ARTICLE

Integrated Planning and Scheduling in the ROBOCARE Project

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Abstract

This article sketches the research of the Planning and Scheduling Unit of the ROBOCARE Project, aimed at designing and implementing distributed systems for generating user services for the care of the elderly. We will briefly outline the lines of research our unit is involved in.

Introduction

ROBOCARE is a research project which involves several Italian universities and research institutes (see `http://robocare.ip.rm.cnr.it`). Its aim is to develop distributed systems in which software, robotic and human agents cooperate in order to generate services for human assistance. Our research focuses mainly on two scenarios, the first being a domestic environment in which domotic technology, robotic components and care-givers contribute to the common goal of assisting an elderly person in his or her daily life. The second scenario is a health-care institution, an environment in which these actors cooperate in order to enact a predefined workflow of activities for the care of the elderly. Both these settings provide a rich set of challenges for the problem solving technology which is the scope of our team's research, motivating also the development of new solving tools which address the particular issues connected to improving the level of autonomy for older adults.

With respect to these two scenarios, the role of our unit in the ROBOCARE Project is to develop an infrastructure which is capable of supervising and providing proactive support for elderly people in their daily routine (see Figure 1).

In particular, the domestic scenario calls for capabilities that extend beyond the technological boundary of current domotic technology.

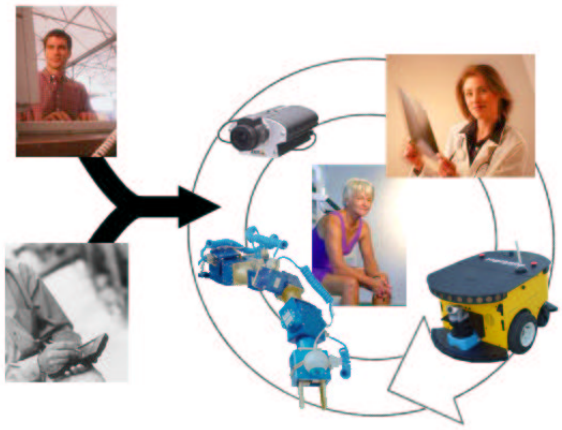

Figure 1: The Active Supervision Framework supervises and provides proactive support.

For instance, actively monitoring an elderly person at home implies that the system must be able to predict potentially hazardous or unwanted behavior (like forgetting to wear glasses before wandering around the house or dangerously leaving a cumbersome obstacle near the staircase). On the other hand, the big workflow problems which are generated in the context of a health-care institution (in which each guest has particular medication, diet, therapeutic requirements) require problem solving tools which are capable of compiling an efficient schedule of tasks to be carried out. The objective of our unit is to develop what we have called an Active Supervision Framework [8] for these two scenarios, which would be in charge of centrally controlling and monitoring the situation, adapting to all contingencies thanks to its powerful reasoning capabilities.

The Role of Different Solvers

The diverse needs of older adults, both in the domestic and in the health-care institution context, require for deductive systems which are capable of reasoning

both in terms of causal constraints (for the predicting functionality) and in terms of time and resource constraints (for workflow management). The scenarios we have mentioned require both types of reasoning, but in different proportions.

In the domestic environment, we envisage a proactive support for the elderly person, thanks to which he or she can count on a set of tools (robotic assistants, intelligent sensors and so on) which provide a cognitive (as well as physical) support. These supporting functionalities range from "intelligent" reminding to automation of routine tasks. Nevertheless, they all require an interpretative step, in which the framework gathers information on the assisted person and the environment in order to understand the needs of the person and to devise a set of measures which satisfy these needs.

In the domain of a health-care institution, the capabilities of the problem solving technology we dispose of are useful for allocating resources (humans, robots and sensors alike) to tasks and finding efficient instantiations of these tasks in time which satisfy a set of predefined constraints. Current technology is capable of dealing with very big problems, in which there are hundreds of tasks to be allocated with very stringent constraints.

With respect to both scenarios, we are currently investigating the use and integration of an array of technological components, such as fixed and mobile heterogeneous robotic components, sensors, PDAs and various types of household and medical equipment. This functional integration is made possible by the centralized nature of the deductive framework, which constantly monitors the evolution of the assisted and the environment. Most importantly, though, the Active Supervision Framework interacts with human operators. These actors can be, e.g., a physician, who updates the medication requirements for the assisted, or the elderly person himself, who might want to summon a robot for a particular request, like bringing water. Indeed, the Active Supervision Framework enforces a synergy among the various components of the future home or health-care institution which results in a proactive support for the elderly.

Automated Planning and Scheduling

The research which has been spawned from the involvement of our unit in the ROBOCARE Project is twofold. On one hand, it is necessary to provide proactive support for elderly people. This entails functionalities such as monitoring and diagnosis, thanks to which the system is capable of actively finding solutions for the assisted person. This requires:

1. interpreting the needs of the assisted person, that is, understanding the goal a human being has set forth to obtain;

2. deducing a course of action for the assisted person which achieves his or her goal by means of causal reasoning capabilities.

In this context, we are investigating the use of some well-known planners, such as BLACKBOX [7], HSP [2] and PRODIGY [9].

On the other hand, in both of the above mentioned scenarios the system requires time- and resource-related reasoning. As we have said, the need for this component is evident in the health-care institution scenario, in which a tight schedule of tasks is to be generated for the human and robotic agents. It should be clear though, that also in the domestic environment such capabilities are necessary, for instance when it comes to diagnosing resource contentions such as synchronizing the operation of the various sensors and domotic components. In this context, we are implementing prototypical control infrastructures based on O-OSCAR [6], a versatile, general purpose CSP solver which implements the ISES algorithm [5].

With respect to the integration of these two forms of problem solving, our preliminary findings include an implementation of a component-based integrated planning and scheduling architecture [8] based on BLACKBOX and O-OSCAR. The result is an architecture which is effectively capable of solving quite

a number of problems, and which has been extensively used in the development of a preliminary Active Supervision Framework. It is not trivial to notice that even this primitive form of integration has two important advantages. First, the only necessary additional development is an adaptation procedure, in other words, an information sharing mechanism which "couples" the planning and the scheduling modules. Also, it is a general purpose tool, thanks to the PDDL planner input on one hand, and to the high expressivity of the scheduling problem specification [3, 1].

Integrating Automated and Human Solvers: The Mixed-Initiative Approach

The idea behind cognitive aid is to support human beings which are somehow impaired in carrying out their routine tasks. Yet even the most advanced artificial solvers are humbled by the problem solving capabilities of humans. Indeed, it is our view that integrating human and automated solvers is the only effective way to make the technology we have spoken of in sections 0.4.1 and 0.4.1 really useful.

Based on established research which has been conducted by our unit [4], the philosophy which is guiding us in the development of supervision technology for the care of the elderly can be referred to as Mixed-Initiative problem solving. In this context, the tools we are developing contribute to the enhancement of human problem solving capabilities. This is reflected in an array of support tools which provide friendly representations of problems and ensure complete control on behalf of humans in problem solving processes. Thanks to these interfaces, the system can count on the high-level problem solving capabilities of humans, which typically contemplate complex cost functions which are not easy to model mathematically, and the combinatorial solving power of planners and schedulers.

The use of intelligent interfaces with flexible problem solving techniques contributes to the implementation of cognitive support tools which can take advantage of the complementary solving skills of humans and artificial solvers. Thus, the ultimate aim of the Active Supervision Framework, both in a health-care institution domain and in the household scenario, is to actively support elderly people through a continuous interactive process which involves the assisted persons and the other intelligent agents of the system.

Conclusion

The development of effective technology for aiding elderly persons is an important challenge for the scientific community. It is becoming clear that AI problem solving techniques are part of the answer to the diverse issues related to ensuring an independent lifestyle for elderly people. In particular, the delivery of cognitive support by humans, robots and other technological devices is made possible by their inclusion in a centralized supervision framework which enables them to cooperatively contribute to the well-being of the persons to be assisted. Among the many issues which are being studied is the acceptability of the technology. In fact, the development of an Active Supervision Framework as described above requires singling out the aspects of their lifestyle the users are willing to receive cognitive support in. This is a rather delicate issue, which requires a great deal of study and testing. Nonetheless, the issue of user acceptance is a fundamental one, in that a successful deployment of such technology will ultimately determine the applicability of current AI technology in supporting independent lifestyles for older adults.

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