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A Planning-Based Assistance System for Setting Up a Home Theater

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Abstract

Modern technical devices are often too complex for many users to be able to use them to their full extent. Based on planning technology, we are able to provide advanced user assistance for operating technical devices. We present a system that assists a human user in setting up a complex home theater consisting of several HiFi devices. For a human user, the task is rather challenging due to a large number of different ports of the devices and the variety of available cables. The system supports the user by giving detailed instructions how to assemble the theater. Its performance is based on advanced user-centered planning capabilities including the generation, repair, and explanation of plans.

Introduction

Technical devices become more and more complex and often cause mental overload to human users operating them. Companion Technology (Biundo and Wendemuth 2010; Wendemuth and Biundo 2012) enables the development of companion systems – cognitive technical systems that assist the user in operating a technical device. In our paper *"Plan, Repair, Execute, Explain - How Planning Helps to Assemble your Home Theater"* (Bercher et al. 2014), we showed how planning and HCI capabilities were integrated to allow for advanced user assistance – illustrated in an example scenario, where a human user wants to connect various devices of his home theater. Here, we describe a mobile version of the prototypical *Companion System* presented there.

Application Scenario – Assembling a Home Theater

We want to assist a human user in assembling her or his HiFi components, s.t. every component receives the required audio/video signals. We consider an example scenario, where the user wants to set up a theater consisting of a television, a blu-ray player, a satellite receiver, and an audio/video receiver. More technically, the task is to connect these devices in such a way that the television receives the video signals of the blu-ray player and the satellite receiver and that the audio/video receiver receives the audio signals of these devices. For connecting the devices, there are several different cables and adapters available.

We are not aware of any tool that is capable of assisting a user with such an assembly task. In practice, one would have to consider the operating manuals of the various devices and to come up with a solution by oneself.

It is straightforward to model the task in terms of a planning problem, where actions correspond to plugging cables into devices. We described an excerpt of the domain model[1] in our earlier work (Bercher et al. 2014). We solve the planning problem that encodes the assembly task using a hybrid planning approach. It fuses hierarchical planning with Partial-Order Causal Link (POCL) planning. That approach is well-suited for our intent of providing user assistance, as the causal links allow for the explanation of plans (Seegebarth et al. 2012), thereby justifying the system's behavior. Further, they allow for the smooth integration of plan execution and repair. The hierarchy, if introduced, can be used for limiting the search space and improving plan explanations.

While the generation of plans allows to give detailed instructions to the user in the first place, plan repair allows to assist in cases, where execution failures occur. Plan explanation allows to question the necessity of certain instructions.

System Description

Our system implements a generic architecture for Companion Systems introduced in earlier work (Bercher et al. 2014, Fig. 1). Its domain-independent components enable the realization of assistance systems in many application areas.

In our example application, user assistance is based upon a sequence of instructions that, if executed by the user, solves the assembly task. That instruction sequence is based upon a plan, which is a solution to the given planning problem. Since in hybrid planning such plans are only partially ordered, a most-suitable total order must be chosen. While every total order respecting the partial order of the plan solves the given planning problem, some of them might be more plausible to human users than others. We devel-

[1] The domain model can be downloaded from the SiGAPS website http://users.cecs.anu.edu.au/~patrik/sigaps/

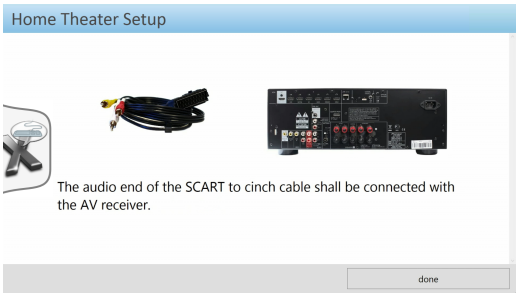

Figure 1: The figure shows a single user instruction that visualizes a single action of a solution plan. The respective ports of the audio/video receiver are flashing in red.

oped several domain-independent plan linearization strategies (Höller et al. 2014) and employed a strategy that seems most plausible in our example scenario.

We now investigate how a single user instruction looks like. Every instruction is based upon a (primitive[2]) action. The corresponding action schema basically looks as follows:

plugIn(SRC-H, SRC-P, SNK-H, SNK-P)

That action schema has four parameters. The terms SRC-H and SNK-H represent the source and the sink hardware, respectively. The terms SRC-P and SNK-P represent the ports (such as HDMI) of the two hardware devices that are used for plugging SRC-H and SNK-H together. When presenting an action, these constants are used by the dialog and interaction management (Honold et al. 2013) to generate an appropriate user interface. This includes pictures of the devices and their ports as well as natural language text that verbalizes the respective instruction (see Fig. 1). We have done an empirical evaluation of our system with test subjects. A majority of these subjects perceived the system very well in particular because of the pictures of the devices and the highlighting of the used ports (Bercher et al. 2014).

During interaction, the user may always state execution errors or ask for justification of the currently presented instruction. For that purpose the user may touch/click on the large X on the left side of the presented instruction (see Fig. 1). Then a dropdown box occurs listing "The cable is broken!" and "Why should I do this?". The user may also interact with the system using speech input that is recognized using off-the-shelf software.

If "The cable is broken!" is selected, the currently used cable is marked as unusable and the system initiates plan repair. After a solution has been found that incorporates the execution failure (in this case, the unexpectedly broken cable), the new plan is presented to the user in the same way the original plan has been presented before. In our demonstration, we did not model unplug actions, so cables that have already been used cannot be plugged out (depending on the cables that became unusable this might be necessary to find a repaired solution, however).

[2]In hybrid planning, actions may be primitive or abstract. Solution plans only contain primitive actions, however.

The user may also select "Why should I do this?". In that case the system uses plan explanation to derive a justification for the currently presented action. Such a justification is a chain of proof steps proving the purpose of the respective instruction. That proof is translated into natural language and presented to the user. As an example consider the explanation for the action depicted by Fig. 1: "You have to connect the SCART to cinch cable to the AV receiver to transmit audio data from the satellite receiver to the AV receiver."

Discussion & Future Work

We described a system that supports a human user in the task of setting up her or his home theater. The system's capabilities include plan generation, plan execution, plan repair, and plan explanation. The task to solve is encoded as a planning problem given in advance. To obtain a fully general system, we want to enable to user to specify the given hardware and the task to solve. We also want to extend the domain model to allow unplugging cables. Concerning plan repair, our demo system only allows to specify broken cables as execution failure. However, our plan repair approach is more general and allows to handle arbitrary state changes. So, we want to allow the user to specify any state variable that unexpectedly changed its truth value.

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