Out of Place Robot in the Wild

Envisioning Urban Robot Contextual Adaptability Challenges Through a Design Probe

Yu, Xinyan; Tran, Tram Thi Minh; Wang, Yiyuan; Mah, Kristina; Cao, Yidan; Johansen, Stine S.; Johal, Wafa; Lupetti, Maria Luce; Rose, Megan; Rittenbruch, Markus

DOI
10.1145/3613905.3651002

Publication date
2024

Document Version
Final published version

Published in
CHI 2024 - Extended Abstracts of the 2024 CHI Conference on Human Factors in Computing Sytems

Out of Place Robot in the Wild: Envisioning Urban Robot Contextual Adaptability Challenges Through a Design Probe

Xinyan Yu
xinyan.yu@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

Tram Thi Minh Tran
tram.tran@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

Yiyuan Wang
yiyuan.wang@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

Kristina Mah
kristina.mah@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

Yidan Cao
yidan.cao@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

Stine S Johansen
stine.johansen@qut.edu.au
Australian Cobotics Centre,
Queensland University of Technology
Brisbane, QLD, Australia

Wafa Johal
wafa.johal@unimelb.edu.au
School of Computing & Information Systems, University of Melbourne
Melbourne, VIC, Australia

Maria Luce Lupetti
m.l.lupetti@tudelft.nl
Faculty of Industrial Design Engineering, TU Delft
Delft, The Netherlands

Megan Rose
megan.rose@unsw.edu.au
ARC Centre of Excellence for Automated Decision-Making and Society and Vitalities Lab, University of New South Wales
Sydney, NSW, Australia

Markus Rittenbruch
m.rittenbruch@qut.edu.au
QUT Design Lab, Queensland University of Technology
Brisbane, QLD, Australia

Rodney G Zsolczay
rodney.zsolczay@hdr.qut.edu.au
Queensland University of Technology
Brisbane, QLD, Australia

Marius Hoggenmüller
marius.hoggenmuller@sydney.edu.au
Design Lab, The University of Sydney
Sydney, NSW, Australia

ABSTRACT

The increasing deployment of robots in urban spaces calls for design strategies to ensure their adaptation and to mitigate potential disruptions to complex urban contexts. Our research aims to initiate the discussion of contextual adaptability issues of urban robots by exploring everyday scenarios where their presence would appear out of place. We created a design probe for people to carry in their daily lives, facilitating them to envision the robot's presence and capture scenarios where a robot seems to be disruptive. We collected data by distributing the probes among the research team and conducting a city walk activity using the probe at a workshop. This paper presents factors arising from the collected scenarios, encompassing temporal, spatial, cultural, and social dynamics, as well as various stakeholders that robots need to adapt to. These findings provide a blueprint and potential research directions for future research into robot contextual adaptability in urban environments.

CHI EA '24, May 11–16, 2024, Honolulu, HI, USA

ACM ISBN 979-8-4007-0331-7/24/05
https://doi.org/10.1145/3613905.3651002

CCS CONCEPTS

• **Human-centered computing → Empirical studies in interaction design**.

KEYWORDS

Urban Robot, Design Probe, Scenarios

ACM Reference Format:
Xinyan Yu, Tram Thi Minh Tran, Yiyuan Wang, Kristina Mah, Yidan Cao, Stine S Johansen, Wafa Johal, Maria Luce Lupetti, Megan Rose, Markus Rittenbruch, Rodney G Zsolczay, and Marius Hoggenmüller. 2024. Out of Place Robot in the Wild: Envisioning Urban Robot Contextual Adaptability Challenges Through a Design Probe. In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '24), May 11–16, 2024, Honolulu, HI, USA.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3613905.3651002

1 INTRODUCTION

As technology advances, robots are moving beyond semi-controlled and routine-shaped settings, such as industrial [16] and domestic environments [17], to undertake tasks in urban environments, thereby becoming an integral part of our cityscapes. These diverse and dynamic environments introduce new challenges for robotic operations, necessitating adaptations to the uncertainties and complexities of real-world interactions with humans. This involves not only the technological capability necessary for efficient task execution but also contextual adaptability that ensures the robot is aware of and appropriately aligned with its socio-contextual settings.

Unlike robots operating in relatively static environments, e.g., interacting with a consistent group of users and operating within a narrow set of dimensions and parameters, adaptability for robots in public urban environments implies a much broader scope. Urban robots encounter a diverse range of individuals encompassing various demographics and engaging in different activities. In addition, a significant portion of these individuals are bystanders who do not intend to interact with the robots [2, 15], and their existing activities in urban environments could be inadvertently disrupted by the robots' presence. Therefore, beyond merely completing tasks effectively, a robot's ability to recognise and respond to the socio-contextual settings it operates in is crucial [20]. Focusing solely on task execution may render robots out of place and disturb the everyday lives and activities of the urban dwellers surrounding them.

A notable example occurred in September 2022, when a delivery robot crossed into a crime scene, blatantly ignoring the police tape, leaving the surrounding people confused and surprised by the situation. The video[1] capturing the incident went viral on social media, sparking widespread discussion about the potential disruptions caused by such robotic presences in urban environments. This instance is representative of the many real-world scenarios where the presence of robots seems out of place and abrupt, highlighting the need for human-robot interaction (HRI) researchers to study and understand the diverse contexts to which robots must be adeptly adapted. Although it is impossible to foresee the full spectrum of dynamic scenarios that might occur in urban spaces, some of these can be envisioned and reflected upon to anticipate issues of contextual adaptability in the design and development of urban robots.

To envision real-world contexts where robots might be misfits, we developed a design probe, inspired by the cultural probe method by Gaver et al. [11]. Our probe, a pocket-sized photo frame, was designed to elicit imaginative reflections by conceptually integrating robots into everyday urban life and identifying scenarios where the robot's presence could be disruptive or out of place. Data was collected by two means: a) distributing the design probe among an academic workshop organising team and recording their responses (i.e., photographs and reflections) through an online brainstorming board, and b) conducting a city walk [10] activity with the same probe and online board during an HRI workshop conducted at the OzCHI'23 conference[2], with all participants subsequently joining as authors of this publication.

In this paper, we report preliminary insights into the desirable contextual adaptability of urban robots based on the analysis of 27 collected entries. Our contributions are two-fold: First, the situational factors and stakeholders necessitating contextual adaptability that emerged from the analysis can serve as a blueprint for fellow researchers to delve deeper into this topic. We further interpret these findings to point out future research directions into robot contextual adaptability in urban environments. Second, our detailed documentation and reflections on the study's methods offer a template for replicating this research in more diverse urban settings.

2 METHOD

Understanding the potential misfit of urban robots in everyday urban contexts presents a unique challenge, primarily because these scenarios are often ephemeral and highly dependent on specific contexts and timing. This makes it difficult to anticipate situations where the presence of urban robots would be out of place without actually being in such scenarios. Compounding this challenge is the fact that urban robots are still a relatively novel phenomenon, so their infrequent deployment offers limited opportunities to observe and understand these intricacies in everyday life.

Sumartojo et al. [18] pointed out the role of imagination in understanding public perceptions and feelings about robots in urban spaces. Adopting an imaginative approach, they created photo collages to visually depict future robots in various spatial contexts and used these images to facilitate discussions about the current and possible roles of robots in public areas, as well as public attitudes towards these robots. Building on the proven effectiveness of using imagination to understand robots in urban contexts, we developed a design probe aimed at eliciting imaginative and reflective responses regarding scenarios in which urban robots might be out of place. We collected data by distributing these probes among our research team and by conducting a city walk activity with the probes during an HRI workshop at OzCHI'23 conference. In this section, we introduce the design probe, along with the data collection and analysis process.

2.1 The Design Probe

The cultural probe method, initially introduced by Gaver et al. [11], utilises various materials such as cameras and diaries for participants to document their daily activities. This approach has been widely adopted in design research as it offers a relatively unobtrusive and lightweight method for gaining insights into how technology can integrate into, or sometimes clash with, specific environments [12, 21]. Its aptitude for capturing fragments of daily life and aiding in the collection of autobiographical narratives [5] aligns well with our research objective to identify everyday scenarios where urban robots potentially misfit. Therefore, we employed this method and developed a design probe to facilitate reflection and develop narratives that reveal how robots might be 'out of place' from everyday life observations.

We developed the design probe as a pocket-sized photo frame (see Figure 1A), featuring a robot represented in a geometric cube. This basic shape would allow enough space for imagination of potential urban robot form factors and applications. Made from a 1.5 mm screen board using a laser cutter, the frame is portable for participants to incorporate into their daily routines. They could capture various scenarios with the robot image included (see Figure 1B for an illustration of a person taking a photo with the probe). The probe is accompanied by printed instructions when distributed to participants (see Figure 1C). We designed this probe to prompt people's reflections through the direct visual representation of robot presence within various scenarios.

[1]Available at: https://www.vice.com/en/article/93adae/food-delivery-robot-casually-drives-under-police-tape-through-active-crime-scene.
[2]http://www.ozchi.org/2023/

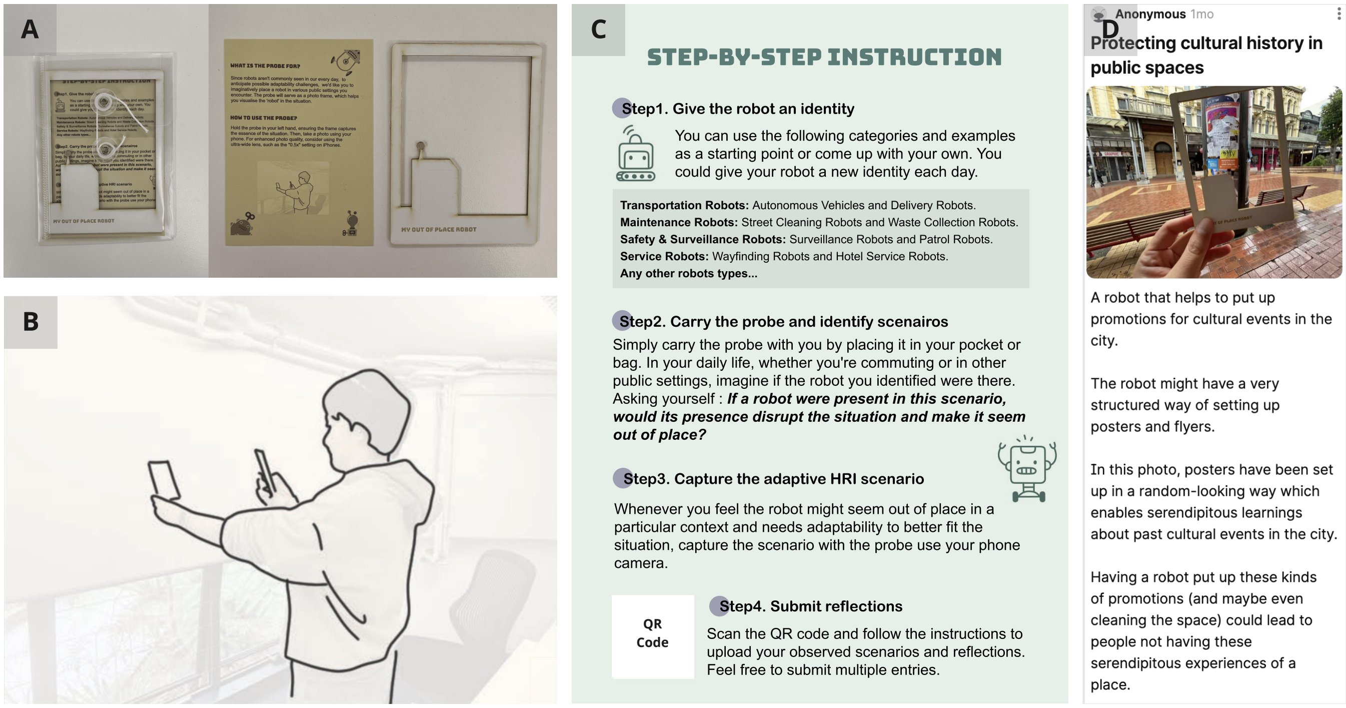

Figure 1: Design probe and its application: (A) The design probe, (B) Illustration of photo-taking with the probe, (C) Instruction guide, (D) Example post

2.2 Framing Imaginative Encounters with Urban Robots

2.2.1 Initial data collection. Data collection commenced with the design probes being distributed to researchers from Design Lab, the University of Sydney, to which four of the authors are affiliated. The research team was instructed to first assign an imaginative identity to the robot (e.g., delivery robot, cleaning robot) and carry the probe with them, envisioning the robot in various everyday life scenarios. In cases when they encountered scenarios where the robot’s presence seemed disruptive or out of place, they were asked to capture the scene using their phone camera, framing the scenario with the probe. Afterwards, participants submitted their captured photographs, descriptions of each scenario, and their thoughts on why the robot seemed out of place, to a public content-sharing board, Padlet[3] (see Figure 1D for an example post). Throughout this stage, we validated the working of the probe and refined the printed instructions.

2.2.2 City walk activity at a workshop. At a workshop held as part of the OzCHI’23 conference in New Zealand, eleven participants, comprising four workshop organisers and seven workshop attendees who later co-authored this paper, engaged in a city walk activity near the workshop venue. This area, located in the central area of Wellington city and characterised by a variety of shops, restaurants, and schools, provided a diverse urban setting for the activity. Each participant was provided with a design probe and paired up to freely explore this area. The activity followed similar procedures to those in the initial data collection stage and utilised the same Padlet board.

In anticipation of rainy weather on the workshop day, we also prepared a virtual city walk using Google Street View[4]. The virtual city walk started with participants choosing a starting point from locations like the center business district, pedestrian zones, and residential areas, as pre-identified by the workshop organisers. Participants then assumed the identity of a robot and navigated freely using the 360-degree imagery function, imagining the presence of their chosen robot in those scenarios. Whenever they encountered a scenario where the urban robot seemed out of place, they documented this discordance by capturing the scene on their screen together with the probe. After thoroughly exploring one location, they moved to the next pre-identified location and repeated the process.

In total, eight participants proceeded with the actual city walk, while three participants opted for the virtual city walk. Both activities lasted approximately one hour. After the city walk, each participant presented the observed scenarios they encountered to all participants. Following this, all participants engaged in a discussion to identify common patterns emerging from the scenarios, and challenges for robots to adapt and integrate smoothly into the urban environment.

2.3 Data Analysis

We received a total of 27 entries from both stages of data collection. To ensure data trustworthiness, we conducted the data analysis

[3] https://padlet.com

[4] https://www.google.com/streetview/

with a team consisting of three coders [7]. The analysis process commenced with each coder independently applying open-coding [8] to the collected entries, adhering to an inductive approach. Subsequently, the coders adopted a thematic analysis [4] approach to examine the initial codes, searching for common patterns and themes. This phase was followed by a meeting to review and resolve any discrepancies in coding, and to discuss the initial themes identified. Based on the discussion, the first author revised the codes and themes, which are presented in the Results section.

3 RESULTS

3.1 Robot Types and Roles

The robots featured in the Padlet posts were predominantly ground robots, with three posts mentioning drones. Regarding functionality, many of them were conventional robots with functions that have already been partially implemented in the real world. This includes delivery robots (n=6), way-finding robots (n=5), cleaning robots (n=2), and robots with authoritative roles (n=3) such as surveillance drones and parking fine robots. Five posts depicted more speculative uses of urban robots, such as street entertainment, animal protection, and seed planting. Six posts did not specify the robots' functionalities.

3.2 Situational Factors

3.2.1 Temporal dynamics. Urban contexts are inherently time-sensitive, and a key aspect highlighted in the scenarios is the adaptability of robots to **the rhythm of urban life** and its time-varying contexts. An illustrative example from the Padlet posts mentioned the differing behaviour of people in a train station elevator: the hurried pace during rush hour contrasts with a more relaxed demeanour during weekends. The post raised concerns about the robot being obtrusive if *'fail[ing] to fit into the workday vibe'* by remaining stationary and blocking people urgently ascending the steps.

The temporal aspect extends to robot responsiveness in **emergency situations**, which can alter urban dynamics suddenly and significantly. For example, one post featured an imaginative fire evacuation scenario, where the inability of a robot to react properly could impede the flow of people during evacuation.

Moreover, the robot **adaptation over deployment time** represents another factor for consideration. In the initial stages of introducing a robot into a new environment, a crucial adjustment period is required for the robot to adapt to the novelty effects it has on local inhabitants. Over time, as the robot's presence becomes a normalised and integrated aspect of the everyday environment, a recalibration of its behaviours may be necessary to stay in tune with the evolving dynamics of human-robot interactions.

3.2.2 Spatial Dynamics. The spatial landscape of urban environments is always subject to unpredictable transformations, largely driven by **human activities**. These changes can range from the emergence of construction sites to motorcycles being left in ways that obstruct pathways. During our city walk, a notable instance of this was observed: A previous motorway was transformed into a temporary sidewalk due to construction works blocking the usual pedestrian route. This scenario prompted participants to question how a pavement cleaning robot should respond in such situations: *'Would it seem inappropriate to clean the temporary pedestrian path? Would it seem inappropriate to stop there?'*

The analysis also revealed how human activities and **environmental conditions** intertwine to shape urban landscapes. During the city walk—taking place on a slightly rainy day—we observed an interesting behaviour pattern. As people sought shelter from the rain, they naturally moved under the porches along the street. This resulted in the covered sidewalk becoming crowded, while the exposed side remained empty. This scenario highlighted the risk of *'tripping over the [small] robot'* if the robot fails to adapt to crowded conditions (e.g., by subtly indicating its presence).

3.2.3 Social Dynamics. People rely on **social norms** as a foundation to interact and negotiate with one another. This significance has also long been recognised as an important aspect to consider in designing interactions between humans and robots [6]. One illustrative scenario depicted a crowd of people standing outside a coffee shop entrance. The participant imaginatively introduced a delivery robot picking up an order in this context. Their post highlighted the potential of the robot being out of place if it was not aware of social norms, which in this case involves asking people if they are queuing or simply socialising and then taking an appropriate course of action.

In addition, in everyday social interactions, people sometimes prioritise mutual understanding and practicality over strict adherence to formal regulations. One post pointed out the significance of this **flexibility in regulations**, raising intriguing questions about robots' ability to adapt to such fluid social norms. Another post captured a situation where a vehicle had been waiting extensively long at the crossing, yielding to pedestrians. Despite having the right of way, the author of the post chose to step back, signaling the driver to go ahead, in recognition of the driver's extended wait. This instance raised concerns that if a robot were to merely rely on the legal right of way, either proceeding without regard for waiting times or crossing at a consistently slow pace could be perceived as *'inconsiderate'*.

3.2.4 Cultural Dynamics. Compared to the explicit temporal and spatial dynamics, the more subtle and ambient changes in **cultural atmosphere** also play a crucial role in shaping a place. Thus, a robot that fails to adapt to the local cultural characteristics risks being out of place and disrupting the community's vibe. Our city walk activity took place in an area celebrated as the cultural heart of the city, known for its thriving artistic scene. During the walk, one participant noticed a pillar covered with a collage of posters advertising past and upcoming events, and recognised the importance of these posters in expressing the unique character of the place. Their reflection post expressed concerns over robots taking over cultural tasks, potentially diminishing the area's organic charm if they fail to grasp their cultural significance. For instance, a robot organising posters too neatly could undermine the area's distinctive character.

3.3 Impacted Stakeholders

3.3.1 General bystanders. The HRI community has long recognised that robots in public spaces impact not only their direct users but also non-users who encounter them in shared environments

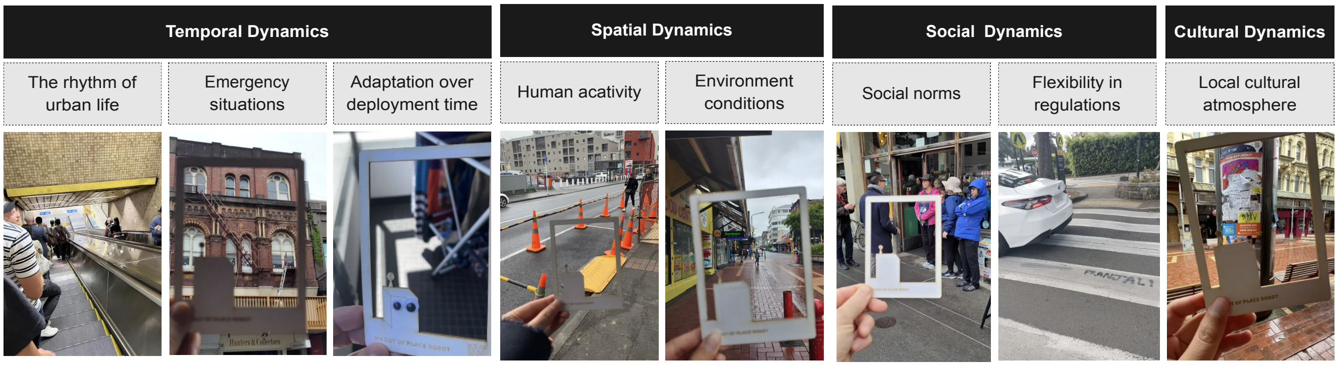

Figure 2: Situational factors and example scenarios.

without any intention of interaction [13, 15]. Our study captured scenarios where people's activities would be interrupted if the robot, serving other purposes, could not adapt to the situation. One illustrative post highlighted these **interrupted individuals** in the city waterfront area, a place often bustling with tourists and street performances. The author imagined a tour-guiding robot operating in this area and noted that its presence could unintentionally interfere with the surrounding activities and events. In addition, the purpose of the robot sometimes may conflict with the interests of people. An intriguing example of this is an imagined parking fine robot operating in a residential area. The author noted that some people may *'hate'* these robots due to their enforcement role. This situation highlights the necessity for robots to be contextually adaptive to ensure their operational tasks do not lead to alienation or aversion among **individuals with divergent interests**, which is crucial in fostering harmonious human-robot coexistence.

3.3.2 Vulnerable populations. In public spaces, it is natural to extend extra care to **people with disabilities**, such as people with mobility issues or visual impairments. One post illustrated this consideration, describing how people typically make way for individuals in wheelchairs on narrow sidewalks. It emphasised the necessity for robots to adapt similarly, stating: *'If a delivery robot fails to recognise the situation and not making way somehow, it's not very appropriate.'*

Another post discussed the importance of street cleaning robots to recognise **homeless people**. The participant suggested that while performing its task of maintaining urban cleanliness, the robot should be designed to be aware of and accommodate the unique living conditions of this often-forgotten group of vulnerable people.

3.3.3 Non-human inhabitants. Humans are not the only inhabitants of urban environments. Urban spaces are shared with a variety of other non-human living beings. One post depicted a serene morning scenario: people waiting for coffee at a cafe with a well-behaved dog patiently waiting alongside its owner. The author expressed concern about the potential disturbance that a delivery robot might cause for **pets** in the scene. They worried that if a robot were to come close to pick up an order, its proximity to the dogs could make them nervous, leading them to bark and disrupt the quiet of the early morning.

Besides domestic animals, urban environments also host **wild animals** such as birds that are integral to the city's ecosystem, coexisting with human activities. One post collected during the city walk activity put the spotlight on a pigeon, and raised discussion among workshop participants on how robots that primarily serve human needs can *'protect the animal's right to live in the space as well'*.

Vegetation, another crucial component of the urban ecosystem, often receives less attention during the design of technology for public spaces. One post highlighted the potential impact of a delivery drone on tree branches. Noting that the volume of leaves changes with the seasons, it posed the question: *'How much does a drone have to avoid the leaves? What if it is delivering emergency goods?'* The post underscores the necessity for the robot's contextual adaptability to take into account these less-considered living organisms present in the urban environment.

4 DISCUSSION

4.1 Adapting to Contexts and Being Reciprocal

Our investigation has revealed multiple dimensions shaping the operational contexts of robots in urban environments, encompassing temporal, spatial, cultural, and social factors. The ever-changing urban environments render certain robot behaviours appropriate in some scenarios but not in others, much like the need for humans to adapt to changing urban dynamics. This highlights the limitations of fixed, pre-programmed robot behaviours and underscores the necessity for contextual adaptability. Achieving this adaptability entails both comprehensive design investigations to uncover the specific contextual requirements and the integration of advanced context-aware AI systems [1].

Furthermore, HRI field studies have documented instances where humans accommodate robots in constrained urban spaces, often interrupting their own activities to assist or make way for them [14, 20]. However, this one-sided adaptation suggests an unsustainable imbalance for long-term coexistence. Robots should reciprocate this accommodation, adjusting to the needs of people around them. Our study identifies scenarios necessitating this reciprocal adaptability, ranging from recognising and prioritising the urgent needs of commuters during rush hour to addressing the special requirements of vulnerable populations. This is not only a technical requirement

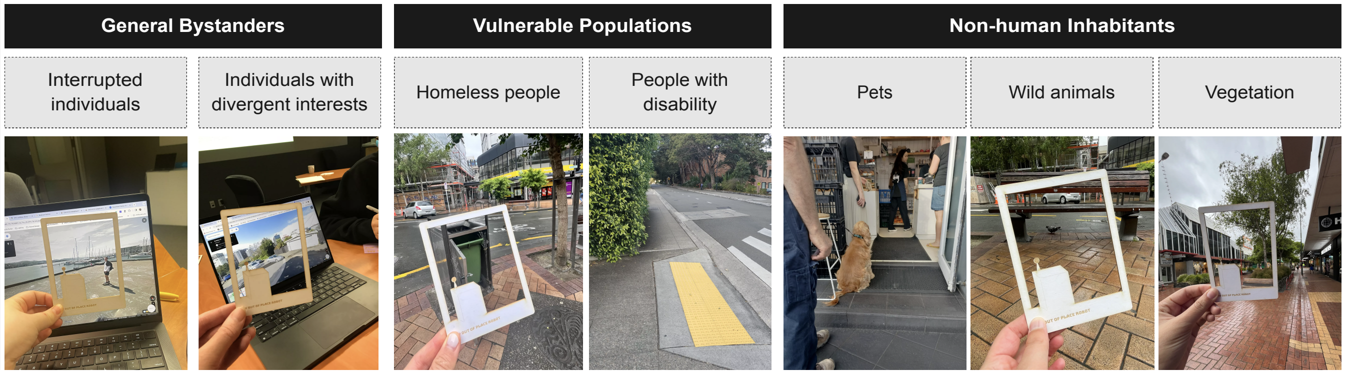

Figure 3: Impacted stakeholders.

but also a social obligation for ensuring a harmonious and sustainable human-robot coexistence in urban environments. Thus, future research should not only investigate how urban robots can blend into their surroundings but also foster reciprocal adaptability that benefits both parties.

4.2 Implicit and Indirect Interruptions

The potential interruptions discovered in our study are not limited to explicit and immediate impacts such as noise or inappropriate disruptions to social activities. They can manifest as subtle influences on the community environment or cultural atmosphere. This becomes evident in cases like the poster-placing robot post (see Figure 2), highlighting the importance of robots being capable of acknowledging and preserving the cultural atmosphere of the community they inhabit. Furthermore, interruptions in urban environments can arise indirectly from entities interacting with robots, not just from the robots themselves. An example is a dog barking due to nervousness caused by a robot in one post (see Figure 3), where the disruption (e.g., noise) is indirectly linked to the robot's presence. Such interruptions are often unforeseen and easily neglected. Therefore, future research should not only address implicit interruptions caused directly by robots but also the implicit impacts and those interruptions that occur in interactions between urban robots and other urban inhabitants.

4.3 Unheard Voices from Overlooked Stakeholders

Our investigation resonates with the recent call for HRI scholars to investigate 'who lives and works in the spaces that robots enter' [14], offering insights into a diverse array of urban inhabitants that are often overlooked. Our findings underscore the necessity of special considerations for vulnerable populations, including children, individuals with disabilities, and homeless people. Expanding further, we advocate for including non-human entities as critical stakeholders in urban robotics. In the broader HCI and interaction design community, the historical focus for a human-centred methodology is being reevaluated in light of emerging research, advocating for inclusive perspectives such as more-than-human [9] and life-centred design [3, 19]. This becomes particularly salient in urban robotics. Urban environments, being ecosystems that host diverse non-human life forms, necessitate considerations that include the broader biological and ecological milieu. Future research should address these overlooked stakeholders by considering their habitation into urban robot design processes.

4.4 Reflections on the Design Probe and City Walk Activity

Reflecting on participant feedback, key insights were gained regarding the probe and city walk activity. The physical probe effectively integrated imaginative robot presence into real-world scenarios, with its simple design aiding focus on contextual relevance rather than robot form. Participants noted that scenarios could evolve rapidly, leading to missed photo documentation opportunities. Addressing this, a redesigned probe, either attachable to smartphones or utilising digital AR for photography, would enhance portability and immediate accessibility.

Regarding the city walk activity, while the virtual city walk was suggested to be easy to follow, it has limitations in capturing temporal dynamics and certain environmental effects are more evident in outdoor activities. During the onsite city walk activity, there was an intriguing observation that many participants, who had travelled to the city for a conference and were unfamiliar with the surroundings, approached the activity with a fresh perspective, leading to more imaginative and speculative robot use cases. This observation suggests the potential to enhance the activity by focusing more on envisioning futuristic robot interactions, thereby encouraging innovative and forward-thinking ideas.

This study serves as a pilot test of our probe and city walk activity, and the first stage of data collection. Our future work will build upon these reflections to enhance the probe and activity. We also plan to expand data collection to a larger general population to generate a comprehensive understanding of robot contextual adaptability in urban spaces.

4.5 Conclusion

Using a design probe, our exploratory study gains insights into the contextual adaptability of robots in urban environments. By identifying crucial situational factors and the diverse stakeholders that robots must adapt to, we have laid a foundational blueprint and potential research directions for future research. Our study lays the groundwork for the seamless integration of robots into urban life, fostering their harmonious coexistence with urban inhabitants.

ACKNOWLEDGMENTS

This study is funded by the Australian Research Council through the ARC Discovery Project DP220102019 Shared-Space Interactions Between People and Autonomous Vehicles. We thank all the authors for taking part in this workshop and contributing to the publication.

REFERENCES

[1] Unai Alegre, Juan Carlos Augusto, and Tony Clark. 2016. Engineering context-aware systems and applications: A survey. *Journal of Systems and Software* 117 (2016), 55–83. https://doi.org/10.1016/j.jss.2016.02.010

[2] Susanne Boll, Marion Koelle, and Jessica Cauchard. 2019. Understanding the Socio-Technical Impact of Automated (Aerial) Vehicles on Casual Bystanders. In *1st International Workshop on Human-Drone Interaction*. Ecole Nationale de l'Aviation Civile [ENAC], Association for Computing Machinery, Glasgow, United Kingdom, null. https://hal.science/hal-02128379

[3] Madeleine Borthwick, Martin Tomitsch, and Melinda Gaughwin. 2022. From human-centred to life-centred design: Considering environmental and ethical concerns in the design of interactive products. *Journal of Responsible Technology* 10 (2022), 100032. https://doi.org/10.1016/j.jrt.2022.100032

[4] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101. https://doi.org/10.1191/1478088706qp063oa

[5] EunJeong Cheon and Norman Makoto Su. 2018. Futuristic Autobiographies: Weaving Participant Narratives to Elicit Values around Robots. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction* (Chicago, IL, USA) *(HRI '18)*. Association for Computing Machinery, New York, NY, USA, 388–397. https://doi.org/10.1145/3171221.3171244

[6] Bartneck Christoph and Forlizzi Jodi. 2004. A design-centred framework for social human-robot interaction. In *RO-MAN 2004. 13th IEEE International Workshop on Robot and Human Interactive Communication (IEEE Catalog No.04TH8759)*. IEEE, Okayama Japan, 591–594. https://doi.org/10.1109/ROMAN.2004.1374827

[7] Sarah Church, Michael Dunn, and Linda Prokopy. 2019. Benefits to Qualitative Data Quality with Multiple Coders: Two Case Studies in Multi-coder Data Analysis. *Journal of Rural Social Sciences* 34, 1 (2019), Article 2. https://egrove.olemiss.edu/jrss/vol34/iss1/2

[8] J. Corbin and A. Strauss. 2014. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. SAGE Publications, California, United States. https://books.google.com.au/books?id=hZ6kBQAAQBAJ

[9] Paul Coulton and Joseph Galen Lindley. 2019. More-Than Human Centred Design: Considering Other Things. *The Design Journal* 22, 4 (2019), 463–481. https://doi.org/10.1080/14606925.2019.1614320 arXiv:https://doi.org/10.1080/14606925.2019.1614320

[10] Clara Crivellaro, Rob Comber, Martyn Dade-Robertson, Simon J. Bowen, Peter C. Wright, and Patrick Olivier. 2015. Contesting the City: Enacting the Political Through Digitally Supported Urban Walks. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI '15)*. Association for Computing Machinery, New York, NY, USA, 2853–2862. https://doi.org/10.1145/2702123.2702176

[11] Bill Gaver, Tony Dunne, and Elena Pacenti. 1999. Design: Cultural Probes. *Interactions* 6, 1 (jan 1999), 21–29. https://doi.org/10.1145/291224.291235

[12] Tuuli Mattelmäki. 2006. *Design Probes* (2 ed.). Publication series of the University of Art and Design Helsinki. A, Vol. 69. University of Art and Design, Helsinki. https://aaltodoc.aalto.fi/items/65a46fd8-1dc4-4202-b8a9-520a011f8232

[13] Frederik Moesgaard, Lasse Hulgaard, and Mads Bødker. 2022. Incidental Encounters with Robots. In *2022 31st IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, Napoli, Italy, 377–384. https://doi.org/10.1109/RO-MAN53752.2022.9900591

[14] Hannah Pelikan, Stuart Reeves, and Marina Cantarutti. 2024. Encountering Autonomous Robots on Public Streets. In *ACM/IEEE International Conference on Human-Robot Interaction*. Association for Computing Machinery, Colorado, USA, 11–pages. https://doi.org/10.1145/3610977.3634936

[15] Astrid Rosenthal-von der Pütten, David Sirkin, Anna Abrams, and Laura Platte. 2020. The Forgotten in HRI: Incidental Encounters with Robots in Public Spaces. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction* (Cambridge, United Kingdom) *(HRI '20)*. Association for Computing Machinery, New York, NY, USA, 656–657. https://doi.org/10.1145/3371382.3374852

[16] Allison Sauppé and Bilge Mutlu. 2015. The Social Impact of a Robot Co-Worker in Industrial Settings. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI '15)*. Association for Computing Machinery, New York, NY, USA, 3613–3622. https://doi.org/10.1145/2702123.2702181

[17] Eike Schneiders, Anne Marie Kanstrup, Jesper Kjeldskov, and Mikael B. Skov. 2021. Domestic Robots and the Dream of Automation: Understanding Human Interaction and Intervention. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (<conf-loc>, <city>Yokohama</city>, <country>Japan</country>, </conf-loc>) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 241, 13 pages. https://doi.org/10.1145/3411764.3445629

[18] Shanti Sumartojo, Robert Lundberg, Leimin Tian, Pamela Carreno-Medrano, Dana Kulić, and Michael Mintrom. 2021. Imagining public space robots of the near-future. *Geoforum* 124 (2021), 99–109. https://doi.org/10.1016/j.geoforum.2021.06.006

[19] Martin Tomitsch and Steve Baty. 2024. *Designing Tomorrow: Strategic Design Tactics to Change Your Practice, Organisation, and Planetary Impact*. Bis B.V., Uitgeverij (BIS Publishers), Amsterdam. 256 pages.

[20] David Weinberg, Healy Dwyer, Sarah E. Fox, and Nikolas Martelaro. 2023. Sharing the Sidewalk: Observing Delivery Robot Interactions with Pedestrians during a Pilot in Pittsburgh, PA. *Multimodal Technologies and Interaction* 7, 5 (2023), 53 pages. https://doi.org/10.3390/mti7050053

[21] Joseph Wherton, Paul Sugarhood, Rob Procter, Mark Rouncefield, Guy Dewsbury, Sue Hinder, and Trisha Greenhalgh. 2012. Designing assisted living technologies 'in the wild': preliminary experiences with cultural probe methodology. *BMC medical research methodology* 12, 1 (2012), 1–13. https://doi.org/10.1186/1471-2288-12-188