MIRO:

Adaptive Middleware for a Mobile Internet Robot Laboratory

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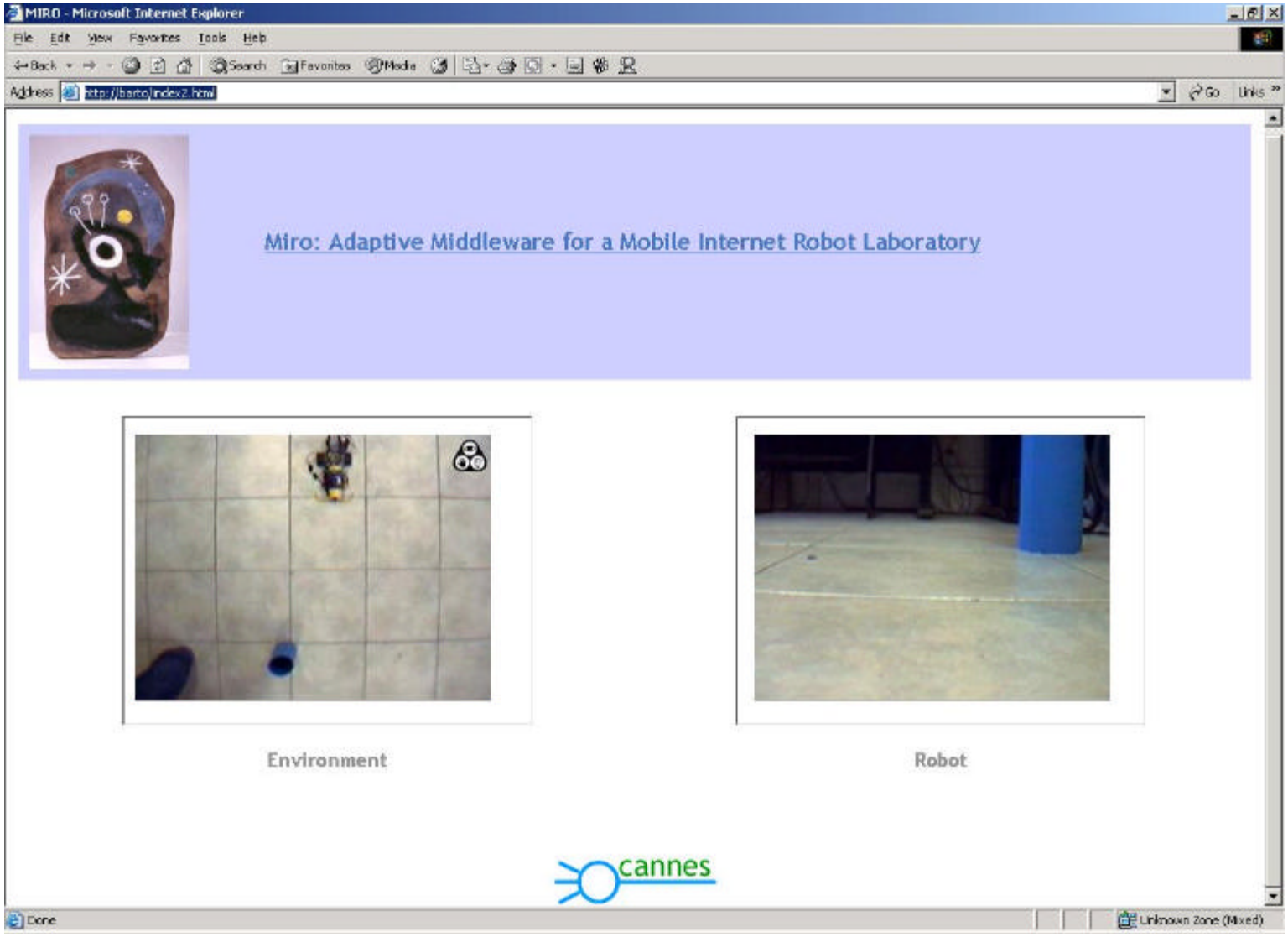
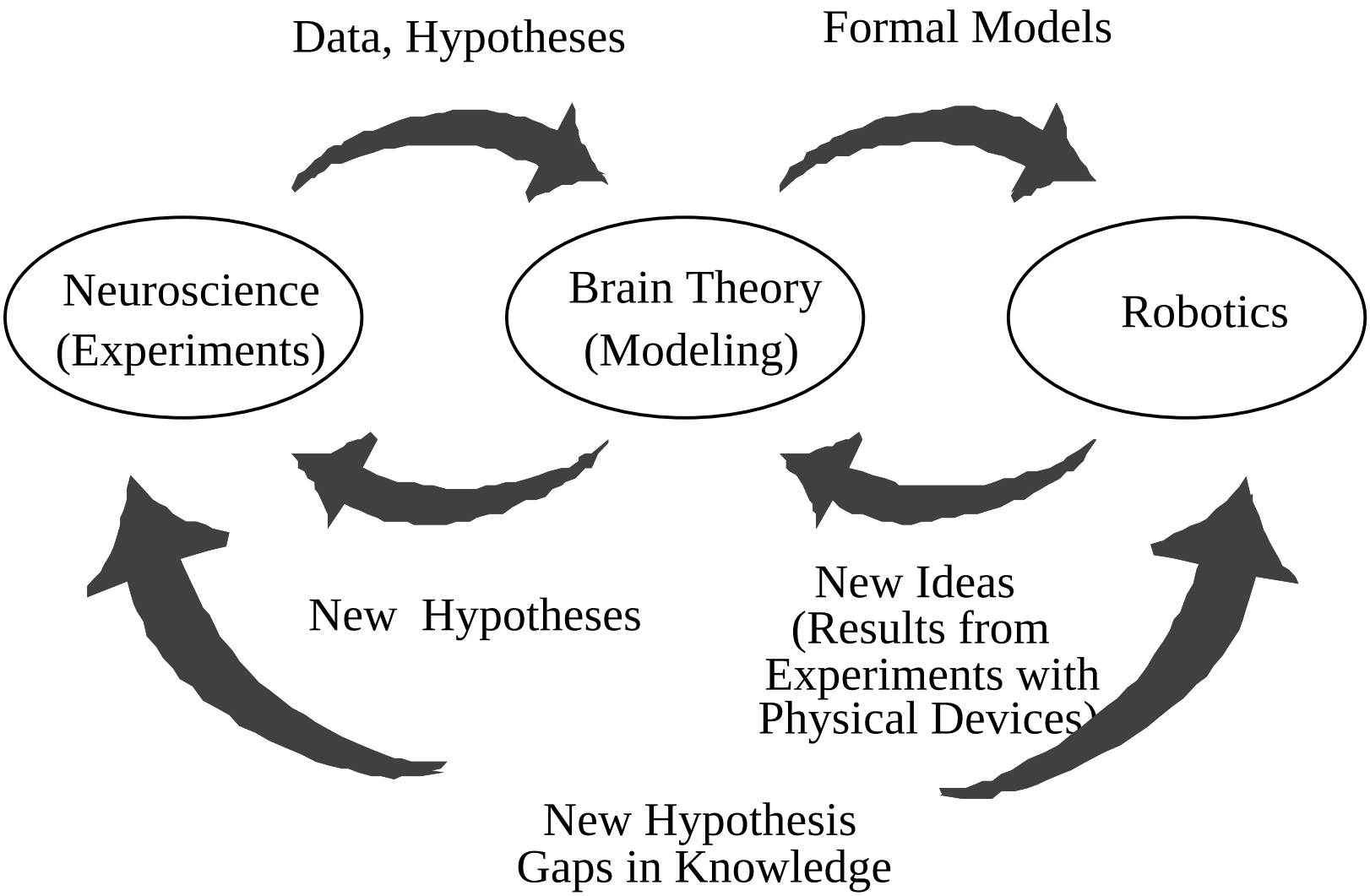
Objective

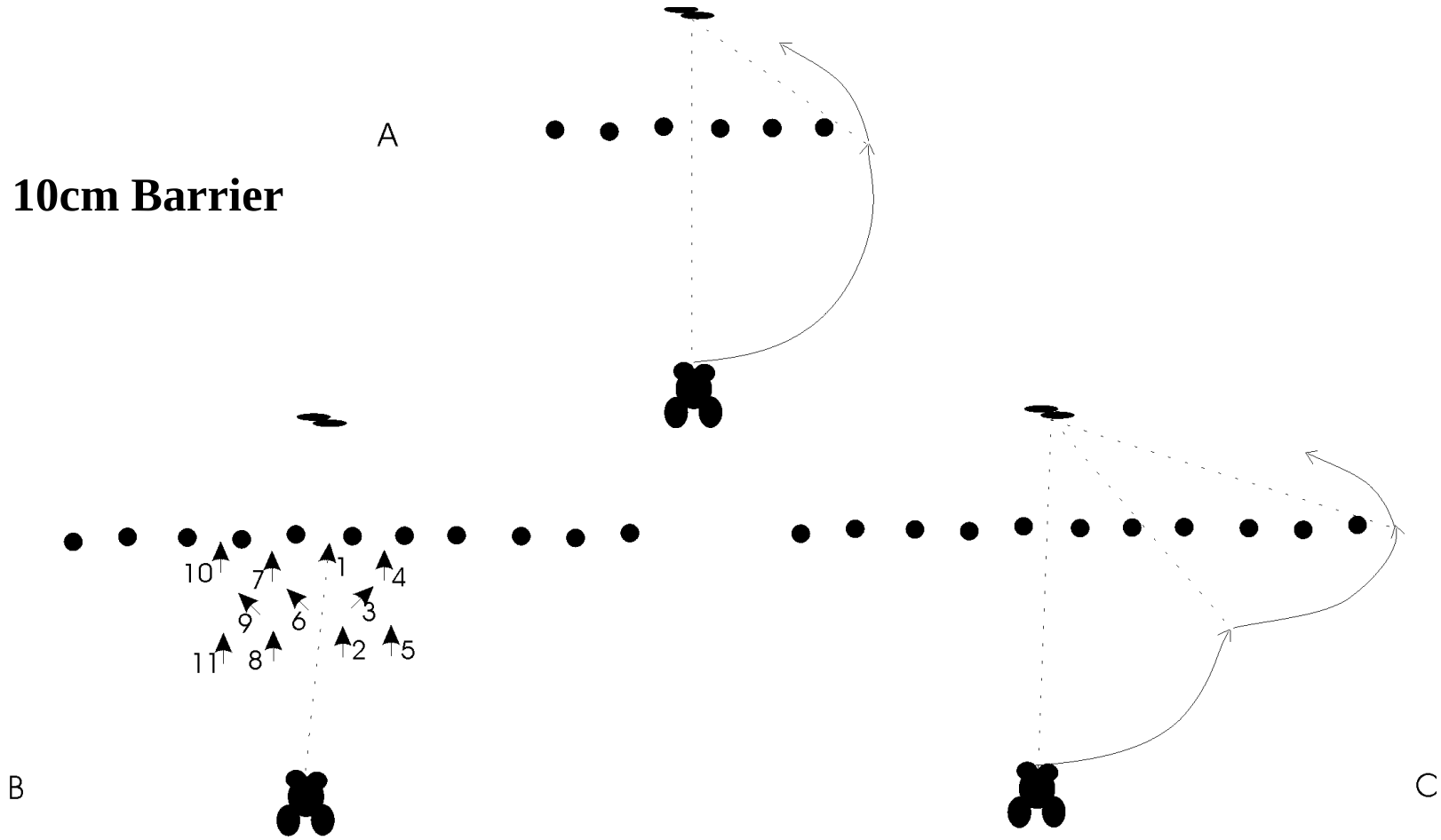
Develop an Internet2 virtual laboratory for real time monitoring of visually guided mobile robots.



Background: Neuroscience Research Cycle

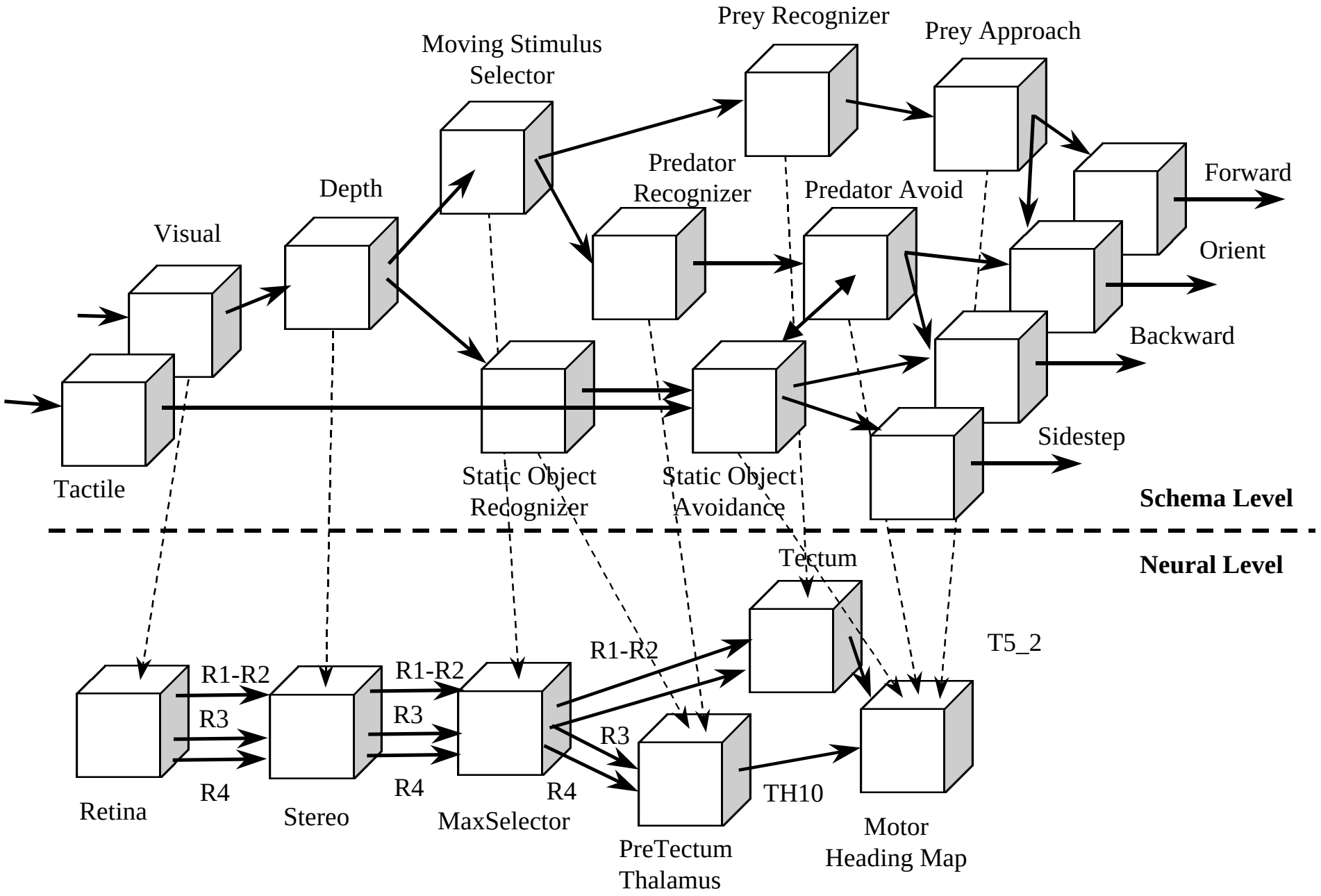


Background: Toad Prey Acquisition with Detour Behavior Before and After Learning [Corbacho and Arbib 1995]



20cm Barrier Before learning **20cm Barrier After learning**

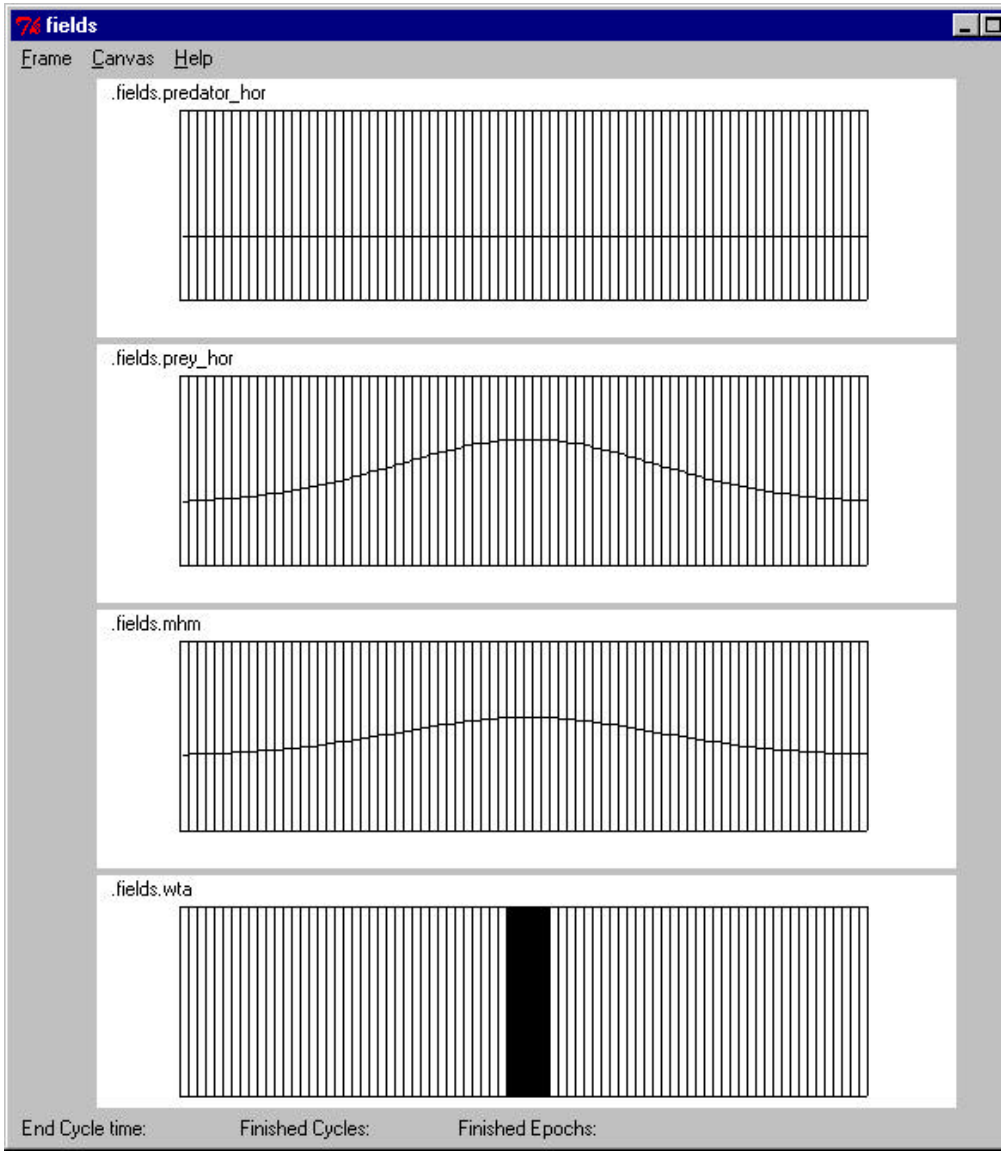
Background: Toad Schematics



Background: Prey Acquisition

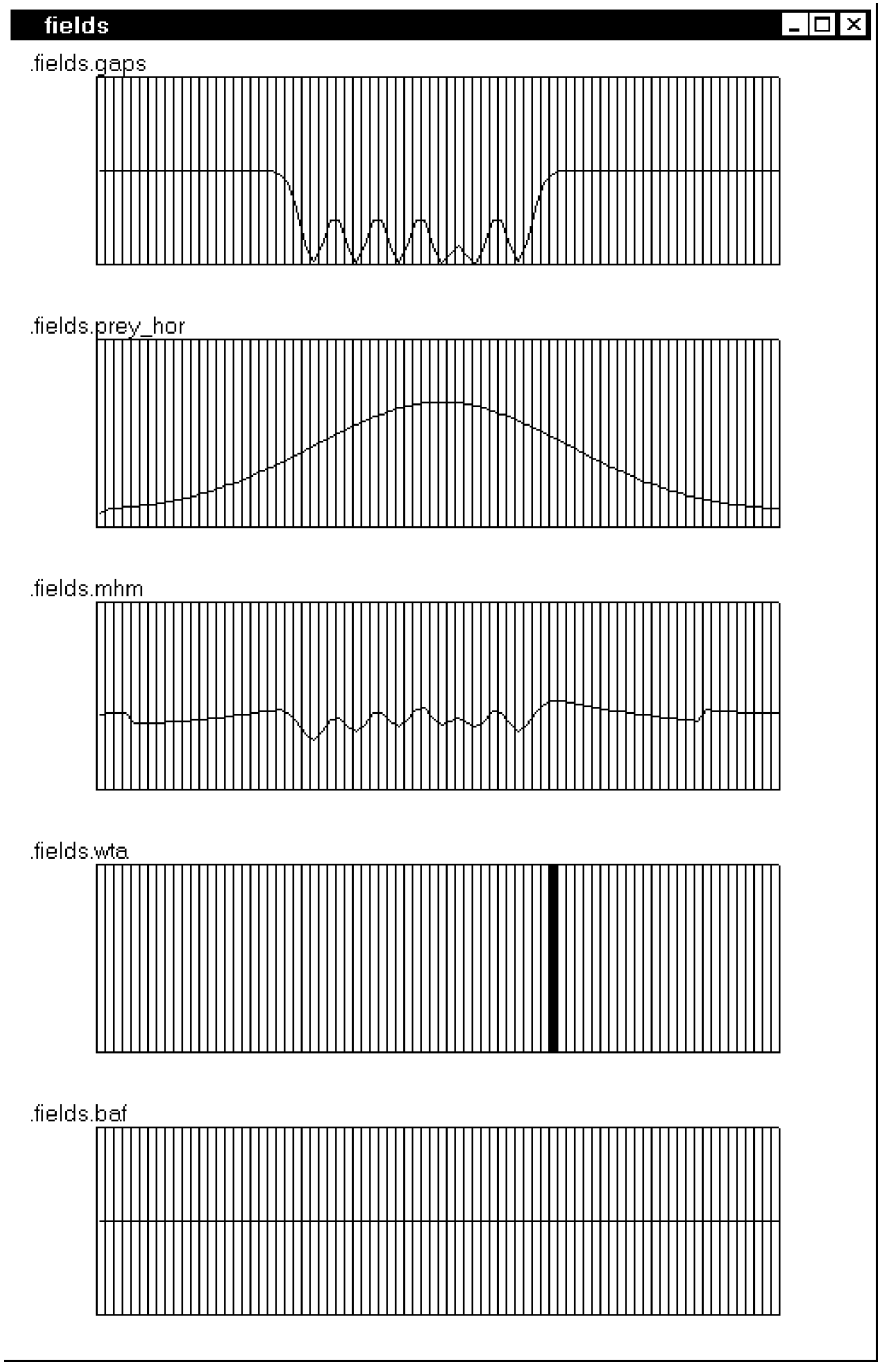
Visual Fields

- Predator (PreTectum)
- Prey (Tectum)
- Integrated (MHM)
- Heading (MHM)



Background: Prey Acquisition
(10 cm Barrier)

- Barrier (PreTectum)
- Prey (Tectum)
- Integrated (MHM)
- Heading (MHM)
- Tectile



Background: Prey Acquisition
(20 cm barrier before bumping)

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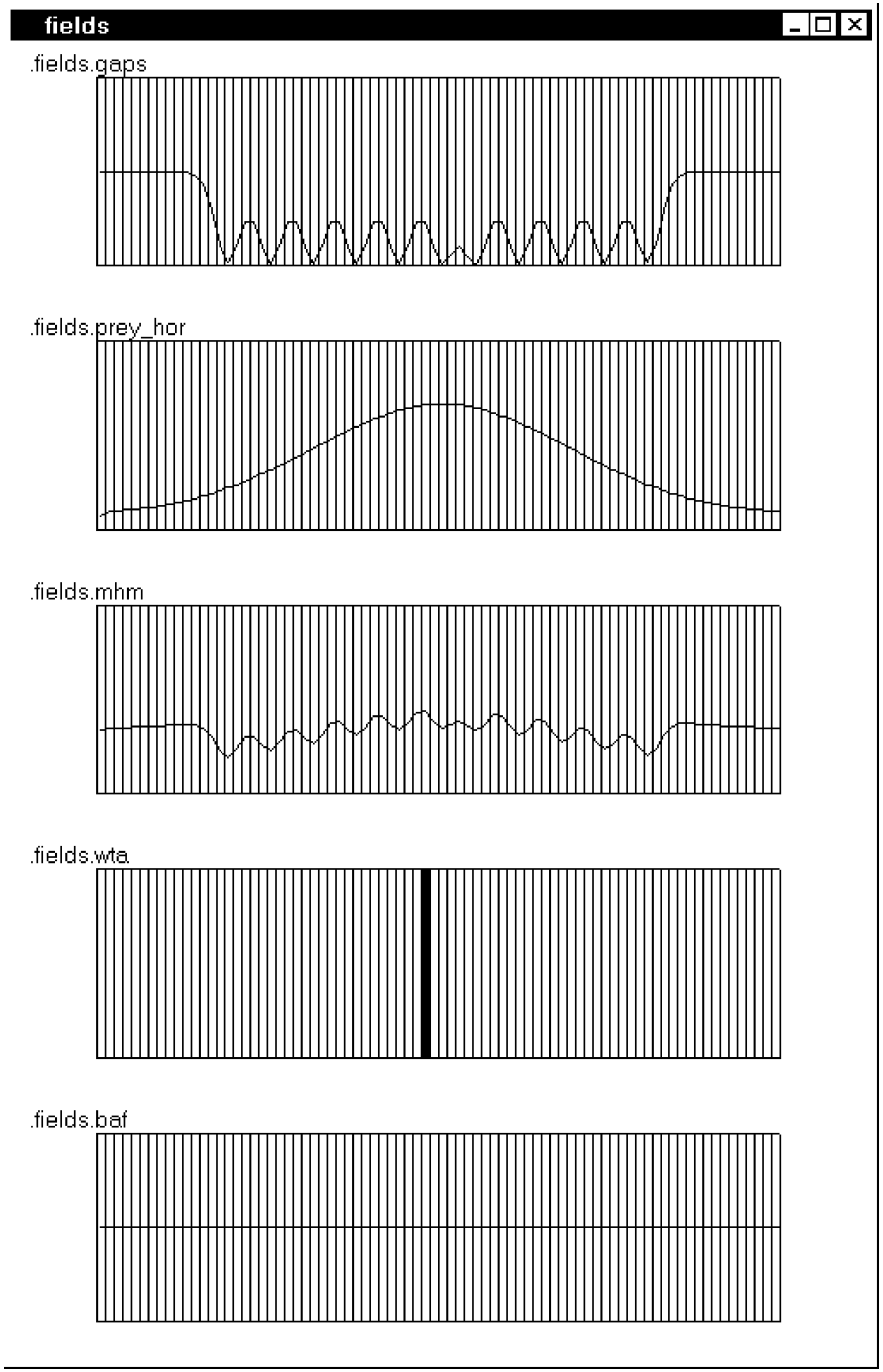

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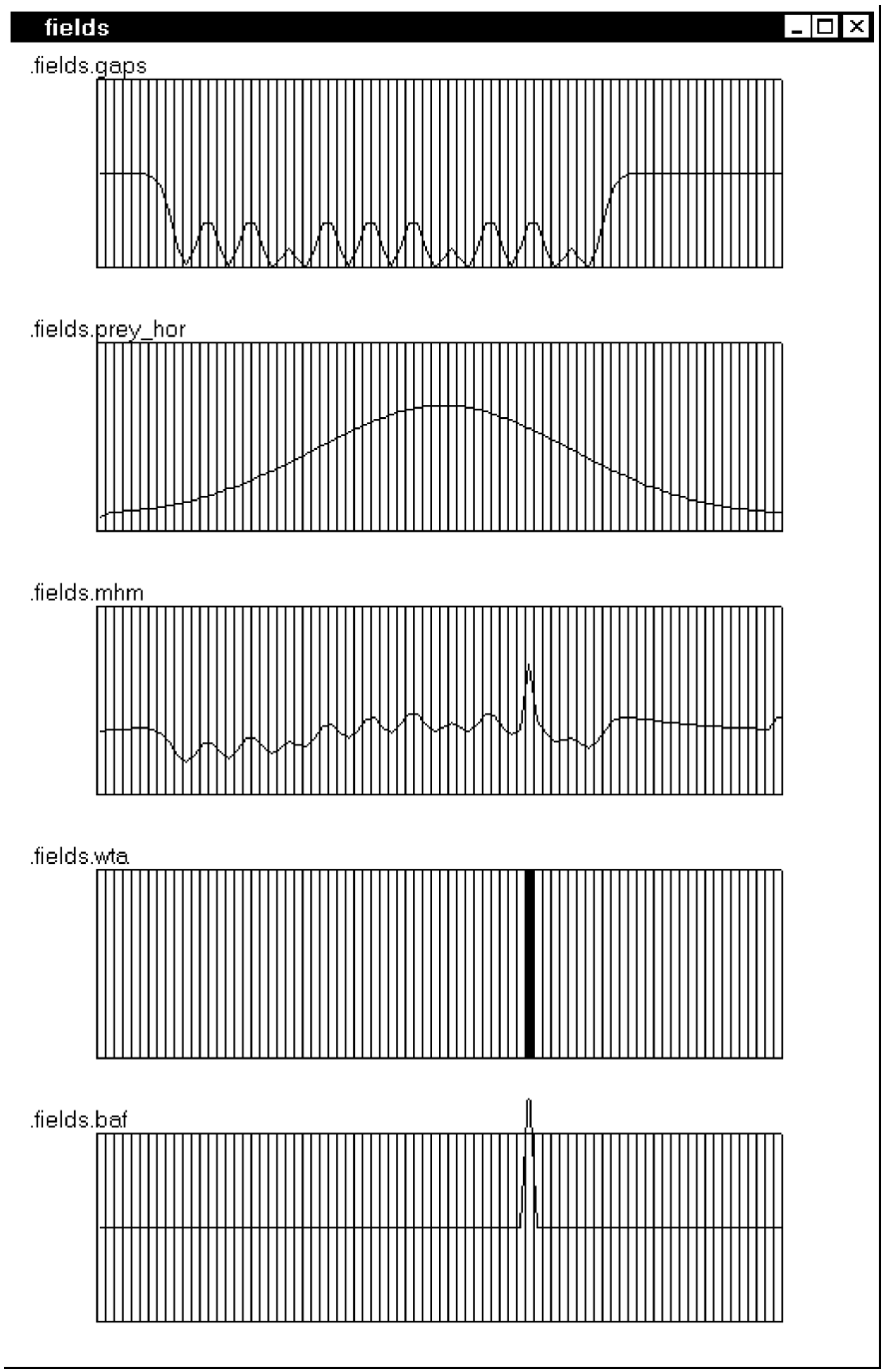

Background: Prey Acquisition
(20 cm barrier after learning)

- Barrier (PreTectum)
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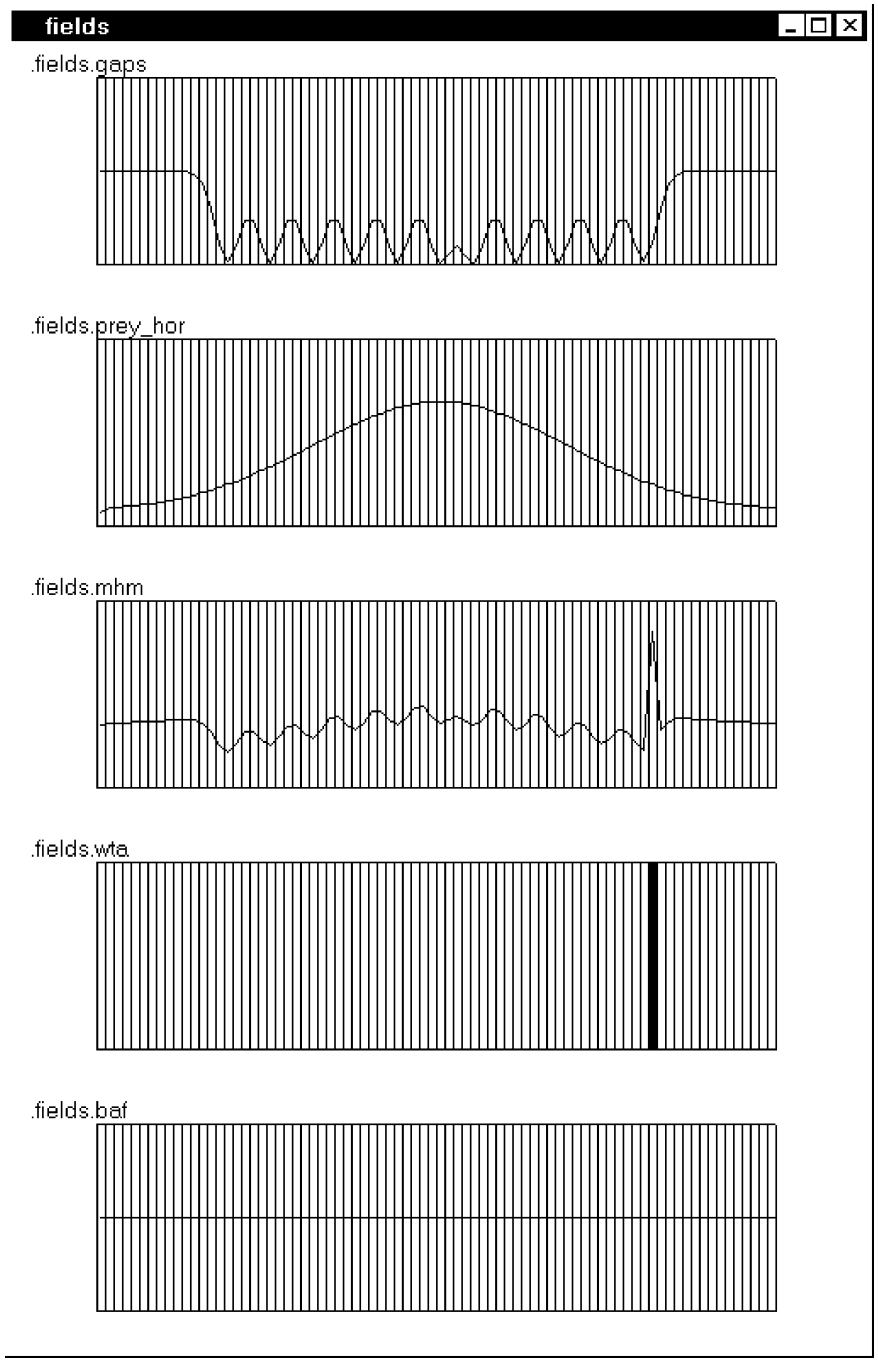
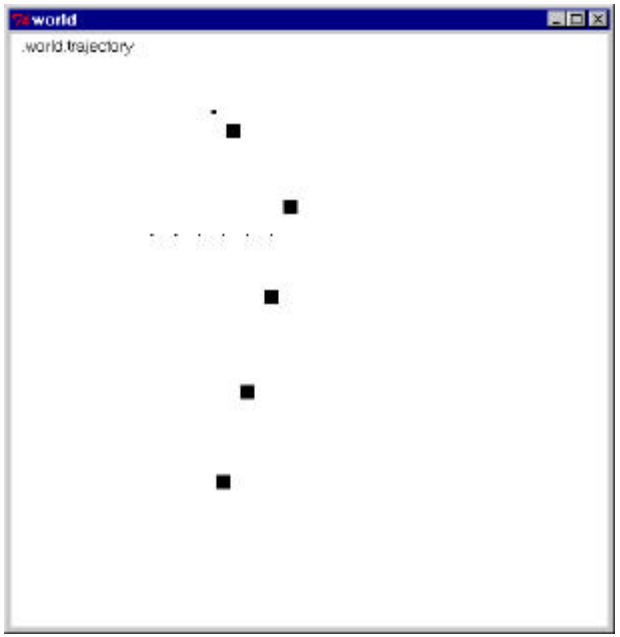
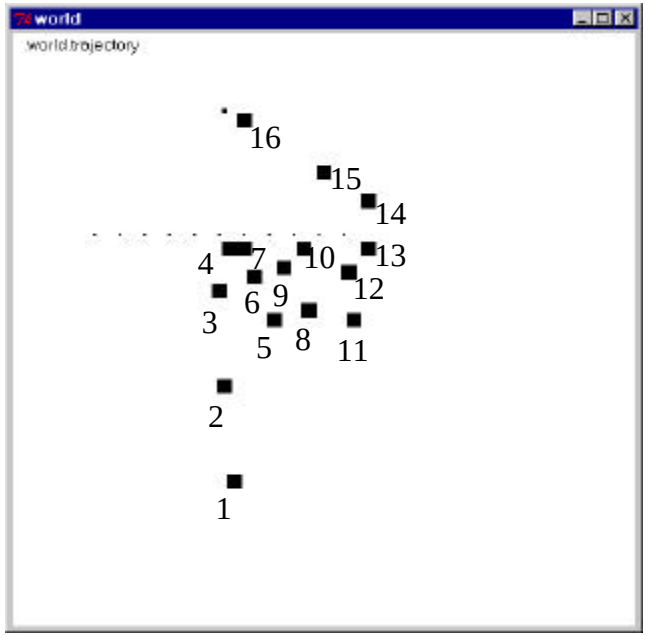
- Integrated (MHM)
- Heading (MHM)
- Tactile



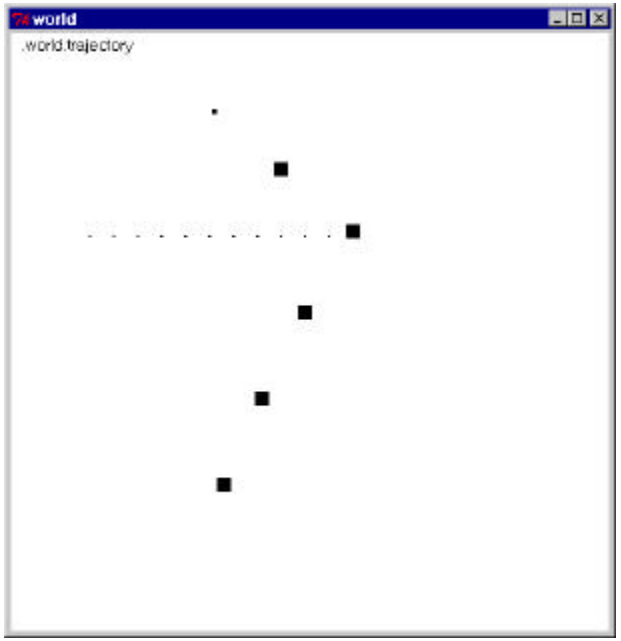
Background: Simulation Results



10cm barrier



20cm barrier
Before learning



20cm barrier
After learning

Neural/Robotic Issues

Problem1: Simulated models simplify interaction with environment.

Solution1: Experiment with real robots with real cameras.

Problem2: Robotic hardware can be very expensive, with limited processing and hard to program.

Solution2: Develop “embedded” architecture where inexpensive small robots communicate (wireless) with remote computational resources.

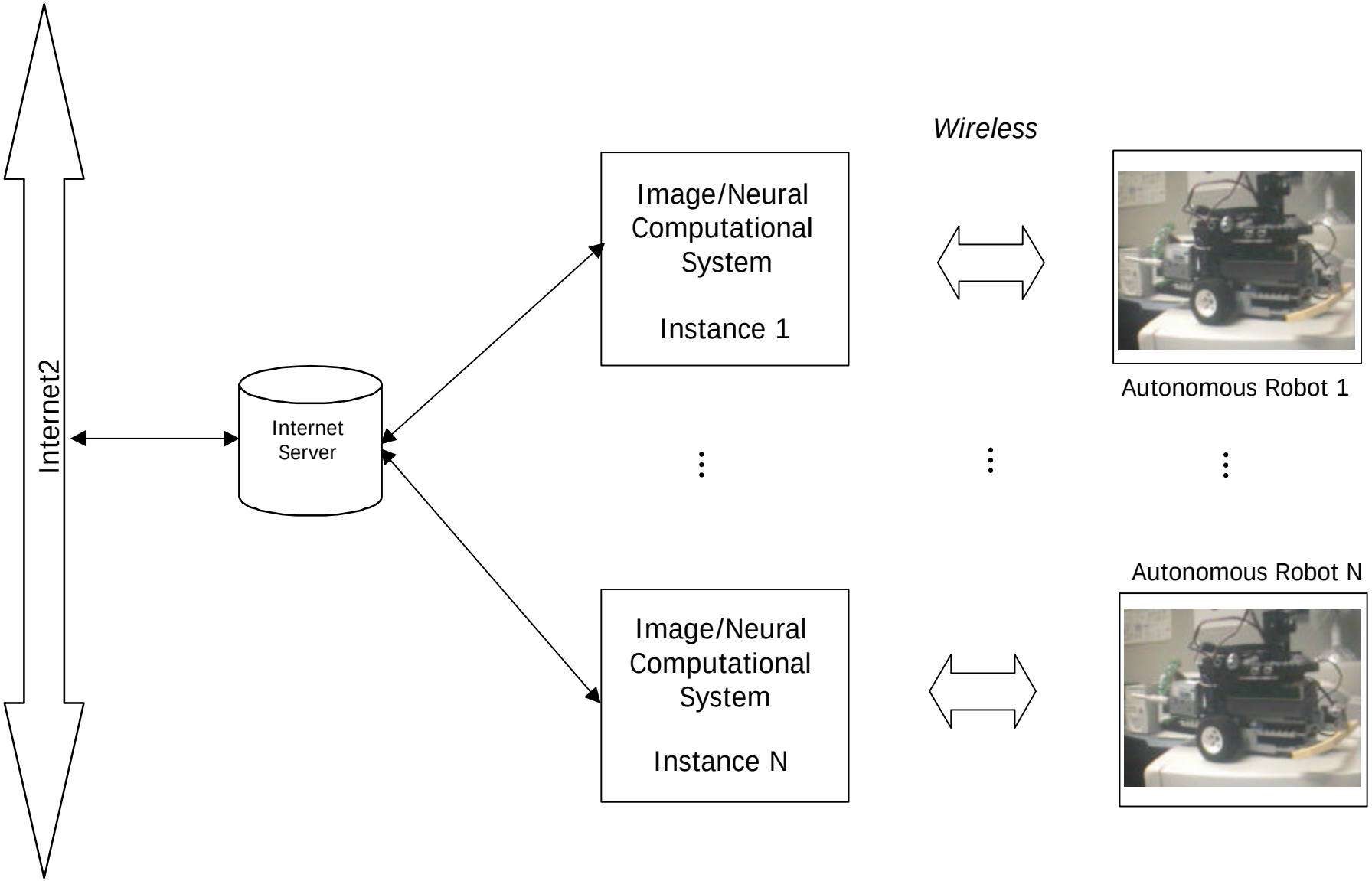
Problem3: Neural processing cycles can take seconds to minutes.

Solution3: Distribute neural processes between multiple computers.

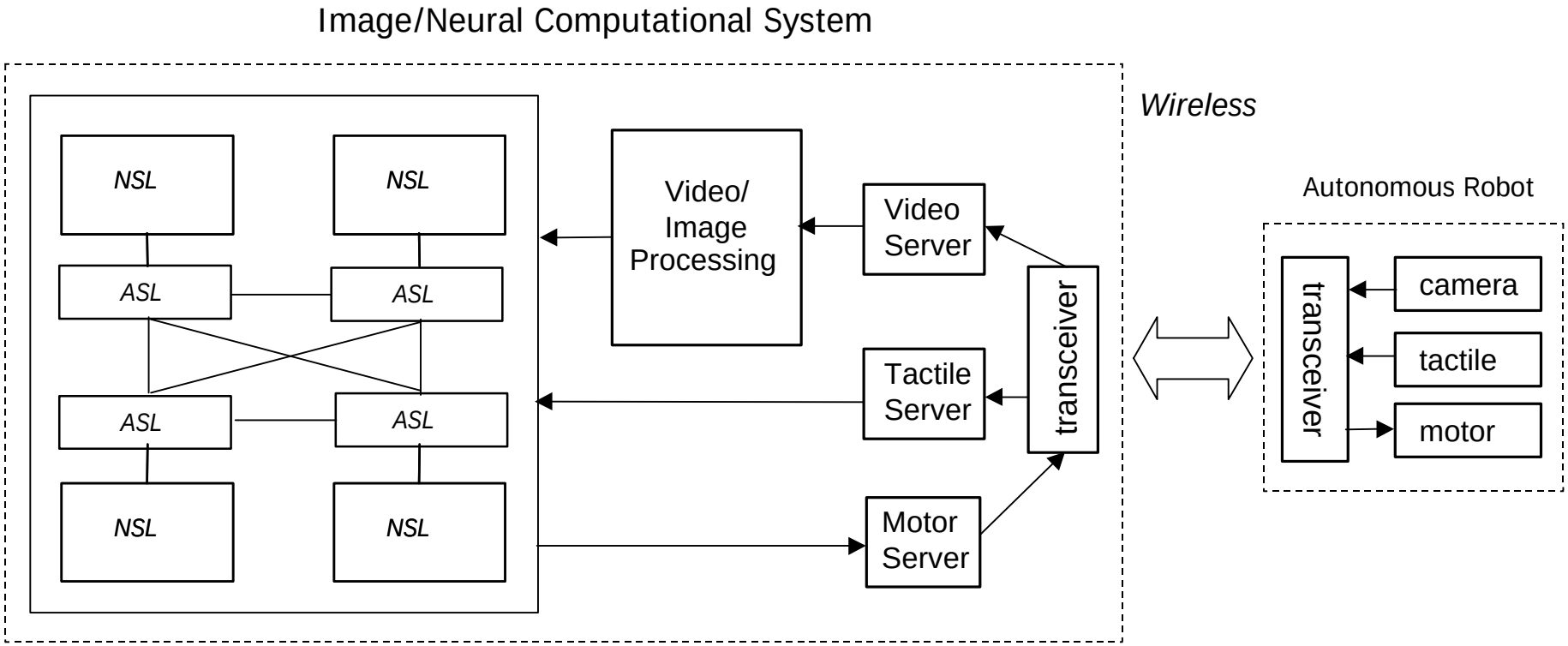
Problem4: Robotic experimentation requires external as well as internal model evaluation.

Solution4: Visualize and interact in real time with robots via Internet2.

Distributed Embedded Robotic Architecture



Distributed Embedded Robotic Architecture Detailed



Communication Issues

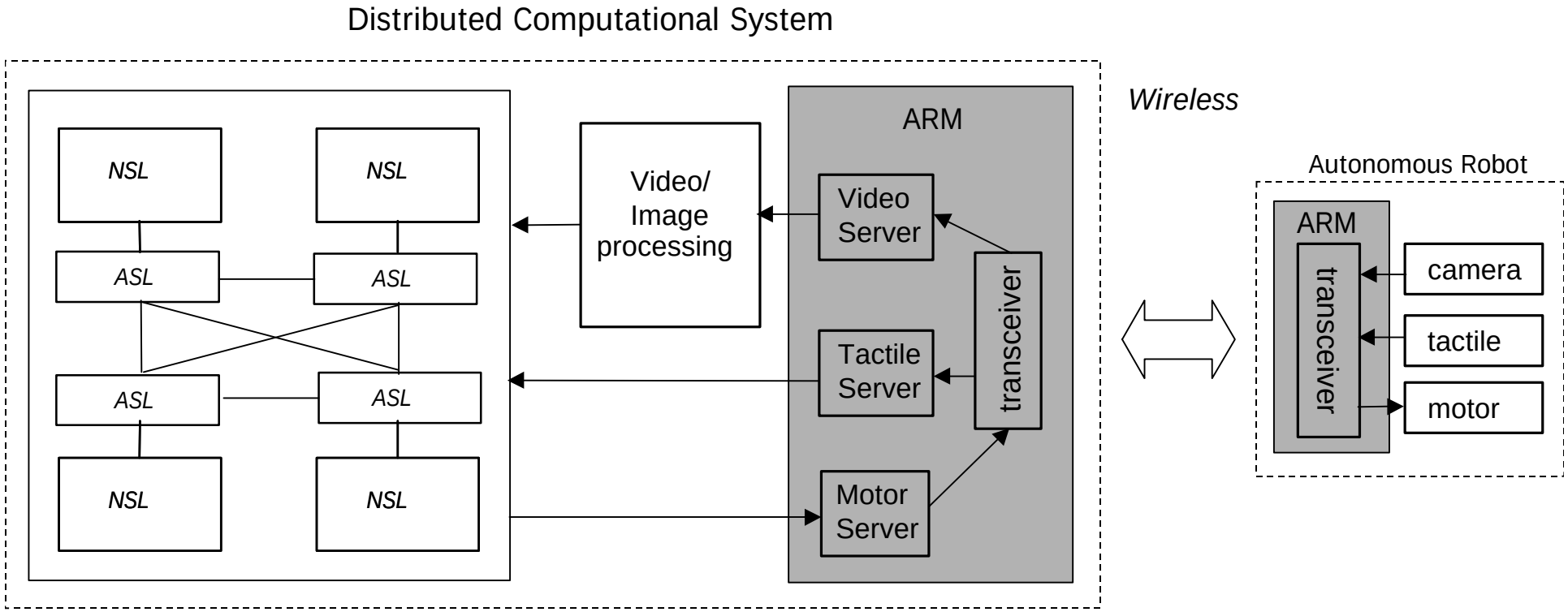
Problem5: Wireless communication conditions (bandwidth, reliability, protocols, security, etc.) dynamically change affecting robot performance.

Solution5: Incorporate adaptive middleware managing robot in response to varying network conditions.

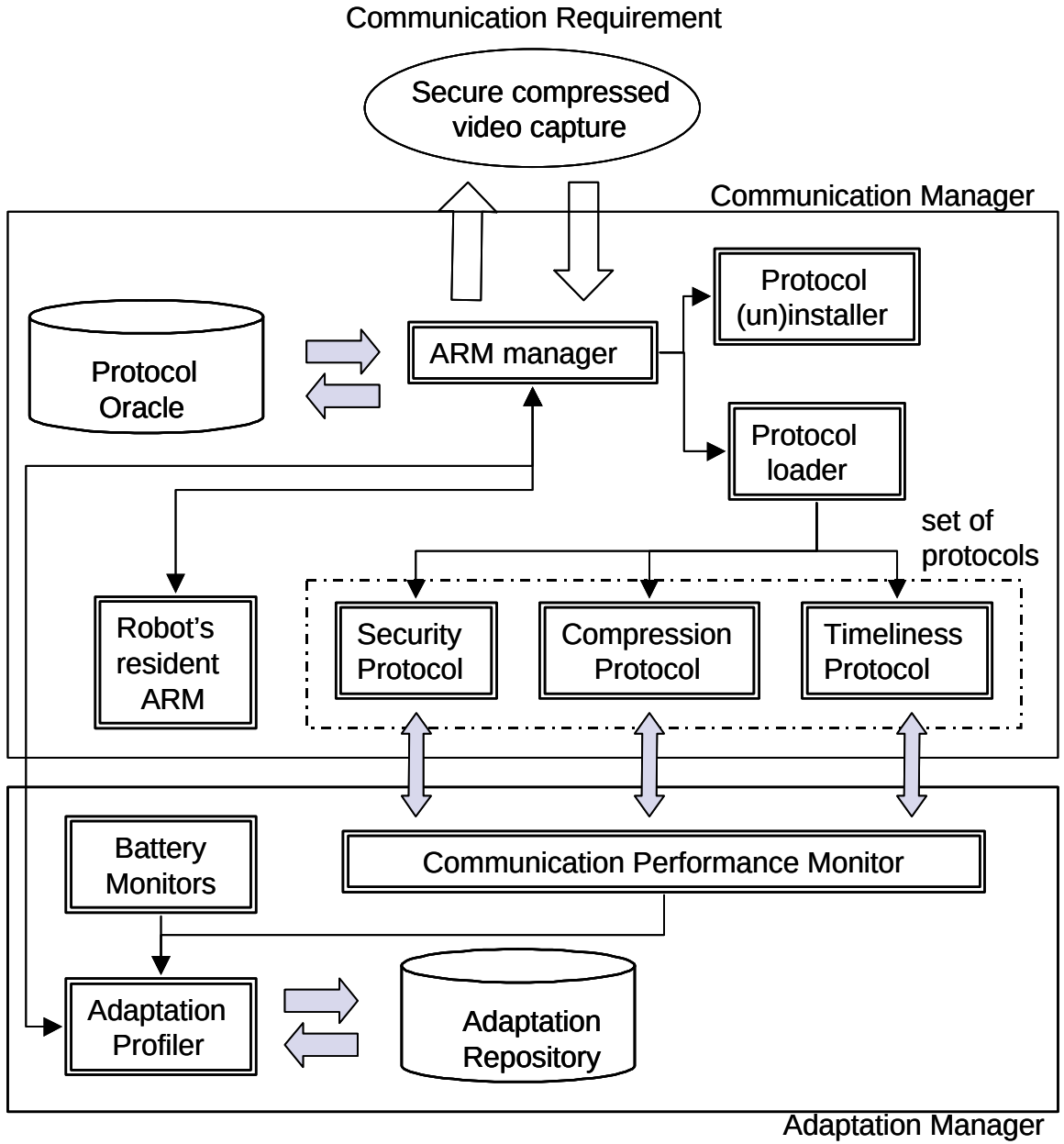
Problem6: Battery usage is a major concern in mobile robots.

Solution6: Add battery monitoring capabilities to adaptive middleware together with mechanisms to optimize resource management.

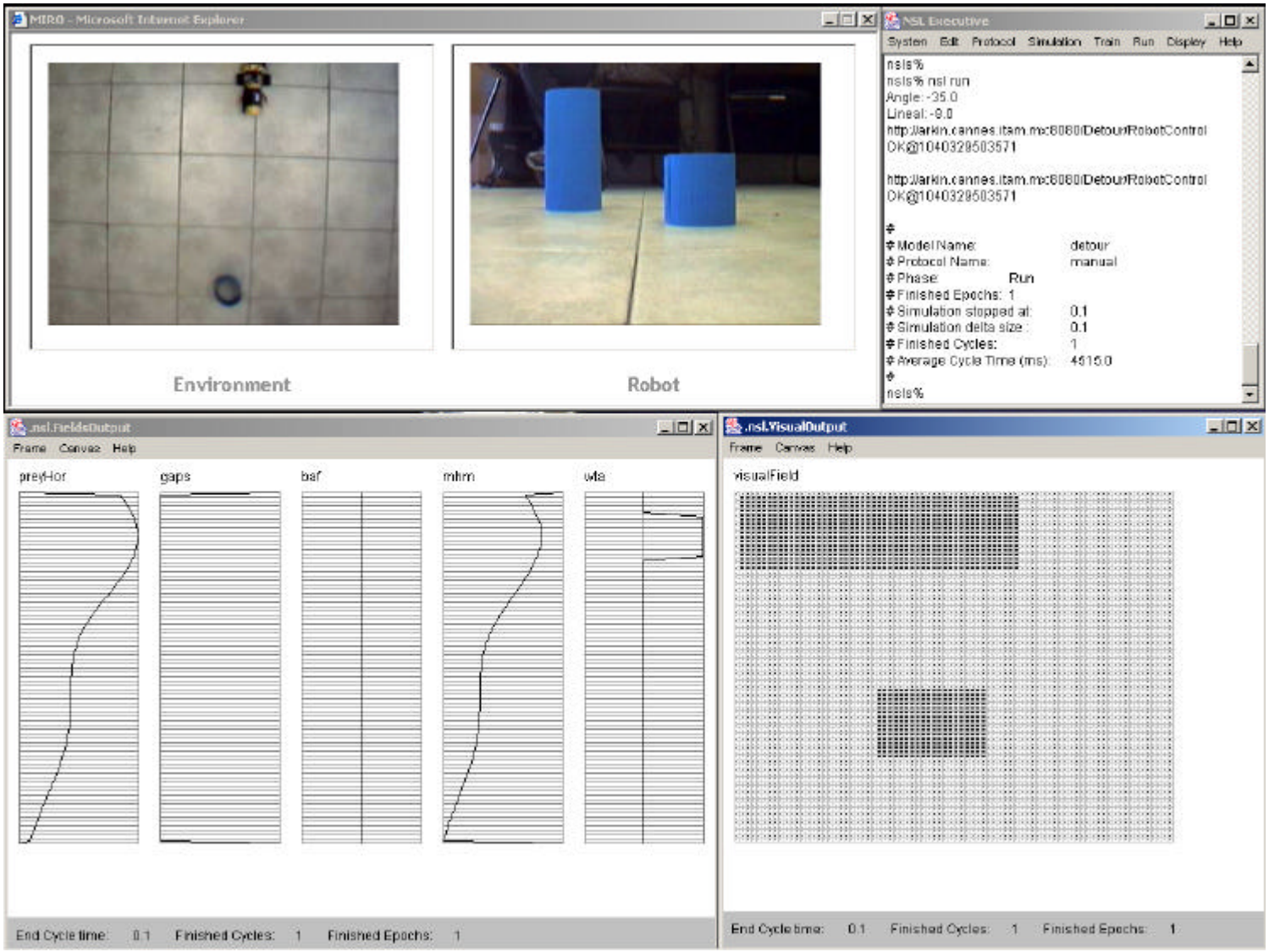
Distributed Embedded Robotic Architecture
Adaptive Robot Middleware (ARM)



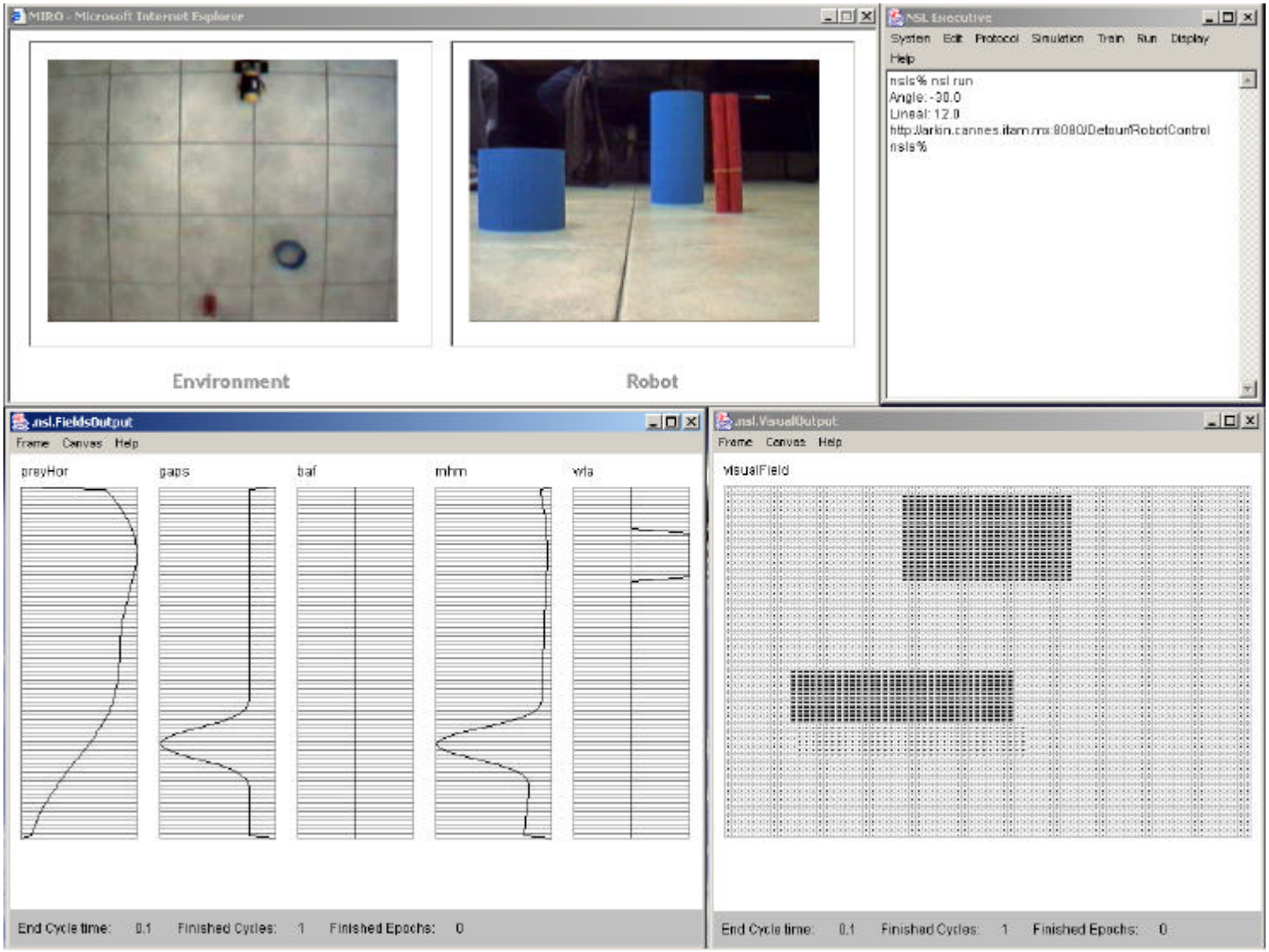
Adaptive Robot Middleware (ARM) Detailed



Experimental Results
2 Preys



Experimental Results
2 Preys & Predator



Progress

- Developed initial MIRO architecture with linkage to Internet based NSL simulation system and wireless control of robot and camera.
- Experimented with single robot tasks (prey acquisition, predator avoidance, detour)
- Developed initial middleware prototype with monitoring capabilities.
- Developing neural simulator distributed version (NSL Java).
- Developing middleware adaptation capabilities.
- Building new robot hardware (OOPIC & PC/104).
- Extending to multiple robots and tasks.

Conclusions

- Internet2 robot laboratories let remote users experiment with remote and sometimes expensive hardware resources.
- Embedded Internet2 robot architectures require efficient handling of communication and processing in supporting real time tasks and monitoring.
- Adaptive middleware is crucial in supporting real time performance and managing varying network and robot conditions (battery).
- MIRO can be used in other “non-biological” robotic applications taking advantage of pervasive Internet linkage.