The Double 3: a Mobile Robotic Telepresence system

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Whilst remote and hybrid ways of communicating and collaborating are being increasingly accepted and embraced, the current technological solutions are limited in their capacity to make up for the loss of the clarity and flexibility of in-person interactions. Mobile Robotic Telepresence (MRP) systems are proposed as a potential solution, as they afford the users an embodied physical presence and the ability to move autonomously in a the environment. MRP systems generally consist of a videoconferencing screen mounted on a fairly simple, remotely controlled, mobile base. This paper describes one such system, the Double 3, by Double Robotics.

CCS Concepts: • **Human-centered computing** → *Collaborative and social computing devices.*

Additional Key Words and Phrases: robotic telepresence, mediated interaction, MRP, videoconferencing

ACM Reference Format:

Andriana Boudouraki. 2023. The Double 3: a Mobile Robotic Telepresence system. In . ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/nnnnnnn.nnnnnnn

1 INTRODUCTION

Even as remote and hybrid methods of communication and collaboration gain growing acceptance and adoption, the existing technological solutions remain limited in their ability to fully support remote participation [3]. One possible avenue to explore is the used of Mobile Robotic Telepresence (MRP) systems, such as the Double 3. MRP refers to systems which combine videoconferencing with mobile robotics; usually consisting of a screen mounted on a robotic base on wheels [1]. A remote user is able to project their face on the robot's screen, and drive the robot using an online interface. As such, MRPs are often marketed as a solution to hybrid meetings because they afford the users an embodied physical presence and the ability to move autonomously in a the environment. This paper presents the Double 3, a commercially available MRP system by Double Robotics [4], outlining its technical characteristics and experiences that it can accommodate.

2 OVERVIEW

The Double 3 consists of a 9.7 inch screen, equipped with camera, microphone and speakers (see figure 1). The screen is attached to a thin pole, which sits on a cylindrical base. On each side of the base are wheels, which enable the device to move around. The system also comes with a docking station, in which the robot rests when not in use in order to charge.

On the remote side, a user is able to log into to the robot through an iOs app or a browser interface (see figure 2). That interface allows the remote user to drive the robot (see section 3), and acts as a videoconferencing platform, where the remote user is able to see and hear through the robot and project their face and voice through it. In terms of driving, the remote user can move the robot using the keyboard arrow keys, or through self-driving way-point navigation, by clicking on a point on the visible floor and letting the robot move there autonomously. The system utilises sensors to

Manuscript submitted to ACM

read the floor and avoid obstacles. The interface also utilises some Augmented Reality features, with buttons and signs overlaid over the remote user's view of the mediated environment (see figure 2).

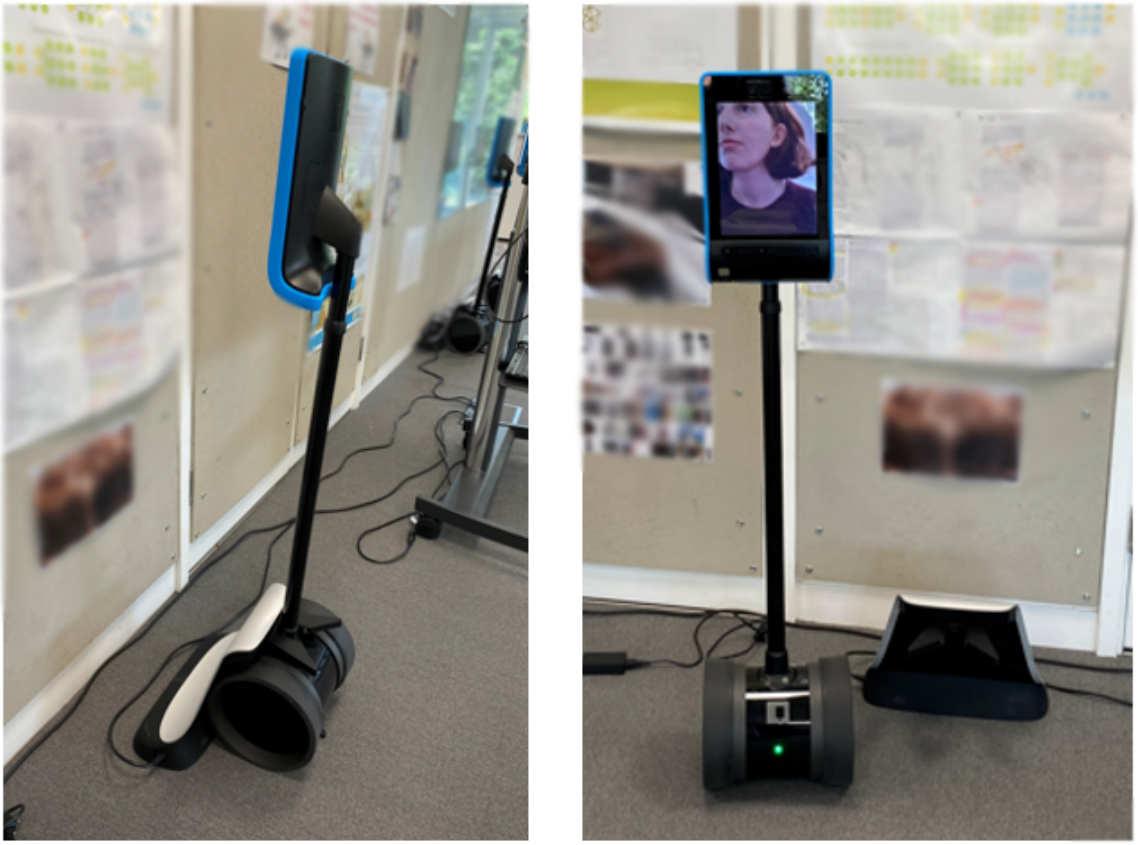

Fig. 1. Left: The Double 3 telepresence robot, resting in its docking stating. Right: The Double 3 telepresence robot in use with a remote user's face shown on its screen.

3 TECHNICAL CHARACTERISTICS

- **Immersion**
  The Double 3 offers the remote user a wide field of view, with further ability to pan, tilt and zoom their view. It has two 13 megapixel cameras, one with super wide angle lens, one with a super zoom lens, and 30 FPS and Night Vision Mode. Of course the remote user can also move and rotate the robot in the physical space in order to see things outside that view as well. With regards to audio, the system has 6 digital microphones with beamforming, but does not provide spatial audio.
- **Physical interaction**
  In terms of mobility, the Double 3 has two wide, self balancing wheels at its base. Using those wheels, the robot can move at a speed of 1.8mph and rotate in all directions. The robot moves as one unit with the wheels and the screen always facing the same direction (i.e., there is no independent 'neck' turning). The system uses sensors,

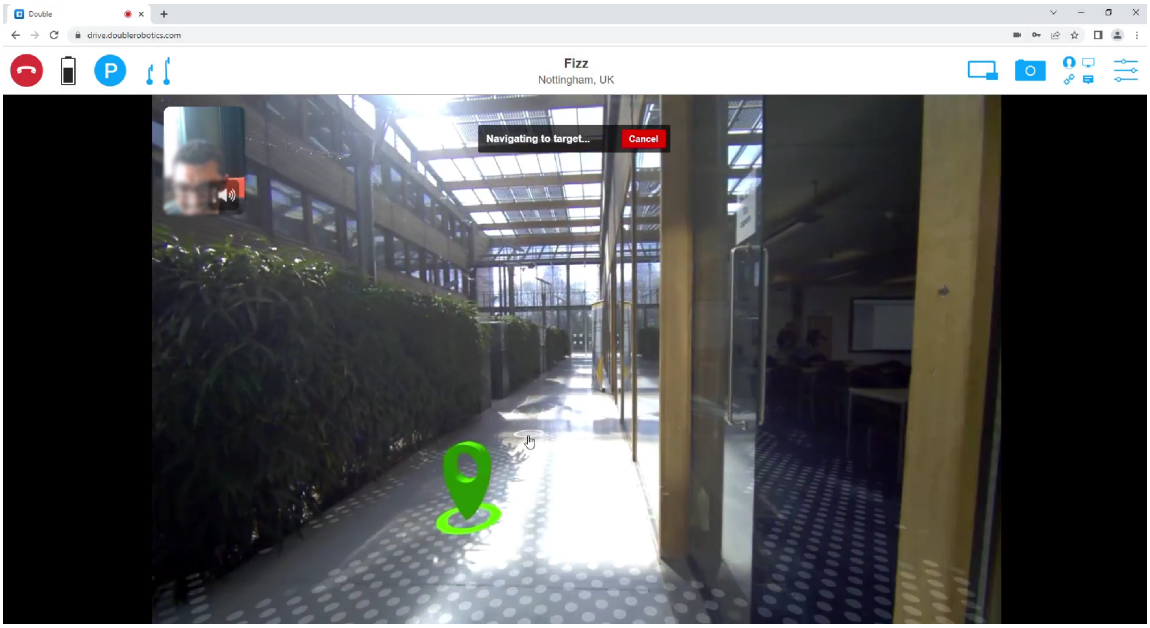

Fig. 2. The remote user's browser interface, showing their view of the mediated environment. The green navigation pin icon indicates a point selected by the user, towards which the robot is moving. Further in the distance, the user's cursor hovers over other clickable floor areas that they can select for navigation.

in order to read the floor, avoid obstacles and allow for autonomous way-point navigation. Specifically, it has 2 stereovision depth sensors (Intel® RealSense™ D430), 5 ultrasonic range finders, 2 wheel encoders (2048 PPR each) and a Inetial Measurement Unit (9 DoF). The interface presents the remote user with an overlay of dots on the accessible floor (see figure 2). The user can then click on a point on those dots, and the robot will drive there by itself. Alternatively, from the desktop interface, the user can drive the robot using the keyboard arrow keys. The Double 3 will not allow a user to drive it over areas it can not read - which, protects the robot from falling over gaps or hitting against objects in the environment but can also be problematic as it will sometimes struggle to read a tiled or glass floor.

- **Convenience**

  The Double 3 weights approximately 7.3kg and has a remotely adjustable height ranging between 1.20m to 1.52m tall. Only one robot device is needed in order to interact through the Double 3, but the remote user must also have access to an iOs device or a PC with a browser. At both ends, the remote user and the robot, need to be connected to the internet and the robot specifically needs to be connected through Wi-Fi so that it can move freely. With regards to power, the robot can run for 4 hours, and needs 2 hours to recharge by parking it in its docking station (figure 1).

  In terms of number of users, the Double 3 can support one main remote user at a time who can interact with a any number of local users (i.e., people physically co-located with the robot). Whilst there is no technical limit to the number of local users, it is generally more effective in smaller groups (e.g., 1-4 local users) given the lack of spatial audio and slow speed of the robot. The main remote user can also invite other users to remotely join on

the call. In that case, those secondary remote users will not be able to drive the robot or project their face on it, but they will be able to observe the interaction and speak through the robot. Of course it is also possible to have people sitting next to remote user who also observe and take part in the interaction peripherally (e.g., [2]).

4 EXPERIENCE

- **Social interaction**
  With the main feature of the Double 3 being its mobility, one of the uses proposed with regards to social interaction is as a way to foster a sense of presence in a workplace through casual, unplanned conversation. One such scenario may be that a remote worker logs into the robot at a time when she knows that on-site colleagues have a coffee break. She may drive it to the office's lounge area to see who is there. On her way, she may bump into people in the hallway and exchange some greetings. The people in the office are familiar with the robot so they are not surprised. Upon arriving at the lounge, 2 or 3 colleagues are sitting there. She could position the robot in a central point, to become part of the conversation or approach someone more closely for a 1-on-1 chat. She could increase the height of the robot to meet the eye-level of colleagues sitting on bar stools or lower it to meet those sitting on the sofa, thus further directing her attention to the person she wishes to speak to.
- **Hybrid meeting**
  In the context of planned meetings, it makes sense to use the Double 3 in scenarios where being able to move around the room is beneficial to the task. One such scenario may be in overseeing the work taking place during a hands-on workshop. For example, participants have been invited to assist a design team in a co-design task that involves creating and testing physical prototypes. A member of the team is not able to attend in person, but she wishes to observe what the participants are doing, ask them questions about their process and give them prompts that relate to the task they are engaged in. To that end, she uses the robot to move around the tables in the room. Using the Double's capabilities she can view the prototypes from many angles and zoom in to inspect details. In doing so, she is also communicating to her on-site colleagues and other participants what she is paying attention to. Being able to move near individual participants, she is also able to have conversations with them more closely, without having to engage the attention of everyone in the room.

ACKNOWLEDGMENTS

This work was supported by the Engineering and Physical Sciences Research Council [grant numbers EP/M02315X/1, EP/V00784X/1, CASE studentship 18000109] and Microsoft Research Cambridge

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