Real-Time Remote Control via VR over Limited Wireless Connectivity

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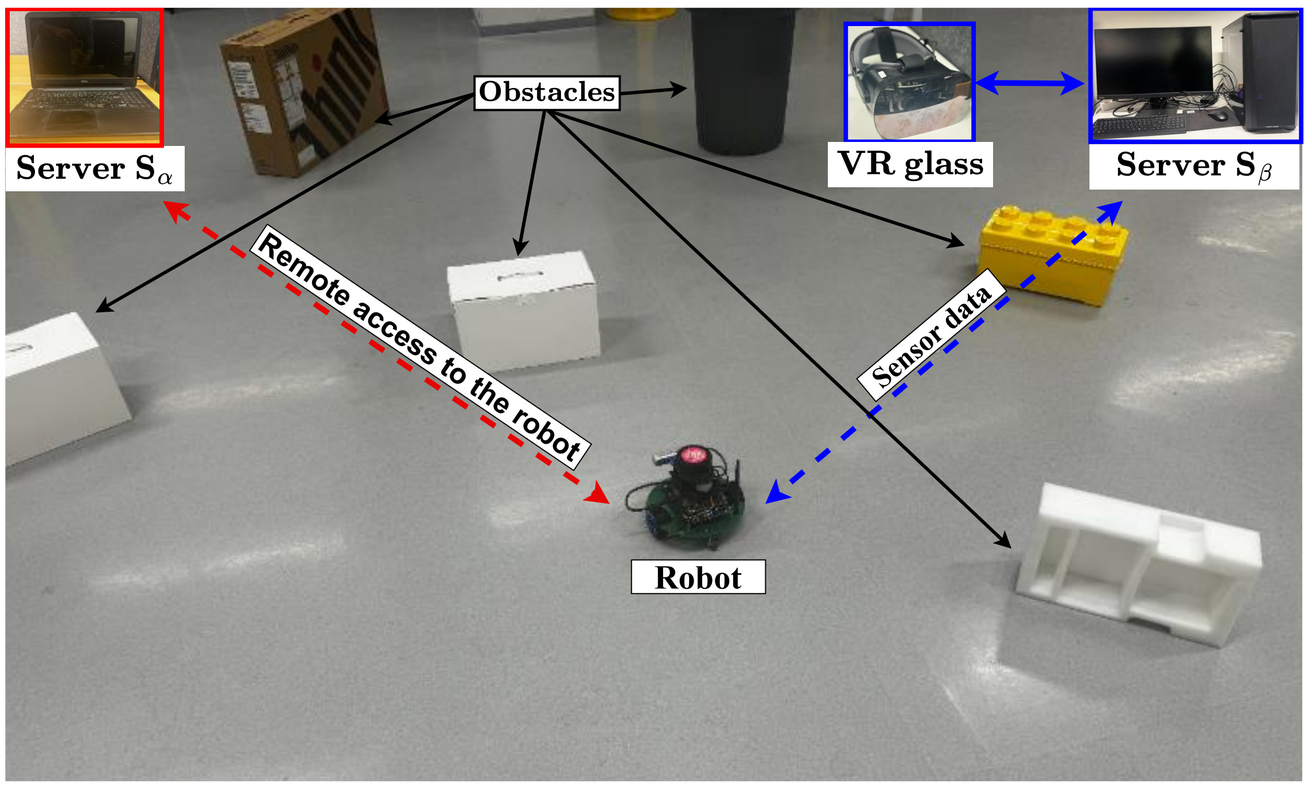
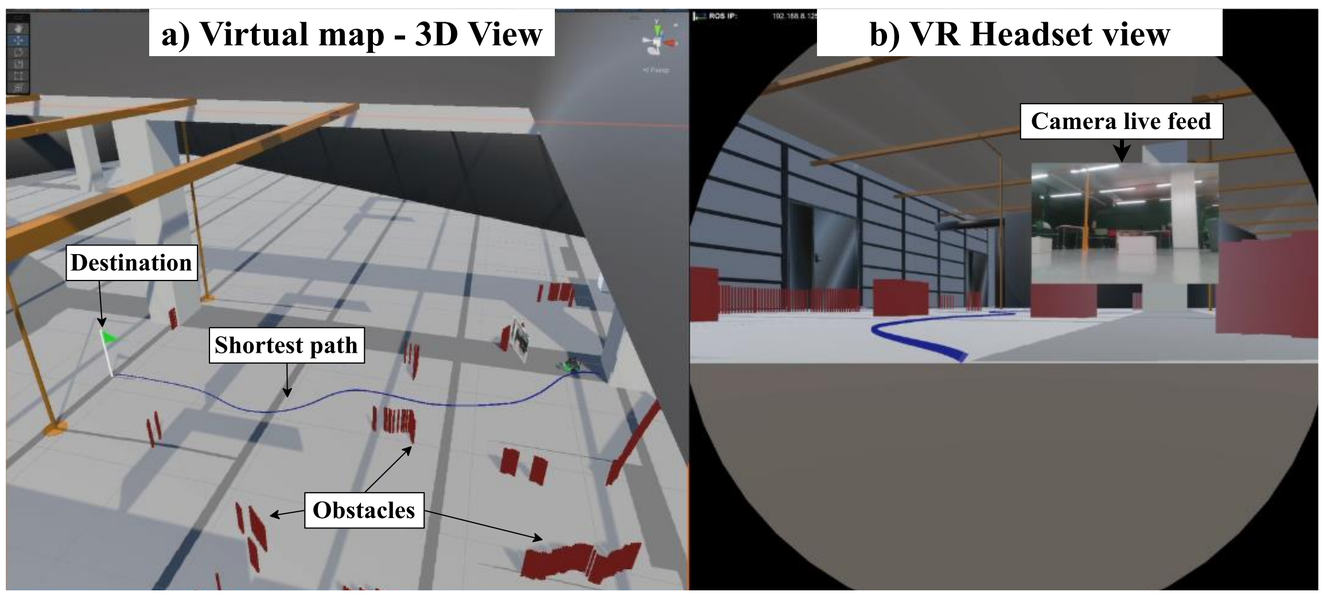
Introduction

This paper presents a solution for enhancing **human-robot interaction** over limited wireless connectivity. By integrating VR-based remote control and autonomous navigation, our system ensures seamless operation. It enables smooth transitions between remote control and autonomous mode, improving efficiency and reliability in dynamic environments.





Implementation Steps

Environment Mapping — The robot uses SLAM to create a 2D map of its surroundings.

VR-Based Control — Operators control the robot through a VR headset, visualizing the environment in real-time.

Connectivity Monitoring — The system continuously monitors connectivity status and switches to autonomous mode when connectivity is lost.

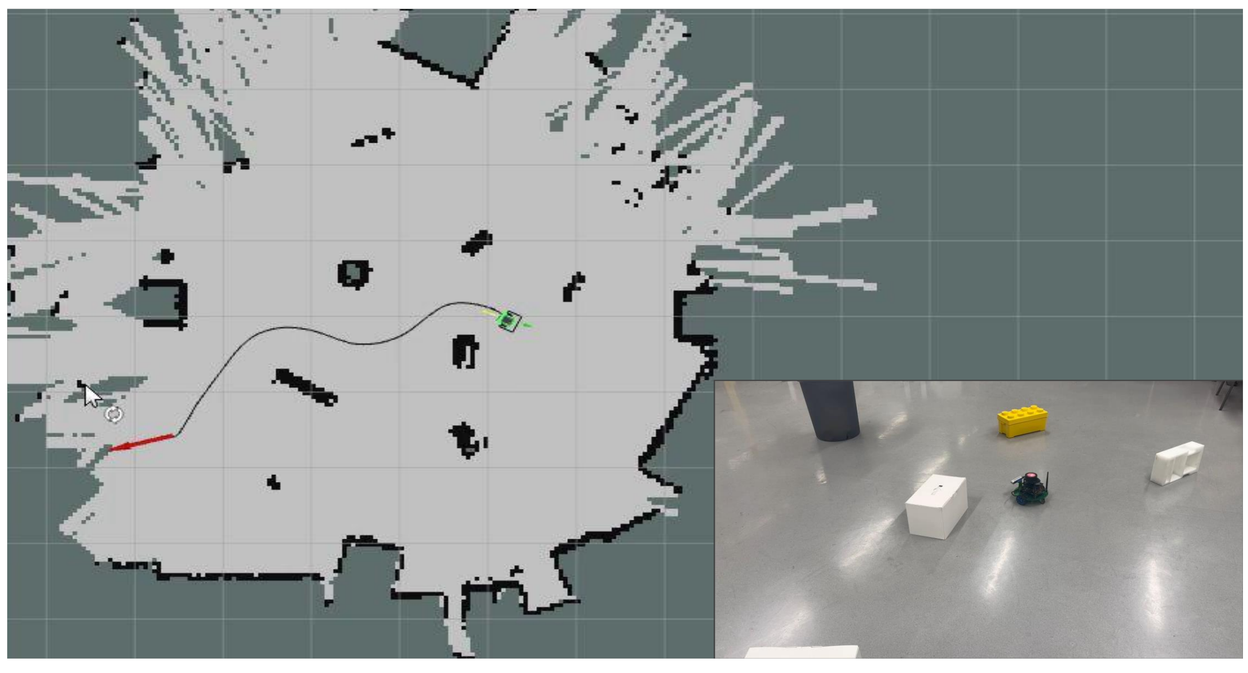
Autonomous Navigation — The robot autonomously navigates to its destination using an occupancy grid map and dynamic obstacle avoidance.

Visual Distraction Mitigation — Implement a buffering mechanism to preload map data and the robot's planned path, reducing the impact of lag and freezes during connectivity loss.

Hardware

- **Robot**: Waveshare "JetBot ROS AI Kit", including a Nvidia Jetson Nano developer module.

  Sensors:
  - RPLiDAR A1
  - Inertial measurement unit (IMU) sensor
  - motor encoder sensors
- **VR Glasses**: Varjo VR-1 headset
- A gamepad controller.



References

[1] M. Selvaggio et al., "Autonomy in physical human-robot interaction: A brief survey," IEEE Robotics and Automation Letters, vol. 6, no. 4, pp. 7989–7996, 2021.
[2] S. Kalamkar et al., "Remote monitoring and teleoperation of autonomous vehicles—is virtual reality an option?" in 2023 IEEE International Symposium on Mixed and Augmented Reality. Los Alamitos, CA, USA: IEEE Computer Society, 2023, pp. 463–472.
[3] SLAMKit, "RPLIDAR A1," Available at https://www.slamtec.com/en/ Lidar/A1/, 2016.
[4] Varjo, "VR-1 headset," Available at https://varjo.com/, 2019
[5] Varjo, "Unity XR SDK," Available at https://developer.varjo.com/docs/ unity-xr-sdk/unity-xr-sdk, 2019.
[6] ROBOTIS e manual, "TurtleBot3," Available at https://emanual.robotis.com/docs/en/platform/turtlebot3/overview/#overview.
[7] UBICOMP, "Virtual Campus," Available at https://ubicomp.oulu.fi/ infrastructure-virtual-campus, 2016.

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