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Cognitively Intelligent Models for Human-Robot Interaction with MIRob

Moratuwa Intelligent Robot, shortened as MIRob, is the first successful outcome of the research conducted by the Intelligent Service Robotics Group (ISRG) of the Department of Electrical Engineering-UoM. The tremendous effort of a team of Masters, MPhil and PhD students made MIRob project a success. Chapa Sirithunge is the most recent graduate from the team, who recently defended her PhD with the Intelligent Service Robotics Group. Her research: Framework for Adaptive Human-Robot Interaction Initiation for Domestic Environments, was supervised by Prof. Buddhika Jayasekara, lead of the group.

This research explores how a robot should gather knowledge upon a scenario between a robot and its user and then generate appropriate intelligent responses towards its user. Therefore, cognitive models were developed to act as a robot's intelligence or the brain to make situation-specific decisions. Such insightful decisions will help the robot act in a social environment without disturbing its user or other humans around.

Intelligent robot companions contribute significantly to improve living standards in the modern society. Therefore human-like decision-making skills and perception are sought after during the design of such robots. On one hand, such features enable a robot to be easily handled by a non-expert human user. On the other hand, the robot will have the capability of dealing with humans without causing any disturbance by its behavior. Mimicking human emotional intelligence is one of the best and reasonable ways of laying the foundation for such an emotional intelligence in robots. As robots are widely deployed in social environments today, perception of the situation or the intentions of a user should be identified prior to an interaction. Proactive, social robots are required to understand what is communicated by the human body language before approaching a human. Social con-

straints in an interaction could be demolished by this assessment.

Chapa's thesis addressed the problem of perceiving nonverbals in human behavior and fusing human-environment semantic representations with a robot's cognition before interacting with humans. The novelty lies in laying the background to relate nonverbal human behavior and the features of the environment to generate context-aware interactive responses during robot-initiated interaction. That informs the robot about its environment. Toward this end, she introduced novel methods of perceiving human nonverbals and spatial factors in the environment which make up a context. Chapa and the team integrated that knowledge to determine appropriate responses from a robot to assist its user. Visual information acquired by a vision sensor was analyzed, and the level of emotional engagement demanded by the user's nonverbals was evaluated, before a robot initiates an interac-

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tion. After such an analysis, a robot's conversational and proxemic behavior was adjusted to maintain an empathetic relationship between the user and the robot. These algorithms efficiently sustained the empathy between user and robot so that the interaction resembles human-human interaction to a larger extent. To assist the main problem, the research team formulated novel methods to recognize human nonverbals such as postures, gestures, hand poses, psychophysiological behavior of humans and humanactivities, and decode the emotional hints displayed to the outside world. In support of this work, the team conducted a series of human studies to explore the patterns in human behavior which could be perceived by a proactive robot using its cognitive capabilities. The team also introduced separate systems which can decode the sentiments of humans using observable cues based on accepted social norms. They detail the meanings of human nonverbals by observing human behavior over time and evaluating the context for any patterns in behavior. Ambiguities in human behavior and random, meaningless behaviors could be omitted through this approach. This approach further omits the negative effect of human responses that can be faked, such as facial expressions and words. Finally, they introduced an adaptive approach towards robot-initiated human-robot interaction by letting a robot observe a context and generate responses while changing its responses continuously as human behavior changes. They first developed algorithms based on a limited number of observable human cues and decoded their sentiments based on modern psycho-physiological interpretations of human behavior. Next, they expanded such approaches towards multiple observable human cues. Finally, observations from the human and the environment which create the context during Human-Robot Interaction (HRI) were integrated.

Basic cognitive models of robot were developed with techniques such as fuzzy logic and Auto-regressive models etc. However, at a later stage deep learning and reinforcement learning techniques were deployed to train a robot coop well with the environment. The team created an artificial domestic environment with actual furniture and equipment for experiments with MIRob. A depth camera, microphone and a stereo vision camera have been used to acquire information from the environment in which the robot walks. MIRob was equipped with a navigation platform to walk around and map the environment and has a structure with a hand to manipulate objects. It further had a microphone and a speaker to communicate with people. Later MIRob has been improved with more sensors such as LIDAR sensors and advanced depth sensors to improve its cognitive capabilities and the perception of its surrounding.

A considerable amount of outstanding research articles was originated with MIRob including Chapa's thesis as well. With these improvements, at present several other students are working on improving locomotion and environment mapping of MIRob as a continuation of preexisted research.

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