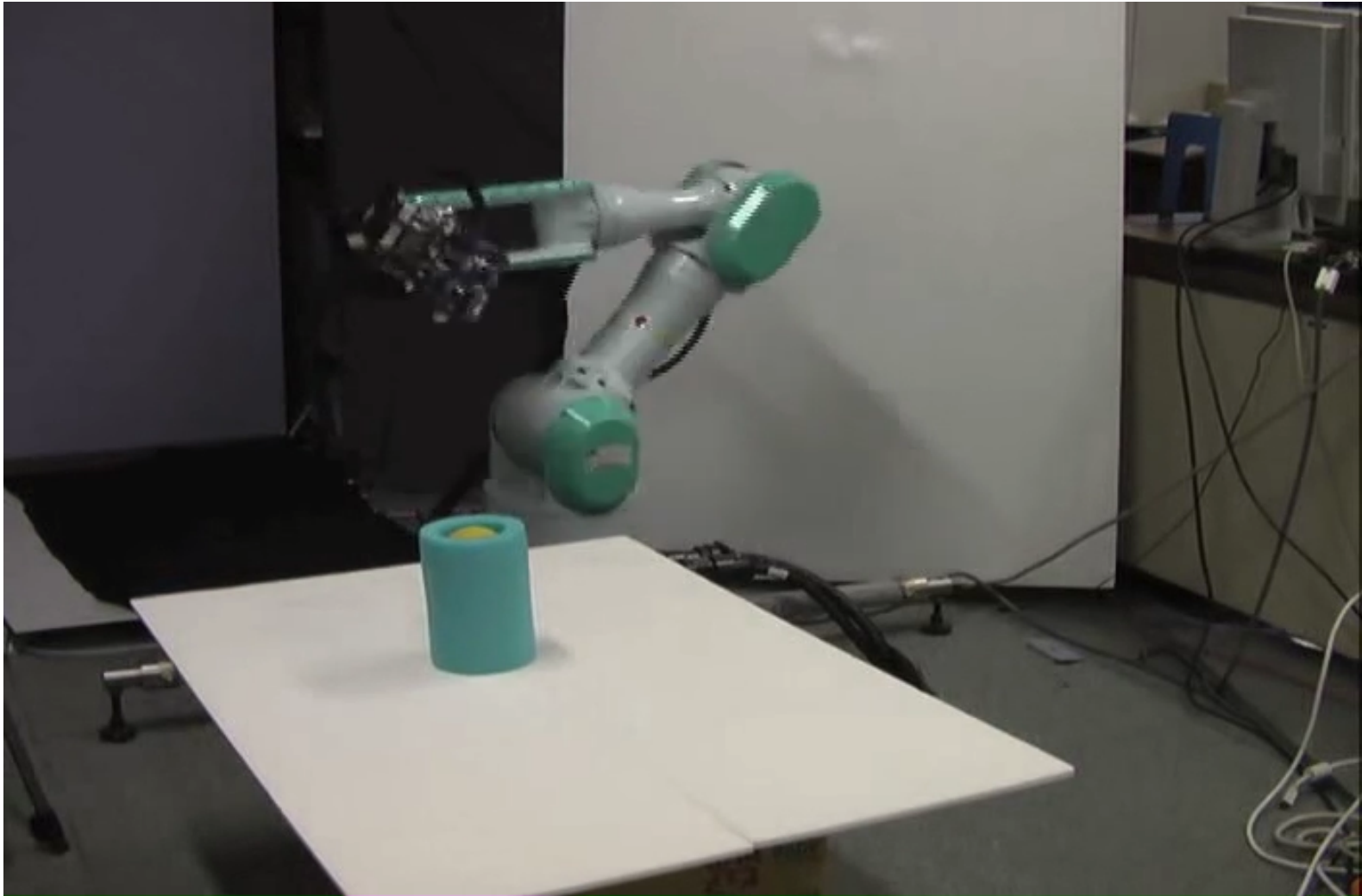
Key characteristics

- ▶ Affordances are perceived directly (a.k.a. direct perception) not through mental inference.
 - ▶ Affordances provide perceptual economy.
 - ▶ Affordances are relative.
 - ▶ Affordances are general
-
- ▶ They are simply consequences of learning from the interactions of the robot with the environment using our formalism.

Planning with affordances



Chain affordance predictions to reach goals



On working inter-disciplinary

Gibsonian Affordances for Roboticists

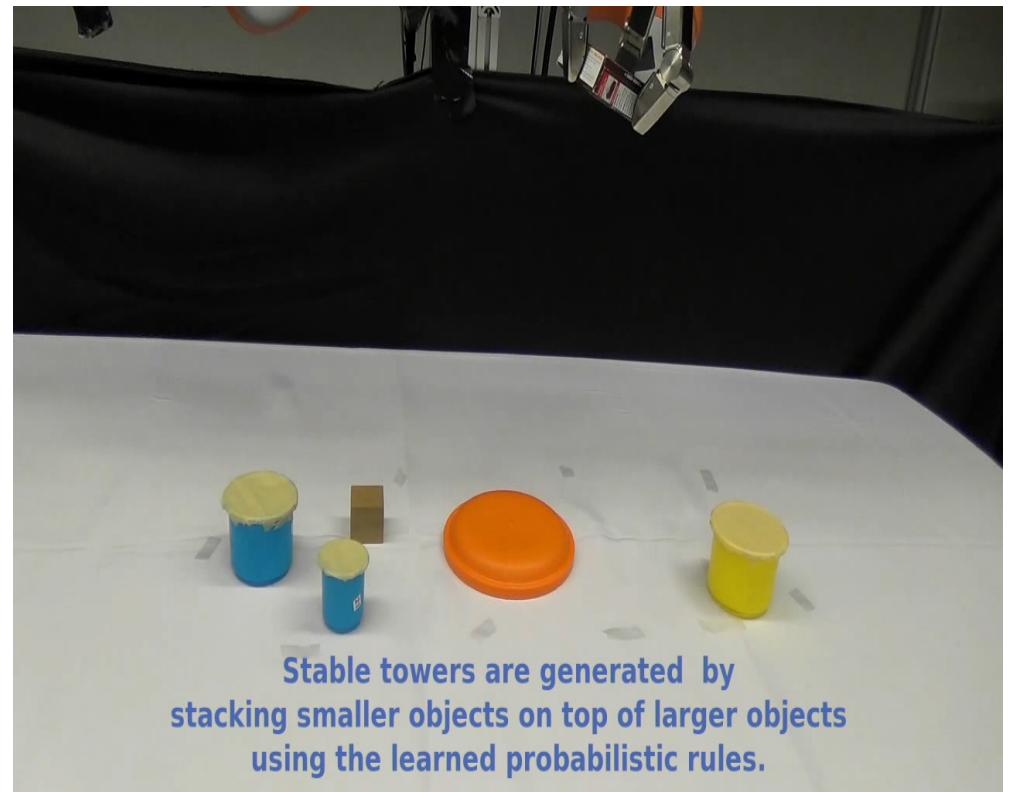
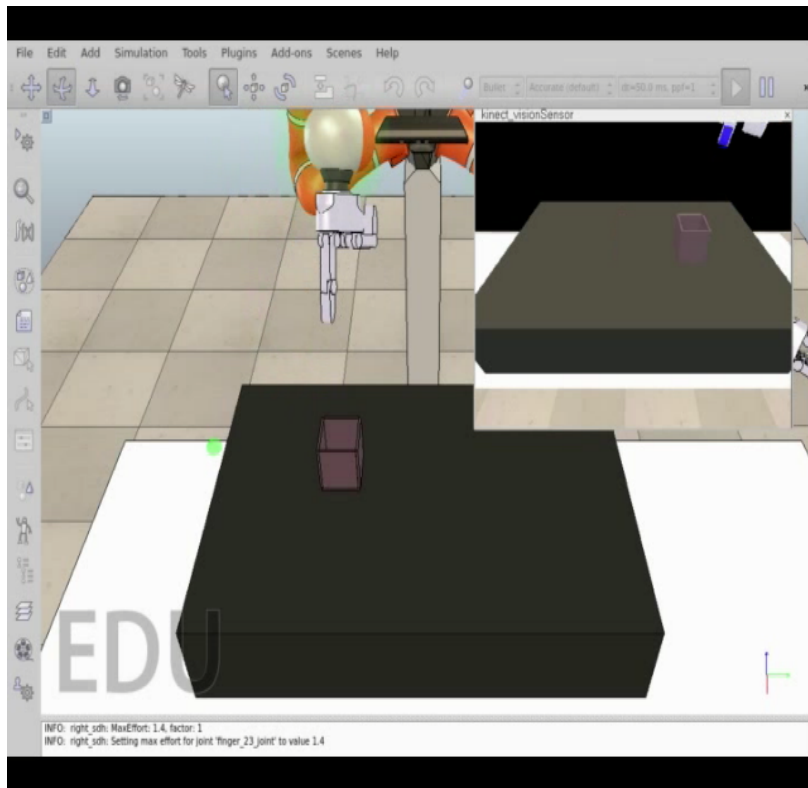
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Using hypersets as an analytic tool, we compare traditionally Gibsonian (Chemero 2003; Turvey 1992) and representationalist (Sahin et al. this issue) understandings of the notion 'affordance'. We show that representationalist understandings are incompatible with direct perception and erect barriers between animal and environment. They are, therefore, scarcely recognizable as understandings of 'affordance'. In contrast, Gibsonian understandings are shown to treat animal-environment systems as unified complex systems and to be compatible with direct perception. We discuss the fruitful connections between Gibsonian affordances and dynamical systems explanation in the behavioral sciences and point to prior fruitful application of Gibsonian affordances in robotics. We conclude that it is unnecessary to re-imagine affordances as representations in order to make them useful for researchers in robotics.

Keywords affordances · Gibson · hypersets



Stable towers are generated by
stacking smaller objects on top of larger objects
using the learned probabilistic rules.