Robots as a Social Species: the MICRobES Project

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Abstract

This paper proposes an "Open Collective Robotics" research field, defined as an experimental study of the concepts and techniques that could lead to true collectivities between Humans and Robots. We discuss the kind of social aptitudes required for such robots groups and defend the notions of physical and social situatedness. We also present the MICRobES Project, which is a long-term experiment involving a group of 10 autonomous mobile robots immersed in an environment inhabited by humans.

Introduction

A few years ago, (Hewitt & Inman 1991) proposed the name "Open Systems" for work groups mixing human and software agents. As an analogy, we claim that a major issue in Collective Robotics in the next years will be an "Open Collective Robotics", i.e. robots groups immersed in human collectivities. First, we discuss the theoretical issues of such a research field. We will then describe the MICRobES Project, the purpose of which is to experiment concepts and techniques that would lead to Open Collective Robotics.

Towards "Open Collective Robotics"

From our point of view, an "open collective robotic system" can be characterized as follows:

- its components are, on the one hand, a human collectivity, and on the other hand, a group of autonomous mobile robots;
- both communities must interact harmoniously with each other;
- the environment the robots operate in is a human one, thus it is not particularly fitted out for the robots and is therefore highly dynamical and widely unpredictable.

Such a definition implies that the robots need three kinds of competences:

1. *individual abilities* to navigate, avoid obstacles, recharge themselves, learn features of the environment, build maps to localize themselves, and exploit resources. Those competences are an essential basis: a group of robots that would need to be manually recharged would be an unbearable source of disturbance in the human collectivity; thus they have to operate in an autonomous way.
2. *collective abilities* (an "endo-sociality" or "intraspecific" sociality), i.e. a set of behaviors and representations allowing a self-organization of the group of robots, including possibly complex social competences such as a representation of social relations between robots (for instance, if they are given a mechanism for individual recognition). A social organization among robots prevents or solves conflicts resulting from the access to resources, and allows coordination between agents to complete complex tasks. In addition, it is a way of considering other agents as resources or tools which can be used to solve individual problems (e.g. the localization).
3. *interaction abilities* (an "exo-sociality" or "extraspecific" sociality), since the robots have to share their environment with humans. From the point of view of a robot, humans (as a social species) can turn into a very useful resource, if correctly manipulated. From the humans' viewpoint, a robot is worth interacting with if its behavior can be interpreted in an intentional way(Dennett 1987). The more easily humans can understand the behavior of robots, the more likely they will interact with them to the benefit of the robot.

Until now, those three topics have not been investigated together in dynamical environments. There are already interesting examples of single robots designed to operate in a human environment, e.g. as museum tour guides (Burgard *et al.* 1999; Thrun *et al.* 1999), and which have therefore to solve complicated problems of mobile robotics. But, though fruitful, envisaging a group of robots in this context would be a rather difficult extension, since those robots are not designed for being social agents (Thrun 1998).

Other works on social aptitudes in multi-robot systems, for instance (Mataric 1995; Arkin 1998), rely on a priori known communication and interaction abilities – which excludes heterogeneous collectivities.

Regarding collective robotics, until now all experiments have been done either in a close, controlled environment (e.g. the RoboCup challenge (Asada *et al.* 1998)) or in open ones which are, in counterpart, completely adapted to the robots. Since such an assumption cannot be fulfilled in a

"real" world (especially in an environment inhabited by humans), those experiments are usually described as the first step towards designing fully autonomous systems.

We rather think that this approach leads to a practical and theoretical dead-end. Brooks for instance (Brooks 1991) emphasizes the importance of the physical situatedness to have a robot solve its *relevant* problems, while a robot under excessively controlled conditions or a simulated robot is mostly confronted to biased ones. The same claim has been made regarding sociality (Dautenhahn 1998; 1999). In addition to this, recent experiments regarding the communication between humans and robots (Billard, Dautenhahn, & Hayes 1998; Breazeal & Scassellati 1998) emphasize the concept of "embodiment" as an essential basis for interaction. Therefore, we argue that "Open Collective Robotics" should provide the agents with abilities to build grounded behaviors and representations at the individual (physical), endo-social (robots group), exo-social (human group) levels at the same time.

The MICRobES Project

The MICRobES Project[1] is an interdisciplinary experiment in the field of "Open Collective Robotics" (Picault & Drogoul 2000), started in April 99 at the LIP6 (Computer Science Laboratory of the University of Paris 6).

It involves three research teams of our laboratory: Multi-Agent Systems (under the supervision of Alexis Drogoul), AnimatLab (Jean-Arcady Meyer) and Symbolic Learning (Jean-Daniel Zucker). In addition, three sociologists from the CSI (Center for the Sociology of Innovation, École des Mines de Paris, headed by Bruno Latour) and from the EHESS (École des Hautes Études en Sciences Sociales) take part in the project.

The MICRobES Project consists in studying the long-term adaptation (2–3 years) of a micro-society composed by autonomous robots (at the beginning, 10 Pioneer 2DX, from ActivMedia, which should be joined by other kinds of robots such as legged ones or flying ones), immersed in the laboratory. It is driven by a pragmatic approach and an incremental design of the behaviors, representations, competences given to the robots.

It addresses multiple issues from individual robotics, distributed AI and human-machine interaction at the same time. But our approach focuses on the relationships between the three levels (individual, endo-social, exo-social), especially on grounding social interaction (inside the robots group and towards humans) in the physical experience of the agents. For instance, the preliminary models for map-building and localization, based on unsupervised exploration, that have been elaborated (Hugues 2000), provide the robots with the ability to exchange their percepts to build a shared, grounded representation of their environment. This information exchange will contribute to the social relations between the robots, on the basis of previous work on the representation of social relations in primate societies (Picault & Collinot 1998). In the same way, the robots will learn symbolic representations of relevant features of their environments by making associations between words taught by humans and salient percepts in the context of the interaction (Bredèche & Zucker 2000).

The point we would like to emphasize is that the robots have no given functional task (from a human point of view) to perform. Their only purpose is to "survive" in an unknown and highly dynamical environment, i.e. to ensure their energetic autonomy and avoid dangerous places, such as lifts or stairs. Designing robots *for* a specific functional task introduces too strong biases in behaviors, representations and techniques, as the experience of the RoboCup challenge demonstrated (Asada *et al.* 1998). Of course, the humans will have the ability to teach "useful" tasks to the robots and ask them for a service (such as distributing mail); some of the researchers involved in the project are currently working on this issue. Anyway, from the point of view of the robot, the human helper is a kind of tool for a particular action. To perform a task, a physically and socially situated robot may use other robots or human helpers, in addition to, or instead of, its own competences. Survival is then a more general problem than any specific task, and can be solved through individual, collective or human-aided ways, each one implying a set of competences and knowledge.

We will particularly focus on evaluating to what extent the robots will be accepted by people who inhabit the experiment field (the laboratory), who are computer scientists, or technical or administrative staff. The MICRobES team is about 15 people large only and most of the lab people have nothing to do with the project. Thus, there is a kind of robot-habituation gradient among the humans involved in the experiment, which must be taken into account.

Sociological observations take place regularly together with the researchers of the CSI and the EHESS. First, we try to understand how humans adapt themselves to robots, seen either as individuals or as a group. This study is of high interest to sociologists, since humans are not used to share their everyday environment with any other social species. If humans are used to live with dogs or cats, and to attribute to them intentions, thoughts, etc., very few people live with a *pack* of dogs. From the viewpoint of the MICRobES team, the analysis of the reactions of people, of the reasons why they accept or reject the robots, why they help them, play with them, or close their door, is helpful to improve the interaction abilities. Especially, the robots will have to learn social habits to avoid disturbing people, or to be sure to find them when they need some help. This kind of representation, from the viewpoint of the robots, might be only the attribution of specific properties to humans seen as resources.

The second topic of the sociological investigations is the building from scratch of an artificial society, which addresses the problem of group formation. A rather important difference (from a sociological viewpoint) between natural and artificial groups is that the second ones can provide an exact explanation of how they build their social representations from interactions between individuals. The last point is to study the MICRobES team, so as to elicit the evolution of the concept of "robotic sociality", depending on multiple

[1] named after a French acronym meaning "immersing robots collectivities in a social environment"

scientific, literary, cultural influences, and on the feedback resulting from our experimental approach.

Conclusion

In this project, we emphasize the importance of taking into account at the same time individual, organizational, and interactional aptitudes for robots collectivities intended to share their environment with humans. Particularly, from the viewpoint of physical and social situatedness, humans are not only seen as moving obstacles but also as potential resources for solving difficult problems.

We also propose an experimental approach, in which the aptitudes of the robots are initially designed for survival "only", to avoid biases resulting from a too specific functional task. The robots can improve their competences by learning and by adaptation to their physical and social environment, which make their integration to the human collectivity easier.

In addition, the reactions of the humans involved in the experiment (the MICRobES research team as well as other people working in the lab) provides helpful indications on the acceptation of an artificial social species in a human group and on the way to enhance an harmonious cooperation between robots and humans collectivities.

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