Interactive Task Planning through Multiple Abstraction: Application to Assistant Robotics

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1 INTRODUCTION

Assistant robotics has become an emergent field within the robotic and artificial intelligence communities ([1],[2]). The main characteristic of assistant robots is that they are designed to serve non-expert people within their environment. They must plan and act efficiently to accomplish tasks specified in a human-like manner, i.e. "take this envelope to Peter's office". Thus, an assistant robot must manage a symbolic model of its environment -its *world model*- that involves human concepts.

A human-inspired world representation can be used to endow assistant robots with that mentioned capability. It is stated in literature that humans widely use the mechanism of *abstraction* ([3],[6],[8]). Abstraction allows humans to work with abstract concepts that group other, more particular concepts. For instance, when somebody refers to "my office" she/he is talking about an abstract concept, dropping unnecessary details like door, wall, table, chair, cabinet, etc.

A robot managing a world model that includes human concepts allows users to specify tasks in a human-like manner. Furthermore, the user can also interact with the robot during the planning process since the robot reports an understandable plan to the human.

The work presented in this paper is intended to jointly cover human interaction and task planning efficiency, by using a hierarchical model of the environment. For our purposes, a multihierarchical world model called *Multi-AH-graph* ([6],[7]) has been implemented with two hierarchies of abstraction: the *task planning hierarchy* devoted to efficient task planning and the *cognitive hierarchy* engaged in human communication. The use of these two hierarchies requires a translation process to transform concepts from one hierarchy to the other, which is addressed in this paper.

The paper is structured as follows. Section 2 briefly reviews the Multi-AH-graph model. Section 3 is devoted to describe the human interaction mechanism in robot task planning and its application to a real robotic application. Finally, some conclusions and future work are outlined.

2 THE MULTI-AH-GRAPH MODEL

A Multi-AH-graph is a graph representation that includes hierarchical information possibly in more than one hierarchy. Abstraction produces different layers, called hierarchical levels, that can represent symbolically the same environment with different amount of detail. These layers are flat graphs whose nodes represent elements of the environment (concepts), and whose arcs represent different relations between those concepts (for example, "navigability"). A simple example of a Multi-AH-graph with one hierarchy that models a typical scenario is shown in fig. 1.

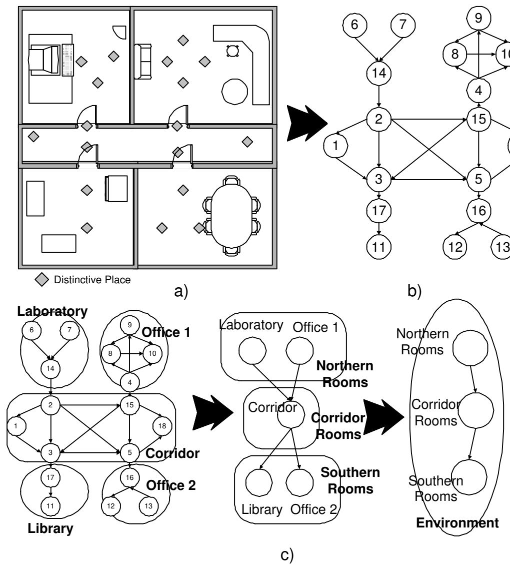

Figure 1. An example of an Multi-AH-graph (with one hierarchy). (a) A schematic plan of a real environment. (b) The lowest hierarchical level (ground level). (c) Upper levels of the hierarchy.

Broadly speaking, a Multi-AH-graph is a set of hierarchies interwoven in a directed acyclic graph structure, where each hierarchy level may can be shared by others hierarchies. Using a symbolic multihierarchical representation of the environment has demonstrated to provide important benefits for robot operation (please refer to [6], [7] for more detail).

3 HUMAN INTERACTION IN ROBOT TASK PLANNING

Among other advantages [7], the Multi-AH-graph model provides efficiency in hierarchical task planning [4]. In this paper we use a multihierarchical scheme to enable a human to supervise and interact with the robot task planner. In our scheme, a translation process (section 3.1) is required to shift concepts between two hierarchies managed by the robot.

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3.1 The Translation Process

The plan translation process comprehends two phases (see fig. 2) that are interleaved with user interaction.

1. The first stage consists of translating the user task request, which can be specified at any level of the *cognitive hierarchy*, to the *planning hierarchy*. It is done just by shifting the involved human concepts down to the shared ground level of both hierarchies.
2. The second stage is carried out in the opposite direction. A plan produced by the task planner must be reported to the user using concepts of the cognitive hierarchy.

The plan translation process uses two functions for refining and abstracting plans.

- *Refining function for plans*. The refining function increases the amount of detail of a given plan p. It yields all the possible plans that include the subnodes of those concepts involved in p.

- *Abstracting function for plans*. This function works in the opposite way. It reduces the amount of information contained in a plan by abstracting the world elements that it involves.

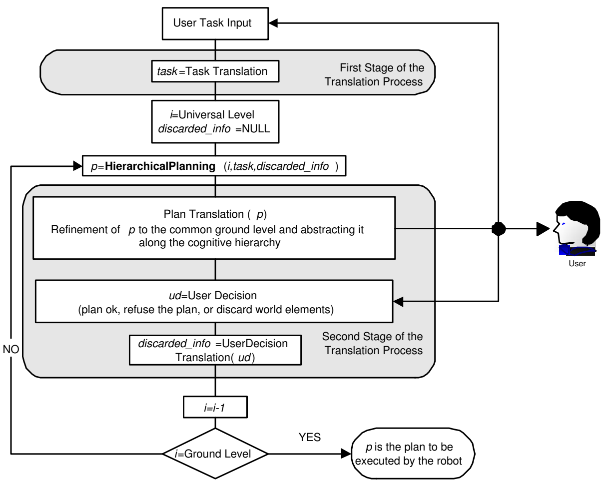

Figure 2. The Translation Process. The interactive planning process is a iterative process where the user is well-informed about the sequence of abstract plans obtained by the hierarchical planner at each stage.

3.2 Application to an Office Robot

Our interactive planning scheme has been tested using our mobile robot *RAM-2* (see fig. 3). RAM-2 is endowed with a robotic arm and several sensors and actuators (see [5] for more detail).

Fig. 1 depicts part of the environment used in our experiments. Upon the ground level the cognitive hierarchy establishes the cognitive interface with the human (see fig. 1). The planning hierarchy (not shown) arranges properly world concepts in order to improve task planning [4].

In this scenario, let us consider the following application. An employee is in charge of distributing mails. To facilitate his work, RAM-2 can carry objects within the office, so this user has only to give the proper envelope to the robot and select the destination, i.e. "go to the laboratory".

Figure 3. The mobile robot RAM-2. It is equipped with a robotic arm, and several sensors as a laser scanner, ultrasonic sensors, and a CCD camera.

Once the task planner produces abstract plans, the user can proceed in the following ways:

1. *Inquiring a more detailed plan*. When the translation of an abstract plan does not provide enough information, the user can request more information in two ways: a) she/he can ask the robot for a translation of the same plan using more detailed concepts of the cognitive hierarchy, b) the user can ask the planning process for planning a new solution at a lower level of the planning hierarchy.
2. *Rejecting part of a plan*. The user can reject certain concepts of the provided plan. The discarded concepts are translated again (through the refining/abstracting functions), reporting to the hierarchical planner what concepts from the planning hierarchy must not be considered when providing a new solution.
3. *Suggesting an abstract plan*. Abstract plans report useful information to the user. The user can suggest the desired abstract concepts to solve a plan. Thus, the planer yields a plan considering only concepts embraced by the ones suggested by the human.

4 CONCLUSIONS AND FUTURE WORK

This paper has described an interactive task planning scheme for assistant robots. A multihierarchical model successfully used in previous works ([4],[7]) has been used to join two problems underlying assistant robotic applications: human-friendly interaction and task-planning efficiency. Future works aims to provide automatic mechanisms to construct good hierarchies for planning and communicating with humans.

References

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