Macaco - Merging Social and Navigation Behaviors into a Head

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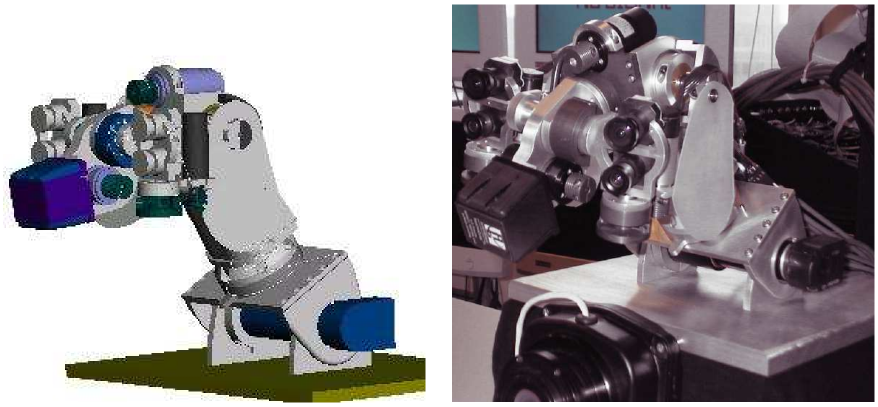
The Problem: This research derives from the evolution of the Macaco project - head and brain development for a mobile robot in joint collaboration with the MIT Leg Lab. Macaco is a 7DOF small and light robotic head, with four color CMOS cameras and one thermal camera. This head will be incorporated into a moving body. The merging of social competencies with navigation capabilities requires an architecture that integrates all the modules coherently, such that Macaco is given a personality demarcated by curiosity and a wish of interacting with people, together with a strong instinct for safety.

Motivation: One approach of AI is the development of robots whose embodiment and situatedness in the world evoke behaviors that obviate constant human supervision [2]. With this in mind, Macaco was designed for navigation in unstructured environments. Thus, its vision system must comprise methods of assessing the constantly changing terrain. Navigation for obstacle and potentially treacherous landscape avoidance, slope detection, and gaze stabilization are all requisites for such competence. Furthermore, in order to be a convincing social participant, the vision system must also allow for person detection and inference of human gaze direction. All of these vision modules must also be accessible to each other and concurrent with other sensor input from the rest of the body.

Previous Work: There has been much machine vision work done involving the many 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, such as elements of vergence and object tracking [3]. Furthermore, we will integrate formerly tested stabilization and motor control algorithms. Currently we have initial original versions of the face detection and gaze stabilization algorithms and a working motion tracking algorithm. Macaco head design and manufacture is currently concluded (see Figure). The robot's aesthetic ressemble's a dog's head, but it may also ressemble other animal heads (including ape/humans) by switching just one part (out of the 48 mechanical parts). The hardware arquitecture and networking were also finalized.



Macaco - a robotic head

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.

Difficulty: There is inherent difficulty in the formulation of each of the algorithms- each one being a full-time endeavor in itself. The integration of all these models also pose challenging problems. Especially as Macaco moves in the environment, image data is quickly changing in terms of relative perspective derived from the movement as well as from the traversed terrain. Normalization of the proprioceptive motion over a spectrum of speeds and actions will be necessary for veridical environment assessment.

Impact: Such a comprehensive vision system that is integrated with other sensory systems has far reaching implications- from the study of intelligence to industrial applications. Such vision-guided robots will be able to engage in any environment. Specifically, Macaco may be used for land mine searches, surveillance, and in other situations that may be too risky for humans. Once equipped with robotic legs, Macaco might be used to infer safe navigation directions or even to extract information that would allow the legs to overcome obstacles. In addition, Macaco may be segued to the toy and service sectors.

Future Work: With the robot fully assembled, the next step is to develop the software architecture. Some of the vision algorithms for people interaction need also to be developed, as well as most of the navigation algorithms. The vision system should be made adaptable to increased agility, speed, and sensor acquisition of the robot. It may also be possible to implement learning strategies to enhance this flexibility. In addition, a thermal camera was already added to the robot, facilitating person and obstacle detection and enabling night vision.

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References:

[1] C. Breazeal. Sociable Machines: Expressive Social Exchange Between Humans and Robots" Doctoral Dissertation, EECS-MIT, 2000.

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

[3] A. Bernardino and J. Santos-Victor. Visual behaviors for binocular tracking. *Robotics and Autonomous Systems*, 1998.

[4] J. Velsquez. Modeling Emotion-Based Decision-Making AAAI Fall Symposium, Orlando, AAAI Press, 1998.