Sensory-Motor Primitives as a Basis for Imitation: Linking Perception to Action and Biology to Robotics

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Imitation: "the capability to acquire new skills by observation, based on the imitator's existing behavioral repertoire"

Motivation for Imitation

- Natural Systems
  - Development of language and communication
  - Learning and relearning skills for children, athletes, and those recovering from injuries
- Artificial Systems
  - Automated programming and control of robots
  - More natural interaction with robots

Learning Model

- Selective attention
- Mirror neurons:
- Motor primitives
- Classification-based learning system
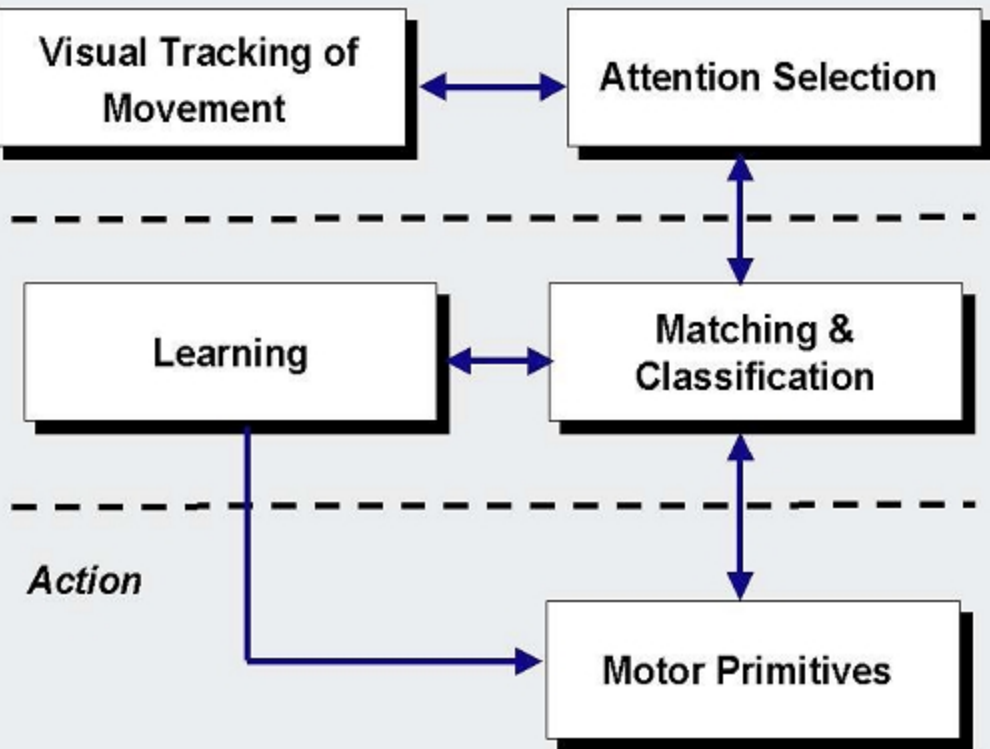
Mirror Neurons

- Shown to exist in humans and monkey
- The link between perception and action
- Research shows that infants can imitate facial expressions without visual feedback
- Suggests built in primitive movements, not learned

Selective Attention

- Idea: Imitation is built on a perception system which is specially attuned to biological movements

- Specialized perception may use not only visual input, but motor primitives to predict and model

Eye-tracking

- Studies involving participants watching unfamiliar movements, either with or without the goal of imitating them.
- Attention was the same, focused on the end-effector
- Only difference was pupil dilation
- Results serve as basis for attention model

Motor Control and Motor Primitives

- A motor system is composed by a set of primitives
- These can be executed sequentially and super-positioned
- The span of the motor primitives is all possible motions of the motor system.

Coding

- Primitives are combined into "motor programs"
- Mirror neurons map perception to motor programs

Attentional Model

- Focus on the end-effector, resolution decreases with log of distance from focus
- More detail in Jenkins 2000
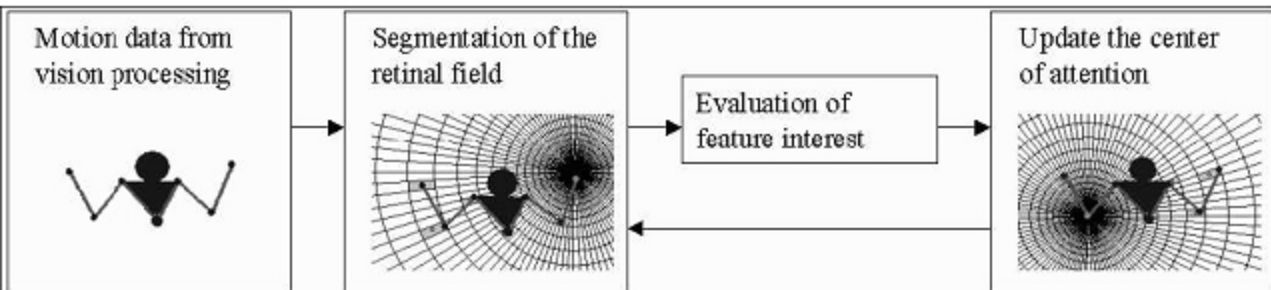
Kinds of Primitives

- "discrete" - straight line movements
- "oscillatory" - repetitive movements
- "postural" – arrangement of joints

Learning Expectations

- Learning more skills increases the chances of matching future skills, making learning easier

- Learning a skill similar to a known skill is faster than a totally new skill

- Refining a skill similar to another skill is more difficult because it may be improperly matched to the other skill