Imagining the World with Your Robot in It: User Story Mapping as a HRI Design Method

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Abstract: The article describes a goal-based method of requirements elicitation for the initial design of robots and robotized processes on both prototype and production levels. The method utilizes a top-down approach similar to the User Story Mapping, widely used as an ideation tool in software development. It does not require special training to use, but it works best when professionals from different areas of expertise are involved in the ideation process. It results in a holistic model of the robotic product or process that accommodates both end-users and stakeholders and balances the scope of features to develop with deadlines in hand.

1 INTRODUCTION

Robotics is a dark horse of modern technology. In 2017, BCG updated its estimation of robotics market growth from $67 to $87 billion by 2025 (Sander, A. & Wolfgang, M., 2014). However, even this optimistic forecast might be an underestimation considering recent healthcare challenges that trigger technology push. Elevating demand in delivery services, disinfection, and telepresence may drastically increase the adoption rate of service robots and widen its fields of application.

The market growth would increase in the number of users from different backgrounds who will find interaction with robots to be a part of their professional duties or everyday routine (Rogers, E.M., Singhal, A., Quinlan, M. M., 2008). Designing robots, the team should consider various environments where robots will be applied, the feasibility of production and transportation, the possibility of off-label use, and multiple other factors. Achieving those goals may be challenging unless adequate design methods are employed.

To reduce the gravity of stakeholders 'convictions and cognitive biases, we suggest fusing several time-tested tools from the field of software development and adapting them for practical use in robotics. Display quotations of over 40 words, or as needed.

2 USER STORY MAPPING AS HRI DESIGN METHOD

For robot design, we suggest adapting the User Story Mapping method. User Story Map is a holistic model of a final product based on the estimated needs of users divided by roles they adopt while interacting with a robot. For the sake of robotics design, we use the method derived from Jeff Patton's original technique. Alterations were necessary due to a significant difference in the range of design considerations caused by the cyber-physical nature of robots (Michalos, G. et al, 2015).

The reason to choose this particular approach is that it allows a research and development team to take the point of view of every particular stakeholder and acknowledge their possible professional and personal reservations against using the product (Buckles, D., 1999). It is also critical to notice potential contradictions of stakeholder's goals and find a way to eliminate those from the very early stages of the design process or at least be aware of their existence. It also helps all the interested parties to get an overview of the target product beforehand and align their expectations.

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2.1 Overview

The ideation part of the design process aims to develop a comprehensive model of the final product. Suggested steps are the following:

- identify user types that later will become “roles”;
- assume user’s personal and professional goals;
- list tasks they should perform to achieve those goals;
- define an array of features to enable performing those tasks;
- prioritize them with timeline and available resources in mind;
- set realistic expectations for the product by reducing the scope according to deadlines or technical feasibility reasons.

Since brainstorming is proven to be a highly effective problem-solving technique (Osborn A.F., 1963), the ideation process typically includes several moderated brainstorming sessions with representatives of stakeholders present along with engineers, designers, and project managers (if any). Moderator’s responsibilities include:

- Writing down all the ideas from all the participants nondiscriminatory;
- Making sure participants communicate respectfully, feel like they work together toward a common goal, and have the same opportunity to share their ideas as any other team member to keep healthy group dynamics and facilitating performance and creativity of individuals and a group as a whole (Allport, F. H. 1920), (Carr, P. B. & Walton G. M., 2014), (Cwir, D. et al 2011), (Walton, G. M. et al, 2012);
- Introducing and enforcing a schedule: sessions would likely be lengthy so that breaks will be necessary to eliminate adverse cognitive effects of mental fatigue (Boksem, M.A.S. et al, 2005) and promote productivity;
- Directing conversations so they would be productive. Informal chats happen, but if they become distractive or unrelated to the topic, a moderator should interfere or call on break. People struggle to focus when they are tired (Boksem, M.A.S. et al, 2005);
- Summarizing ideas at the beginning and the end of the sessions to maintain the context of the session;
- Preparing final deliverables.

Team members may raise valid but untimely questions, which could cause elaborate yet misdirecting debates—providing pens and sheets of paper for participants to write down their questions and concerns should help keep them from disrupting the brainstorm-like flow of the session. After all parts of the session are done, a moderator should address those notes.

Moderators can provide their ideas as any other team members, but they cannot censor suggestions of other participants in any way. Another moderator’s goal is to prevent team members from assuming authority over other participants, influencing the team as a whole, and keeping others from sharing their ideas aloud (Anderson, C., & Kilduff, G. 2009).

Assumptions are written on sticky notes for convenience: placing and removing them is faster and easier than using digital stickers (Jensen M. M., et al, 2018) or editing a table. In this way, team members will not be reluctant to throw away the results of the time and effort spent on solutions that do not serve the purpose. Every session should start with a quick recap of the progress so far and end with housekeeping: removing repetitive or obsolete items. It is essential to keep in mind that similarly-worded items may have a different meaning when applied to different roles, goals, or tasks (Milicic, A., et al, 2014).

2.2 Model Structure

The model has four layers: roles, goals, tasks, and features. The advice is to work on each layer on different days to manage the mental workload of the team. That will also help to take a fresh look at every layer before starting to work.

2.2.1 Roles

“Role” is essentially a model that describes a particular subset of users, personal or professional, including people who maintain and fix robots, administer associated software, pack and move it as a physical object, and so on. Modeling roles instead of designing based strictly on testimonials of actual users helps avoid focusing on personality traits rather than actual needs. Which, in turn, may result in designing unscalable products (Cooper, A., 1999).

Most common roles

End-users, or rather, immediate users — people who will interact with a robot directly. For example, for delivery robots, those are people who retrieve or load the packages; for collaborative industrial robots, those are automated line workers; and for non-collaborative industrial robots, those are automation operators;

- clients — people who own the robot and use it to provide services to their customers;
- hardware maintenance engineers — professionals who design, maintain, or fix robot's hardware;
- software engineers — professionals who develop, set up, and upgrade robot's software;
- movers — people who will pack, handle and transport robots or parts to clients or servicing facilities;
- assembly line workers — staff involved in the production of robots.

Additional roles for mobile robots

- bystanders — people or animals who do not interact with robot directly, but may be affected by it: be startled or hurt by a moving robot, forced to change their route, or experience similar inconveniences while the robot is on the mission;
- vandals — people or animals who may attack or drabble robot;
- hackers — people who may access robot's control system and use it for prank or attack, steal users 'personal data or gather data with robot's sensors.

Depending on the environment, more roles may be worth considering. For example, if robots are to be used in airports or high-impact international events, the roles of security inspectors would probably appear. Security consideration, in turn, may greatly influence design choices regarding the component configuration inside the robots.

2.2.2 Goals

Goals are the personal needs of people who will use, maintain or profit from a robot. It is essential to acknowledge that users 'goals in particular roles may contradict the goals of the development team or users in other roles. For example, client employees may want to maintain the existing process they are familiar and comfortable with rather than adopt a new one due to misgivings about their part in that new process, even if it will potentially reduce their workload. That occurs because people are naturally aversive toward losses, even if they are hypothetical (Kahneman, D. & Tversky, A., 1992). The development team may miss that particular factor and operate under the assumption that potential reduction of a workload is the only goal that client's employees may have.

It is also important not to confuse professional duties with personal goals and goals developers would like users to have with ones they do have. For example, keeping a healthy work-life balance or feeling that their work matters might be a primary goal (Hu, J., & Hirsh, J. B., 2017) of customer service workers. While developers assume their primary goal is to close as many tickets as possible during their shift. Which, firstly, is not a goal but a task, and secondly, it is unlikely a primary objective of this subset of users.

Considering personal goals can potentially align the product to the needs of all potential users and avoid the risk of sabotage caused by frustration from technology Lazar, J. et al, 2006) that negatively affects the emotional comfort of users or even increases their workload.

Goals may be benign or adversarial. For example, the goal a professional might have is to appear competent (Jones E. E., Pittman T. S., 1982). This particular goal is benign regarding end-users or customer service workers and adversarial regarding vandals or hackers because their means for achieving those goals would be different. At the early stage of the design process, we should consider all of them. That will help anticipate ways robots can be damaged or misused and prevent or reduce potential harm.

2.2.3 Tasks

Tasks are actions users should take to reach every particular goal. For example, to stay and keep others safe, a security official in the airport most likely would want to look inside the robot to ensure it is safe and does not carry any forbidden items inside. Close inspection of the robot and the packaging it arrived in is a task.

Goals and tasks may be confused, so it is a moderator's responsibility to avoid this confusion. For example, to feel competent, customer service workers should study instructional materials about the robot or undergo training. Feeling competent is the goal, but studying for it is a task. Instructional material for customer care specialists and means to access mechanisms of the robot for a safety inspection, on the other hand, are featured.

2.2.4 Features

Features are tools we can provide users to help them complete their tasks and achieve goals with the robot. For purposes of robotics, we recommend keeping features at the bird-eye view and leave it to designated professionals to define the scope of every particular feature and develop user stories, if needed. For example, in software development, features can be zoomed in to "upload image via web-link" or "sign-in with Facebook." However, when it comes to robotics, it is best to leave it at “mobile app” as a feature for the “summon the robot” task or “joystick” as the feature for “create an initial map of the floor” task. Otherwise, design sessions may take an excessive amount of time and result in unintelligible deliverables.

Designing end-to-end robotized processes, the team should treat features as not functions of the device per se but as tools designed to perform tasks. Hence, user manuals, safety guidelines, third-party contracts (e.g., branding and logistics), spare parts, tools, and transportation boxes are all the features to be considered. The feasibility of disassembly for storage and transportation may be critical for sizable robots, although it is not vital for smaller ones.

3 RESULT PROCESSING

3.1 Revisions

It is best to read aloud the entire wall of stickers wrapping up sessions and after every break to eliminate contextual duplicates; otherwise, the team may end up repeating themselves and unnecessarily extending their workload. It is perfectly normal for some roles to have similar goals; the same tasks can be performed to achieve different goals. If there are duplicates, it is recommended to remove the corresponding extra stickers from the wall. It may result in a lacking model for a particular role, but overall it will be reduced to necessary yet fully comprehensive.

3.2 Triage

The number of features the team can come up with might be unrealistic to implement. Prioritizing them is essential in terms of getting actionable results. The simplest way to approach prioritization is to do it iteratively, starting with removing features that the team agreed not to implement and range the rest of them by priority (1, 2, 3 or red, yellow, green). The last stage of prioritization our team calls “to draw a thick black line.” It is an imaginary line on the wall of stickers symbolizing a deadline or reasonable scope for a prototype if time is not an issue. Features that cannot be implemented before the deadline or not crucial to a prototype, starting with low-priority ones, go below the line. That will leave the team with an image of an achievable result.

3.3 Deliverables

Moderator makes sure the entire wall of stickers is digitized as an excel table or any other document and sent over to all contributors when the process is fully complete. Contents of table cells may occur as ready for development or require additional research and outside consulting. However, the final document is a convenient reference to get back to if design and development go off track.

4 PRACTICAL APPLICATION

The altered USM method has proven suitable for generating product requirements for various robots and robotized processes. It may be instrumental in facilitating the ideation process resulting in a holistic model of the final product.

4.1 Outcome Analysis

Nevertheless, other outcomes are possible, such as the discovery of weak links in the initial idea. According to empirical data, two major potential issues could be discovered while analyzing the model: first, a robot is not the most feasible solution for achieving a majority of listed goals; second, too much is unknown implementation-wise.

- The majority of features are not directly related to robots.
- The number of non-robotic features that would successfully cover all listed tasks may equal or overweigh exclusively “robotic” ones. It does not necessarily mean the cost or quality of robotic and non-robotic solutions will be the same, but it calls for more profound product-related research. However, in some cases, a robot indeed is not the most feasible solution in a particular situation. Addressing those issues in the early stages of a project may help to advocate for a robotic solution competently or avoid predicaments related to a robot's practical application later on.
- The overall level of uncertainty is too high.
- Suppose most features require additional research or outside consulting. It may signify that the current level of technology is not there yet, or the skillset of the existing team does not cover the majority of work to be done. Understanding either factor early on may provide valuable insights and help to acknowledge nonobvious obstacles on the way toward the initial goal.

4.2 Considerations and Limitations

Even though the altered USM performs well during gathering product requirements, it has its constraints.

- Albeit group work may increase the productivity of its members and promote overall job satisfaction, it also may lead to low productivity (Campion, M. A et al, 1993) and conflict (Alderfer, C. P., 1977) within the team.
- The USM design session may require up to 20 hours of group work and additional time to digitize results.
- Professionals from various fields should be present, including those who can effectively represent clients and end-users. That introduces some logistical challenges.
- The resulting model is relatively low-fidelity, and designing particular features may require additional design sessions, validation of technical feasibility of implementation, or research.

5 CONCLUSIONS

In our robotics laboratory, we had a positive outcome from employing goal-based modeling of the final product not only for robots per se but also for robot-related services. We can recommend it to gather initial requirements and as a first step in the design process. It also may be used as a fast way to find out that robotization is not a feasible solution for particular processes, and users 'goals can be achieved by other means. Which may contribute to negotiations with internal clients in corporate laboratories and significantly reduce resources allocated to the project. We recommend using this method as a design practice combining or complementing it with persona design and user journey mapping if necessary.

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