Exploring the Potential of Information Gathering Robots

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ABSTRACT

Autonomous mobile robots equipped with a number of sensors will soon be ubiquitous in human populated environments. In this paper we present an initial exploration into the potential of using such robots for information gathering. We present findings from a formative user survey and a 4-day long Wizard-of-Oz deployment of a robot that answers questions such as "Is there free food on the kitchen table?" Our studies allow us to characterize the types of information that InfoBots might be most useful for.

Categories and Subject Descriptors

H.1.2 [**Models and Principles**]: User/Machine Systems—*human factors, software psychology*

General Terms

Design, Human Factors

1. INTRODUCTION

Autonomous mobile robots are starting to enter human environments. The last decade has witnessed some of the early instances of long-term robotic autonomy [1] and the commercialization of such robots[1]. Despite the ability of these robots to continuously stream data from their onboard sensors, the potential of using them as information gathering agents has not been explored in depth. The use of robots for information gathering has been limited domains such as urban search and rescue (*e.g.* [2]) or space and oceanic frontier exploration (*e.g.* [3, 4]), while their use in indoor, human-populated settings has remained unexplored. Such robots could monitor the state of a building to report unusual events or maintenance needs, and they could respond to questions and requests by occupants of the building. In this paper, we present an initial exploration to understand the demand and potential for such information gathering robots ("InfoBots") and gather requirements for their design. We present findings from a user survey and a four-day-long Wizard-of-Oz (WoZ) deployment of an InfoBot that answers questions.

Information checking. Our exploration focuses on information *checking* tasks, as opposed to *monitoring* or *searching* tasks. Checking tasks involve answering a question about the environment by going to a particular location and reporting the requested information. In this framework, the user first enters their question to the system. From this question the system extracts target location attributes and the requested information type (Fig. 1). Then, this information is converted to a target robot configuration (map location, rotation, and camera angle) for capturing the requested information. Next, the robot moves to the target configuration, takes a sensor recording, and infers the answer from the sensor recording.

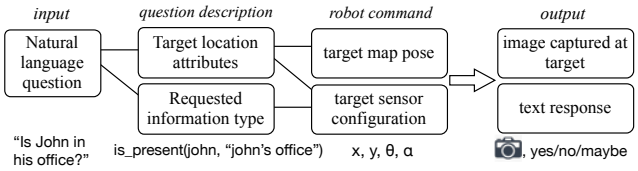

Figure 1: The information checking framework.

2. USER SURVEY

Method. The primary stakeholders of InfoBots are the users who request information. From the perspective of these users, we created a survey to determine the types of information that would be most useful and to identify constraints and requirements on how this information would be requested and provided. The survey presents respondents with sample questions to asked to an InfoBot and presents three rating scales for each: **(1)** The ability to ask this type of questions would be [5:Very useful – 1: Useless]; **(2)** I would ask this type of question [5:Multiple times a day – 1: Never]; **(3)** I would require a response [5:Immediately – 1: No rush]. Fig. 2 shows the exact question examples and rating scale values used in the survey. In addition, the survey includes questions about the desired interface.

Findings. The survey was completed by 80 occupants of a computer science department building. The results are summarized in Fig. 2. On average 84% of the respondents thought that the ability to ask the example questions would be "good to know" or better ("useful" , "very useful"). Participants thought that asking if a person is in their office and asking about availability of food were most useful. More people indicated that they would never ask a question (14%) than they indicated the question as being useless (4%).

Respondents had high expectations from InfoBots in terms of the speed with which the response is to be delivered. 49% of respondents said they required a response immediately or faster than a human. 30% of respondents said they required a response at the same speed as a human. Despite the overall high expectation, we found that there are some questions that people are okay with getting a response in human-speed or lower, and that some users are willing to wait longer for certain questions.

[1] `http://www.savioke.com/`, `http://www.vecna.com/`

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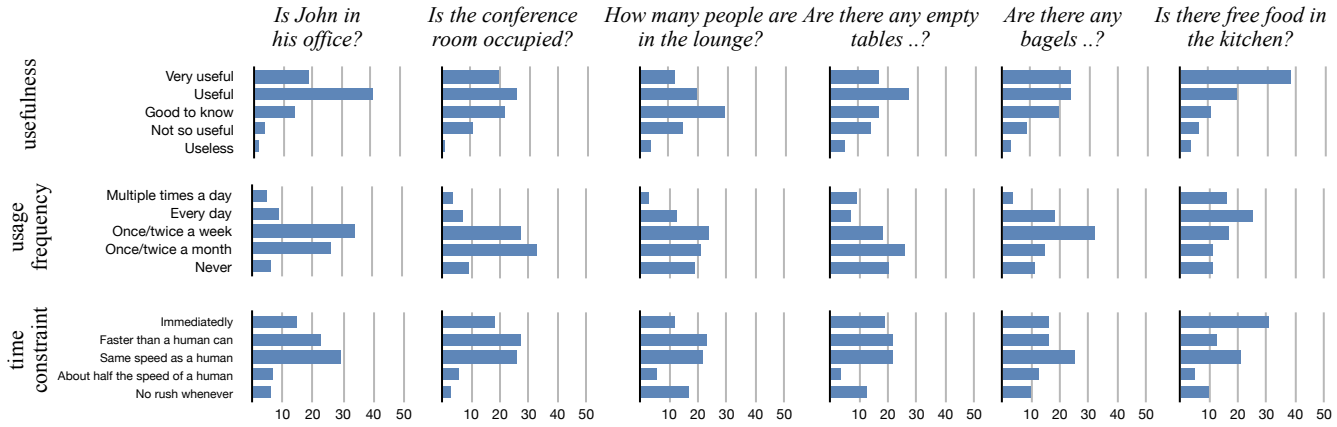

Figure 2: Summary of results from the user survey.

3. DEPLOYMENT

Next, we implemented a WoZ InfoBot and deployed it in the building where the survey was conducted. The platform used in our study is shown in Fig. 3(a). The front-end is a web interface where the users can post questions in free form and check the status of questions (Fig. 3(b)). This interface was designed based on the responses to interface-related questions in the user survey.

Our system was deployed for four business days (9am-5pm). Users were recruited from graduate and undergraduate students, staff and faculty inhabiting the building. The robot was supervised by a human operator. When a user asked a question from the web interface, the operator received it and accepted it if it was a checking-type question that could be answered through a static picture taken by the robot. The operator then supervised the robot to go to the target location in the building based on the question and positioned its camera to take a picture. The question was answered by only looking at the taken picture.

Findings. Over the deployment period, we received 88 questions posted by 45 unique users.

Question Types: The majority of questions (71%) concerned the presence of things at certain locations in the building. Users were mostly interested in the presence of people (33%). Common examples of this type of question were: "Is there anyone at {location}?" and "Is {person} in his/her office?". Among questions concerning objects in the environment, users were most interested in the presence of food and mail, *e.g.* "Is there anything in my mailbox?" and "Is there any food in the downstairs kitchen?". These results align with the findings from our survey.

Another major group of questions concerned the state of the environment at target locations. We observed a variety of questions ranging from checks about the accessibility of various services (*e.g.* "Is the door to the conference room open?", "Is the reception still open?") to ambient conditions ("How noisy is it in the atrium right now?" or "Is it raining outside?"). Several questions were clearly submitted with the purpose of challenging the system (e.g. "What do you look like?", "Are there any mirrors in the building?") or simply as jokes (e.g. "Who let the dogs out? :)").

Question Asking Behavior: Overall, 73% of users used the service more than once. 40% of the users asked more than one question with at least an hour between questions. This indicates that despite the short deployment duration, some people used our system beyond their initial exploration of the system, to actually gather information.

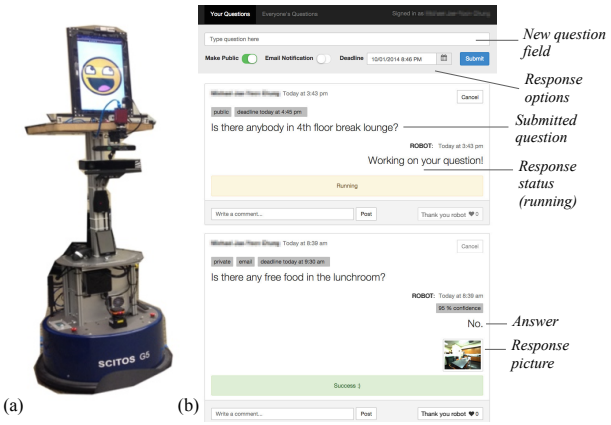

Figure 3: (a) Robot platform. (b) User interface.

4. CONCLUSION

We investigate the potential of autonomous mobile robots as InfoBots. We present a survey that show promise in terms of usefulness of InfoBots and gathers requirements. We also present findings from a short-term deployment of an InfoBot indicating that the types of information requested by users are suitable for a mobile robot implementation.

5. REFERENCES

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