Priority List: What Users Want to Know About a Drone

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ABSTRACT

With the decrease in the price of aerial robots and advances in technology, more groups of people are using aerial robots, including hobbyists, bridge inspectors, photographers, etc. As a result, more people are being exposed to aerial robots both as direct robot operators/pilots and also as bystanders and/or people having unwanted/unplanned interactions with aerial robots. For example, if a hobbyist flies a robot in a neighborhood, neighbors may be involved in the interaction just because they are in the same environment as the robot. As these interactions become more commonplace, it is critical to intentionally design robots around both explicit and implicit interactions. To this end, we are interested in learning more about what type of information users might want to know while interacting with aerial robots. We created videos of a user interacting with an aerial robot and collected user responses regarding possible information a user might want to know about the robot in a survey with 50 participants on Mechanical Turk. While some of our results support findings in prior work in human-robot interaction, they also reveal several new priorities for drone researchers to consider in improving human-drone interactions.

KEYWORDS

aerial robot, user study, priority list, human-drone interaction

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INTRODUCTION

In the last few years with the advances in technology, robots are used more than anytime and this is still growing. Aerial robots are going to be used for to go where users can't go e.g., bridge inspection [8], help astronauts on the international space station (ISS)[5], for package delivery [9], etc. Other than traditional industrial robots which only exists in cages, there are new mobile industrial robots which move around the factories and warehouses and perform a variety of tasks such as moving payload or shelves [17]. Some of these mobile base robots have a manipulator and can perform a manipulation task [10, 12]. In a human-human interaction, people are good at interpreting the signals coming from the opponent e.g., if two people passing by each other in a narrow hallway, often they are good at signaling/interpreting signal which path (right or left) are they going to take. If they can not perform a good job, the mentioned interaction would become an awkward situation. For a good interaction, both human and robot should have a basic understanding of each other. It is essential for a human to know more about the state of the robot and it is necessary for the robot to convey needed information to the user.

There is a large amount of literature about human's mental model [2], the works that have been done to convey specific information [3, 4] and what signals to use to convey specific information[7]. As an example to convey "where the robot is moving next", Szafir et al. used gaze and lights [14], other researchers used Augmented reality [11, 13, 15, 16], Cha et al, used sound [6].

In this paper instead of "what medium to signal specific information?" , we are curious about "what information should the robot conveys?". This is an important question for designers/researchers to keep in mind while making a robot. Other than specific use cases e.g., designing the bomb defusing robots [1], to best our knowledge no one asked what type of information users needed to know about the robot.

We recruited 50 participants in 3 groups on Mechanical Turk. We asked them about the information they want to know about the robot and we would share our finding in the result section.

SURVEY AND PROCEDURE

We designed a survey with 4 sections. In the first section, participants watched two short videos, each approximately 30 seconds in duration. Both videos depicted a user completing a pick-and-place task while sharing an environment with an aerial robot (Figure 1). There are two tables in the environment. One table contains the user instructions and two boxes, while the other table contains various wooden blocks with associated numbers. The instructions required the user to follow a sequence of steps in

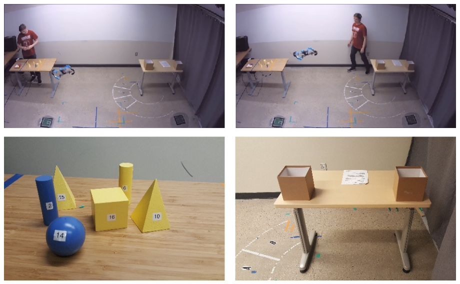

Figure 1: Top left: The robot doing a supervisory task. Top right: The robot intentionally interferes with the path the user is taking. Bottom: Pick and place task that the user is performing in the videos.

which they selected a specified block from one table and placed it in one of the boxes in the other table (e.g., "1. The yellow pyramid with number 15 should go in Box A").

In both videos, the robot acted as a supervisor, which meant that it occasionally flew over the tables and checked the current status of the task (e.g., how many objects were in a box or whether objects were placed in the correct box). In the first video, the robot was on the opposite side of the table and completely isolated from the user (Figure 1 top left). However, in the second video, the robot flew on the same side of the table as the user and thus at times was in the way of the path that the user tried to take (Figure 1 top right). Our goal in designing these two videos was to highlight scenarios in which users may simply coexist in shared environments with drones (i.e., bystander interaction) as well as scenarios requiring more direct interaction (e.g., to resolve right-of-way issues) as the information that users desire from the robot may depend on the amount and type of interaction.

After watching the videos (participants could re-watch videos at anytime of the survey), participants ranked 22 items, each of which corresponded to some sort of information that the robot might convey, in order of how important the participant perceived this information to be were they to interact with a robot as in the videos they had just watched. These items were drawn from a list of possible information that users might want to know from the robot created by reviewing prior HRI literature and a series of brainstorming sessions with expert roboticists with at least 5 years of experience.

We can roughly categorize the items in 3 major groups. First, several items correspond to various information the robot might convey about itself, such as “The robot conveying whether or not its camera is recording” or “The robot conveying when and in what direction robot would move next” etc. The second group represents information that the robot might convey about the task it is doing, for example “The robot conveying a list of successfully/unsuccessfully completed tasks (task history)” or “The robot conveying whether or not any faults/errors are detected (e.g., electric circuits damaged, payloads/sensors not mounted correctly, etc.).” Finally, the third group corresponds with information related to whether it is safe and/or appropriate for human interaction, such as “The robot conveying whether or not it is safe to get close to it” or “The robot conveying whether or not it currently knows where you are.” For each participant, the list of items was presented to participants randomized in order to reduce the potential for initial placement bias. Participants were tasked with re-ordering the list of items in order of their perceived priority.

In the next section, participants were asked to provide a 1–7 Likert-type rating regarding their perceived importance for each item they ranked in the previous section. Here 1 was defined as “not important” and 7 was defined as “very important.” This section of the survey served two primary purposes. First, this section helped provide supplementary information on perceptions of absolute importance to contextualize the information on relative importance from the previous section (e.g., even items ordered near the end might be perceived as highly important by participants). Second, these questions provided a validation method for the items in the previous section (i.e., items ranked

Most important			
Rank	The robot conveying ...	Mean	SD
1	whether or not it is safe to get close to it.	8.0	5.2
2	whether it is currently acting autonomously or being controlled by a person.	8.3	6.1
3	what it knows about the surrounding environment.	8.8	4.3
4	whether or not any faults/errors are detected.	9.6	5.8
5	when and in what direction robot would move next.	9.7	5.7

Least important			
Rank	The robot conveying ...	Mean	SD
18	its most recent maintenance report.	13.9	5.5
19	its total flight duration.	13.9	5.7
20	how to look up more information about the robot.	15.5	6.4
21	the current time and date.	15.9	6.1
22	contact information for how to leave feedback about the robot.	15.9	6.8

Table 1: List of the most important items based on participants ranking for aerial robot

lower in the prior section should also receive an equal or lower score in this section). This validation helped us identify and control for the quality of participant responses.

While we created a large sample of items corresponding to different types of information it may be useful for a robot to convey, we recognize that our list is not exhaustive and might be missing potentially critical aspects. As a result, the next section of the survey provided participants with open-ended questions where participants could suggest any other information they think would be helpful to know about the robot or useful for the robot communicate to them. For each suggestion, we also asked participants to provide a Likert-type rating of 1–7 regarding how important they believe this suggested information might be. Each participant had the option to provide and rate 3 new suggestions.

In the last section of the survey, we collected demographic information regarding age, gender, education and the level of familiarity of participants with robots in general. We also included a question about obvious features in the two videos, in this case, we asked the number of boxes on the table in order to ensure that participants actually watched the videos.

With IRB approval we deployed the survey on Amazon Mechanical Turk and collected responses from 50 participants. After initial validation analysis, we removed data from 2 participants who didn't pass the video sanity check and 11 participants with inconsistencies across the ranking and rating sections. As a result, we ended up with 39 responses for full analysis.

RESULT AND FINDING

Among valid responses, 16 participants identified themselves as female while 34 identified as male. Average participant age was 33.7 (SD = 9.6), with a range of 22 - 70. On a seven-point scale, participants reported a moderate prior familiarity with both aerial robots (M = 3.8, SD = 1.4). The ranking table can be find in **??**. Safety and privacy are the most important concern of the participants and information about robot was the least important. Category wise Both safety and privacy (M = 5) is the most important followed by Interaction (M = 14), task (M = 14.2) and Robot (M = 16.28) is the least important category.

For the open-ended questions, 45 answers were received from 28 participants (M = 1.21). 17 participants provided a suggestion, 5 provided two suggestions and 6 participants provided 3 suggestions. Annotators group the responses in the following categorise: navigation (%8.8 of total responses and Avg score = 5.75) , safety (%26.6, Avg = 5.6), robot capabilities (%17.7, Avg = 4) , communication (%20, Avg = 5.3), environment (%6.6, Avg = 3.33) and privacy (%11.11, Avg = 4.6). Some of the user responses are as follow:

(1) Navigation
- **Participant 36, importance 5:** "How quickly will the robot move?"

List of all items	
	The robot conveying ...
1	whether it is currently acting autonomously or being controlled by a person.
2	whether or not it is safe to get close to it.
3	what it knows about the surrounding environment (i.e., the objects and people it can sense).
4	whether or not it needs assistance.
5	whether or not any faults/errors are detected (e.g., electric circuits damaged, etc).
6	whether or not its camera is recording.
7	when and in what direction robot would move next.
8	its battery life remaining in time (hours/minutes/seconds).
9	whether or not there is a problem with the engines/motors.
10	whether or not it currently knows where you are.
11	its current task progress (as a percentage of the whole task).
12	its wireless signal strength.
13	when it will change its altitude.
14	a list/schedule of upcoming/planned tasks (task queue).
15	the name of its current task along with a short description.
16	a list of successfully/unsuccessfully completed tasks (task history).
17	its remaining battery life as a percentage.
18	its most recent maintenance report (e.g., last time propeller was changed).
19	its total flight duration (from takeoff to the current moment).
20	how to look up more information about the robot (e.g., where to find a manual).
21	contact information for how to leave feedback about the robot.
22	the current time and date.

Table 2: List of all the items to rank in the survey

- **Participant 46, importance 6:** "What direction it is facing."
- **Participant 41, importance 6:** "Overall flight path"

(2) Safety
- **Participant 37, importance 6:** "It could tell me when it is too close with a beep or similar."
- **Participant 33, importance 6:** "Anything that is shaking the robot due to a failing part."
- **Participant 45, importance 7:** "If the robot is on a collision course."

(3) Robot Capabilities
- **Participant 22, importance 2:** "If the robot is on a collision course."
- **Participant 50, importance 4:** "How new is it's technology and how well it operates."
- **Participant 21, importance 6:** "What it is made out of."

(4) Communication
- **Participant 5, importance 6:** "If the robot can change objectives before completing one."
- **Participant 45, importance 5:** "How the robot perceives my actions."
- **Participant 38, importance 7:** "if it can react to my questions or concerns"

(5) Environment
- **Participant 15, importance 2:** "Rain or Water alert"
- **Participant 20, importance 5:** "Whether it is entering a restricted area."
- **Participant 15, importance 3:** "Heavy Wind alert"

(6) Privacy
- **Participant 34, importance 6:** "What is the robot doing in relation to me? Is it guarding something, is it recording me?"
- **Participant 4, importance 5:** "The distance from what it is recording from"

CONCLUSION

To summarize, in this paper we tried to answer a basic question "what information naive users want to know about a robot?". We believe this is a critical question and help the robot designers, design robots with knowing their needs. Often, we see this is not happening in the design process. We ran an online study of 50 participants on Mechanical Truk and asked them to rank a list of information they want to know about a robot. We find out that naive users have concerns about safety, navigation around robot and privacy.

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