Telepresence Robots in Daily Life
Technical Report
This report is an extended version of [4].

Robby van Delden∗
Human Media Interaction,
University of Twente
P.O. Box 217
Enschede, The Netherlands
r.w.vandelden@utwente.nl

Merijn Bruijnes†
Human Media Interaction,
University of Twente
P.O. Box 217
Enschede, The Netherlands
m.bruijnes@utwente.nl

ABSTRACT
Mobile remote presence systems (MRPs) are the logical next step in telepresence, but what are the ethical, social, legal, and technical implications of such systems going into the wide wild world? We explored these potential issues by immersing ourselves in a range of possible applications by re-purposing commercially available MRPs. This is a researcher-as-experimental-subject (RAES) approach which allowed us to quickly identify many possible issues that could arise from use of the technology. Considering such issues can help further the use of telepresence robots in real-life settings. Furthermore, we suggest that the RAES approach could be helpful in finding interesting issues that might arise when new technologies are introduced to the consumer market.

KEYWORDS
MRP systems, Telepresence, Telepresence robots, Researcher as experimental subject, RAES, Use-cases

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1 INTRODUCTION
The profound technical, social, legal, and ethical benefits and challenges that accompany the introduction of new technology can have a broad impact on society and as such are important to study. The scientific work done in labs and the use cases explored by developers of commercial platforms can only show part of this impact; it is the actual use in the wide wild world that shows a more complete set of the concerns and opportunities that the new technology brings.

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1 ortid.org/0000-0002-6592-1199
† ortid.org/0000-0002-7842-8213

New technology with the potential to have a profound impact on society is Mobile remote telepresence (MRP) systems. MRP systems allow for two-way communication between a local user (or bystander) and a telepresent (not local) pilot. The telepresent-pilot can steer his robot through the environment of the local-user and both can engage in two-way communication through cameras, screens, microphones, and speakers (we adhere to the terminology of [12]). MRP systems are getting better, cheaper, and more common (e.g. [8]). Thus far, they have been mostly confined to laboratories and controlled environments such as offices. Slowly, we see them going out into the wide wild world†.

In this paper we present our investigation of the challenges and opportunities that arise by day-to-day use of MRP systems. We adopted a researcher-as-experimental-subject (RAES) approach [7], where we engaged as active observers and took into account our first-person experiences in a variety of use cases with MRP systems. The use cases we investigated were focused on the wide wild world and thus mostly lie outside of the ‘standard’ controlled scopes. Our contribution is twofold: 1) through a plethora of use cases we show challenges that need to be addressed for long-term acceptance of MRP technology and possibilities for this technology; and 2) we show that investigating technology with a RAES approach and creative use cases can provide a range of new insights.

2 BACKGROUND
2.1 Research in the wide wild world
Real-life settings are diverse, hard to predict, and hard to control, which can make it challenging to conduct research in such settings. One approach is the researcher-as-experimental-subject (RAES) methodology, which has been successfully used in social psychology [7]. In it, the scientist engages as an active observer. This approach is similar to other practices, such as ‘dogfooding’**, where developers are required to use their own products; an approach particularly popular in software-development. Benefits of dogfooding are apparent (e.g. [11]), for example because small bugs or annoyances the developer encounters in daily use are solved rapidly. In line with these approaches, Roberts suggested that self-experimentation can generate new scientific ideas, where he focused on his health, sleep, and mood [14].

† E.g. blog.suitabletech.com (visited Sep. 25, 2015)
‡ Allegedly this term originates from someone advertising dog food and feeding it to their own dog, or from a dog food manufacturer eating it himself [11].
In an exemplary case, Brćić et al. [3] developed a mobile robot capable of handing out flyers to people. Putting this robot in a shopping centre unveiled a range of unexpected challenges. For example, kids actively harassed the robot - both by insulting the robot and by kicking and hitting it. Though the researchers tried a variety of theoretically sound solutions, in the end the solution that turned out to work in the ‘real world’ was for the robot to (1) predict the likelihood of (a group of) children harassing it and (2) navigate towards the parents of those children.

2.2 MRP systems in the wide wild world

Though a lot of scientific work has been done with MRP systems, including research with specific user groups, most of this work was done in controlled settings ranging from technical laboratories to living labs: see [12] for an overview. At the same time, capabilities and affordability of MRP systems have increased [8]. By now, there is a range of MRP platforms commercially available, for example the Double and the Beam. Other platforms, such as the Giraff, are getting ready for the more general market as well.

Albeit not in a scientific context, this availability has already resulted in a range of uses. For example, Suitable technologies mentioned on their website that the Beam was employed in several use cases outside the common scope of MRP systems. It was used for clean room inspection, for showing around clients in their factory or (cgl-) laboratory, for being present at conferences or trade shows, for supervising medical residents, and to improve a telepresent job interview by showing candidates around. Furthermore, they reported a variety of use cases for bedridden or otherwise disabled people: navigating in the outside world, visiting museums, doing a PhD defence, and even visiting the White House to meet the president of the USA.

3 METHODOLOGY

Following the RAES method, we investigated MRP systems in the wide wild world by actually putting them there in a wide variety of use cases. We ourselves were active observers, either by acting as the remote visitor or by direct observation (and instruction) of those that were co-located with the MRP system.

The use cases were selected to show the variety of possibilities outside the current scope and to provide insights for future use of telepresence robots in society. Specifically, we investigated use cases that ‘a member of the general public’ might come up with if they had easy access to an abundance of affordable MRP systems. We did not intend to create an extensive or complete set of use cases, but rather started from the principle of bringing an MRP system to all activities we normally attend.

Specifically, we investigated use cases (outside the current scope of use) that ‘a member of the general public’ might come up with if they had easy access to an abundance of cheap MRP systems. We did not intend to create an extensive or complete set of use cases, but rather started from the principle of bringing an MRP system to all activities we normally attend. In this way our ethical advisory board considered it standard HCI research and granted us permission to perform the research (see for a more detailed discussion [4]).

Our observations during these use cases were aimed at identifying both specific and general issues and benefits that arose. Afterwards we identified four main domains to which these issues and benefits could be linked: social, technical, legal, and ethical. In the text below we will introduce the different use cases and describe the issues and benefits related to them. At the end of the paper we will then discuss them from an overall perspective.

Central in these use cases are of course the specifics of the MRP system used; there are several types and categories of what can be seen as a telepresence robot. We are aware that each system will have its specifics for how the society will react to it and what challenges or benefits might arise. However, for practical reasons we chose the devices that were available to us: a Double robot and a Giraff robot, see Figures 1a and 1b. Both can be controlled (manually) over the internet to drive around, have a screen that can be moved move up and down, and have video conferencing capabilities. The Giraff can also tilt its screen backward and forward.

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[3][www.doublerobotics.com]

[4][www.suitabletech.com]

[5][www.giraff.org]

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We refer to Kristoffersson [12] for an overview of MRP systems and to telepresence-robots.com/robots (visited Oct. 1, 2015) for an overview of recent systems.
4 USE CASES

The work discussed in this report is part of a project named *Bot (pronounced StarBot). The star is intended as a wild-card where the term that describes a use case replaces the star, combining it with the word ‘bot’. This creates the name for a use case, for instance shopping with an MRP is called ShopBot or visiting an event with an MRP is called EventBot.

4.1 ShopBot

Shopping is a repeating and common task throughout society. It can constitute one of the few possibilities for some form of social contact. Going shopping has a tangibility that goes beyond shopping online. Consequently, one might feel the experience of shopping with a telepresence robot to be more vivid and social than online shopping.

There are various reasons why one might go for a quick shopping expedition with a (telepresence) robot, and we are not the first to embark on such an adventure [5]. One could be preventing physical discomfort (reducing required effort, prevent injuries due to heavy weights or simply avoid going through the rain), or might be unable to go outside otherwise (contagious state, physical disabilities or mandatory physical presence, e.g., looking after one’s children at the same time).

We went out with an MRP system (a Double) to get some groceries. This required some additions to the device: mobile broadband internet with a wifi hotspot (i.e. an Android phone with HSDPA connectivity), a bucket to place the products in (i.e. a flower pot), and a container to keep the money (i.e. a paper envelope).

Finding the cookies, the product we craved, was easy using the video stream. However, for putting the product in the basket we relied on the help of others, we asked people to put the groceries into the bucket. Some shoppers seemed to observe us with curiosity but most remained reluctant to help us. It surprised us that it was so hard to elicit help for such a small task. We expected the novelty [18] of the MRP system to generate interest from the shoppers and that this would make it easy to elicit help. Related to this, it might have been of influence that we did the experiment at the end of the day, as shoppers were keen to get home or were worried the shop might close soon. This means their perceived risk was higher than the perceived reward of interacting with the MRP system and thus they avoided it [18]. Another potential reason for the reluctance to help the pilot with his cookie-quest might have been what Takayama and Harris call ‘presentation of self’ [16].

A technical solution might be possible (e.g. a robotic hand) but with current technology it is difficult to imagine an elegant solution. However, being dependent on people would be hard in an (exaggerated) future scenario where MRP systems are abundant and outnumber the shoppers. A less social alternative, in which one still gets their groceries instead of getting them delivered, is to let the shop owner collect the groceries based on a shopping list and sell them to the MRP that visits the shop, an approach chosen in [5].

We successfully joined the queue for the cashier station. Shoppers did not cut in line and did not engage the robot or the pilot in interaction. They did, however, help the cashier get the cookies and money. The location of the basket and the money on the robot meant that it was difficult for the cashier to reach (Figure 2).

4.2 BeerBot

But what would happen when trying to buy a more regulated product? To find out, we repeated the ShopBot set up, this time to get a beer. Another shopper assisted us by putting a can of our favourite brand in the robot’s basket and we queued in line for the cashier. Confronted with a low resolution picture of the driver that made it difficult to guess his age, as per Dutch law the cashier did what she was obliged to do when in doubt about the age: she asked the pilot for identification. After awkwardly presenting a driver’s license to the camera we were allowed to purchase the alcoholic beverage (Figure 3).

This triggered us to think about the legal and practical issues surrounding identification and identity. Identity theft is also something to keep in mind as it might be easy for a pilot to pose as someone else. For example, an under-age shopper might pose as a parent on the ‘family MRP system’. They might be able to reuse a recorded interaction of one of the parents to buy alcohol.

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7 www.youtube.com/watch?v=YJr4Z26qqm0

Figure 2: ShopBot at the cashier. The basket with the cookies and the cash is encircled.

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4.3 TheftBot

While we do not predict a 'Coming Robot Crime Wave' as Sharkey et al. [15] do, we do see possible ways people might use MRP systems for illegal activities.

Extending on the BeerBot scenario we turned to ethically and legally challenging behaviour: stealing an item from the grocery store using the telepresence robot. We again enlisted the help of a friendly human shopper to place an item in the basket on the robot. Then we needed to find someone who would distract the cashier so we could sneak out with our snack without being noticed (the cashier and the supermarket were informed and gave consent prior to our experiment). We found a group of university students (adults) who were, to our surprise, willing to distract the cashier. With perfect timing they asked: "Miss, miss, where can we get a plastic bag?". Our MRP passed the cashier without being noticed and was ready to leave the shop with the stolen goods (Figure 4).

At this point the experiment was revealed and the students were debriefed on the overall goal of our research project. Because the students had been (surprisingly) accommodating in what to them should have appeared as an illegal activity, we took extra care in debriefing this to them.

This example brings forth a number of interesting aspects regarding legal issues. Are the necessary legal elements to have direct criminal liability of artificial entities present [9]? Mediation by a robotic system can make it more difficult to establish who is responsible. Is it the builder of the robot, its owner or the pilot controlling it? To make things more complicated, the one seen on the screen might not be the actual person controlling the robot. Perhaps these issues are currently far fetched but technological measures (or new laws) might be needed to mitigate them. To name a few suggestions: one might require protocols for secure unalterable webcam feeds, keep records of telepresence-calls, create identification or license plates for MRPs to keep track of stolen MRPs, or limit access to the video feed of the MRP to one owner.

4.4 EventBot

Trade fairs, social events, and conference meetings are crowded with people and create ample opportunities for social interaction. A disadvantage is that one might need to stay close to a stand, limiting the interaction with visitors. Furthermore, such events often require hours of travelling to visit. A trade fair robot would be a solution, and indeed this has been investigated before [17].

To investigate how people respond, what issues arise, and what benefits it would have, we piloted an MRP at three events. With the MRP we could visit other stands, get a drink, and even get some food: all without the need to leave or own stand. In addition, we could attend parts of presentations, see who was speaking, pick an appropriate time to go in or out, and look around the room to find colleagues.

Due to the high levels of noise, combined with limited directionality and quality of the sound it was hard to talk and listen to others using the MRP. This is in line with the findings of Arons [1], describing the detrimental effects of limited directionality and quality of sound on our natural ability (the 'cocktail party effect').
to tune to a single talker and to filter out other conversations. In order to get people, drinks, and snacks to our stand we repeatedly needed to use gestures such as pointing. At some point we resorted to handwritten notes held in front of the camera.

We distinguish three groups of people based on our observations during events: Not-interested, Nice, and Nasty people. The majority of the people were simply Not-interested in the MRP and did not engage in interaction with the pilot while many glanced at it. More interesting was the group of Nasty people that tried to block the robot, blocked the camera (Figure 5), pretended to kick it, and even picked it up. There were also the Nice people that went above and beyond to help us. For instance, a group of people scavenged the event to get us a fine selection of nuts. Others instructed the bar personnel to grab some drinks. A Nice person even did a tucked sideways roll in order to take a photograph while making sure he did not block the MRP (Figure 6).

We also invited the public to control the MRP systems on many opportunities. We found that the (our perceived) personality of the person piloting the MRP had an effect on the success with which people completed ‘missions’ we gave them, such as ‘go to that stand and get a pen’. Introverts appeared to be less successful than extroverts and also gave up sooner. However, these findings came from impromptu experiments and should be investigated using structured experiments.

The second author also used the MRP system for an event when he was bedridden due to a severely broken leg, see Figure 7. This made us realize that the system adds some form of social contact but at the same time it also emphasizes the feeling that you are currently missing out on social contact and events. Being there and sharing a drink is not the same when you are in bed with an empty glass. You are given a voice at the event, yet have difficulties listening to conversations due to occasional connectivity problems. This all emphasises to the user that he or she is not really present and in the end made that we did not often use the MRP system in our bedridden situation.

4.5 KinectBot

In general, a suitable embodied interaction can add to a user experience and increase the immersion [2]. We investigated this by creating an MRP system that could be guided by the movements of the user. Leaning forward, as detected by Kinect’s skeleton tracker, drove the robot forward and leaning backward made the robot brake and reverse. Leaning to a side rotated the robot in that direction. Unfortunately, these control proved hard to use and formed a distraction during social interactions.

4.6 ArtBot

A museum is a setting quite suitable for an MRP system; guests who are not able to physically attend the museum could use it to experience the artworks, or it could allow artists to engage patrons observing their artwork. A ‘robotic eye’ driving around in the museum would work in the first scenario (e.g. [13]), but two-way communication could allow for a more interactive experience. One real-life example is the Beam MRP system allowing disabled people to experience the Seattle Art Museum. During an opening at an art gallery we used an MRP to allow visitors to log in and experience the opening. To prevent damage to artworks we had two human attendants walking in the vicinity

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11 youtube.be/gDQvdNuM2-U
of the MRP. Visitors and employees of the gallery of our use case were so enthusiastic they started a crowd-fund raiser to buy an MRP system for the gallery.

4.7 ActBot

An MRP system might relieve some stage fright tension. Our MRP system starred in Little Red Riding Hood, see Figure 8. Driving in the woods proved near to impossible with the MRP system we used. Acting through a camera was an interesting experience: it proved easy to ‘portray an emotion’ that the director deemed fit for his envisioned portrayal of the folk tale. However, during driving it was sometimes hard to prevent a ‘game-face’.

4.8 LectureBot

Giving a lecture with a MRP system can be a great way to save time, as the lecturer would not have to travel to the lecture room. To investigate this, we used an MRP system to give a lecture. Interestingly, this showed a positive side to having low volume on the MRP system: a filled lecture hall fell totally silent. The students in the back rows had difficulty understanding the lecturer if others made a sound, resulting in an unusual and notable silence. It proved challenging to advance slides while telepresent, so a student had to assist the lecturer.

In a TEDx talk, we used a combination of co-present and telepresent presenters. To illustrate the social aspect of the MRP system, the presenters engaged in some semi-scripted small-talk on stage (Figure 9). We feel one of the exchanges with an overlap in their utterances is prototypical to the effect telepresence can have:

Telepresent presenter: “Yes, I can see you, I am very present there!”

Co-present presenter: “Yes, so how present are you?”

Telepresent presenter: “You know what? I’m even nervous being on stage!”

4.9 RefereeBot

Doing sports is a great way to socialize and increase one’s health, especially for children. However, it can give parents the burden of attending the matches of their children and of refereeing some of the matches. During one of our many discussions with the general public about MRPs, someone suggested using an MRP to referee a hockey match as it would remove the need to travel to the hockey field.

Overall, our experience with RefereeBot was quite mediocre. We had connectivity issues and the video stream lagged often, at times there was almost a full minute’s delay. Moreover, it was unclear whether the robot was still responding to commands or if the delay was also present in navigation. We agree with Desai et al. [8] that it is bad practice to continue transmitting robot commands if the video cannot be transmitted any more. It could have resulted in bumping into the players, though this fortunately did not happen in our case. Additionally, we found that the limited top speed of the robot (approximately 6 km/h) made it harder to follow the game (Figure 10).

4.10 BingoBot

To investigate the use case of a telepresence robot with elderly in the wide wild world, we took an MRP system (the Giraff) and let it participate in the ‘Bingo’-game at a nursing home. We controlled it, as we had found earlier that doing so can be quite challenging,
in particular for elderly people. Because we did not fit the demographic, two inhabitants communicated through the robot instead. We had some technical difficulties with setting up the network and firewall of the nursing home to work with the robot, which we circumvented by using a local network.

The big challenge that arose was the quality of the audio. The sound was a bit metallic, with a lot of echo, which was often not good enough for Mr. A and Mr. C to really understand the number that was being called – which is rather disruptive for Bingo. On the upside, this did cause them to talk quite a bit among themselves and with the person guiding the Bingo and calling out the numbers.

We also found that all the inhabitants were quite interested in seeing the robot at work, for which it was requested to stand in a special central spot, which put it apart from everyone else. Though in the end the two remote visitors did not win anything, everything seemed to work out just fine. Apart from the sound problems, the interaction was deemed quite normal.

4.11 QuizBot

MRP systems seem uniquely suited for attending a get-together because they allow for social presence. To investigate, we organized a (pub)quiz at our department and asked different colleagues to use a robot to interact with their teams (Figure 11). We used a printed pub quiz of which the group had only one exemplar. This introduced a variety of interesting challenges as this artefact could not be easily shared with the telepresent pilot. The limited quality of the sound and video further complicated this. We saw a whole range of strategies to cope with this, from teams ignoring their remote team member to teams selecting the person with the clearest voice to read the questions. In the winning team, at times someone stood with the robot to show some of the images from close-by and to read out the questions clearly.

4.12 TrainBot

Reduction of transportation costs is one of the reasons to use an MRP system. However, it is unlikely that there is a robot at every place one would like to visit. Why not travel with the robot itself to get the robot to your destination?

To investigate, we took the robot with us in a train, being colocated with the robot we piloted. Unfortunately, the internet connection provided by the Dutch railways (NS) had insufficient bandwidth which resulted in poor resolution and a lag in the video feed. We could however drive it around the coupé, even during the train’s acceleration (see Figure 12). Other travellers were interested in the system which resulted in pleasant conversations. We discussed with the conductor whether our MRP system needed a ticket. Luckily, he concluded that it did not. However, he did insist that it would have to be accompanied by a non-telepresent traveller, which was later corroborated by the NS.

4.13 RoadBot

Driving inside a building is exactly what MRP systems were designed to do, driving outside is not, albeit not impossible. Uneven terrain is a challenge for most MRP systems, but with some patience it is possible to travel some distance outside, for example between university buildings. Internet connectivity can become an issue between buildings if the MRP relies on wifi. When the robot switches from access point the connection can be lost. Weather conditions (like rain) can endanger the robot as most MRP systems are not waterproof. We solved these issues by walking with the robot with an umbrella and a wifi hotspot (Figure 13).

Autonomous telepresent travelling over longer distances is not (yet) supported and in some cases prohibited, as was the case with TrainBot. We asked the responsible Dutch government department whether an MRP system is allowed to travel autonomously, partake in traffic, and what traffic rules it should adhere to. Currently, the government sees MRP systems as ‘remote controlled toy-cars’ and as such does not allow them on the road without direct colocated supervision.

4.14 OfficeBot

We used the MRP systems in our office on multiple occasions. For instance, we tried to bring a USB-drive to a colleague on a different floor. We found someone willing to call the elevator and press the right floor button for us as we were unable to do this ourselves. The closing of the doors of the elevator cut the internet connection as the elevator acted as a Faraday cage. The connection was automatically restored after the doors opened, but this took some time. When we could drive the robot the doors closed again, resulting in a collision...
with the doors and a robot stuck in the elevator with no connection (Figure 14).

In this setting, we also investigated how easy it was to find people to open doors, get us coffee, or carry us up or down the stairs. Different student populations occupy different areas in our university building and it turned out that this mattered for the success rate of our ‘missions’. In some areas we were greeted with enthusiasm and interest and people were willing to help us, while in other areas we were harassed. Harassment included: people blocking our camera, ignoring our pleas to leave us alone, mooning, and we were extensively followed by a bully who shoved the robot and blocked the camera.

5 FURTHER USE CASES

MRP systems can be used for many more situations than we explored. Based on our interactions with people from outside the project we found many more interesting use cases to consider:

**CatBot:** Most people enjoy interaction with pets and we see many novel technologies being developed for long-distance human-pet interaction (e.g. [6]). Often pets are left alone at home while their owners are at their office or even away for small holidays. Checking in with them every now and then could be beneficial for both the pet and the owner\(^\text{17}\); a great opportunity for MRP systems.

**DeathBot:** An MRP system at a hospital that can give family members and friends that cannot reach a critical patient in time a chance to say goodbye. Ethical and technical challenges can be expected.

**SecurityBot:** Use a MRP system to secure locations, buildings, or objects at night. A security guard could patrol a remote area with

\(^{17}\) Commercial application of an interactive cat toy has been implemented in shelters in the US and increased donations and adoptions of pets, see iPet [http://ipetcompanion.com](http://ipetcompanion.com)
We will discuss the issues and benefits we encountered in the use of an MRP. Technical challenges might arise, for instance dealing with deliberate interference.

WhereIsItMadeBot: Offer customers of a foreign product the chance to see where and how it is made. For example, a tea company could offer telepresent tours over their tea plantation showing the positive impact of their environmentally friendly approach.

QuarantineBot: Currently social interaction can be limited for people that are, for whatever reason, in quarantine. For instance, an MRP would allow social interaction with (potentially) highly contagious patients.

ParkRangerBot: Have a park ranger show fragile nature in a classroom, allowing kids to observe beautiful nature while interacting with an expert in the field. Technical challenges similar to ActBot can be expected.

StadiumBot: Take a friend (from far away) to a sports stadium to cheer on your favourite sports team and show the atmosphere in the stadium.

ProtestBot: Join a protest through an MRP system. This might offer possibilities for people from remote areas to have their voice heard, but also for politicians or journalists to keep tabs on the sentiments in society.

QueueBot: Use an MPR system to queue in line for an event or item (e.g. a new phone). MRPs might offer a solution when an online (web) queue is not viable, while waiting outside in the rain and cold is also not preferred.

6 DISCUSSION
We have explored several use cases and pointed out possible future applications for an MRP system. We were the pilot of the system and took it with us in our daily lives. Doing this we encountered several types of issues. This included interesting ethical, legal, technical, and social issues. We will discuss these four types of issues below. A classification of the issues on these four themes gives easy reference to relevant issues for different stakeholders of MRP systems. We end this section discussing our use of the Researcher As Experimental Subject approach.

6.1 Issues exposed
We will discuss the issues and benefits we encountered in the use cases according to the four identified themes.

6.1.1 Ethical Issues. We found several issues related to ethical considerations, for instance, the case deception in the form of taking someone else’s identity with an MRP system and the need for asking people to help our ‘less than perfect’ robot. In the most extreme case, we have seen that pilots are able to make other people accomplices in illegal activities. Could the technology play a transforming role influencing the voluntariness of other people? Despite apparent benefits of MRP systems, for example bedridden people (re)joining social life, an important ethical question always remains: Is the burden that pilots lay upon other people justified? Besides the ethical issues regarding possible implementation of these systems doing research with the RAES approach also brings along ethical issues, which we will discuss at the end of this paper.

Note that ethical issues have overlapping legal and ethical aspects. There is a thin line between allowing people to adjust their appearance and facilitating to take someone else’s identity. In certain cases legal restrictions and formal descriptions can be worthwhile to consider.

6.1.2 Legal Issues. The first issue crossing into the domain of legal issues is the issue of liability. In some cases the designer will become (partially) accountable. For instance, once the MRP system requires functions for identification (see BeerBot) the designers will have to deliver a trustworthy system, this seem comparable to what has happened for internet shopping. By extension the designer, often in the entity of a company, can become liable in cases where the designer or company makes (legal) claims. For instance, when an MRP company offers a payment extension and advertises it as safe, but it turns out that it is not safe due to negligence, the company would be liable. However, it is unrealistic to fully assign liability to the designer as the possible ways for misuse can only be countered up to a certain level. During informal discussions with a lawyer about the TheftBot case it became clear that liability lies with the person initiating the action. These discussions share similarities with the discussions surrounding liability and the recent rise of autonomous driving cars and the use of drones.

It can become blurry who the legal entity is that is represented by the robot and this has legal consequences. Technological solutions for identifying and driving can be provided but as far as we found in our use cases currently the legal entity is the one driving the robot, the one initiating the actions. The robot itself is therefore not the one doing the purchase as ’it’ does not represents the intent. This question and the philosophical aspect of when we go beyond the creator’s control was eloquently put forward with the art exhibition of Carmen Weisskopf and Domagoj Smoljo (Mediengruppe Bitnik) that made an AI that went shopping on the dark-net for illegal goods.

Legislation on novel technology is often lagging and MRP systems are no exception. Government officials expressed interest in the social and legal issues that we found. However, the conclusions they arrived at were often conservative, with both the NS and the Dutch government limiting the use of MRP systems (see RoadBot and TrainBot) almost by default. This might hinder broad acceptance of MRP systems in the future.

6.1.3 Technical Issues. Interestingly, for the often technologically oriented domain of MRP systems we found that for most use cases there were plenty of technical issues which we see as proof that the technology should ‘just work’ and breakdowns are detrimental in almost all use cases.

Several issues contained multiple underlying aspects. There were technical issue of connectivity in how the MRP systems dealt with loss of connection, speed and lag, or time to reconnect. There were issues regarding the environment, regarding the capability to manipulate the environment such as picking stuff up, opening doors, or paying; and with being manipulated by the environment such...
as vandalism or encountering obstacles. There were issues regarding agility & stability of the MRP system, as it showed a lack of proficiency with some terrain, obstacles, and recovery from falling. There were navigation issues of the MRP system with regard to how far the average starting pilot was able to ‘work together’ to navigate an environment. Communication efficacy is the success with which an interaction can be carried out between the pilot and a co-located user. A primary technical concern was the lack of Status & feedback. When interacting with MRP systems, it is of utmost importance to know if the other actually received a message. During several occasions we have had issues that we did not know what the other end was seeing. During interactions without direct communication it is hard to gather such feedback from the partner. It leads to frustration having to repeat messages and makes it hard to troubleshoot technical issues. The screen of the MRP sometimes showed a frozen image of the video feed of the pilot while the device was still moving and showing camera feed to the pilot. We also saw the device moving with a big delay (see RefBot and EventBot). These kind of issues should be addressed with haste by the HRI community as it is frustrating for the user but seems relatively easy to solve them.

During several interactions we were afraid that the MRP system would break down. The actual fragility of the system was reasonable and during all the use cases we only encountered a stuck robot in the woods (ActBot), a severe imbalance (EventBot), a perceived fragility during a sports match leading to avoiding behaviour (RefBot), and a non-essential part of the MRP broke loose during transport.

The amount of technical difficulties we encountered, specifically the connectivity issues and communication efficacy, suggests that the MRP systems we used might not yet ready for some of the uses in the wide wild world.

6.1.4 Social Issues. The opportunity to provide social contact for those who were more limited before has a clear impact on our society. It can become a societal issue if MRP systems stimulate forms of lower quality social interactions. On the one hand the robot can provide some forms of autonomy by providing new ways to initiate social contact for instance for bedridden people. On the other hand, our own experience is that it also emphasizes the lack of full autonomy.

Novelty seemed to influence how people interacted with the device. People were interested to find out what the device could do and started interacting with it at events. Some people did things they would not do in their normal interactions with other people (see EventBot and TheftBot). We argue this might be due to cognitive load, as interacting with some new technology might take significant cognitive load and thus, there might not enough cognitive capacity available to refuse a malicious request [10]. However, it took quite some effort to get help doing shopping. How people will interact with these devices in the future will probably change but although our insights helped we can only guess how this will turn out.

For the authors the perceived presence when using the system was definitely higher than that experienced during a normal teleconference. Most of the other people using the MRPs also mentioned a similar experience during the informal discussions we had with them. The experience did still lack some elements especially making it clearly distinct from truly being there due to the limited quality of audio.

6.2 Applying the RAES Methodology

In traditional experimental setups many of the issues with MRP systems we identified can not be found, as the lab-environment is much ‘cleaner’ and more controlled than a real-world situation. For example, when an MRP is used in a lab or office environment there are less sounds than you can expect in the wide wild world. Thus in a lab-setting, issues with audibility or understandability can easily be overlooked. Instead we used the RAES approach that yielded relevant findings.

Following Corti et al. [7], we do not propose to step away from the normal third-person approach in HRI and HCI research. Instead, we propose that a first-person approach can be beneficial in exploratory cases such as those discussed in this paper. The related (auto-)ethnographic approach differs, as that requires one to be truly embedded in the social or cultural environment preferably in a longitudinal form. Our approach is instead less in-depth but, as shown, still capable of finding interesting issues. In line with what Harrison [11] said in relation to ‘dogfooding’, we feel that companies and researchers that develop (MRP) technology might not be able to find novel use cases (or markets!) because they get ‘stuck with what they know’. As we showed with this paper, external users will stumble upon insights that otherwise might have been overlooked.

One aspect that helped us to let external users stumble upon insights was the use of videos. We often showed videos we made during use cases to other researchers and participants. A benefit was that these videos made the, often abstract, discussions of for example ethical issues much more specific and relatable. In addition, the discussions inspired several new use cases such as the referee case, and the wide range of suggested further use cases.

The RAES approach has several benefits, but there are also several considerations to be taken into account. First of all, traditional procedure of getting ethical approval and asking for consent might not suffice. During the interaction unforeseen situations can pop up at which researchers have to make ad-hoc decisions. These can change the study significantly from the proposed study and while this can provide important insights it can also create ethical issues. Thus, for RAES studies, targeted ethical training for the researchers is essential. Such training will allow the researcher to make ethically sound decisions in the field. Additionally, researchers should check their ad-hoc decisions with their ethical committee. These reflections should occur after each ad-hoc decision and always before more than one experimental session is performed.

7 CONCLUSION

In conclusion, the RAES approach was useful to identify a wide range of implications for the use of novel technology such as MRPs. Precisely because of this wide range, and the opportunity for surprising user actions, researchers should stay alert to challenges that arise during these case studies. When traditional experimental setups in a controlled setting might be unsuited to find real-life issues.
with MRP systems, RAES can be a tool that might be worthwhile to identify these issues in the wide wild world.

With our work, we have also shown that there are various useful possibilities for MRP systems, and fitting this topic: there is more than meets the eye. However, there are also many aspects that will have to be considered and resolved before telepresence robots will really become part throughout our daily life.

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REFERENCES