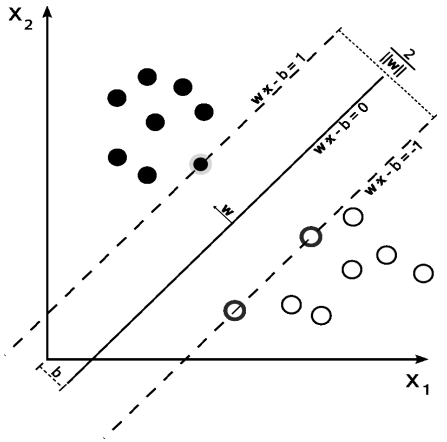
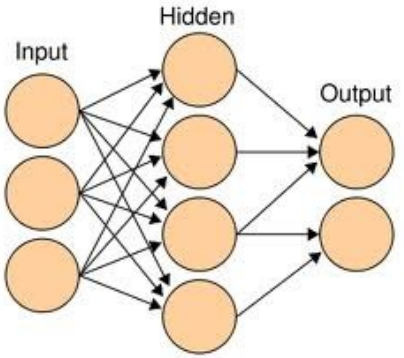
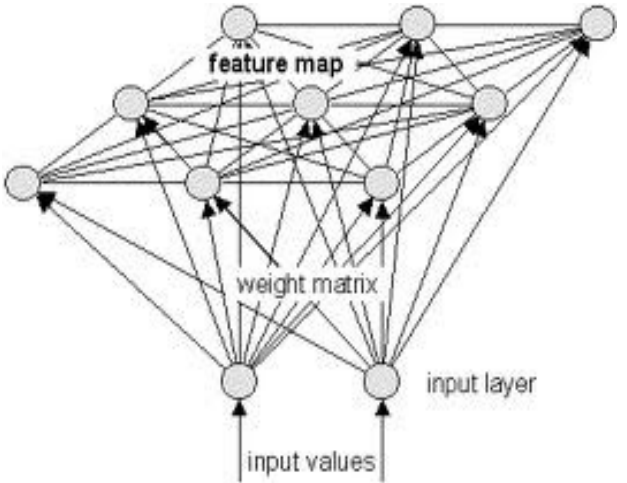
Machine Learning Application in Robotics

Learning Models

- Support Vector Machines
  - Linear Classification and Regression
  - Supervised Learning
- Artificial Neural Network
  - Complex Pattern Recognition
  - Highly Adaptive
- Self Organizing Map
  - Low dimensional representation
  - Vector quantization for training





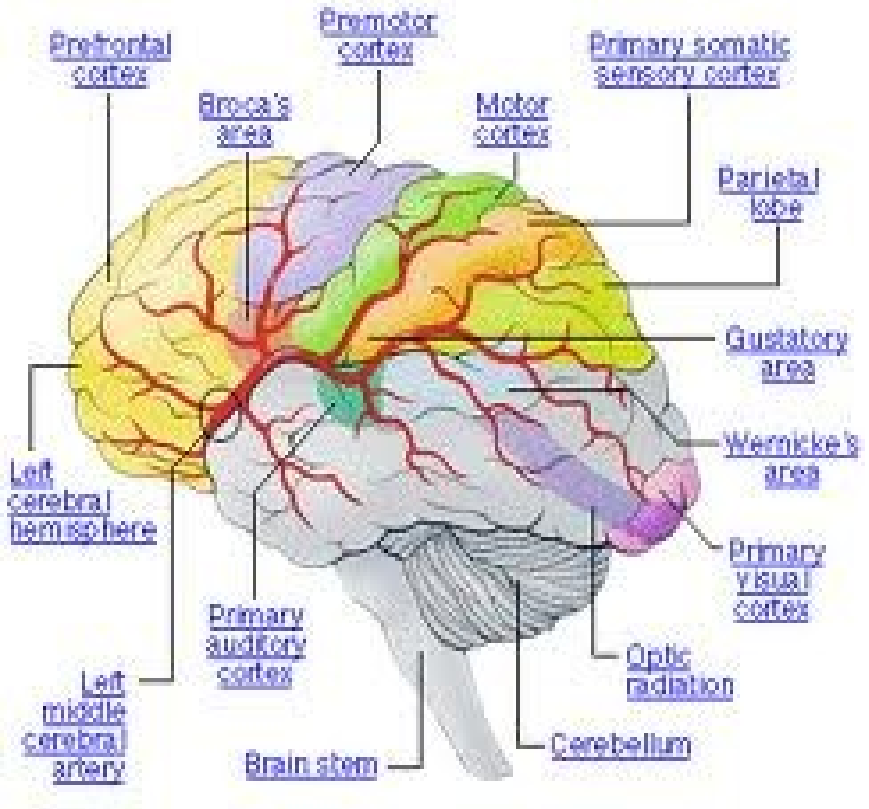


Some Robotics Problems

- Modeling the grasp space
- Robust grasp planning
- Maintaining a stable grasp
- Not destroying the object

Bio-Inspired Modeling

- Robots historically bad at these
- Living things naturally good at these
- Model control systems after living things
  - Study grasp acquisition in brains to create better models
- Origin of Artificial Neural Networks



- Specialized brain areas performing tasks
- Specialized learning models for single tasks
- Strengths and Shortcomings of individual learning algorithms

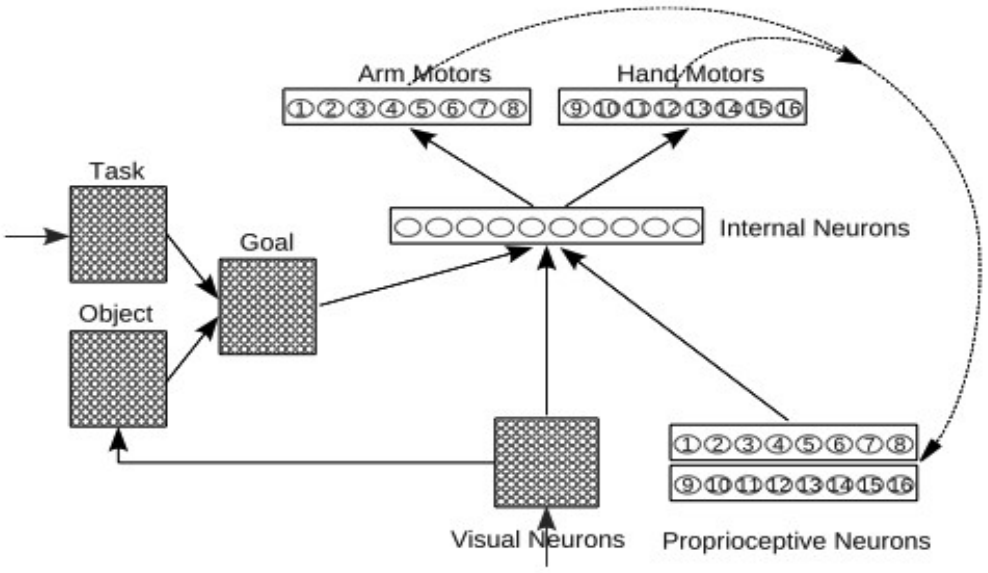
Examples

- Grasp Planning
  - Macura et. al. “A Cognitive Robotics Model of Grasping”
- Grasp Feedback
  - Johnsson; Balkenus, “Neural Network Models of Haptic Shape Perception”
- Grasp Space Modeling
  - Patrizia et. al. “Brain Area V6A: a Cognitive Model for an Embodied Artificial Intelligence”

A Cognitive Robotic Model of Grasping

- Simulated iCub robot
  - 16 degrees of freedom
  - 6 tactile sensors
- Connectionist Neural Networks
  - Sobel Filter of Visual Input
  - Identify Object
  - SOMs for Task

    Goal and Object



Result

- Small number of objects
- Predetermined five high level grasp sequences
- Trained on four grasp sequences
- Adapted fifth grasp sequence to objects

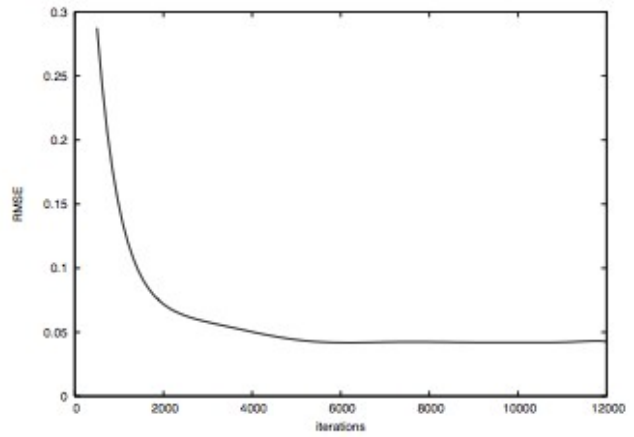


Figure 4: Average RMSE during the neural network training

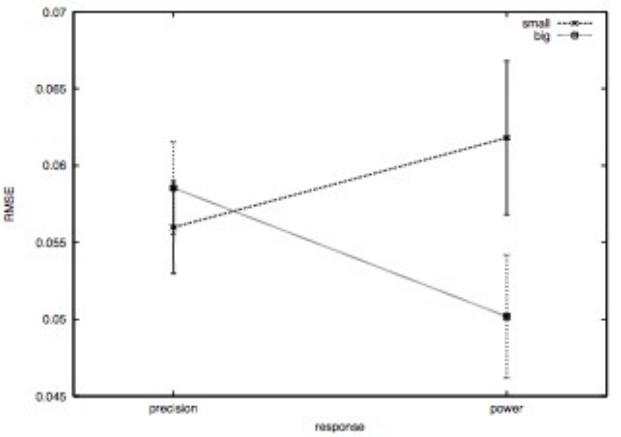
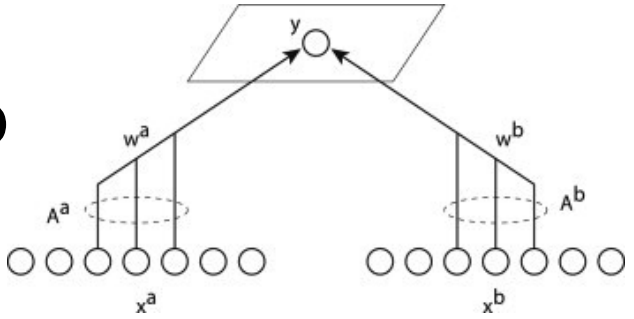


Figure 5: Compatibility effect in congruent and incongruent trials

Neural Network Model of Haptic Shape Perception

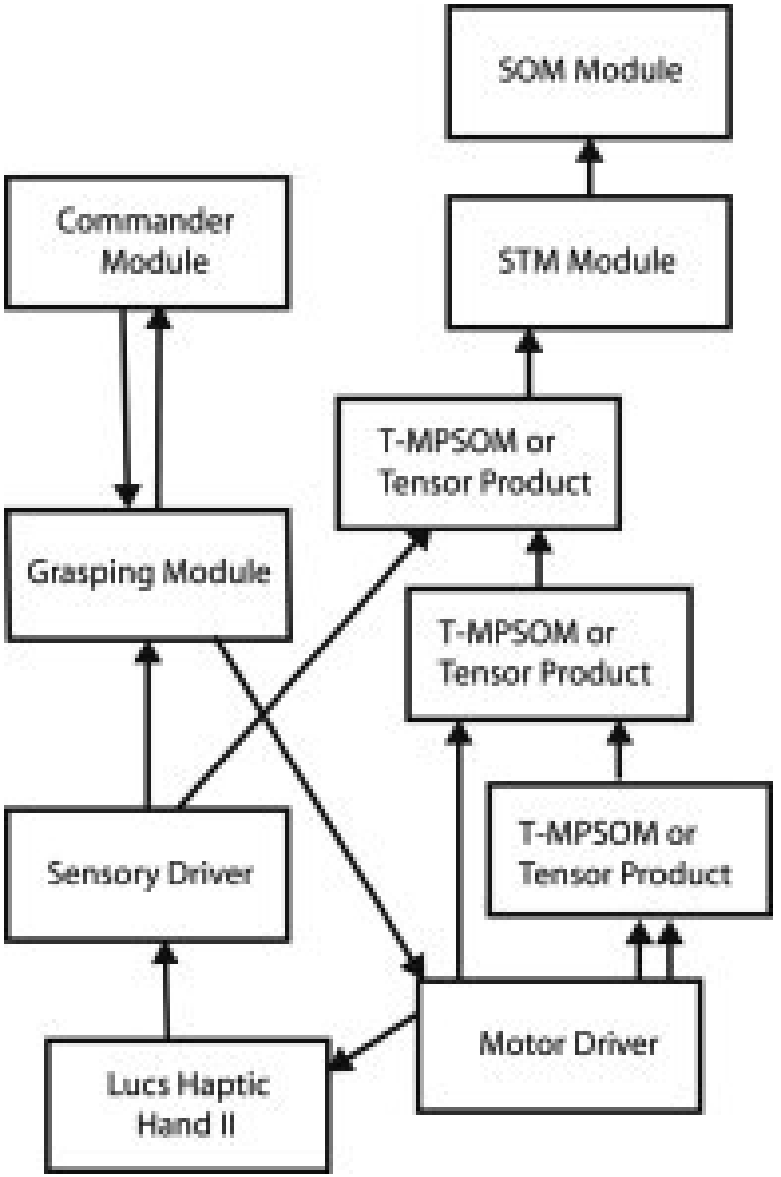
- Uses Modified Kohonen Map
  - Tensor product self organizing map
  - Takes two weighted input vectors



- Controlled LUCS haptic hand
  - Three fingered
  - 8 degrees of freedom
  - Piezoelectric touch sensor on each finger

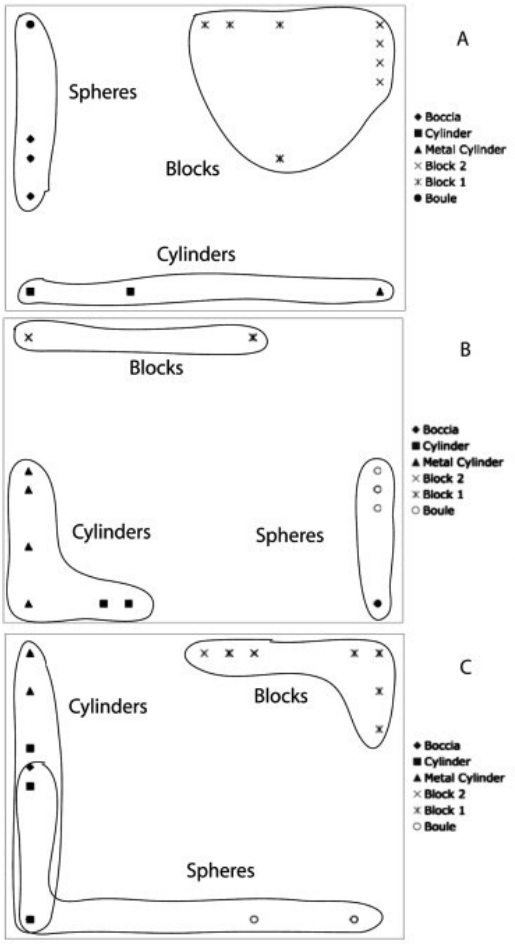
Model

- Bio-Inspired



Results

- Learned to classify various objects by shape and material



Brain Area V6A: A Cognitive Model for Embodied Artificial Intelligence

- Studied macaque brain for visualization and grasping
- Identified visual neurons and connection between modeling space, modeling arm position and planing grasps
- Proposes likely applications for robotics but not concrete cognitive model
- Possible area for future study

References

A Cognitive Robotic Model of Grasping

A Neural Network Model of Haptic Shape Perception

Brain Area V6A: A Cognitive Model for Embodied Artificial Intelligence