How Do People Talk with a Robot? An Analysis of Human-Robot Dialogues in the Real World

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Abstract
This paper reports the preliminary results of a human-robot dialogue analysis in the real world with the goal of understanding users' interaction patterns. We analyzed the dialogue log data of Roboceptionist, a robotic receptionist located in a high-traffic area in an academic building [2][3]. The results show that (i) the occupation and background (persona) of the robot help people establish common ground with the robot, and (ii) there is great variability in the extent that users follow social norms of human-human dialogues in human-robot dialogues. Based on these results, we describe implications for designing the dialogue of a social robot.

Keywords
Human-Robot dialogue, speech-based interaction, Human-Robot Interaction

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Many Human-Robot Interaction studies have explored diverse ways in which people communicate with a robot using natural languages [1][6].

To our knowledge, however, there has been no research investigating the content of dialogue that people use with a robot in the real world over an extended period of time. How would people talk with a robot if the robot were situated in their daily routine? Would they talk about topics that they would discuss with a human receptionist? Would people follow social norms of human-human conversation when talking with a robot even when the novelty effects of a robot fade away? Understanding these users' interaction patterns will help designers build the dialogue models that are able to answer the questions that users will ask, and potentially adapt dialogue depending on users' interaction styles. This will contribute to a smoother transition of robots in the lab to the real world.

This paper reports on the preliminary results of an analysis of human-robot dialogue in the real world with the goal of understanding users' verbal interaction patterns with a social robot. In particular, we analyze the dialogue log data of Roboceptionist, a robotic receptionist located in a high-traffic area in an academic building [2][3] (Figure 1). As the robot has been deployed in a public setting for over five years, it provides a great opportunity for observing users' natural behaviors with the robot and various interaction styles of different users.

Dialogue Data and Analysis

Roboceptionist

Roboceptionist has a humanoid-face on a computer screen and is situated in a booth where pictures and props are placed to describe the robot's persona. To interact with Roboceptionist, users type using the keyboard located in front of the robot. Depending on users' input, the robot greets people, gives directions, or looks up weather forecasts. In addition, the robot has its own persona (e.g., personal history, memory, and preference), so he provides his personal information when people ask. Users can swipe their ID cards, so the robot can call the names of the user. The robot's dialogue is all scripted and spoken in a voice generated by text-to-speech software.

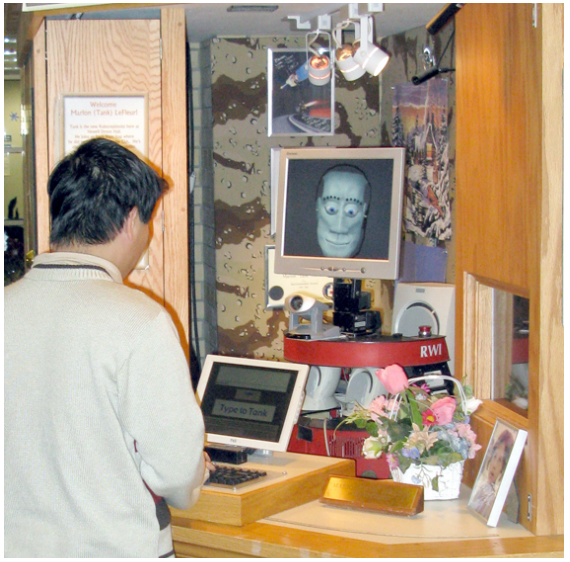

Figure 1. A photo of Roboceptionist.

The 197 individual interactions collected over one week (Mon-Fri) in March 2008 were analyzed. Each interaction is defined as a dialogue that occurs from the moment a user approaches the robot until she leaves. Two individual coders manually coded the topics of each interaction (kappa = 0.70). In addition to topics, one of the coders also noted users' interaction patterns – whether users greeted the robot in the beginning of the interaction (greeting), whether they thanked the robot (gratitude), whether they said farewell at the end of the interaction (farewell), and whether they used a keyword command instead of using full sentences (keyword command).

Results

Dialogue Topics

Four main categories of dialogue topics emerged from the analysis (Table 1). Few people (7.69%) talked about more than one topic in one interaction. Each category is described below.

- Seeking Information: Users talked with the robot in order to get useful information such as location and direction for a person or place or weather information (41.54%). The examples included directions to specific buildings on campus or cafeteria areas, office numbers of a person working at the institution, or Pittsburgh's forecast for the next day.
- Chatting: Users also talked with the robot to chat about the robot or (rarely) about users themselves. The most common questions were about the robot's name and age, its family (parents, wife), and the creator of the robot. Questions about the robot's former workplace (Army, CIA), or its favorite novel (*Hitchhiker's Guide to the Galaxy*) were also commonly observed.
- Saying Hello: About 20% of users just greeted the robot, occasionally said farewell right afterward, and just left. It seemed that they just wanted to say hello to the robot when they passed by it.
- Nonsense/Insult: About 10% of users exhibited impolite behaviors such as typing nonsense words (e.g. cslkjkj), or insulting the robot (e.g., shut-up). However, they stopped their rude behaviors when the robot expressed that it could understand users' behaviors (e.g., saying "stop banging my keyboard.").

Topic	Percentage
Seeking Information	
Location of person/place	30.77%
Weather	8.21%
Date & Time	2.56%
Chatting	
Talking about robot	26.15%
Talking about user	1.54%
Saying hello	21.31%
Nonsense words/insult	7.18% / 3.08%
Others	1.02%

Table 1. Frequency of topics that users talked with a robot.

Except for the Nonsense words/Insult category, the other three main categories were all directly related to the role and background story of Roboceptionist. It seemed that people assumed the robot would have knowledge about his surroundings (e.g., general

information about Pittsburgh and/or Carnegie Mellon University) or places relevant to his background or occupation. This is consistent with the findings from a lab experiment where users used the background information of a robot to establish common ground and infer the robot's knowledge [4][5].

Interestingly, the influence of physical props in the robot's booth was minimally observed. There were only two users who asked about the bone on the robot's desk and the pictures hung on the wall.

Dialogue Style

Greeting was the social norm of human dialogues that users followed most. Many users greeted the robot with greeting such as "hi", or "hello" (60.30%). Some users also said a human-like farewell at the end of their interactions (24.22%).

Most users asked a series of questions in a row rather than following up the robot's response. However, few (1.55 %) showed sympathy to the robot's response or followed up what the robot said by asking more specific question. The following excerpt is an example of how few users continued conversation with the robot by following up.

> *User*: do you like Pittsburgh
> *Roboceptionist*: It's a bit like Afghanistan. Without the Taliban, of course.
> User: Afgahnistan?
> *Roboceptionist*: When I first arrived in Afghanistan I was all the rage. The soldiers and locals all loved me.
> *User*: Pittsburgh?
> *Roboceptionist*: I've not been here that long, but I like the Carnegie Museums, and South side has some nice shops.

Some users exhibited more personal, and relationship-oriented behaviors. 7.73% of users called the robot's name when they started interacting with the robot (e.g., "Hi, Tank").

Very few talked about themselves first, in particular their emotional status (1.54%). For example, some people expressed that "I'm lonely", or "I'm bored", or

	Greeting	Farewell	Gratitude	Keyword command	Nonsense/Insult
Greeting					
Farewell	0.2374**				
Gratitude	0.2219**	0.4040**			
Keyword command	-0.0736	0.1341	0.2702**		
Nonsense/insult	-0.3140*	-0.0730	-0.0946	-0.1421	

Table 2. Correlation among different features in each interaction. * p.<.05, ** p <.01

"I'm stressed" as the first sentence of the dialogue. The current dialogue mechanism of Roboceptionist cannot recognize such sentences. But if the robot could respond to users' proactive self-revelation in a more active way, it might contribute to a positive attitude toward the robot by users.

14.95% of users used a keyword command (machine like command) (e.g., Pittsburgh weather, or University Center) instead of using full sentences as they would with a human receptionist (e.g., "Could you give me directions to University Center?"). 14.95% of users also properly thanked the robot when given the information that they wanted, even when the robot was not able to understand what the user said. Correlation analysis showed that people who thank the robot are likely to say a proper farewell to the robot (Table 2).

It was not the case that people who use full sentences as in human-conversation would exhibit more polite behaviors, and people who use a short sentence such as keyword command would use less polite behaviors. Table 3 shows that users who use keyword commands said more farewells and thanked the robot.

	Full sentence	Keyword command	P value
Greeting	0.6182	0.5172	0.3080
Bye	0.2182	0.3793	0.0623
Gratitude	0.1091	0.3793	0.0001

Table 3. Comparison between users who used full sentences vs. keyword commands.

Discussion

The results suggest that the occupation and background story of a robot may play an important role in establishing common ground between a user and a robot. For instance, most people asked Roboceptionist questions that are relevant to tasks that a human receptionist does such as the locations of offices or where to get taxi. Because the robot used to work in the army, users also asked about whether the robot is a patriot, or whether the robot is pro or against the war. Physical props such as a picture of a dog on the wall, or a bone on the reception desk were less frequently mentioned.

Approximately half of the users followed a minimum level of social norms of human-human dialogues such as greeting, saying farewell, and thanking when assistance is provided. Interestingly, people who used keyword commands instead of full sentences exhibited more polite behaviors to the robot than those who used full sentences. Understanding why people follow social norms to a varying degree requires further investigation. Potential reasons could be their previous experience with the robot and how much they anthropomorphize it.

Some users disclosed their emotions to the robot, while others only asked the robot about itself. These types of users might be ones who have interacted with the robot for an extended time or those with introverted personalities.

To explain the behaviors of people just saying hello to the robot requires further investigation. One potential reason might be that people ritually say 'hi' as they pet a pet when they walk on the street, or say 'hi' to the other passers-by or shoppers. This may be an indicator

that the robot is a part of their routine, not just a novelty anymore. If they are first-time visitors, it will be likely that they would try to talk more to find out the capability of the robot.

Design Implications

The preliminary analysis of the dialogue between Roboceptionist and users identifies potentially fruitful design implications. First, as the occupation and background story of the robot set common ground between people and the robot, designers can seek to design them to produce a synergetic effect for an efficient task completion. For example, a natural history museum guide robot can have a background story as a retired explorer, so it can naturally induce visitors to ask questions about sites the robot has been or methods the robot has used.

Some interaction patterns could be used to adapt robot dialogue behaviors. For example, the robot can provide more personalized and friendly services to users who respond to the robot's speech in a sympathetic manner.

Conclusion and Future Work

In this paper, we enumerated interaction patterns of human-robot dialogues. This research opens up a series of questions that still remain untested in Human-Robot Interaction.

To answer these questions, we will conduct surveys with users to better understand users' interaction behaviors over time or depending on whether the user is a first-time visitor or repeat visitors. We also plan to analyze a larger data corpus by automatically coding it.

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