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Persistent Robot-Assisted Disaster Response

Extended Abstract

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ABSTRACT

We report on a field exercise in which a team of human fire-fighters used robots to enact a realistic disaster response mission in an industrial environment. In this exercise we evaluated the technical working of an integrated robotic system and gained insights concerning the manner in which robots and information streams can be utilized effectively. We have learnt important lessons regarding the employment of human-robot teams in complex, realistic missions.

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1 INTRODUCTION

Robots assisting human teams in disaster response missions can help extend operational capability and increase operational safety. Robots for example enable disaster response teams to gather data and establish situation awareness in an extended range of situations, while decreasing the risk for humans. There have been deployments of robots in disaster response, see [3] for an overview of the early ones, [2] for a more recent example.

While the deployments reported in the literature typically involve research teams assisting responder organizations, some responders have been acquiring robots as part of their own response equipment. The deployments of robots in real disaster response have in common that the missions are carried out in tele-operation and relying on the most robust functionalities available. Not surprisingly, the high-risk situations do not allow experimentation.

On the other hand, various advanced robot capabilities are being developed in research projects. These are typically tested in isolation, benchmarked under controlled specific circumstances. This process rarely involves realistic scenarios with end users. However, such tests are necessary because the success of robotic deployments depends largely on whether the robots and the related information systems can be properly embedded in an actual disaster response effort. We therefore advocate that the various aspects of more sophisticated robotic systems must be tested and evaluated in realistic, holistic experiments. Only when integrating all these aspects in complex, 'messy' and unpredictable situations of realistic missions, we learn what aspects are relevant for actual deployments.

In our project [1] we apply a strongly user-centric approach to realize this goal. We define relevant realistic scenarios and identify the ensuing functionality requirements in close collaboration with end-users.

Motivated by practical deployment experience we place particular emphasis on the notion of *persistence*. As disaster response missions may stretch over extended periods, it is crucial to accumulate data and build up experience over time. Since disaster sites are dynamic due to weather, explosions/fires, structural instabilities etc., the environment is likely to change over time. The robotic system needs to be able to cope with these changes.

In this paper we report on the setup and outcomes of our industrial incident exercise in November 2017.

2 INDUSTRIAL INCIDENT EXERCISE

We conducted an industrial incident exercise at a training plant to evaluate the robotic system under realistic circumstances with end-users. Figure 1 provides an illustration of the disaster environment.

2.1 System capabilities

The system consisted of the following components:

- Mobile command post from which a team leader and human operators control the mission.

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Figure 1: Illustration of the exercise environment

- Ground robots with varying capabilities, e.g. SLAM, autonomous terrain traversal, autonomous navigation (multi-robot exploration and patrolling), robotic arm for in-field manipulations, 2-way audio system to speak to victims and various sensors such as omni-cameras, thermal cameras, gas, smoke and fire detectors.
- Centralized data management system, including Operator Control Units (OCUs), tactical maps, reporting tools, and "smart interpretation" of data through e.g. speech recognition, agent technology and working agreements

2.2 Exercise setup

The exercise scenario involved an industrial accident in which an explosion had occurred on site. This resulted in partially collapsed buildings and rubble with possible human victims and a risk of more explosions due to hazardous substances. First responders utilize the robotic system to establish situation awareness without entering the site. They search for Points of Interest (POIs), including victims and potential explosion sources, such as gas and fluid leakages, fires, or barrels with chemical substances that need to be closed.

2.3 Outcomes

A total of 10 different robot sorties were executed by multiple teams of fire-fighters with robots. Figure 2 shows the operators during a mission. During these sorties, the teams assessed the situation by inspecting and – if needed – manipulating the POIs related to the scenario. Four UGVs with different sensory- and capability-configurations were available. Up to two UGVs could be deployed simultaneously. The teamleader thus had to make tactical choices regarding which UGVs to use when. Over the course of the mission, information was gathered and situation awareness was acquired. Mission-critical information was stored in appropriate forms in the system databases, resulting in a persistent record of the situation. The team gradually located all victims, and identified all hazards.

Both the robots and the overall system performed in a stable manner (which was a notable improvement compared to exercises conducted in previous years). This allowed for rigorous testing of various system functionalities.

Figure 2: Responders operating the UGVs using the OCU (bottom) and tactical map (top).

During the exercise it became clear that – in order to fully utilize all functionalities the system offered – more extensive training of the end-users would be required. Although we scheduled one full day for training (more than in previous years), which allowed the end-users to experience all system functionalities, it was not sufficient for them to master the operation. As a result they did not use or fully exploit certain functionalities during the exercise. This outcome was somewhat counter-intuitive, because the sophisticated automation and various support functions offered by the robots and the system should have made the fire-fighters' tasks easier. However, more extensive training appears to be needed than expected to fully utilize and trust the complex system.

Generally though, the end-users were positive about the possibilities the robotic system offered. Although they suggested improvements, they indicated that with the current capabilities, the robots would be very useful for some situations and that they definitely would want to employ them in real missions.

3 CONCLUSIONS

Through exposing the system to end-users, important lessons were learned regarding employment of robots in complex, realistic missions with human team members. The system was mostly stable, allowing for multiple sorties each day and a long mission time. The system thus supported the creation of persistent situation awareness during a disaster response mission, supporting first responders to deal with an abundance of information in a timely manner. Ultimately such a system may help saving lives.

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