

Developmental Learning: from Infants to machines

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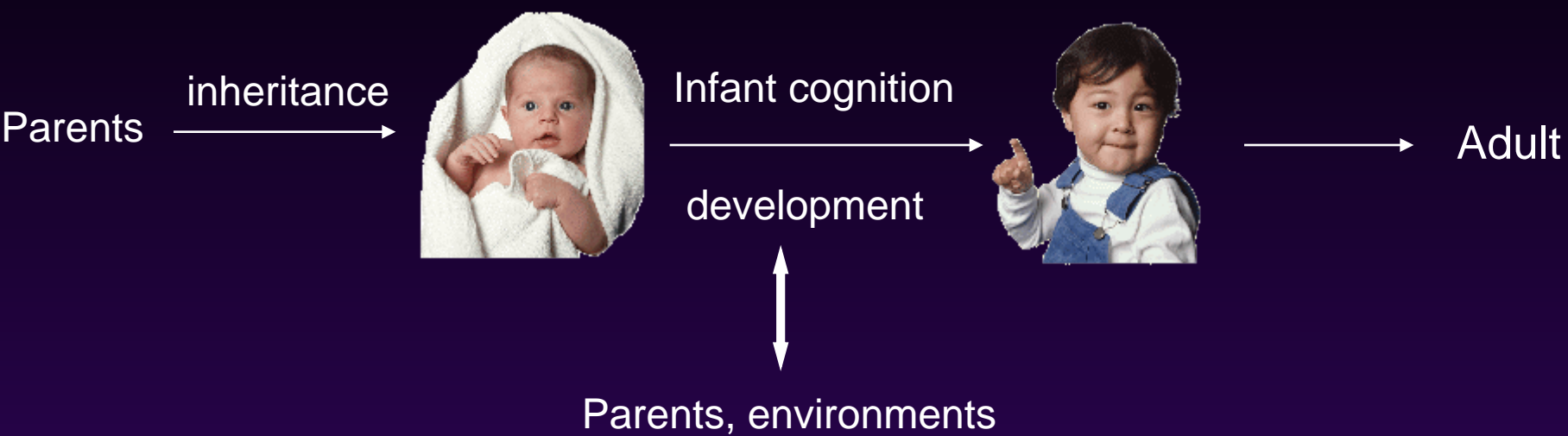
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Working in the areas:

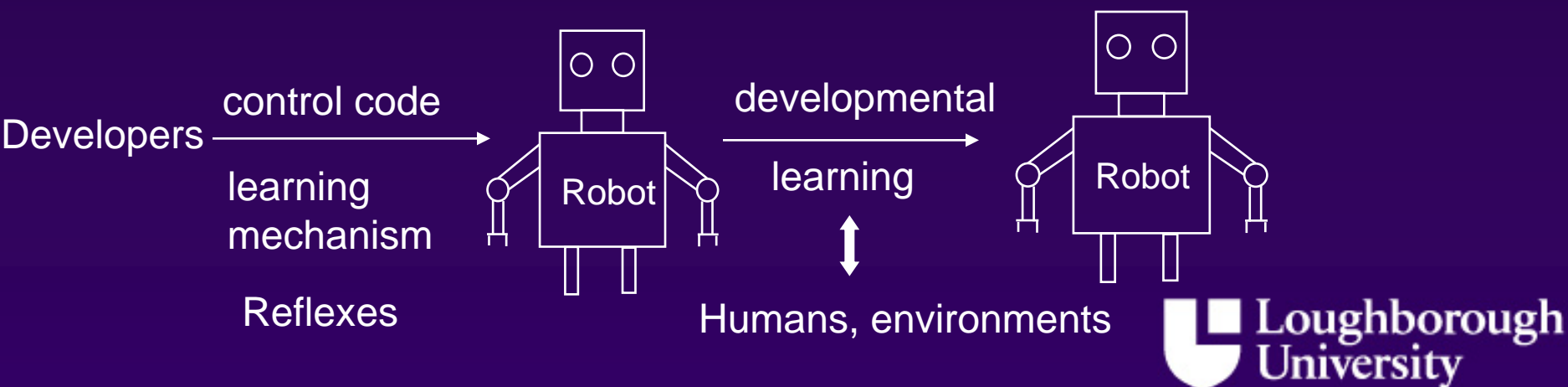
- Biologically and psychologically inspired robot learning and control, sensory-motor coordination.
- Learning from imitation and adaptive behaviour
- Computer vision, and image processing
- Human-robot interaction
- Multi-robot system, and networked robots
- Human facial expression recognition, human motion and behaviour analysis
- Intelligent robotics and assistive robotics
- Unmanned aerial vehicle

Developmental Learning: from Infants to machines



physical development: taller and stronger

Cognitive development: through internal changes(e.g. neural growth), and external environmental changes(e.g. The effect of an action).



Developmental learning

- Sensory-motor interaction (eye/head/hand coordination learning)
- Incremental and self-organizing learning
- Intra-modality and inter-modality mapping
- Staged learning, scaffolding by constraints
- Motivation, novelty and habituation, self-exploration and active learning
- Neural plasticity: Growing & shrinking of neurons
- Adaptation to the environment and bodily changes : tool use



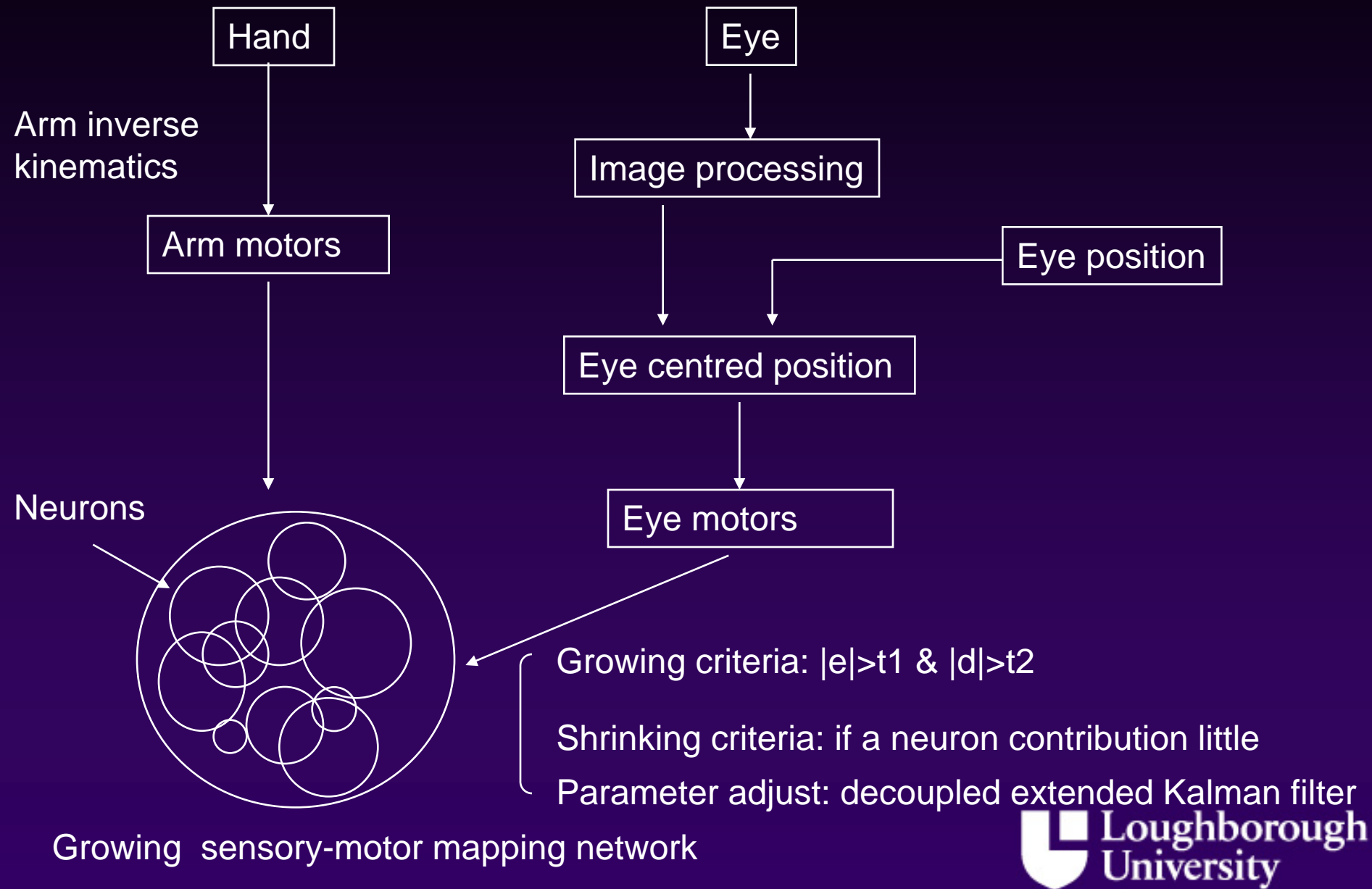
Jean Piaget

9 Aug 1896—16 Sept 1980

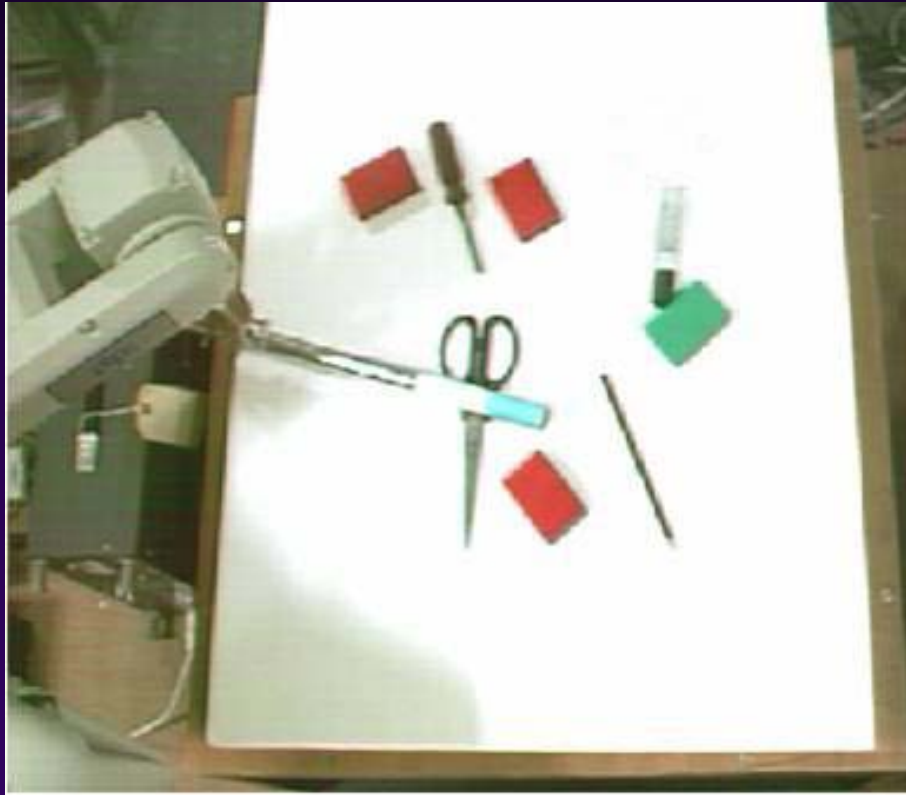
Our Experimental Developmental Learning System



Example: eye/hand coordination

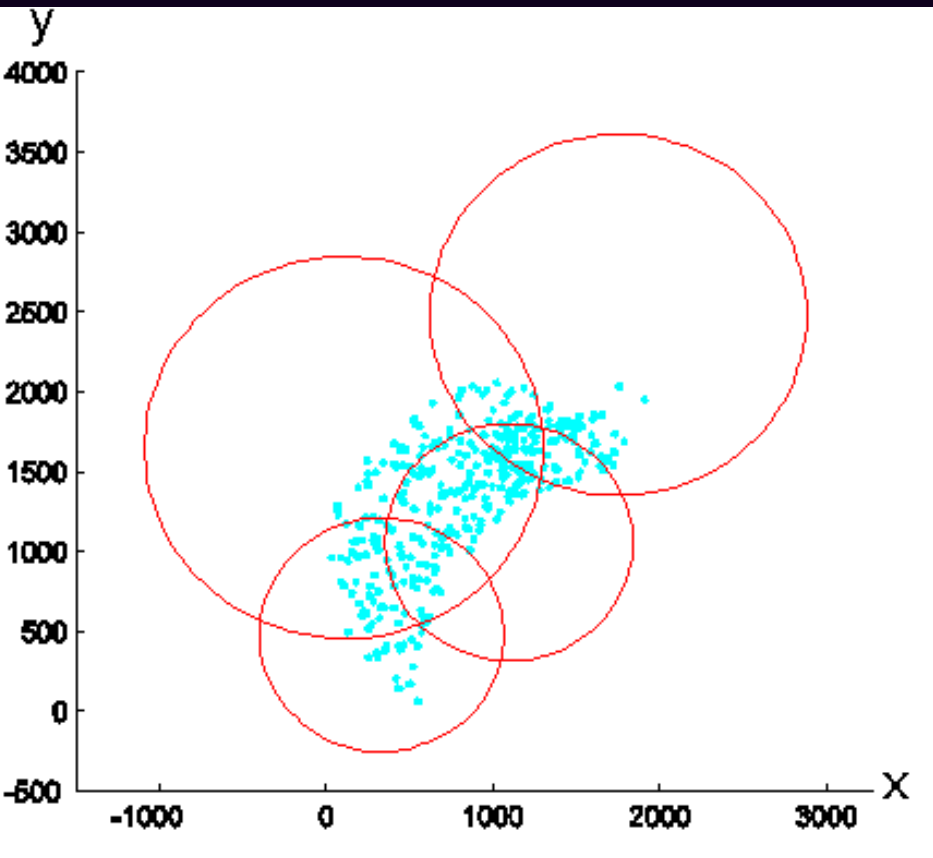


Example: Eye/hand mapping learning

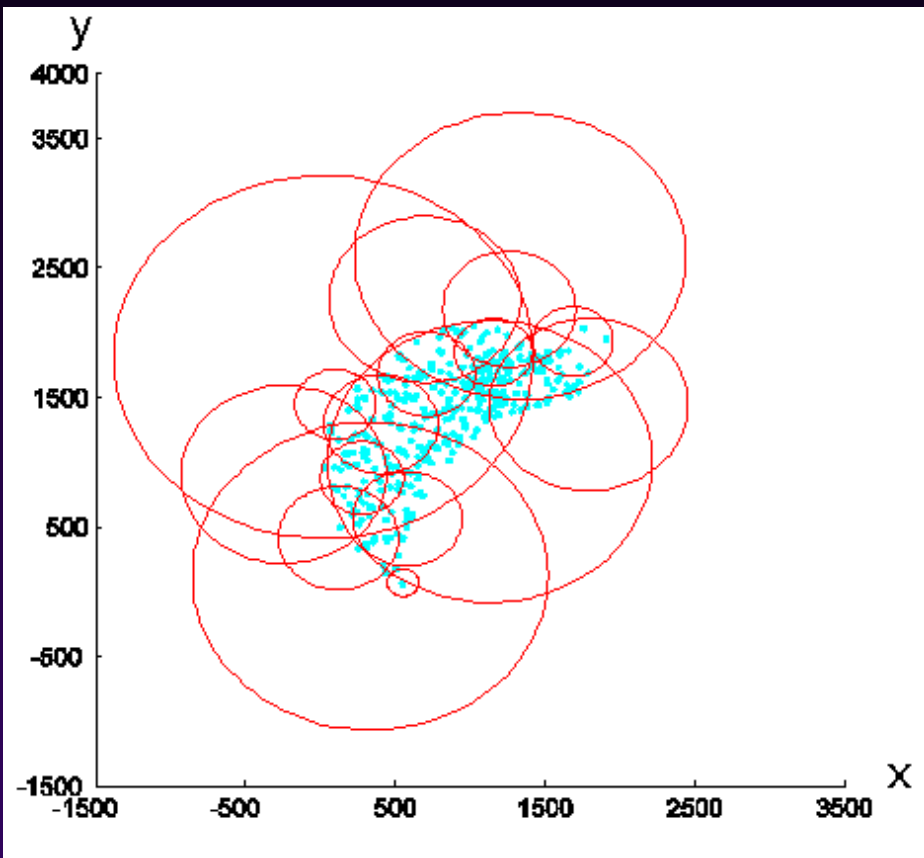


- Eye locates the green object
- Calculate the centre of the object
- Move head to focus the object
- Hand finger points to the object

Neuron growing and distribution in learning



After 100 learning steps

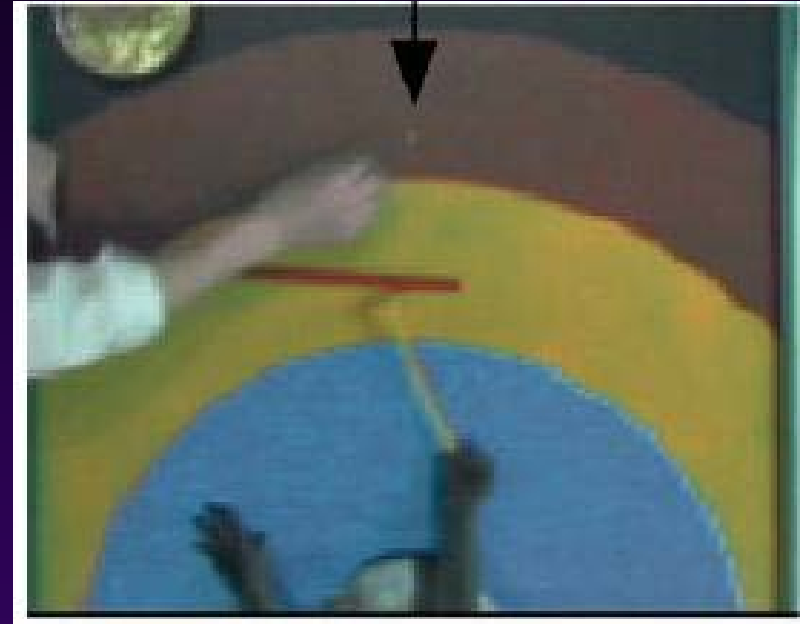


After 1600 learning steps

Adapt to structure changes

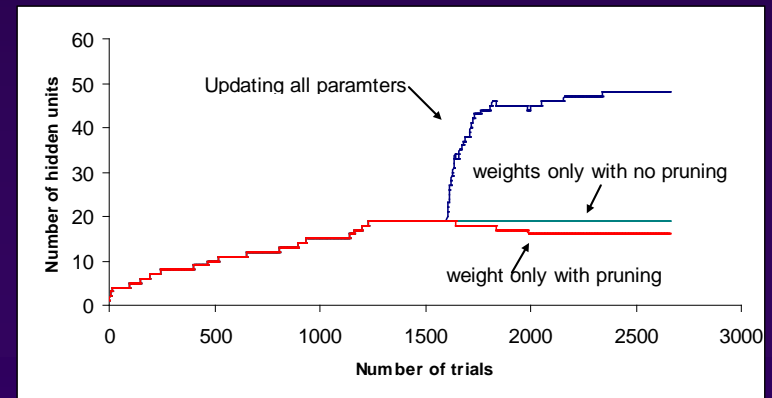
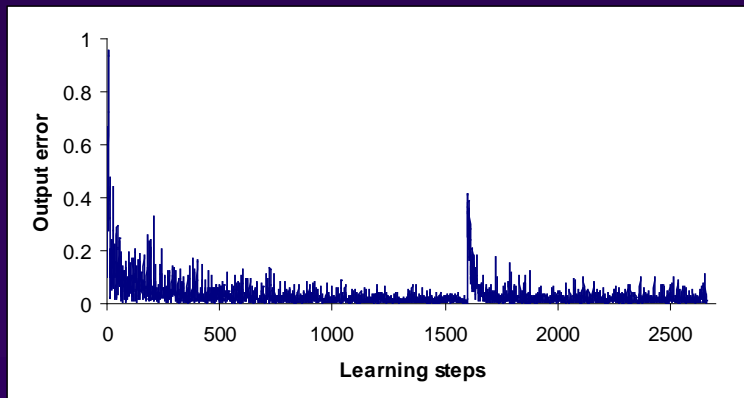
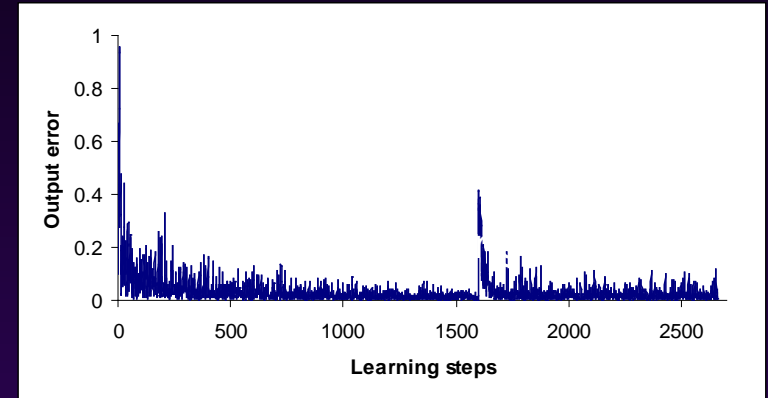
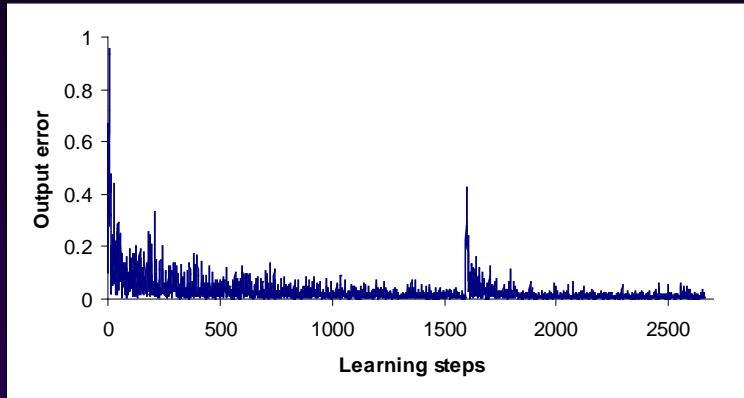
- reuse and refine learned knowledge

- Most traditional calibration methods: recalibration
- Humans and animals can quickly adapt to the structure changes such as tool-use
- Full adjustment of the learned network after a structural change.
 - adding new hidden nodes or remove existing
 - adjusting the centres and widths of the existing nodes
 - updating the weights
- Adjusting the weights, removing the insignificant hidden units, keeping the rest of the hidden units unchanged.
- Only adjusting the weights, keeping structure of the network unchanged.



- Neuron growing and shrinking in brain
 - Many biological evidence
 - Basis functions exist in human brain (Pouget & Snyder, Nature, 2000)
- Biological support from humans and animals during tool-use
 - Japanese macaque monkey studies in tool-use:
Bimodal neurons in anterior intraparietal sulcus dynamic alter their visual receptive field properties (Maravita & Iriki, Trends in Cog. Sci, 2004)
 - Humans: Updating plastic neural networks in the brain for tool-use (Johnson-Frey, Trends in Cog. Sci. 2004)
- Kalman filters in human brain?
 - In the entorhinal-hippocampus loop (Szirtes Neurocomputing, 2005)
 - Visual information processing (Rao, Ballard, Nature Neuroscience, 1999)
 - Motor coordination control (Todorov & Jordan, Nature Neuroscience, 2002)
 - Spatial learning (Bousquet, PSB'98; Szirtes Neurocomputing, 2005)

Adaptation of the mapping network to structure changes





Pan/tilt vision system (robosoft)



Schunk 7DOF arm with 3-fingered gripper

Other research areas can be found from my current PhD students' projects:

1. Ibrahim Tholley
 - Robot learning to dance with music (Sony AIBO dogs)
2. Syah Razali
 - Immune system inspired multi-robot cooperation
3. Afizan Azman
 - Driver's cognitive distraction detection
4. Santoshi Joshi
 - Rail track inspection
5. Mohammed Saada
 - Intelligent aids for elderly people at home
6. Kai Cao
 - Human behaviour pattern detection
7. Simon Hunt
 - UAVs (Unmanned Aerial Vehicles)