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Robbie – A tele-operated robot with autonomous capabilities for EnRicH-2019 robotics trial*

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Abstract— **In public emergencies such as nuclear accidents or natural disasters, an immediate and accurate overview as well as an assessment of the area is the basis of all coordinated plans and actions for the rescue team. The persistent lack of such information leads to high risks and casualties for rescue workers. Mobile robots help to minimize risks and support the rescue teams with urgent information, as well as with debris clearing and search and rescue operations. This work discusses the necessities and requirements of mobile robots in search and rescue (S&R) applications such as an nuclear disaster. Further it describes the current hardware setup as well as the software architecture of the mobile robot *Robbie* of UAS Technikum Wien.**

I. INTRODUCTION

One of the main reasons why deaths follow disasters is that the rescue team takes too long to find the victims because they need to grant their own safety [3]. Rescue robots have been designed for situations like these which are too dangerous for humans, e.g. hostage situations or nuclear disasters [6]. To support developing rescue robots, the European Robotics Hackathon - the EnRicH 2019 - takes place at the nuclear power plant (NPP) Zwentendorf. A nuclear disaster is simulated at the competition. The UAS Technikum Vienna participates in cooperation with the Austrian Armed Forces at the EnRicH 2019.
The competition includes three different tasks:

- **Exploration:** Generate a 3D map of the area and detect and mark radiation sources inside of it.
- **Manipulation:** Identify a specific pipe containing radioactive coolant and close the corresponding valve.
- **Search and rescue:** Locate human dummies inside the building and mark them on the digital map.

In this work the mechanical construction, sensor configuration as well as the implemented software of Robbie are described for the participation at the EnRicH 2019. The following section II outlines the mechanical and software requirements, followed by the implementation results in section III. Finally section IV summarizes this work and gives an overview concerning feature work.

II. SYSTEM CONCEPT

The following section characterizes the requirements regarding the hardware and software architecture of the mobile robot to successfully participate in this search and rescue hackathon.

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A. Hardware

Disaster sites usually are covered with rubble, therefore the base platform of the mobile robot needs to be capable of manoeuvring in rough terrain. Further to enable the rescue part an actuator needs to be placed on top of that base platform. The mobile robot platform "*Tracker*" of the company Taurob GmbH was used as the fundamental building stone. As figure 1 visualises the base platform is steered using tank like tracks and a four degree of freedom robotic arm as an actuator. This base platform was on the one hand chosen because of its tank like track steering, since they add stability, can move on rough terrain and allow the robot to climb steps up down [8], and because of its ROS API implementation.

Beside this base platform a number of sensors need to be included to fulfill the tasks of the hackathon. Since the hackathon takes place inside an NPP and therefore in a GPS restricted area depth and ranging sensors, such as RGB-D (RGB-Depth) cameras or LIDAR (Light Detection and Ranging) systems, need to be used for localisation and mapping. Further Inertial Measurement Units (IMUs) can be used to further improve the localisation, using sensor fusion such as Extended Kalman Filters, and to provide input for a tip-over control [1], [5], [7]. Further to measure the radiation and to be able to detect human dummies radiation sensors and thermal imaging cameras need to be equipped on the robot.

To teleoperate the robot a operator station needs to be developed and connected to a processing unit on the mobile robot.

B. Software architecture

To evaluate the previously introduced sensors and to steer the actuators the Robot Operating System (ROS) is used as high-level API. Besides the basic communication with the actuators, sensors and the operator station ROS is used because of it's scaleability and open source infrastructure. Thus with ROS in combination with the Taurob Tracker a basic teleoperated mobile robot is provided to build on top. Therefore making it a perfect fit for R&D applications. To further improve the teleoperation process a graphical user interface plugin for rviz [9], which displays all sensor data and allows for easier teleoperation of the robot arm, needs to be developed. Additionally a radiation measurement and simultaneous localisation and mapping package needs to be developed to map the radiation sources of the environment and mark them inside the generated digital map. The last package that needs to be created, in order to successfully achieve the tasks of the EnRicH, consists of the inverse kinematics of the robot arm to enable precise calculation of the arm movements.

III. RESULTS

The following section introduces the hardware setup as well as the generated/ used ROS software packages.

The current setup of the mobile robot Robbie is displayed in figure 1. The fundamental building block is, as mentioned above, the unmanned ground vehicle (UGV) *Tracker* [2]. The Velodyne PUCK VLP-16 LIDAR system

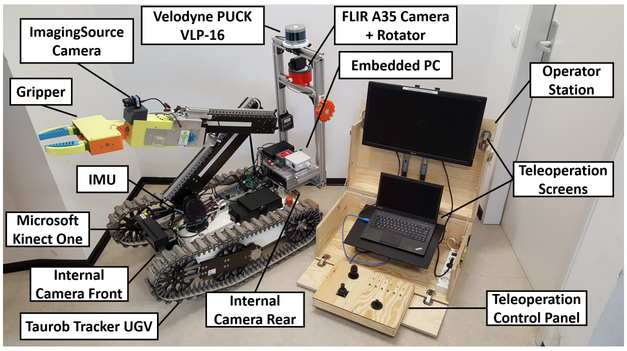

Fig. 1. Robbie hardware setup for EnRich 2019

and a PhidgetSpatial IMU were used in combination with "Google's Cartographer SLAM" [4] to generate a digital map of the environment. The internal cameras as well as the Kinect are used to enable seeing while teleoperating. The ImagingSource camera attached to the gripper is utilized to operate the end effector.

Figure 2 visualises the generated 3D map using the sensor configuration as described above. Further figure 2 visualises

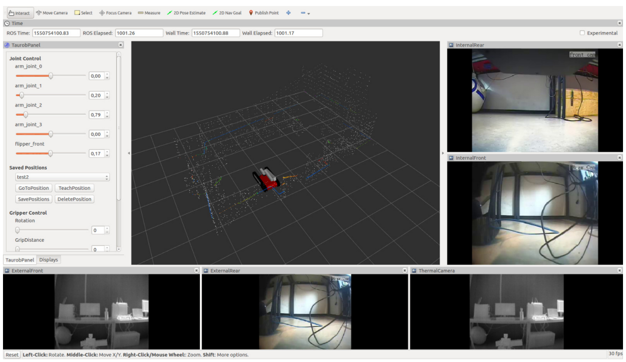

Fig. 2. Generated point cloud example using Cartographer, LIDAR and IMU and the developed rviz GUI

the GUI plugin for rviz with which enables precise movement of the robot arm and flipper joints, via the slide bars, and visualises the video stream of the attached cameras for easier teleoperation.

Finally figure 3 visualises a 2D digital map of the same environment as in the previous picture with marked radiation sources inside of it.

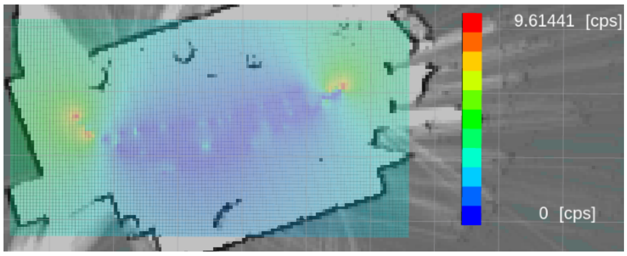

Fig. 3. Generated 2D map with marked radiation sources

IV. SUMMARY AND OUTLOOK

In this paper we described the necessary hardware setup and software architecture of a mobile robot for S&R applications inside an NPP. We utilized "Google's Cartographer SLAM" [4] to build a 3D pointcloud map of the environment using RGB-D, LIDAR and IMU sensors and build a application on top of it to visualise radiation sources inside the projected 2D map. Further a portable operator station was built to enable easier teleoperation and a rviz plugin was developed for visualisation of all sensor data of Robbie. Furthermore, an inverse kinematics application was developed for accurate calculation of the movement of the robot arm's axis.

Further projects will tackle the tasks of Human-detection using the equipped infrared camera (FLIR) as well as calculation of the perfect gripper positioning to drag humans out of hazardous environments. Moreover "*No-Go*" areas need to be defined for the robot arm so that it will not self-collide. Additionally, a tip-over control, using IMU and the robot arm, needs to be implemented so that Robbie will not tip over if the centre of mass and the slope require it.

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