

Introduction

Project **MACS** - **M**ulti-sensory **A**utonomous **C**ognitive **S**ystems Interacting with Dynamic Environments for Perceiving and Using Affordances

The main objective of the MACS project is to explore and exploit the concept of affordances for the design and implementation of autonomous mobile robots acting goal-oriented in a dynamic everyday environment.

Affordances do not exist "per se", but are individual in the sense of sensoric, physical, and experience level. A natural way of getting at them is learning.

Affordances



"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 [affordances] something that **refers to both** the environment and the animal." (Gibson, 1986)



Following the affordance approach, the environment is perceived in terms of function with regard to the acting agent

Properties

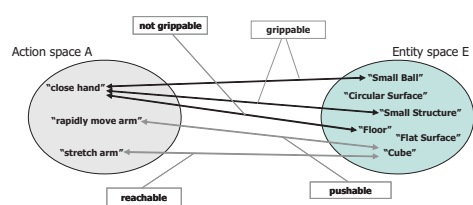
- grey
- small
- 200g
- ...



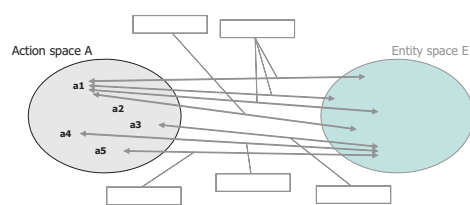
Function

- grippable
- liftable
- pushable

Human biased view



Artificial agent's initial view



Roadmap

Towards purposeful usage of affordances by an artificial agent

- Performing **reactive behaviour** (A)
- Perceiving own actions
- Gaining knowledge about **entities** (E)
- Gaining knowledge about **outcomes** (O)
- Building **A-O-E triple repository**
- Ready for goal driven behaviour

- Phase 0: **Performing** reactive behaviour
- Atomic actions (e.g. Close gripper, lift arm, move)
 - Triggers
 - Action sequences
- Phase 1: **Learning** basic affordances (e.g. grippability)
- Learning the meaning of applying atomic actions
 - Gaining knowledge about the involved entities
- Phase 2: **Learning** complex affordances (e.g. stackability)
- Learning the meaning of applying action sequences
 - Gaining knowledge about the involved entities
- Phase 3: **Using** affordances for goal driven behaviour



Reactive Behaviour

Reactive behaviour in animals

- Atomic actions } Innate reflexes
- Triggers
- Action sequences



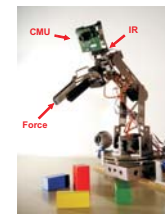
Reactive behaviour in humans

- Grasping reflex
- Blink reflex
- Swallowing reflex
- ...



Performing Reactive Behaviour

- Tracking reflex (curiosity drive)
- Gripping reflex
- Lifting reflex
- ...

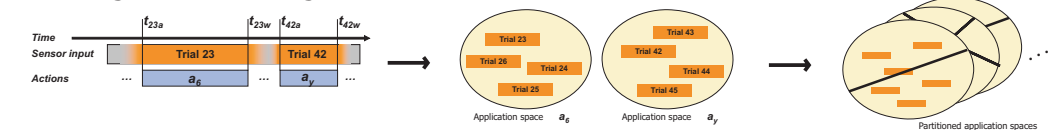


- Robotic arm with 5 DOF
- CMU cam
- Infrared distance sensor
- Force sensor
- Two cameras



Perceiving own Actions

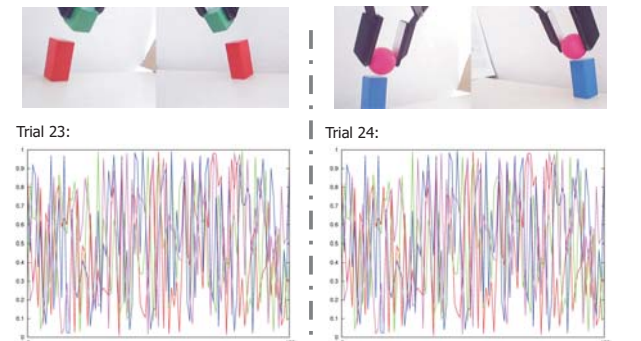
Collecting data for learning



Sensor modalities

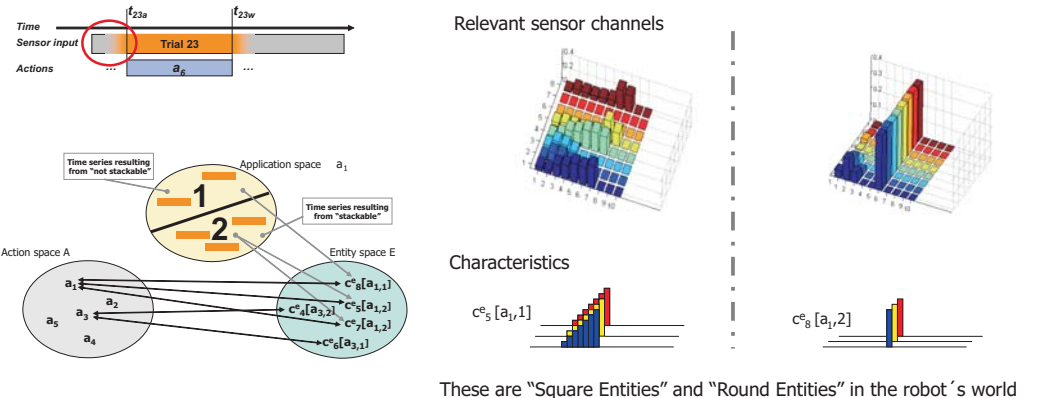


- Ultra sonic
- 3D laser scanner
- Infrared
- Force
- Color blob detector
- Camera
- Proprioception



Gaining Knowledge about Entities

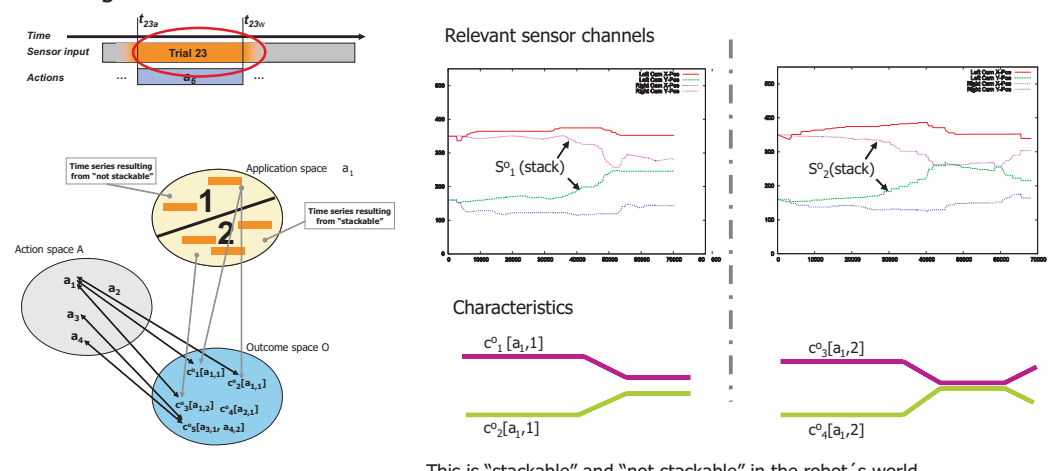
Deriving characteristics from relevant sensor channels



These are "Square Entities" and "Round Entities" in the robot's world

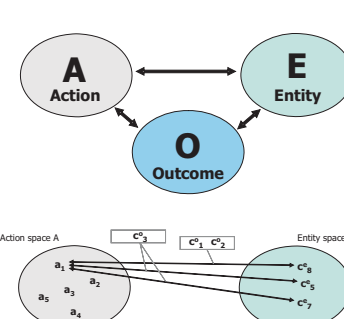
Gaining Knowledge about Outcomes

Deriving characteristics from relevant sensor channels



This is "stackable" and "not stackable" in the robot's world

Result - A-O-E Triple Repository



- **Return actions** $\{o,e\} \rightarrow \{a,\dots\}$ which lead to a given outcome when performed on a given entity
- **Return outcomes** $\{a,e\} \rightarrow \{o,\dots\}$ which result by performing a given action on a given entity
- **Return entities** $\{a,o\} \rightarrow \{e,\dots\}$ which result into a given outcome by using a given action
- **Return entity action tuples** $\{o\} \rightarrow \{(a,e),\dots\}$ that lead to a given outcome
- **Return action outcome tuples** $\{e\} \rightarrow \{(a,o),\dots\}$ that are related to a given entity
- **Return entity outcome tuples** $\{a\} \rightarrow \{(e,o),\dots\}$ that are related to a given action

Acknowledgements

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