Social Intelligence and Robotics

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Abstract

Having robots interact with each other and with humans requires some form of social intelligence, and there is still a lot to learn about this aspect by doing experiments and by studying aspects related to the intelligence of living organisms. This paper describes various projects underway at the Université de Sherbrooke in regard to this research area.

Introduction

One research goal of LABORIUS, a research laboratory working on mobile robotics and intelligent systems at the Université de Sherbrooke, is to design intelligent systems that assist humans and improve the quality of life, and to improve our understanding of the mechanisms responsible for the generation of intelligent behavior. The research interest is primarily focussed on social robotics, i.e., robots interacting with each other and interacting with humans.

In that regard, various projects are underway in which we are studying different topics related to social intelligence and robotics:

- Designing robotic toys for entertainment and pedagogical purposes;
- Using 'artificial emotions' for managing social behavior;
- Localizing and identifying other robots, and communicating information using visual signs.

The following sections describe these topics, the goals pursued, the observations made so far and future research directions.

Mobile Robotic Toys

Designing a mobile robotic toy requires minimizing the cost of the product and maximizing what the product can do. It must be appealing to children, create interesting and meaningful interactions, and be capable of facing the wide variety of situations that can be experienced. Children can be extremely hard on their toys, and the robot must be adapted to face the great variety of interplay situations and the various situations that may be encountered while navigating in a household environment (like the presence of other objects on the floor, different operating surfaces, other "living entities" like dogs and cats, etc.). To account for all of these possibilities, we came up with a design that integrates the physical structure of the robot, its dynamics and its control to create interactions that are particular to the robot.

Figure 1: A 10 months old boy playing with Roball.

The robot is called Roball, a rolling robot (Michaud & Caron 2000). Roball is encapsulated inside a sphere with two motors attached to its extremities to make the robot move. Steering is done using the battery as a counterweight that is moved by a servo-motor to change the center of mass of the robot. Tilt sensors are used to detect the horizontal and vertical inclinations of the internal plateau supporting the microcontroller. Roball interacts with children by moving autonomously in the environment, asking the child to do special things like spin the robot, push the robot or shake the robot. Our goal was not to create the illusion that the robot needs to be nurtured, but generate interactions that are more related to the dynamics and the structure of the toy.

The experiments done up to now were oriented toward observing how different children would interact with Roball in various environments. A general observation is that different games emerge using Roball with children of different ages and interests, and in different environments. For instance, a 10 month old child played a game of catch-andgrab with Roball; an two years old boy playing near its bed tried to make the robot stay underneath it (and he also threw the robot on the floor a couple of times); an active 3 years old boy threw a basketball on it and expected the robot to understand what he was saying; a calmer 3 years old boy liked to let the robot roll in between his legs. Compared to a simple moving toy, the autonomous behavior of Roball was a more appealing factor for the children, and created a diversity of interplay situations also affected by the objects in the environment.

We also used Roball with autistic children, trying to see how a mobile robot can help autistic children open up to their surroundings, improve their imagination and try to break repetitive patterns. Again, each child had his or her own distinct way of interacting with the robot: some remained seated on the floor, looking at the robot and touching it when it came close to them, lifting it and making it spin (but not always when requested by Roball), or making the robot roll on the floor between their arms and eventually letting it go by itself. Others moved around Roball, sometime showing signs of excitation. While it may be difficult to generalize the results of these experiments, we can say that Roball surely caught the attention of the children, even making them smile. Autistic people have a kind of fascination for rotating objects (like a ventilator). Some children were intrigued and fascinated by seeing the internal plateau turn inside Roball, and we can use this as a reinforcement when the child responds correctly to specific requests made by the robot.

Robots with other shapes and functionalities can be used with autistic children, and other research projects are currently underway (Dautenhahn 1999a; Werry & Dautenhahn 1999; Michaud *et al.* 2000a). The goal is to see how a mobile robot can get the attention of an autistic child: is it by its movements, by its appearance, by having moving parts, by musical or speech interactions, etc.? To explore these different aspects, the Department of Electrical and Computer Engineering of the University of Sherbrooke organizes, for two years now, the RoboToy Contest[1]. Teams of students are asked to design mobile robotic toys for that purpose. Since we do not know yet the best ways to capture the attention of the child, having multiple teams of students coming out with ideas and implementing them provide a rich source of potential solutions to the problem. Each team plays in fact the role of a small research group, trying to find new and appropriate ways to design a robot for autistic children.

Since the event is not adequate for testing the robots with autistic children, teams that want to put their robot in the hands of autistic children can do it afterward. Figure 2 shows robots used in the experiments conducted with autistic children, each robot offering different ways of interacting with the child: moving tail or head, vibrate when the robot is held, different games (like dancing and shape identification) involving geometrical shaped and colored push buttons, heat sensors to follow people, bend sensors as whiskers or on the legs, making bubbles. All used a voice recording and playback device to generate speech messages and music in their interactions with the child.

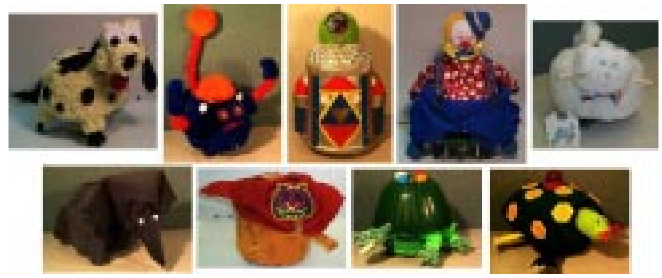

Figure 2: Robots from the RoboToy Contest.

Our experiments revealed that autistic children are interested by the movements made by the robots, and enjoy interacting with these devices. Robustness of the robots is surely of great importance, as some of the more fragile designs got damaged (by pressing on the pyroelectric sensors, removing plastic caps that were covering LEDs displays, etc.). By having the robots behave in particular ways (like dancing, playing music, etc.) when the child responds correctly to requests made by the robot, this becomes an incentive for the child to continue playing with the robots. One interesting observation made was when one child started to follow the walls of the room (as she usually does), and interplay with one robot for short amount of times as she went. Eventually, the robot moved away from the walls and she slowly started to stop (first at one particular corner of the room, and then at two different places) and look at the robot moving around. At one point, she took the robot by its tale and brought it back to the center of the room where she believed the robot should be. She even smiled and made eye contact with some of us, something that she did not do with strangers. This experiment clearly showed that a mobile robot can help an autistic child to break out repetitive behavioral patterns and awareness of the outside world.

In conclusion, the field of mobile robotic toys for entertainment and pedagogical purposes presents important challenges for the research community, with great marketing opportunities. Performance of the robots is based on their ability to entertain or educate, which may be more feasible than accomplishing task-oriented applications (like vacuuming in a household environment). What needs to be done now is to do experiments over longer periods and in normal activities to see how the children interact with the robots pass the familiarization stage.

Artificial Emotions for Managing Social Behavior

The concept of emotion has just recently started to be used in mobile robotic research, mostly for emotive expression in human-machine interactions (Breazeal 1998a; 1998b) or for satisfying basic conditions crucial to survival (Velásquez 1998). But psychological evidence indicates that emotion is in direct association with the **universal problems of adaptation** (Plutchik 1980), which are: Hierarchy, Territoriality, Identity and Temporality. These aspects must be

[1] http://www.gel.usherb.ca/crj.

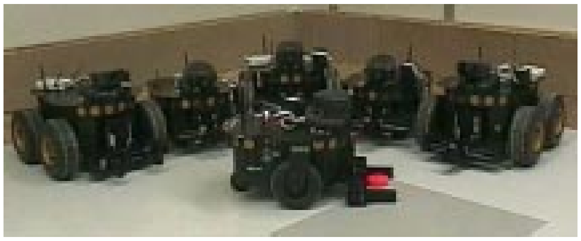

Figure 3: Our group of Pioneer 2 mobile robots.

addressed to design autonomous robots capable of working in real life settings (like our homes, offices, market places, etc.) with humans. Dynamic and unpredictable conditions occur constantly in everyday situations, and a robot has to deal with them with limited energy, perception, action and processing capabilities. Also, a robot operating in such conditions requires the ability to interact with different individuals (robots, humans or other types of agents).

In that regard, artificial emotions (Michaud *et al.* 2000b) can help derive mechanisms necessary for social robotics (Dautenhahn 1999b), like managing the heterogeneity of the group, representing the history of past experiences by being affected by different factors over time, serving as a rich abstraction of the current state and goals of a robot, and establishing a shared meaning and create a basis for communication without having to transmit large amount of data.

We are currently doing experiments involving the use of artificial emotions with our group of Pioneer 2 robots shown in Figure 3. We use a charging station as a shared resource for the group to study how artificial emotions could help manage 'survival' of the individuals in long-lasting experiments. The robots also have to manage difficult situations (like getting out of a narrow corner or a sand pit), and to do dynamic role selection to find the appropriate number of robots for accomplishing a foraging task. We expect initial results by the end of the year.

Interaction Using Visual Signs

Social interaction in a heterogeneous group of robots and humans can be done in various ways: gesture, signs, speech, sounds, touch, etc. Communication is important in social robotics to generate sophisticated interactions between agents. But communication is not enough: robots also need to recognize other agents in the world in order to interact with them. In group robotics, this has been mostly done using IR, explicit radio communication of the positions of the robot obtained from a positioning system (GPS or radio triangulation), and vision (Cao, Fukunaga, & Kahng 1997). Vision is the most interesting of these methods since it does not limit interaction to specific environments, and it is something that humans and animals have, as for an increasing number of robots. For instance, gesture recognition is a more natural way of communicating that do not involve special modifications of the environment. The problem for the robots is then to be able to visually identify, in real-time, other agents of various shapes, sizes, and types.

One possible solution is to use visual cues. In the medium-size RoboCup competition, colors are used to visually identify other agents. However, confusion may occur if other objects with the same color are present in the environment. In addition, discrimination of the identity of the agents is limited by the number of specific colors or combination of colors that can be detected by the vision system. Colored objects are also subject to variations of the lighting conditions like shadows or influences from other illuminating sources (natural or artificial). To resolve these difficulties, we use a colored-light signaling device (Michaud & Vu 1999), shown in Figure 4. Compared to colored objects, a light-emitting system is more robust to lighting conditions in the environment. The coding protocol used to generate signals allows to distinguish another agent from an object (which should not be able to communicate), and the identity of another agent can be communicated to discriminate between individuals operating in the environment. Also, if this coding protocol is simple enough, humans can easily interpret what is being communicated by the robot, and can communicate too if they have a signaling device (a flashlight for example) at their disposal. Finally, by having the agents relatively close to each other, they share the same perceptual space, which allows them to sense or deduce implicit information concerning the context of their interaction.

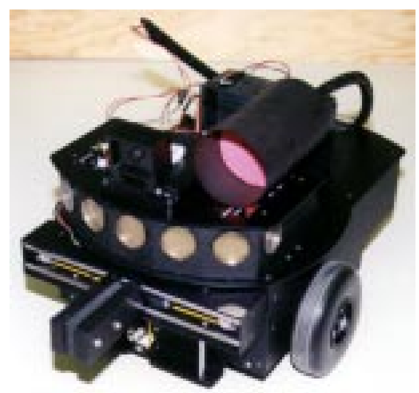

Figure 4: Our Pioneer I robot equipped with the visual signaling device on the right, next to the camera.

Another way of providing visual cues is to develop an approach that makes the robot capable of recognizing symbols used to identify other agents or to give indications to the robot. Making a robot recognize printed signs is an interesting idea because it can be a very general method for robots to communicate information to and identify each other. The symbol recognition technique that we are currently developing is done in four steps: 1) image segmentation using colors, 2) robot positioning, 3) features extraction of color segments and 4) symbol identification using an artificial neural network. Each recognizable symbol are assumed to be contained in one segment, i.e., all the pixels of the same color representing the symbol must be connected (8 neighbors) together to avoid recombination of boundary boxes. The robot positioning phase consists of orienting the robot using a Pan-Tilt-Zoom camera, and to extract printed symbols in the robot's environment. Special symbols like arrows and letters are used to guide the robot to specific locations. Features extraction are rotation and scaling independent, using a centroid based method. Finally, character identification is implemented with a standard back-propagation network. The network is trained with designated symbols of different rotations, scales and noise ratios. This approach will be used in the experiment described in Section . It was also demonstrated at the AAAI-2000 Robot Challenge. The robot used this ability to get direction for attending the AAAI conference. The robot was also equipped with a touch screen for interaction with people. Figure 5 shows the robot docked at the charging station, with a symbol on the side.

Figure 5: Our entry to the AAAI Robotic Challenge.

Conclusion

The projects described in this paper address different issues related to socially intelligent agents and considerations of the 'human-in-the-loop', like the robot-child interactions with robots of different capabilities and shapes for entertainment and pedagogical purposes, the study of emotion in living organisms and how it can be useful in managing social behavior for robots, and the use of visual signs for localizing, identifying and communicating information with robots. These are only starting points to the variety of issues to address in social robotics, and a lot remains to be learned from human abilities to behave socially with living and artificial entities. To do so, we need to create more opportunities in which robots and humans interact together in real life situations and not in controlled conditions, to identify the fundamental characteristics required to make robots be a part of our everyday lives.

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