Flexible, Portable Robotic Brains/Heads

Artur M. Arsenio

Artificial Intelligence Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts 02139

http://www.ai.mit.edu

The Problem: This research derives from the evolution of the M4, a dog-like robot, to the M2-Macaco project, a primate-like mobile robot in joint development with the MIT Leg Lab. It consists of the development of a portable and flexible robotic brain/head which both fits a quadruped and a bipede automaton. Merging social competencies with navigation capabilities requires an architecture that integrates all the modules. Furthermore, it must incorporate a vision system that allows for real-time interpretation of its surroundings.

Motivation: The design of flexible robotic creatures reduces the cost of development, increases the range of applications for the device, and improves the assemblage process with other robotic devices. Indeed, a carefully design mechanism may be *transformed* both aesthetically and functionally, inasmuch flexibility is implemented at all levels: mechanical, hardware and software.

Another issue is portability of both the mechanical device and its brain. Thus, besides having a small weight, the robotic head was also equiped with small and light hardware consisting of five CPU modules, framegrabbers, network communications and a Inertial Sensor.

Several vision modules must also be accessible to each other and concurrent with other sensor input from the rest of the body, with different abstraction levels, for increased flexibility.

Previous Work: There has been much machine vision work done involving many of the different visual modules. However, most of this work has been applied to slow or stationary unintegrated systems with less complex motility requirements. We will adapt as much of this previous work to our system as is feasible. Most of the visual modules have already been developed and are being integrated with the stabilization and motor control algorithms.

Macaco mechanical head designs and manufacture is currently concluded (see Figure). The robot's aesthetic ressemble's either a dog's head or a primate's head, but it may also ressemble other animal heads by switching just a few parts. The hardware arquitecture and networking were also finalized. The hardware integrates two PC104-plus compact all-in-one modules with a AMD k6-2 CPU at 400MHz, as well as three half-size all-in-one compact modules with PentiumIII at 600MHz.

Approach: The Macaco head was created with flexibility in mind: flexible design, manufacture and assembly; and aesthetic flexibility on ressemblance with different creatures. The brain for this robotic head consist of a flexible arquitecture that integrates the people interaction and functional navigation modules. The systems being developed include an updated version of a Visual Attention mechanism, with several vision modules computing the basic features; Releasers from body sensors, that consist primarly on modulation signals from inertial sensors and force sensors on the legs; Motivation drives, to embbed personality into the creature, which includes curiosity, social interaction preferences and an instinct for self-preservation; Competing behaviors, with embedded plasticity to combine or generate new behaviors; and a stereo vision system to support navigation.

Impact: The development of mobile robots which are embodied and situated in the world [2] requires portable systems, with high processing capabilities and real-time assessment of the surrounding environment. This compact mechanical and hardware design was achieved in Macaco. Furthermore, robot aesthetics is becoming increasingly important for the implementation of social competencies that facilitate learning, [1]. Thus, flexible robots may ressemble different creatures, turning down developing costs.

In addition, vision-guided robots with a modular software arquitecture should be able to engage in a wide spectrum of environments. Such a comprehensive vision system that is integrated with other sensory systems has far reaching implications- from the study of intelligence to industrial applications. Macaco may be also segued to

Figure 1: Macaco: the dog-like (left) and primate-like (right) robotic heads. The mechanical design was carried on CAD tools, and the primate-like face was built through a Dura-forming process.

the toy and service sectors.

Future Work: The software architecture is currently being finalized. It may also be possible to implement learning strategies to enhance the robot's flexibility and a speech recognizer/synthetizer system. Since a thermal camera was already added to the robot, it will be used to facilitate person and obstacle detection and enabling night vision.

The last step will be finally the assembly/integration of the primate-like head with the bipedal robot M2 being developed at the LegLab.

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References:

[1] C. Breazeal. Sociable machines: Expressive social exchange between humans and robots. Technical report, Doctoral Dissertation, EECS-MIT, 2000.

[2] R. Brooks. *Cambrian Intelligence.* MIT Press, 1999.