MODULAR NEURAL EXPLORING TRAVELING AGENT

MoNETA

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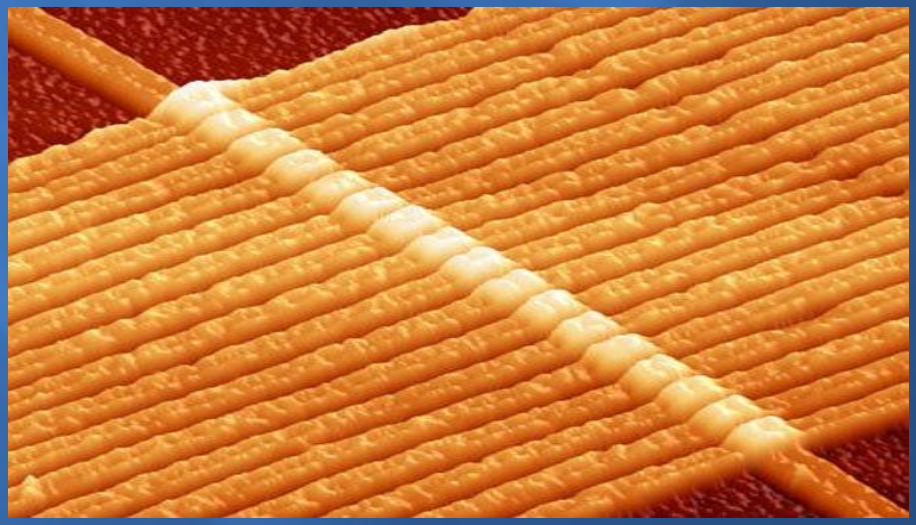
MoNETA

- Being Implemented by BU & HP Lab.
- Brain of an Animat
- Works on Cog Platform
- Basic h/w component used :Memristor
- Version I solves the Morris Water Maze Task

Memristor

- Fourth basic electronic component – 2008 HP
- Resistance depends Charge flow direction
- It remember (or recall) the last resistance it had before being shut down .



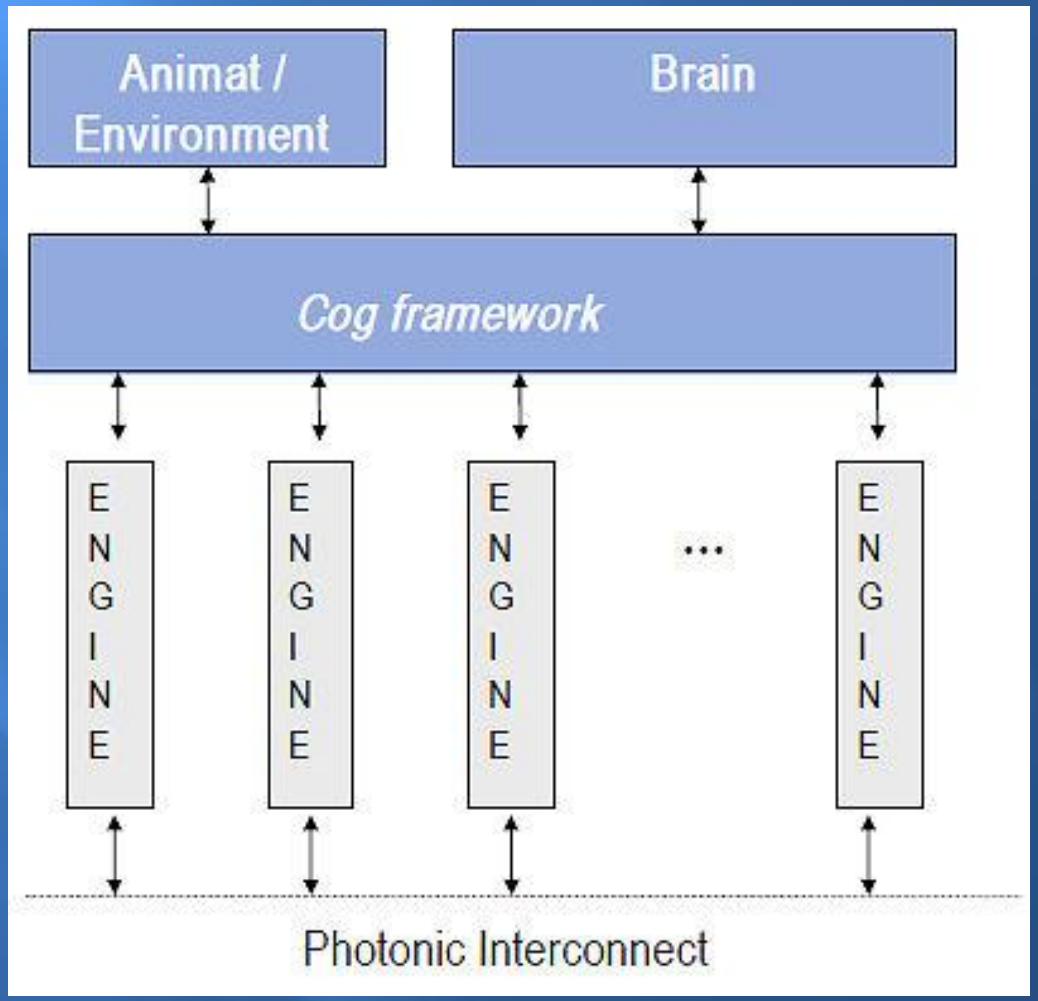
Cog Ex Machina (or Cog)

- It is a neural modelling OS that lets neural designers interact with the underlying hardware to do neuromorphic computation.
- computation that can be divided up between hardware that processes like the body of a neuron and hardware that processes the way dendrites and axons do.
- The dendrite cores in the Cog hardware will be much less flexible than neuron cores, but they will store extraordinary amounts of state information in their massive memristor-based memory banks.

Cog Ex Machina (or Cog)contd..

- Memristors, act as the synapses that mediate the information transfer between the dendrites and axons of different neurons.
- MoNETA models, need high performance computing resources such as GPU cluster called Simcity, features a total of 144 GPUs, 576 GB of conventional memory.

Cog Ex Machina (or Cog)contd..

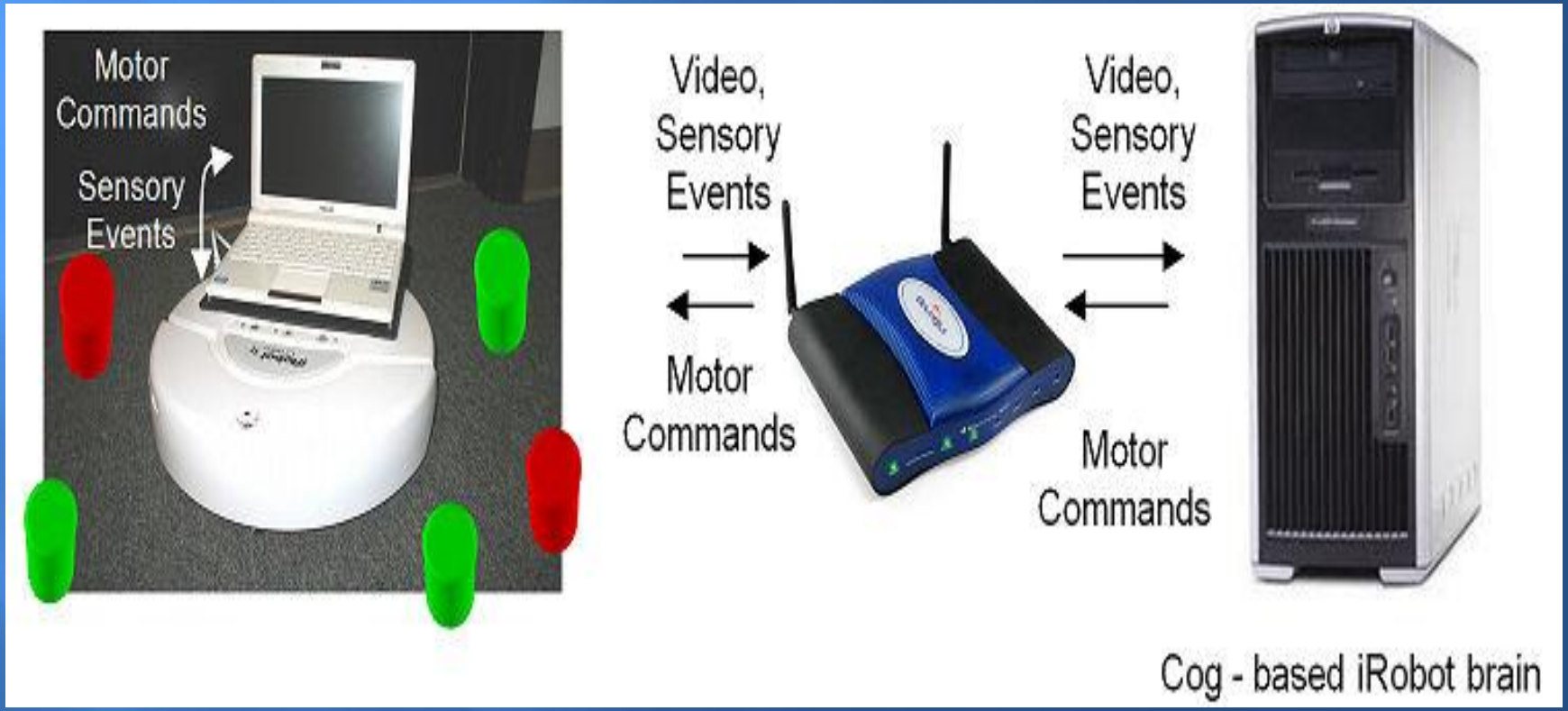


Simcity

ViGuAR

- iRobot
- It explores a world of colour objects. It navigates toward an object if it perceives its colour as attractive based on a reward value .
- The animat also learns the locations of objects it has visited in the past in order to avoid these locations in the future exploration of its world.
- Cog 2.0 based brain that communicate with a netbook attached to a robot serial port via WiFi network

ViGuAR


Motor
Commands
Sensory
Events
Video,
Sensory
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Motor
Commands
Video,
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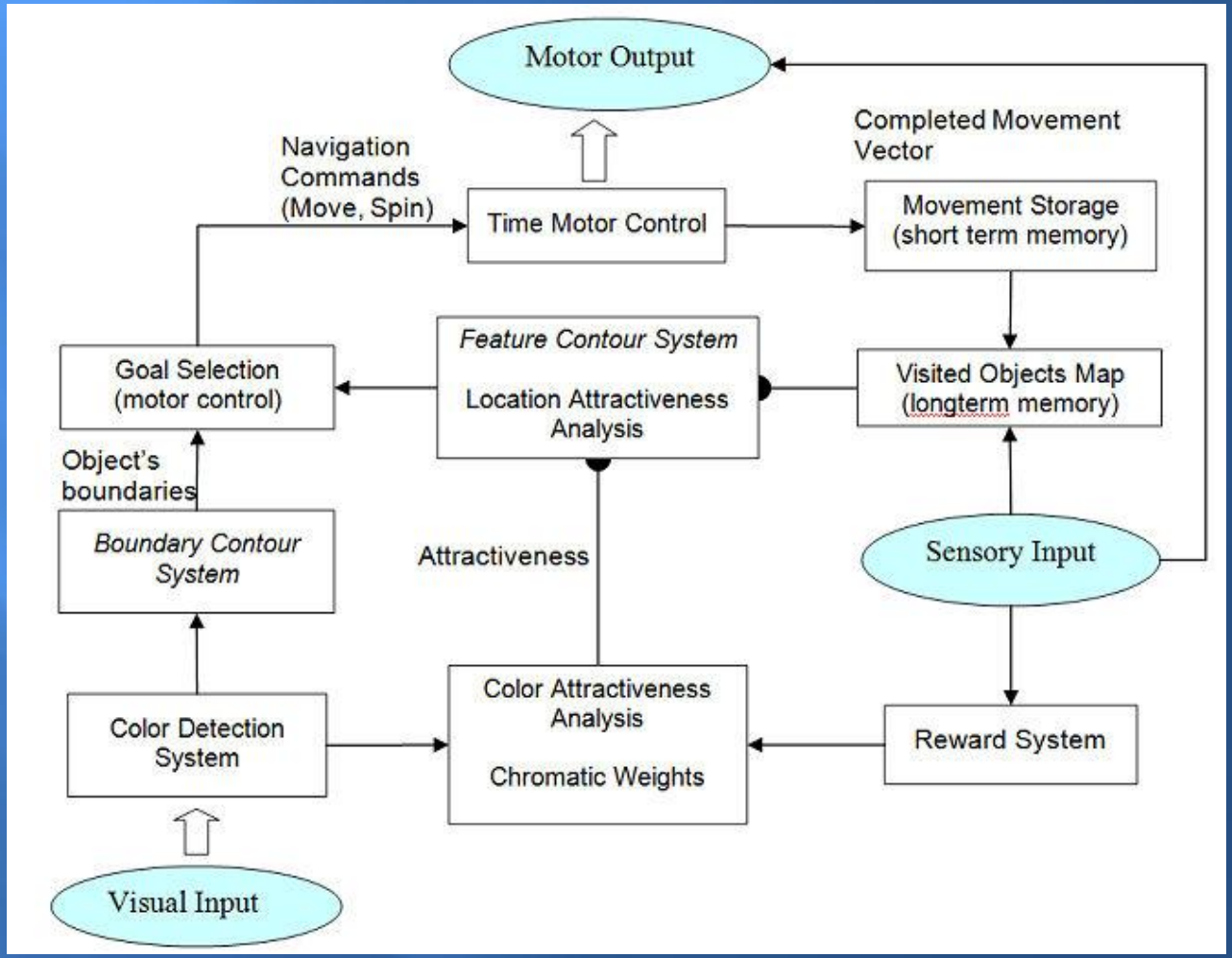
Commands
Cog - based iRobot brain

Neuromorphic architecture of (ViGuAR) brain



Neuromorphic architecture of (ViGuAR) brain (contd..)

- **Color Detection System**

  RGB input → Redness/Greenness

- **Color Attractiveness Analysis Module**

  measure of attractiveness for each spatial location

- **Reward System**

  receives an input from the robot bumper sensors

Neuromorphic architecture of (ViGuAR) brain (contd..)

- **Boundary Contour System**

  colour signal →boundary signal

- **Feature Contour System**

  receives the attractiveness signal for each spatial location

- **Goal Selection System**

  analyzes attractiveness at each spatial location in order to find the most attractive goal in its view.

Neuromorphic architecture of (ViGuAR) brain (contd..)

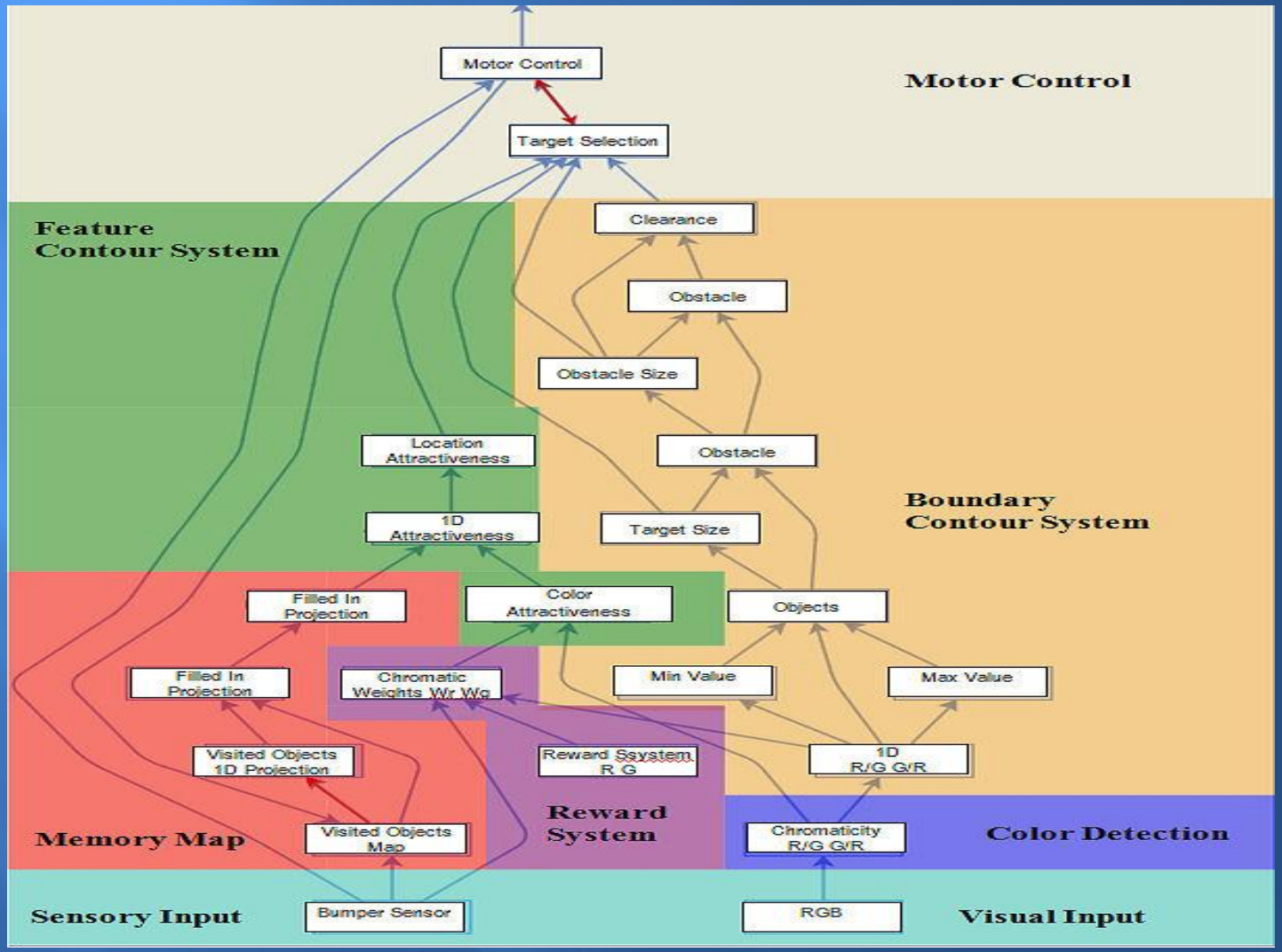
- **Time Motor Control**

  control commands

- **Movement Storage Unit**

  updates a vector of movement of the animat upon completion of each movement.

Cog-based Implementation of ViGuAR Brain



Cog-based Implementation of ViGuAR Brain

- search for an attractive object by object boundary determination
- certain locations are primed the object map projection to the robot retina
- Learning occurs upon contact with an object

Learning in MoNETA

- Single neurons in Cog are implemented based on the following neuron model

$$y = f(W^T X) \text{.....1}$$

- partial inference:- $W^T X$

Learning in MoNETA

- Cog currently supports learning laws for which weight changes can be implemented in the following general form

$$\Delta w_{ij} = \lambda s\,(\Delta w_{ij}^{H} + \Delta w_{ij}^{C} + \Delta w_{ij}^{N}) \quad \text{.....2}$$

- **λ is the learning rate, s is a sign factor (-1 or +1)**

  weight-change terms related to Hebbian, Competitive and Normalization operations

Learning in MoNETA

- General form can encapsulate a number of learning rules performing independent component analysis , and is implemented in Cog as

$$w_{ij}^{1} \leftarrow w_{ij}^{0} + h_j \, x_i \quad \text{.....3}$$

$$x_i^{'} \leftarrow w_{ij}^{1} h_j \;,\; w_{ij}^{2} \leftarrow w_{ij}^{1} - h_j x_i^{'} \quad \text{.....4}$$

$$w_{ij}^{3} \leftarrow w_{ij}^{2} - g_j \, w_{ij}^{2} \quad \text{.....5}$$

Learning in MoNETA

- **Generalized learning law equation**

$$w_{ij} = x_i(\lambda y_j - \alpha w_j(t)) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

- postsynaptic activity yj and an additional decay rate, α .

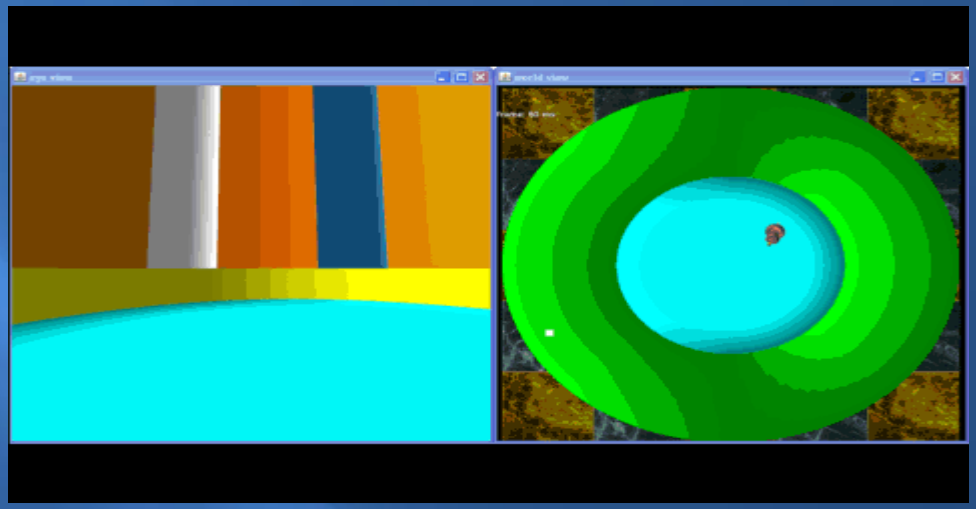
- Implemented by a suitable modification of the network topology, but this would reduce the efficiency of the framework.

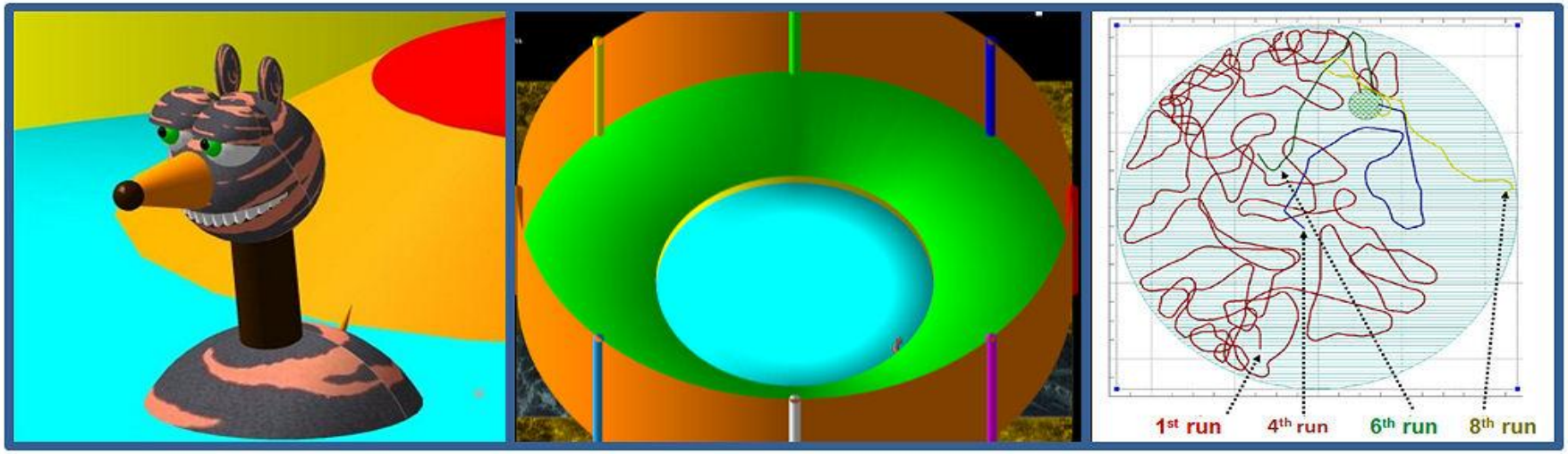
- Generalized by by inserting only one of (hj and gj)

MoNETA Version I

- Autonomous agent learning to perform complex behaviours in a virtual environment. It combines visual scene analysis, spatial navigation.
- Replicate a rodent's learning to swim to a submerged platform in the Morris water maze task.
- Neuroscientists teach a rat to swim through a water maze, using visual clues, to a submerged platform that the rat can't see.

MoNETA Version I





Morris water maze task

MoNETA Version I I

- MoNETA II has a number of modules currently under development, including the following:
- space variant vision and eye movements
- color processing
- attentional modulation
- learning and homeostatic mechanisms for synaptic stabilization of all cortical areas
- auditory processing

MoNETA Version I I

- MoNETA v2.0 will integrate mechanisms involving brain areas ranging from sensory, premotor, motor and frontal cortices, to sub cortical areas to implement more complex decision making.

CONCLUSION

- Neuromorphic chips will eventually come in as many flavors as there are brain designs in nature: fruit fly, earthworm, rat, and human. All our chips will have brains.
- Able to generate observable and measurable activity
- MoNETA's first role will be in the U.S. military, standing in for irreplaceable humans in scout vehicles searching for roadside bombs.

THANK YOU