Socially Constrained Management Of Power Resources For Social Mobile Robots

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ABSTRACT

Autonomous robots acting as companions or assistants in real social environments should be able to sustain and operate over an extended period of time. Generally, autonomous mobile robots draw power from batteries to operate various sensors, actuators and perform tasks. Batteries have a limited power life and take a long time to recharge via a power source, which may impede human-robot interaction and task performance. Thus, it is important for social robots to manage their energy, this paper discusses an approach to manage power resources on mobile robot with regard to social aspects for creating life-like autonomous social robots.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics

General Terms

Human Factors, Algorithms, Theory

Keywords

Robot Companions, Power Management, Social Constraints, Human-robot Interaction

1. INTRODUCTION

In order for robots to act as companions or assistants in social environments such as homes and offices, they should be capable of operating with a great degree of autonomy over a longer period of time. While acting as an artificial social being a robot still needs to fulfill its own physiological needs. Most autonomous mobile robots draw power from batteries and take a long time to recharge. While the recharge behaviour is active, the companion robot may be prevented from performing its normal tasks and this may hinder continuous human-robot interactions.

The robot should also be competent enough to regulate the use of its power resources when it has no active tasks in order to conserve battery. We believe that companion robots should behave in a socially intelligent manner[3] and perform life-like actions to be perceived as a social being. In this paper we present an approach to power management for mobile robots which has a human-like regulation system that can balance both its physiological and social needs.

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2. SCENARIO

The work reported here is carried out as a part of the EU project LIREC (LIving with Robots and IntEractive Companions), the project aims to create interactive, emotionally intelligent companions which are capable of establishing long-term relationships with humans in social environments. The "Spirit of the Building" showcase at the Heriot-Watt University, Edinburgh, aims to produce a social helper robot that can act as a "Team Buddy" an assistant within a lab inhabited by a group of people who work there and facilitate long-term relationships with users. The Team Buddy would perform tasks such as carrying the phone to users, giving out reminders, providing a lab tour for visitors, approaching and greeting users, maintaining a collective memory about user preferences such as lunch breaks and entry/exit time.

The robot (Pioneer P3AT) with an enhanced superstructure is equipped with a laptop PC, and with 6 lead acid batteries (12V, 7Ah each) offering an approximate operational time of 6 hours when fully charged (depending on usage). These batteries require about 8 hours to recharge. Considering this long recharge time and that the robot has to perform several tasks every day, there is an urgent need for a power management strategy. The robot is also equipped with electronic relays boards (controls the switching of sensors, actuators, laptop) and power sensors to measure power consumption on sensors, actuators and laptop.

3. APPROACH

The LIREC project has developed a three-level architecture in which the most abstract and top-most level reuses work from an earlier EU project[1]. FAtiMA-PSI is a body-mind architecture in the Physiological vs Cognitive dimension, where goals are originated from drives. FAtiMA is an extension of the BDI (Beliefs, Desires, Intentions) deliberative architecture [1], that incorporates a reactive component mainly responsible for emotional expressivity and it employs the OCC [5] emotional influences on the agent's decision making processes. FAtiMA architecture is integrated with PSI [4], is a psychologically-founded theory that incorporates all basic components of human action regulation such as perception, motivation, cognition, memory, learning and emotions in one model of the human psyche.

The goals in the overall architecture are derived from a set of basic drives that guide actions. Five basic drives from PSI include: Energy, Integrity, Affiliation, Certainty and Competence. Energy represents an overall need to preserve the

[1] www.e-circus.org/

existence of the robot. Integrity represents well being, i.e. the agent avoids pain or physical damage while affiliation is useful for social relationships. Certainty and competence influence cognitive processes and their values can be calculated automatically. Homeostasis is the main mechanism so that deviations from an upper and lower set point determine the strength of each need. Needs can emerge depending on activities of the robot or grow over time. To be able to produce actions that are able to satisfy needs in a certain situation, the robot builds up intentions that are stored in memory and are - when selected - the basis of a plan.

Each need has value ranging from 0 to 10, where 0 means complete deprivation while 10 means complete satisfaction. A weight ranging from 0 to 1 gives the importance of each need to the robot. In order to operate appropriately, the robot has to reduce a needs deviation from a fixed threshold as much as possible at all time. The strength of a need (Strength(d)) depends on its current strength plus the amount of deviation from the set point and the specific weight of the need

$$Strength(d) = Strength(d) + (Deviation(d) \times Weight(d))$$

By assigning appropriate weights for energy and affiliation (social) needs, robot has the ability to balance both its physiological and social needs. During the start of an interaction, the robot will have a set of initial values for all the needs. Based on the level of its current needs, the robot can generate intentions, that is, it activates goal(s) that are relevant to the perceived situation.

Each goal contains information about its expected contribution to energy, integrity and affiliation, that is, how much the drives may be deviated from or satisfied if the goal is performed. Based on this information, the importance of goal at a particular time instance can be determined, allowing the robot to give priority to goals that satisfy its needs under different situations.

For example, assume the robot has a task to give a reminder to a particular user in the lab, and that this goal can be achieved by Action A or Action B. Action A has a plan involving sub tasks such as navigating to the user's desk and speaking out the reminder message (causing a change of +4 for affiliation but a change of -2 for energy value). Action B has a plan of just speaking out the reminder message without navigating (causing +2 change for affiliation but only a change of -0.5 for energy value). The robot is likely to select Action B in a situation when its current value for energy is low but will perform the same goal. Using this approach the robot can balance its needs in physiological vs social dimension.

4. FUTURE WORK AND CONCLUSION

The architecture FAtiMA-PSI is operational in its current state, but it only takes into account fixed predefined values for needs which decay automatically with time. However fixed values for energy deviation are not realistic and these should take into account the real battery state. We would like to extend the functionality of the system to link the energy value to real battery state to more accurately represent energy decay. We also aim to develop a method to monitor and calculate the power consumption of each action and link it to deviation values for energy for each task (goal execution) refer Figure 1.

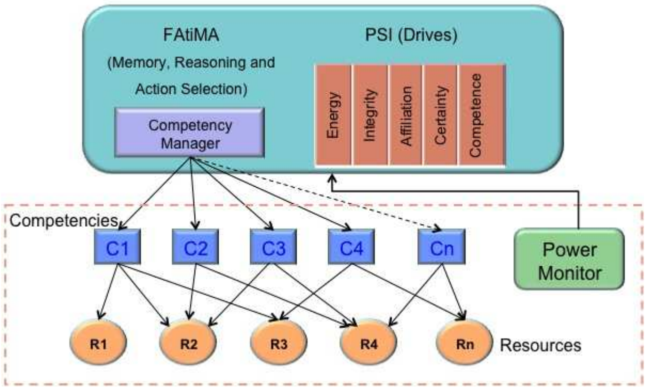

Figure 1: Proposed System

Further more we plan to implement a competency manager to manage competencies (competencies are programs that abstract physical sensors and actuators to logical ones e.g navigation, face detection etc.). The competency manager will also be responsible for regulating the switching of resources (the physical sensors and actuators) by using onboard relays on the robot in order to conserve power while not performing tasks. The regulation of resources behaviour is also found in living beings in form of homeostasis [2].

The challenges with limited battery life on mobile robots, constrain the operational time of mobile robots. We believe that companion robots should behave in a socially intelligent manner to manage the power resources on the robot. In this paper we discussed an approach to power management for social robots which has human-like regulation system that can balance both its physiological and social needs. Additionally, a continuous interaction and task performance with the human users can be maintained.

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