Cognitive Robotics: A Multi-Level Approach

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Abstract

The robotics and biorobotics (CANNES) laboratories at ITAM have been focusing in the development of cognitive robotics systems inspired in individual and multiple animal behaviors to enable the development of more "ecological" robotic systems capable of adapting to their environment while keeping interaction with humans in achieving their goals. Our current research thrusts in achieving these goals:

Human-Robot Interaction - Ideally, research in Human-Robot Interaction (HRI) will allow natural, ergonomic, and optimal communication and cooperation between humans and robotic systems. In order to make progress in this direction, we have identified two major requirements: First, we are studying real robotics environments where technologists and researchers have already developed an extensive experience and set of needs with respect to HRI. Second, we are studying a domain independent language processing system that has psychological validity, and that can be mapped onto arbitrary domains. In response to the first requirement regarding the robotic context, we have been studying human interaction in the context of robot soccer coaching. From the psychologically valid language context, we are studying a model of language and meaning correspondence describing both neurological and behavioral aspects of human language, being deployed in robotic contexts (Weitzenfeld & Dominey, 2007).

Robot Rescue – In recent years robots have demonstrated their usefulness in supporting life-threatening human tasks. Among these, Urban Search and Rescue (USAR) has been an area where robotics is starting to have an important impact. In particular, as a result of earthquakes or other collapsed building disasters, one of the most important tasks involves search and rescue of trapped survivors. The main challenges in rescue operations are posed by the unstable nature of the structures, the hard to reach spaces, the lack of oxygen, and the hazards resulting from fire, toxic gases, or other chemicals. In the past, specialized sensory equipment has been used in assisting rescuers, yet most of this technology is used from outside the disaster perimeter. In order to get closer to survivors, scientists are currently experimenting with mobile robots with varying shapes, sizes and capabilities. The robots will become more autonomous with time, interacting only with human controllers for higher-level decisions making. For this purpose we are developing ad-hoc networking models to enable groups of autonomous robotic systems to communicate in disruptive environments (Obraczka et al., 2007).

Biologically-inspired Robotics – Biology can provide an important source of inspiration to robotic systems. This inspiration can come from "simpler" animals all the way to humans beings. Biological systems can provide insights into many different aspects such as learning and memory in rats (Barrera & Weitzenfeld 2007), learning and adaptation in frogs and

toads (Weitzenfeld 2007a), and prey catching and predator avoidance in single and multiple animals such as wolf packs (Weitzenfeld 2007b). These models will eventually provide a more in-depth understanding of animal brain processing and eventually of human cognitive systems.

Multi-Robot Systems – Complex group behaviors may emerge from the actions taken by the individual members of the group influenced by their goals, local information from their immediate surroundings, and global information gathered from their environment. In nature, we observe these patterns in many kinds of groups: fish swim in schools, wolfs hunt in packs, and sheep move in herds steered by trained dogs. We investigate how to plan motions for groups by integrating individual decisions with adaptive environmental roadmaps. We keep local information in individuals, and global information in environment roadmaps that encode representative pathways for the individuals to follow. These roadmaps also allow the members of the group to store information that may be relevant at later times to themselves or to other members of the group. Then, individuals add to their individual decision taking process, the evaluation of global information found in the areas of the roadmaps they can reach. We can apply these techniques to simulate group coordination of groups in natures, or to coordinate agents exploring an area, or robotic soccer players (Morales et al. 2004, Bayazit et al. 2005).

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