New Perception Approaches for Mobile Robots in Low Visibility Environments

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***Abstract*— In dangerous disaster operations, a mobile robot can gather first impressions of the environment. However, smoke and dust lead easily to disorientation while navigating with the help of traditional sensors, like RGB cameras and laser scanners. In SmokeBot, an EU-funded research project, we focus on the development of fusion strategies, in order to be able to navigate mobile robots manually and autonomously through harsh situations. We are currently working on sensor fusion between laser, radar, and thermal imaging camera in order to generate models of an environment, which are useful for disaster operation planning.**

I. Motivation and Problem Definition

Laser scanners and RGB cameras have established themselves as state of the art for mobile robotics, but they can only partially be applied in environments as shown in Fig. 1. Radar scanners and thermal imaging cameras overcome the aforementioned conditions, but come along with other problems. For example, the resolution and accuracy of a radar scanner is lower than that of a laser scanner. Thermal images contain reflections which lead to misinterpretation by the operator. Furthermore, the estimated temperature of a thermal imaging camera depends on the material of an object and needs corrections.

II. Related Work

The first appearance of radar sensors in the robotic community is tracing back to the Australian Centre for Field Robotics (ACFR) in the nineties, where fundamental work on probabilistic SLAM (EKF-SLAM) algorithms in combination with radar was developed [1]. Also, they built their own radar scanner [2]. Besides the ACFR, Adams et al. [3] were doing research on radar in robotics with the integration of the PHD filter and the application for mapping of mines. The PHD SLAM is working with a commercial NavTech device.

The removal of thermal reflections can be achieved either by hardware or software. One hardware-based solution is to suppress thermal reflections with the help of an infrared polarizing filter placed in front of the camera [4]. Besides expensive infrared filters, this technique requires a strict spatial setup between camera, filter, and object. The reflection handling method most relevant to our work is the use of the camera's changing point of view. An approach to this has been presented in [5].

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Fig. 1. Low visibility environments represent a challenge for traditional sensor modalities.

III. Own Approach and Contribution

In SmokeBot, we use a frequency modulated continuous wave radar (FMCW) scanner from the Fraunhofer Institute for High Frequency Physics and Radar Techniques (FHR), which we combine with a Velodyne VLP-16 laser scanner for modelling the environment. Our algorithm decides, whether to rely on the laser, the radar, or fuse both sensors. Additionally, our work brings contributions to the domain of thermography in mobile robotics. We developed algorithms which remove thermal reflections and correct temperature measurements of both dielectric and metal surfaces. Furthermore, we developed a new calibration setup between laser and thermal imaging camera to fuse a Velodyne VLP-16 and a FLIR A655sc.

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