DESIGNERLY
HRI
KNOWLEDGE

Context-Confrontation: Elicitation and Exploration of Conflicts for Delivery Robots on Sidewalks

Jered Vroon[1], Zoltán Rusák[2], Gerd Kortuem[3]

[1] Knowledge & Intelligence Design, Delft University of Technology, Delft, the Netherlands, j.h.vroon@tudelft.nl
[2] Knowledge & Intelligence Design, Delft University of Technology, Delft, the Netherlands, z.rusak@tudelft.nl
[3] Knowledge & Intelligence Design, Delft University of Technology, Delft, the Netherlands, g.w.kortuem@tudelft.nl

Abstract — Delivery robots are being deployed on sidewalks, but do we actually know which conflicts we should aim to avoid in the design and creation of these systems? Current approaches to social navigation focus on implementing well-established social norms such as proxemics, but it is dubious if these norms are sufficiently applicable to the context of dynamic interactions between such robots and pedestrians.

We argue that, to get rich insight in the actual conflicts, we should confront them within their context. Based on this argument, we outline a new method for user observation that aims to elicit and explore representative social conflicts by ignoring humans: context-confrontation.

Our first preliminary observations using this method suggest unexpected and novel conflicts, well outside of what current approaches seem to be focusing on – perhaps we, the designers/engineers of these robotic systems, should get out there a bit more, to find the conflicts that really matter.

Keywords — Human-Robot Interaction; Conflict; Social Navigation; User Observation; Methodology;

1. INTRODUCTION

Observation #1 – *A small delivery robot is driving through the city, apparently on its own. Staying to the right, mostly, it is sticking to its own path; it does not slow down, speed up or deviate from its trajectory for anyone. It is not crowded, but a decent amount of people is around. And yet, the robot can follow its trajectory completely unimpeded. People do their best to get out of its way – some by making barely noticeable changes to their trajectories or slowing down just a bit, others by steering their walking aids out of its path slowly but clearly.*

Figure 1. Our small robotic prototype almost having a run-in with someone crossing in front of it. We conducted our context-confrontation both indoors in a semi-public area (as shown here) and on sidewalks in the city. Photo stylized for privacy reasons.

Compare our observation above to the delivery robot currently in deployment; it got stuck in the curb before a crossing because it failed to find an ‘acceptable’ path through the people crossing that would not violate its set thresholds for impeding on peoples' personal space – while, in doing so, unfortunately, also blocking a wheelchair user from using said curb to get back on the side walk and continuing her path[1]. Or compare it to the mobile robot that got harassed in a shopping mall [1] or the telepresence robot that got teased by conference goers [2].

When creating HRI, interactions emerge between people and robots. This presents rich opportunities for finding novel ways of shaping and embedding those interactions (e.g. through improvisation [3]). However, as demonstrated by the examples above, it can also give rise to undesirable emergent outcomes (conflicts), in ways so strongly tied to the specific context, that they can be hard to predict upfront. In the creation and design of these systems we ought to be working to pre-emptively avoid or handle these conflicts.

But how can we know which conflicts will emerge? To do so, we need to form – upfront – a representative insight into the conflicts that may arise within the context.

We will explore this question in the context of social sidewalk navigation (Section 2) and use that to look further into the importance of conflicts (Section 3). We propose context-confrontation as a novel naturalistic method for eliciting conflicts by ignoring humans (Section 4) and present some first observations with rather unexpected conflicts and lack thereof (Section 5). This demonstrates, at least for this context, that context-confrontation can yield valuable insights into the conflicts we should be aiming to avoid (Section 6).

2. THE CASE OF SOCIAL NAVIGATION FOR DELIVERY ROBOTS

Small autonomous robots are more and more being deployed for last-mile delivery, navigating on sidewalks to deliver packages to peoples' doorstep. Their core aim is quite intuitive: To efficiently[2] and effectively move from one location to another. In addition, to avoid negative reactions/impressions, they should do so in 'harmony' with other users of the sidewalk and broader public space.

Efficient, effective, and harmonious behavior for mobile robots, and more specifically solutions for it, have been extensively researched in the field of **social navigation** (also known as human-aware robot navigation); current approaches have focused mostly on taking well-established social norms and finding ways to implement them into the behavioral repertoire of mobile robots. For example, based on Hall's concept of proxemics [4,5], mobile robots have been programmed to avoid getting within a specific threshold distance to people, i.e. to avoid 'invading their personal space', in a variety of different ways [6].

It is worth noting, though, that these well-established social norms are generalized from a range of contexts, which are in many ways unlike human-robot interaction with delivery robots. For example, Hall's afore-mentioned work on proxemics [4] is introduced primarily in the context of cultural differences and architecture, and may thus not translate one-on-one to social navigation for delivery robots. A similar commentary has previously been voiced by others as well (see e.g. [7], [8][3]).

While these norms can serve as valuable theory-level descriptions of our interactions, they may thus well fail to fully apply to specific instances, such as those involving delivery robots as well as people – as also evidenced by the aforementioned incident in which a delivery robot blocked the curb for someone in a wheel chair. Before we apply these norms to the specific systems we create and design, we should therefore first acquire more intermediate-level knowledge into which norms apply to those instances and how they apply.

Or, in other words, current work has mostly focused on implementing *solutions* based on social norms, but it is highly dubious if these social norms accurately represent the actual *problems*, the undesirable outcomes, that the designers/engineers of these systems should be aiming to prevent.

3. CONFLICT

To accurately inform designers/engineers about the outcomes they should be aiming to have the system avoid, there thus still is a need to investigate where undesired outcomes will occur during representative use of the system. We will first discuss in more detail what these undesired outcomes entail.

Firstly, it is important to note that whether outcomes are undesirable or desirable will always depend on the context and purpose of the system. For example, being highly engaging to passers-by might be undesirable for a delivery robot as it might hamper the efficiency of its deliveries, while the same property might be highly desirable for a robot handing out flyers.

Secondly, since both the system and the people that encounter it can adapt to each other, resulting in a complex system, these outcomes will always be emergent properties. For example, a delivery robot might be less efficient in making its deliveries when it is more crowded on the sidewalks it uses – i.e., 'not being efficient' is not a property of just the robot, but rather a property that results from the interactions between the robot and the environment in which it is to operate.

Taking both these observations into account, we here define **conflicts** as emergent outcomes that are undesirable with respect to the context and intended purpose of the system. For delivery robots, conflicts could then entail anything from reactions of pedestrians that make the robot less efficient in its deliveries, to behaviors of the robot that seem to cause disharmonious reactions in (some) pedestrians. Such conflicts could include, for example, the robot's presence scaring someone or the robot being teased, but also the robot engaging a passer-by to enthusiastically 'play' with it in a way that hinders its efficient navigation to its destination[4].

4. APPROACHING SOCIAL NAVIGATION BY FIRST EXPLORING CONFLICTS

We propose to explore social navigation by taking a small step back: what conflicts will actually arise within the context of representative interactions between a small delivery robot and pedestrians? Insights in these real conflicts will be a necessary first step for the design and creation of HRI that actively addresses these conflicts.

To answer this question, we here discuss a novel method that deliberately aims to elicit informative conflicts between people (pedestrians) and a representation of the interactive system under investigation (small delivery robots). This method combines standard user observation with a set-up aimed at letting conflicts emerge in a representative way.

Letting natural conflicts emerge by ignoring people Crucially, since conflicts are an emergent property, the (adaptive) behaviors of the system will affect which conflicts arise. If a system has behaviors that preemptively try to avoid conflicts, these behaviors may well give rise to conflicts themselves – again, this is illustrated by the example of the delivery robot discussed in our introduction that did not move from the curb (and thus blocked someone in a wheelchair from using it). In other words; adaptive 'social' behaviors are, by definition, a confounding variable that makes it harder to investigate the actual conflicts.

At the core of our method, context-confrontation, is thus the idea to conduct user observations with a representative prototype that deliberately does not implement any adaptive 'social' behaviors. More specifically, our prototype would ignore all people[5]. Behaviors that did not involve people, i.e. functional behaviors, such as planning an efficient/effective route and following it, were still used.

User observations Beyond those changes and the emphasis on exploring *when* conflicts arise, our method is similar to – and can build on – other approaches for conducting semi-naturalistic or naturalistic user observations within and beyond the field of HRI. It also is reminiscent of breaching experiments, albeit with a focus on finding out specifically in which cases (when) ignoring all people gives rise to conflicts; the specifics of the conflicts are less the topic of exploration, as our aim is to ultimately inform the creation and design of robot behaviors that actively avoid those conflicts arising.

5. OBSERVING A SMALL DELIVERY ROBOT ON A SIDEWALK

Using the method outlined above we are currently in the process of conducting observations. We conducted our observations both indoors and in the city of Delft (approximately 100,000 inhabitants). We created a prototype that was lightweight and covertly controlled by a Wizard of Oz (both for safety reasons). While any method for user observation could be used, we here opted for a combination of observation forms and a researcher's diary to collect or data.

While our findings are still very much preliminary, and though it is too soon to infer patterns from our observations, we will here share some observations, in addition to the one shared at the beginning of this paper, that we feel give a good impression:

> **Observation #2 –** *It is relatively quiet and the small delivery robot is following its own trajectory in a wide open pedestrian space. A pair of young men is walking in the opposite direction, when one of them deviates from his original path, now heading towards a heads-on collision with the robot. The pair looks at each other, smiling. Meanwhile, seemingly oblivious, the robot just keeps going as it was. Just before the last moment, the young man on a collision course steps aside for the robot.*

> **Observation #3 –** *A small group of people is standing still, chatting. There would be enough space to navigate around them, but the small delivery robot's trajectory leads it straight through/at them. When the robot makes an emergency stop to avoid actually hitting them, they engage with it. They take pictures and seemingly start exploring if and how they can get the robot to start and stop moving again.*

Observation #4 – *The small delivery robot is going its own way, which happens to include a zebra crossing. A strong head wind, combined with a weak motor, cause it to come to a near standstill right in front of a car that was waiting for all pedestrians (and the robot) to cross. Then, very gently, an elderly woman pushes it along, giving it just the nudges it needed to clear the crossing.*

6. ELICITATION AND EXPLORATION OF CONFLICTS (FOR DELIVERY ROBOTS ON SIDEWALKS)

We have discussed social navigation for delivery vehicles and introduced context-confrontation as a method to conduct user studies into the conflicts that such delivery vehicles could cause.

Our first observations using this method yielded far fewer conflicts than might be expected from a robot that effectively ignored all people; most pedestrians seemed to be more than willing to get out of its way. In addition, we also saw people help the robot, tease the robot, or engage with it when it made an emergency stop.

These kinds of findings can provide rich insights that are specific to the context of use (intermediate-level knowledge) – and can be invaluable to subsequently inform the design and creation of such systems. Perhaps, per observation #1, and in contrast to a lot of the current work in social (sidewalk) navigation for robots, we don't need to focus overly much on implementing proxemics for these robots? Or perhaps, per observation #3, we should put in effort to make sure a delivery robot does not unintentionally trigger engagement from people?

Choosing to make the robot ignore people let us conduct these observations and so enabled us to explore what conflicts should be handled in the design and creation of the HRI. In that way, context confrontation can help identify and discover – early on – insights in the context that are representative of the robot and the interactions that people may have with it.

Thus, while further observations and analysis will definitely be necessary to truly infer conclusions and confidently make specific recommendations, the current findings already seem to align well with the arguments made in this paper: we should pro-actively aim to find the conflicts that really matter for these interactive systems by going out and confronting the context.

Acknowledgment — Our thanks to all our colleagues from the Knowledge and Intelligence Design (KInD) group for their valuable suggestions and questions on both the storyline of this paper and the method outlined in it.

References

[1] D. Brščić, H. Kidokoro, Y. Suehiro, and T. Kanda, "Escaping from children's abuse of social robots," in Proceedings of the tenth annual acm/ieee international conference on human-robot interaction, 2015, pp.59-66

[2] M. Bruijnes, R. van Delden, and J. Vroon, "Telepresence robots in the wide wild world," 3rd Workshop on Ethical Encounters in HCI: Research in Sensitive Settings, 2017. Available: https://ethicalencountershci.com/.

[3] S. Yang, B. K.-J. Mok, D., H.P. Ive, R. Maheshwari, K. Fischer, W. Ju, "Experiences developing socially acceptable interactions for a robotic trash barrel," in Proceedings of the 24th IEEE international symposium on robot and human interactive communication (RO-MAN), Kobe, 2015, pp. 277-284.

[4] E. T. Hall, The Hidden Dimension. Anchor Books New York, 1966.

[5] J. R. Aiello, "Human spatial behavior," in Handbook of environmental psychology, D. Stokols and I. Altman, Eds. New York: Wiley, 1987, ch. 12, pp. 389–504.

[6] T. Kruse, A. K. Pandey, R. Alami, and A. Kirsch, "Human-aware robot navigation: A survey," Robotics and Autonomous Systems, vol. 61, no. 12, pp. 1726–1743, 2013.

[7] R. Mead and M. J. Mataric, "Robots have needs too: People adapt their proxemic preferences to improve autonomous robot recognition of human social signals," New Frontiers in Human-Robot Interaction, p. 100, 2015.

[8] M. Luber, L. Spinello, J. Silva, and K. O. Arras, "Socially-aware robot navigation: A learning approach," in 2012 IEEE/RSJ International Conference on Intelligent Robots and Systems. IEEE, 2012, pp. 902–907.

---

[1] An account of one person, Twitter user Emily E. Ackerman, experiencing this, can be found on https://twitter.com/EmilyEAckerman/status/1186363305851576321

[2] Time-efficient, cost-efficient, and energy-efficient.

[3] To quote one of their concerns: "*The authors [...] also use Proxemics in combination with a back space model that describes the discomfort of trajectories that pass behind a person for a dynamically navigating robot in a populated environment. However, the latter model was derived from behavior of male subjects in a lavatory context [...] and it is questionable if it extends to robots in a general crowd.*" [7, p.902]

[4] An example of this can be found on https://youtu.be/V1oG66fX2_4

[5] Barring, of course, where doing so could directly or indirectly create dangerous situations.