

Telepresence Robots as a Research Platform for AI

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Abstract

Recently, various commercial telepresence robots have become available to the broader public. Here, we present the telepresence domain as a research platform for (re-)integrating AI. With MITRO: Maastricht Intelligent Telepresence RObot, we built a low-cost working prototype of a robot system specifically designed for augmented and autonomous telepresence. Telepresence robots can be deployed in a wide range of application domains, and augmented presence with assisted control can greatly improve the experience for the user. The research domains that we are focusing on are human robot interaction, navigation and perception.

Introduction

Although the idea of a teleoperated robot for remote presence is not new (Sheridan 1989), only recently have so called *telepresence robots* become available to the broader public (Lazewatsky and Smart 2011; Takayama et al. 2011; Tsui et al. 2011). The idea of a mobile telepresence robot stems from the inherent limitations imposed by traditional videoconferencing systems, in which interaction is restricted to the meeting room only. Such systems do not allow the user to join the - often important - informal part of meetings generally taking place in hallways and coffee corners. A teleoperated robot can provide means for a mobile teleconferencing system, allowing the user to interact more naturally in the remote office environment.

Current commercially available telepresence robots lack autonomy. One of the findings in (Tsui et al. 2011) is that adding some level of autonomy would enhance the user experience, as it would allow to focus more attention to the conversation and interaction, and less to driving. One possible solution, assisted navigation, is investigated in (Takayama et al. 2011); the authors conclude that assisted navigation decreases the number of collisions with objects in the environment. We believe that including more autonomy and integrating the findings of recent AI research into the platform can greatly increase the usability of these robots. Furthermore, it is an ideal platform for researchers wanting to combine different fields, e.g. human robot interaction, navigation and perception, while simultaneously

focusing on the actual integration and feasibility of the approaches.

A telepresence platform can be built at reasonably low-costs using standard components and existing software, e.g. Figure 1 shows a custom-built telepresence robot (Alers et al. 2012). MITRO - Maastricht Intelligent Telepresence RObot - is an ongoing research project at the *Swarmlab*¹. The differential drive robot has a height of about 160 cm. The sensors include a low-cost LIDAR, a Kinect, sonar sensors and two cameras. The advantage of using a custom build system over a commercial platform is the flexibility, extensibility and knowledge of the complete system, which in this stage of the research is crucial.

In the following, we will present the impact of telepresence robots and three use cases which will lead us to our main research goal: creating an autonomous telepresence robot. Subsequently, the research domains resulting from the use cases are investigated. Finally, we conclude with some general remarks and a future outlook.

Impact & Use cases

Telepresence robots can be deployed in a wide range of application domains, e.g. in workplaces, the public sector or for home use. Telepresence robots are already being used in hospitals to allow doctors and specialists to give consultations from afar (Tsui et al. 2011). Assisted living facilities equipped with telepresence systems can provide 24/7 supervision and assistance through remote caregivers. Family members or friends can use the system to pay a virtual visit when time does not allow to be present in person. Telepresence robots can also be used to give people with restricted mobility a new way to reach out and interact beyond their usual living quarters. In all these domains, augmented presence with assisted control can greatly improve the experience for the user.

To further illustrate the impact of telepresence robots, we introduce three use cases. The first use case consists of two persons communicating with each other via a telepresence robot. Here, the robot is remotely controlled by the client e.g. with a GUI as shown in Figure 2. The client is assisted both by visual augmentation and by the robot itself, which is actively ensuring safe navigation. The second use case de-

¹For more information visit: <http://swarmlab.unimaas.nl/mitro>



Figure 1: Social interaction through MITRO.

scribes a scheduled meeting, where the robot autonomously navigates from its charging dock to the venue and back at the appropriate times. The third use case depicts a whiteboard meeting with multiple actors and points of interest. The focus automatically switches between whiteboard and the corresponding actor.

Research challenges

Our vision is to develop an autonomous telepresence robot, i.e. a robot that can perform all tasks as stated in the use cases. We mainly focus on using Artificial Intelligence techniques to enhance the user experience, while finding a good balance between user control and AI intervention.

As the telepresence robot is controlled from a remote location, precise control and feedback of the robot is required. To ensure this, we implemented low level autonomy on the robot in the form of assisted teleoperation. With assisted teleoperation the robot follows the steering commands of the client except for situations when there is a high chance of collision. This can easily occur when the user is not experienced in navigating the robot, the network connection is delayed or an obstacle suddenly appears in front of the robot. Assisted teleoperation is not only about safety, it is also about assistance. Besides preventing the robot from hitting an object it guides the robot, and so the client, around the obstacle by smoothly adjusting the heading direction. To add even more assistance while manually navigating the robot, the video feed can be switched from front- to down-facing, and is augmented with a projection of the expected navigational path.

By implementing situated awareness into the system we are able to let the telepresence robot autonomously drive back to the docking location for recharging after a user logged out of the system. A more elaborate form of autonomous navigation is sketched in the second use case where the client can request a robot to be present at a certain location before a meeting starts; for this we implemented a web-based map server, as shown in Figure 2. The client can select a location on the map of the environment, and the robot autonomously plans a route and drives to it. In future work we plan to use semantic mapping; the representation of the environment will then be augmented with relevant data in both GUI and video stream, making it easier for a client to navigate in unknown surroundings.

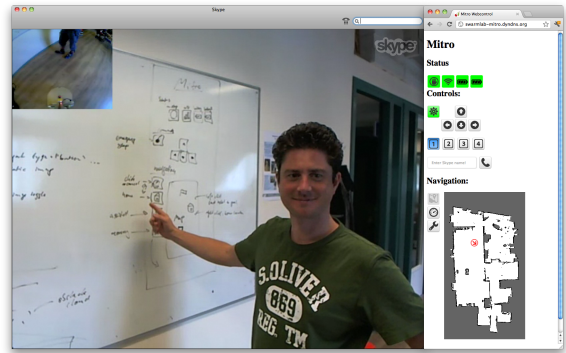


Figure 2: User interface for the client.

For the third use case we are currently investigating if we can use gesture recognition to determine whether the current conversation partner is speaking, pointing or writing on a whiteboard. We apply machine learning techniques on data obtained by skeletal tracking using a RGB-D camera, thus the robot can learn when to turn and where to focus. In future work we plan to add face recognition to make the detection more robust. We also investigated how to have reliable and intuitive robot control through gestures, the integration into the system still has to be executed.

Conclusion

We presented telepresence robots as a research platform for a variety of domains such as navigation, perception, and human-robot interaction. We introduced three use cases with different levels of autonomy leading to several research challenges. We briefly described and outlined current and future work to achieve a user-friendly autonomous telepresence robot, with a good balance between autonomy and user control. While some of the research challenges might already be solved independently, the reintegration of these solutions into a single system is still a challenging task.

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