Artificial Cognitive Systems

Module 8: Knowledge and Representation

Lecture 2: Joint perceptuo-motor representations

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Joint Perceptuo-motor Representations

- Mental imagery – internal simulation – comprises both visual imagery (or, better still, perceptual imagery) and motor imagery

- These two forms of imagery are tightly entwined

  - the **simulation of perception and covert action** both involve elements of visual and motor imagery

  - Neuroscientific evidence for the interdependence of perception & action

Joint Perceptuo-motor Representations

Sensory-motor Theory and Ideo-motor Theory (Stock & Stock 2004)

- Sensory-motor action planning
  - Treats actions as reactive responses to sensory stimuli
  - Assumes that perception and action use separate representational frameworks
  - Builds on the classic uni-directional approach to perception, proceeding stage by stage from stimulus to percept and then to response
  - Doesn't allow the resultant (or intended) action to impact on the related sensory perception

Joint Perceptuo-motor Representations

Sensory-motor Theory and Ideo-motor Theory [Stock & Stock 2004]

- Ideo-motor action planning
  - Treats action as the result of internally-generated goals
  - The selection and control of a particular goal-directed movement depends on the anticipation of the sensory consequence of accomplishing the intended action
  - The agent images (e.g. through internal simulation) the desired outcome and selects the appropriate actions in order to achieve it

Joint Perceptuo-motor Representations

Sensory-motor Theory and Ideo-motor Theory [Stock & Stock 2004]

- Ideo-motor action planning
  - There is an important difference between the concrete movements comprising an action and the higher-order goals of an action
  - Actors do not voluntarily pre-select the exact movements required to achieve a desired goal
  - Instead, they select prospectively-guided intention-directed goal-focussed action

    with the specific movements being adaptively controlled as the action is executed

Joint Perceptuo-motor Representations

Sensory-motor Theory and Ideo-motor Theory [Stock & Stock 2004]

- Ideo-motor action planning
  - How can the goal, achieved through action, cause the action in the first place?
  - How can the later outcome affect the earlier action?
  - Prospection! It is the anticipated goal state, not the achieved goal state, that impacts on the associated planned action
  - Goal-directed action is a centre-piece of ideo-motor theory
  - Also referred to as the goal trigger hypothesis (Hommel et al. 2001)

Joint Perceptuo-motor Representations

Sensory-motor Theory and Ideo-motor Theory [Stock & Stock 2004]

- Ideo-motor action planning
  - Perception and action share a common representational framework

Joint Perceptuo-motor Representations

The Theory of Event Coding (TEC) (Hommel et al. 2001)

- Concerned with perceptual features but not with how those features are extracted or computed
- Concerned with preparing actions — action planning — but not with the final execution of those actions and the adaptive control of various parts of the agent's body
- Perception, attention, intention, and action all work with a common representation
- Action depends on both external and internal causes

Joint Perceptuo-motor Representations

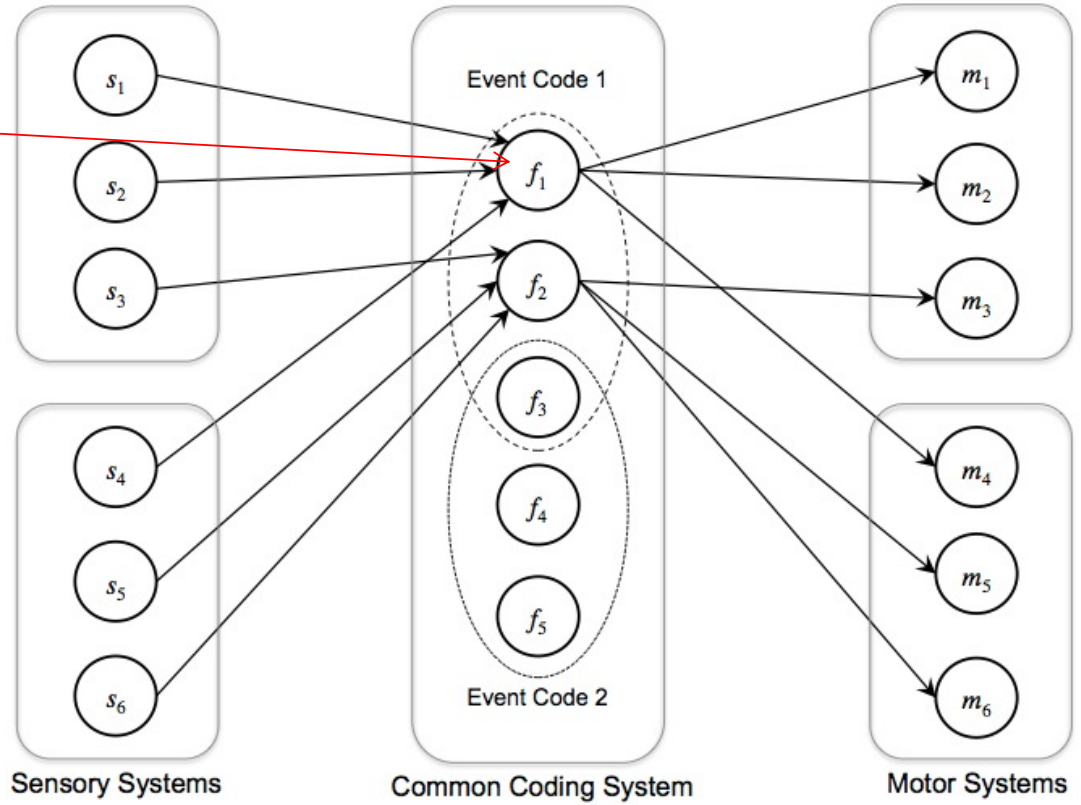
The Theory of Event Coding (TEC) (Hommel et al. 2001)

Feature codes

Simple
(e.g. colour, shape, moving to the left, falling)

Complex
(e.g. as an affordance)

Possibly learned



Joint Perceptuo-motor Representations

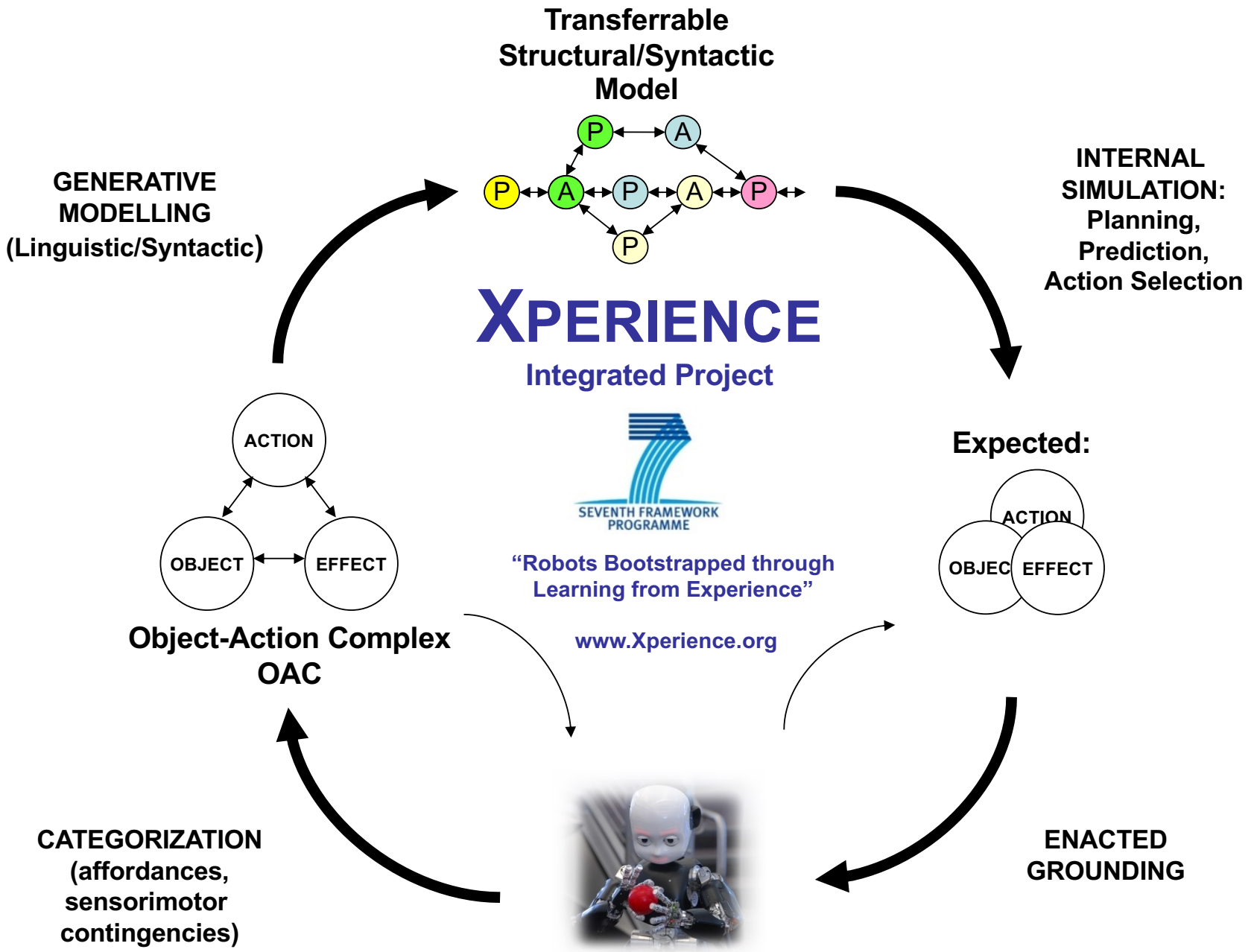
The Theory of Event Coding (TEC) (Hommel et al. 2001)

- Feature codes associated with an event are activated both when the event is perceived and when it is planned

- Features can be elements of many event codes
  - the activation of a given feature effectively primes, i.e. predisposes, all the other events of which this feature is a component

- The features that make up an event are bound together: integrated into some event code

- The nature of the binding isn't specified in TEC
  - the effect of binding is a form of event code suppression
  - one event inhibits other events that share some of the event codes features


Transferrable
Structural/Syntactic
Model
P
A
P
A
P
A
P
GENERATIVE
MODELLING
(Linguistic/Syntactic)
INTERNAL
SIMULATION:
Planning,
Prediction,
Action Selection
XPERIENCE
Integrated Project
SEVENTH FRAMEWORK
PROGRAMME
"Robots Bootstrapped through
Learning from Experience"
www.Xperience.org
ACTION
OBJECT
EFFECT
Object-Action Complex
OAC
Expected:
ACTION
OBJEC
EFFECT
CATEGORIZATION
(affordances,
sensorimotor
contingencies)
ENACTED
GROUNDING

Joint Perceptuo-motor Representations

Object-Action Complex, or OAC (Kruger 2011)

- An OAC is a triple, i.e. a unit with three components: (E, T, M)
  - E is an "execution specification"; think of it as an action
  - T is a function that predicts how the attributes that characterize the current state of the agent's world will change if the execution specification is executed
    - Think of M as a prediction of how the agent's perceptions will change as a result of carrying out the actions given by E. S is just the space of all possible perceptions of the agent
  - M is a statistical measure of the success of the OAC's past predictions

Joint Perceptuo-motor Representations

Object-Action Complex, or OAC [Kruger 2011]

- An OAC: a predictor that links current perceived states and future predicted perceived states that would result from carrying out that action
- An OAC models an agent's interaction with the world as it executes some motor program (low-level control program CP in the OAC literature)
- For example, an OAC might encode how to grasp a object or push an object into a given position and orientation (usually referred to as the object pose)
- OACs can be learned and executed, and they can be combined into more complex representations of actions and their perceptual consequences.

Recommended Reading

Vernon, D. Artificial Cognitive Systems – A Primer, MIT Press, 2014; Chapter 8.