Acquiring a Shared Environment Representation

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ABSTRACT

Interacting with a domestic service robot implies the existence of a joint environment model for a user and a robot. We present a pilot study that investigates, how humans present a familiar environment to a mobile robot. Results from this study are used to evaluate a generic environment model for a service robot that can be personalised by interaction.

Categories and Subject Descriptors:
I.2.9 [Artificial Intelligence]: Robotics;
H.1.2 [Models and Principles]: User/Machine Systems

General Terms: Experimentation, Human factors.

Keywords: Environment representation, cognitive modelling, user study.

1. INTRODUCTION

Service robots are often mobile platforms that provide assistance to humans. This means that such robotic systems have to find their way in human occupied environments to provide their services. Mobile robots can navigate on the basis of metric, often feature based maps, and they can build those maps autonomously while exploring an environment for the first time (Simultaneous Localisation and Mapping, SLAM [2, as an example]). Humans have a topological, (partially) hierarchical, view on their environment as for example demonstrated by McNamara [4]. These two approaches to environment representations have to be integrated into a "shared representation" to enable mutual understanding between a service robot and its user.

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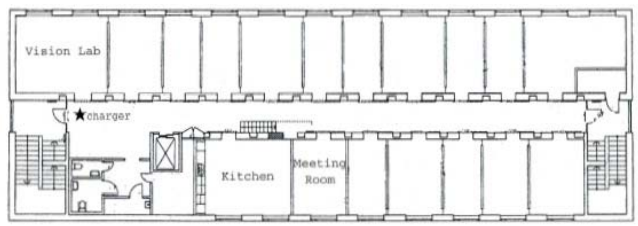

Figure 1: The floor plan of our office environment on which the experiments took place. The star marks the starting point, where subjects encountered the robot

1.1 Human Augmented Mapping (HAM)

In earlier work we already introduced the concept of *Human Augmented Mapping* (HAM,[5]), which allows us to subsume aspects of Human-Robot Interaction (HRI) and robotic mapping. With this concept we can establish the link between a robotic map that enables the robot to navigate and the environment representation of a user (also referred to as "cognitive map"). We use a hierarchical (graph structured) environment model that distinguishes between *regions* and *locations* (locations being specific positions in the environment, representing large objects or activities and regions being areas that can contain one or more of those locations). We assume a scenario of a guided tour to be an appropriate way to teach the robot its environment. The user can take the robot around (by asking it to follow) and name important regions and specific locations. With the help of a generic starting region it is possible to incorporate different ways (orders) of presenting a given environment. The idea of the arbitrary ordering of information is inspired by the findings of McNamara [4], who stated that the human environment representation is rather partially than strongly hierarchical.

1.2 A study on HAM

With the present paper we shortly describe a user study [6] in which subjects guide around an autonomous mobile robot in a complete floor of an office building that they are familiar with. The study investigates how different users present an environment that is well known to them to a robot. We refer to results from a number of pilot experiments used to determine requirements for the mapping process.

2. STUDY SETUP

Our pilot study comprised experiments with five subjects of about 45 minutes duration. Within this time period the subjects spent about 20 minutes interacting with the robot.

The scenario of the study was a guided tour through a portion of an office building. Figure 1 shows the floor plan with offices (not marked), the kitchen, the meeting room and the computer vision laboratory of our office building. Subjects were instructed to show the robot around in the environment so that it later could find its way to known places to perform service tasks.

As important precondition to the study we assumed subjects to know the environment they would guide the robot around in. This precondition is important and based on the idea that potential users will "add" service robots to their (to them already well known) homes and offices. Subjects were therefore recruited from the laboratory environment the experiments took place in.

The task for the subjects was to use a number of commands and explanations to make the robot follow and to present all regions and locations that the subject considered important for the robot to know. In the instruction none of the words *region, location, position* or *place* was named so that subjects were completely free to decide what they would present to the system and how they would name it.

The study was performed with a commercially available Performance PeopleBot[1], equipped with our implementation of a a laser range data based tracking and following system [5] integrated with a metric, laser range data feature based SLAM method [2] and an option to label regions or locations with name tags. In our implementation the labels referred to the position the robot was at, when the respective name was given. We stored the data provided by the robot's sensory systems and recorded the experiments with two digital video cameras (robot and external view). After the experiments the subjects answered a number of questions on the experiment in a short interview.

3. RESULTS FROM THE EXPERIMENTS

Due to the limited number of subjects and the explorative setup it is only possible to analyse the outcome of the experiments in terms of *occurrence* of different phenomena. A conclusion from the pilot study is that individual differences in teaching an environment to a robot exist and should be anticipated to interactively build map representations for robots. In table 1 we summarise these quantifiable results to give an overview over our observations and statements from the interview.

The observed diversity in strategies to introduce, e.g., the kitchen to the robot was quite large, ranging from the pure introduction of *the kitchen* over some combination of *specific locations in the kitchen (e.g., the coffee machine) and the kitchen itself (as room or region)* to *specific locations only.* Already from our small sample of data we can conclude that this variety needs to be handled by the robot's environment representation accordingly. Most of the subjects stated in the interview that they had pointed out locations or rooms they personally considered important but left out others on purpose. We see this as a sign for a strategy to *personalise* [1] the robot's environment representation to personal needs and preferences.

[1] http://www.activmedia.com

Table 1: Quantifiable results (excerpt)

Observation Subject	VR	VR	VR	SE	RR
Interaction time	22 min	19 min	11 min	25 min	24 min
# regions	4	2	–	2	2
# locations	4	4	5	4	8
# regions w o loc.	3	2	–	1	1
# loc. w o region	3	4	5	2	3
# regions w o entering	1	2	1	1	–
VR: Vision researcher, SE: Secretary, RR: Robotics researcher					

Despite some technical problems all subjects expressed their satisfaction with the flow of interaction and communication as well as the robot's performance.

4. CONCLUSION AND FUTURE WORK

In this paper we presented two important aspects of our concept of Human Augmented Mapping, namely the environment representation of the robot and the interactive context that allows a user and a robot to build a shared mental model of an environment while traversing it together. A pilot study was conducted to investigate strategies of users to present a for them well known environment to a robot.

We were able to observe a large variety of strategies to present a known environment to the robot in a "guided tour" that can be used to form design implications for the mapping process. The results from the experiments encourage us to use the proposed setup in a more comprehensive user study and to investigate the applicability of the proposed environment model in a robotic framework in more detail.

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