PocketCERO – mobile interfaces for service robots

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Service robots are meant to automate tasks formerly performed by humans. They are foreseen to be useful, e.g. to elderly or to people with disabling conditions, or to anyone longing for automation taking over home/office tasks. As service robots are mobile, interfaces must take this mobility into account. Interaction situations include the co-located, the teleoperated, the autonomous, and the telepresent robot. Especially the transitions between these interaction situations need to designed for. We suggest that a personal digital assistant (PDA) is a helpful tool for this. Providing interfaces that can be carried around and that make remote control to automation appliances available adds to the personal communication and information management of mobile devices the potential of *having an effect on the physical environment by manipulating physical objects within it.* With seamless network coverage it could give a new meaning to “remote control” by allowing to act upon/within the home/office environment while on the move. We describe different interface design prototypes experimented with, present the integration with existing interfaces and the overall system, and report on the early findings during the design phase.

Service robot, usage situations, PDA, manipulation, interface design prototypes

1. Introduction

In our Human-Robot Interaction (HRI) research we are interested in the communication and interaction with mobile service robots [1]. In the AMS project [2] we built a prototype robot that assists users with everyday transport tasks in an office environment. The targeted users in this project suffer from disabling conditions that make it difficult to move around and to carry objects at the same time, e.g. as walking aids may be used. Interfaces enabling the sending of the robot to different places and deliver or fetch objects are provided for through a traditional Graphical User Interface (GUI, fig. 1), an animated character (named CERO) on the robot-platform as well as a Natural Language (NL) interface.

Robots are embodied, i.e. their physical presence make them an entity in the physical environment and thus an interface to interact with. Unlike the whiteware appliances at home, robots can have the ability to move, either directly controlled (“teleoperated”) or in (semi-) autonomous mode.

In order to act in an as intelligent interpreted manner, robots need to be able to sense their environment. Only with sensory perception of the environment-, task-, and usage-context, are robots enabled to deal with the high degree of uncertainties faced. So while robots are already taking the context into account as proposed by Schmidt [3], the same is not true for the interfaces used to control them.

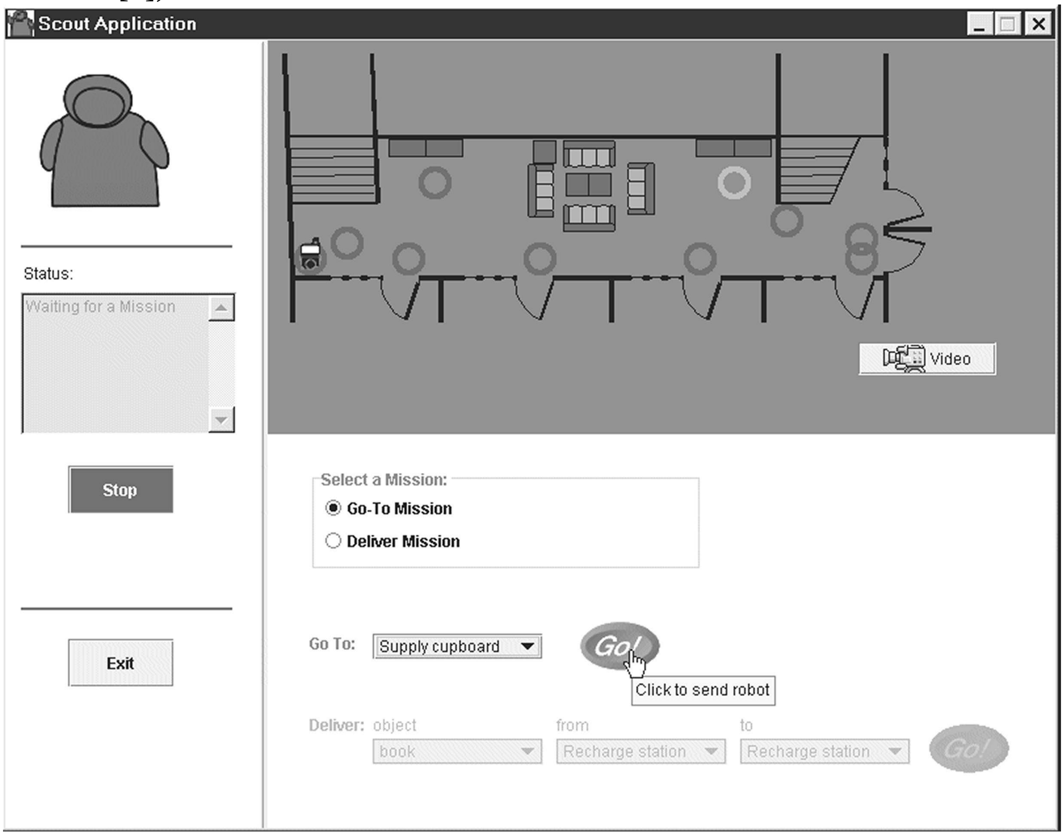

Figure 1: The service robot GUI

Another important differentiation to e.g. computer artifacts on a stationary PC is that robots are neither primarily working with documents nor are they expected to perform mainly management of information or communication. From service robots, users expect the utility of manipulation.

The identified characteristics of service robots have consequences for the interaction and interface design. Service robots might be described and designed with features of consumer electronics, household appliances, and/or embodied agents.

2. Mobile robot interaction situations

As part of the interaction design modeling different basic situations were identified as (1)“*Co-location*”, i.e. the robot and the user are located in close spatial relationship, (2)“*Telerobotics*”, i.e. the robot is under some kind of networked supervisory control; however, the robot and the user are in different locations, (3) “*Autonomous Robot*”, i.e. the robot might or might not be in close spatial proximity, however no interaction between user and robot is required, and (4)“*Telepresent Robot*”, i.e. the primary operator of the robot is not at the same location as the robot, however the robot-operator is communicating and interacting with another person through the robot.

This simplified model of different interaction situations combining spatial relationship, possibly preferred modality of interaction, and situational context has shown to have a flaw: In usage of robot systems, users and robots are often not only in one of the above situations or modes. Instead users require easy interface and modality switching between the different modes.

It is in "bridging" the different robot usage situations by providing users with a mobile control and command platform that we see an added value for mobile computing devices in interaction with robots. Situations in which both the user and the robot are roaming can be dealt with by the small handheld devices enabling nomadic computing [4]. We started off with a usage scenario, where both the user and the robot are roaming the premise and tried to evaluate with a feasibility- and design prototype study if usable operation control can be provided.

3. Prototype designs

The point of departure was our existing graphical and speech dialogue interface [2] and the experiences reported from earlier trials to control a robot with a PalmPilot PDA [5]. Preparing for a usage scenario in which users operate the robot for a longer period of time, we investigated into the design of a mobile interface by letting a student group try a first feasibility implementation on a Compaq iPAQ.

This handheld PDA [6] has a 240 x 320 pixel touch sensitive screen, which is able to display 4096 colors. With 32 MB of memory the iPAQ runs a StrongARM processor and is delivered with Microsoft's PocketPC operating system. A suit of standard application software such as an Internet browser, a mail tool, a calendar-, task- and notes application is also provided. More important is however the PC-Card extension bay, enabling the operation of the robot while connected with an IEEE 802.11 compatible wireless local area network, a GSM-network, or a wireline network.

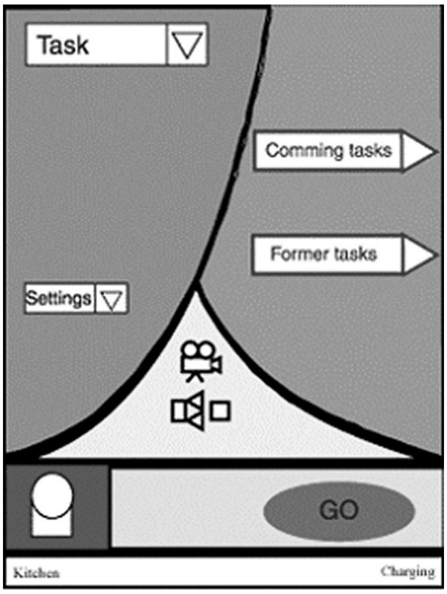

Figure 3: 1st Design sketch

The switching between them enables us to experience and evaluate whether our interface design is suited to maneuver a physical device while being in a different part of the building, the other side of town, or in a different country.

The first implementation (see fig. 3 for a design sketch) revealed points for improvement. The tried PersonalJava from Sun Microsystems worked as expected in the software emulation/simulation, but had bugs which made us look for a 3rd party vendor of a Java Virtual Machine (JVM). The attempted color-coding was found to be inspiring, however too strong and unsuited for the different lighting conditions (the PDA's backlight can be switched off automatically if the application was inactive for a certain time period) as a usability inspection revealed. The darkened screen with low contrast in the power saving mode made it difficult to read the screen elements without first activating the application again by tapping somewhere on the screen. We believe a passive monitoring of the screen elements ought to be possible. Further points for experimental design improvements were identified in the too hierarchical structure of interface screens (a finding in accordance with the recommendation of providing direct access if contents are displayed on small screen devices, see [7]), the differences in respect to the existing robot GUI (fig. 1), and finally, the forced two-hand usage (one holding the iPAQ, the other the stylus to tap on the screen with).

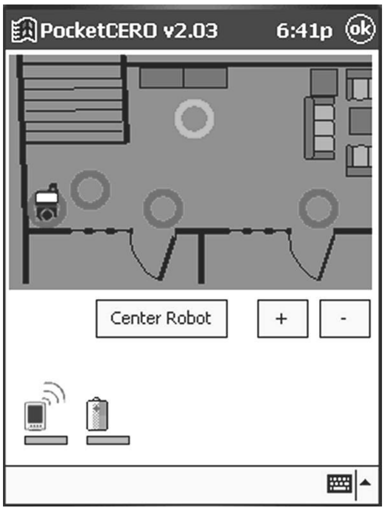

Figure 4: Map based GUI

Figure 5: One-hand GUI

In another design iteration we tried to address these issues while providing the following features in the application: It should be possible to read the current robot status ('free', 'busy on a mission', 'current location'), get feedback on the status of the mobile device (limited to battery and network connection status), enable the sending of the robot to specific places, and finally, make it possible to stop the robot at any time.

As the initial design ideas we came up with were too different in character we decided to try three different designs for a later usability comparison. For this design iteration Microsoft's embedded Visual Basic was used as a rapid prototyping tool. Note that the figures 4-6 show screen captures of the emulation environment in which the applications are debugged.

The ‘Map-based’ design (fig. 4) is closest to the existing GUI designed to run on stationary workstations with large screens. A map of the environment the robot operates in is shown. This corresponds visually with parts of the GUI implementation (cp. fig. 1) and partly fulfills the recommendations of an integrated graphical design made by Nielsen and Søndergaard [8]. The user informs him/herself about the robot’s status by tapping on the robot-symbol; initiating a delivery mission for the robot is done by dragging the robot from the current position to an intended one.

A second design prototype implementation (fig. 5) focuses on the 1-hand usage as guiding idea, despite the finding of Jacobsson *et.al.* [9] who reported that the single-hand operation was not as appreciated as expected. As stated above, users who are in need of walking aids might not be able to interact with a device if two-handed interaction is made a prerequisite. In this design it is thought that the hand holding the device ought to be able to reach all relevant interaction elements either as presented on the screen or by navigating the focus to the relevant element and selecting it with the integrated hardware joystick-button on the iPAQ’s casing.

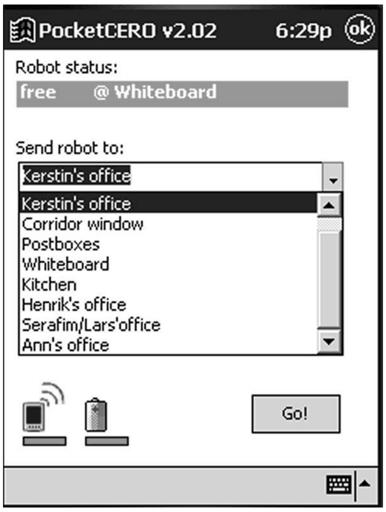

Figure 6: Standard design GUI

The last design (fig. 6) follows a “keep-it-simple” approach. Standard interaction elements are used complying with the look & feel of the PocketPC platform. This interface is thought to support users who prefer standard interaction mechanisms known once they are familiar with the PocketPC’s style of interfaces and interaction. For this design we anticipate that users will (need to) use the two-handed interaction style, and thus rendering this design useless for people needing at least one hand to hold onto a walking support aid. The differences to the existing GUI on a computer with a large screen are justified with the differences in devices used as well as the distinct contexts of usage.

3.1 Technical Integration

The overall system consists of the robot’s hybrid deliberative architecture [10], which in turn is interfaced by different, CORBA-based interaction modules for the human robot interaction management. By enabling communication between the different modules and the robot, all user initiated actions or system status changes can be conveyed to the connected interaction elements (see fig. 7). The integration of the mobile interface was to a large extend straight forward as the necessary programming interfaces already existed in the architecture or only required small adaptations.

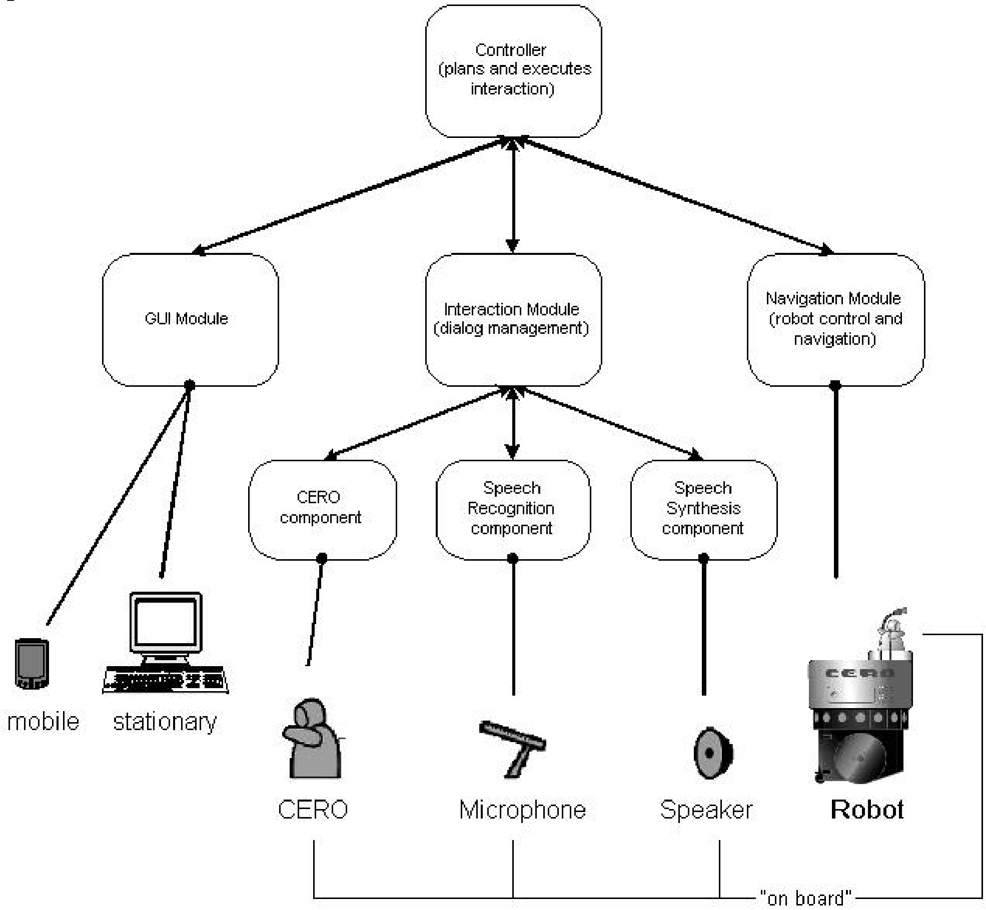

Figure 7: Integrated System

4. Conclusions

With the different design prototypes we put forward implementations to interface a service robot for the home/office environment with a PDA. The character of robots that are mobile, together with the usage and communication situations suggests including mobile devices as part of the provided robot interface components. With porting applications onto mobile devices, designers can allow for the control of other appliances while users are moving about. The controlled devices can be located far from the operators, thus a supervisory control is made available. To generalize, we argue for the idea of using PDAs or other mobile computing devices for *interfacing artifacts that can have an effect on the physical environment by manipulating physical objects within it*, i.e. controlling other (computerized and/or electro-mechanical) systems that have a physical impact on their surroundings.

Acknowledgements

All products and service names cited in this paper are trademarks or service marks of their respective owners.

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