

Project Summary: TRUST-ROB, Towards Resilient UGV and UAV Manipulator Teams For Robotic Search and Rescue Tasks

A. García-Cerezo¹, A. Mandow¹, J. Bravo-Arrabal³, A. Cruz², M. Castellano-Quero³, J. J. Fernández-Lozano², J. M. Gandarias³, J. M. Gómez-de-Gabriel², J. A. Gomez-Ruiz², J. L. Martínez², M. A. Martínez-Sánchez², J. Miranda-Páez^{2*}, J. Morales², A. J. Muñoz-Ramírez², F. Pastor-Martín³, A. J. Reina², J. R. Sánchez³, J. Serón-Barba³, M. Toscano-Moreno³, R. Vázquez-Martín², and P. Zambrana³

¹ Principal Investigator; ² Research Team; ³ Work Team.

Robotics and Mechatronics Group

* Chair for Security, Emergency and Catastrophes

Institute of Mechatronics Engineering and Cyber-Physical Systems (IMECH.UMA),
Universidad de Málaga, Spain.

Abstract. This Project Summary paper reviews the main contributions and lessons learned from the TRUST-ROB project: “Towards Resilient UGV and UAV Manipulator Teams for Robotic Search and Rescue Tasks”, which has been developed between 2019 and 2022 with funding from the Spanish Government (RTI2018-093421-B-I00).

1 Introduction

To meet the upcoming challenge of accounting for robots as key players in the disaster response workspace, it is required that robot teams are designed as safety-critical systems where failure may result in an increased safety risk, not only for the equipment and the environment but also to the survivors and the human rescue team. The goal of the TRUST-BOT project (2019-2022), has been to develop important resiliency and fault-tolerance characteristics required to achieve a heterogeneous team of mobile robotic manipulators, with both unmanned ground vehicles (UGV) and unmanned aerial vehicles (UAV), cooperating in harsh disaster scenarios in order to be able to dependably accomplish their specified search and rescue missions. To this end, the project has addressed major technical problems encountered by robots in actual disaster conditions, including communication disruptions, GNSS-denial, perception limitations due to smoke or lighting, challenging mobility conditions due to surface characteristics, and inefficient decomposition and allocation of tasks. The project has contributed to improve the current multi-robot response team by increasing its robustness and supporting safety and security. End users and emergency response experts have been actively involved in the project through the support of the Universidad de Malaga Chair for Security, Emergency and Catastrophes. Furthermore, the

project results have been validated in realistic emergency drills with professional rescue response teams.

2 Major Results

The major results and publications from the project are summarized in the project's website [1]. In particular, the TRUST-ROB project has addressed the following objectives:

1. Definition of novel fault-tolerant design criteria and solutions for robotic systems based on the analysis of electrical, electronic, mechanical, control, and communication vulnerabilities of UGVs, UAVs, and the mission control centre in disaster response conditions. Resulting fault tolerance techniques will be applied to re-design RAMBLER, QUADRIGA, UTAV, and the mission control post.
2. Development of intelligent human-level reaction capabilities based on machine learning tools for autonomous path planning and motion control in disaster scenarios, including perception limitations due to smoke or lighting and GNSS-denied areas. For UGVs, this objective poses specific challenges regarding soil interaction.
3. Safe physical interaction between the robots and the victims. This is a three-fold objective that involves the design of innovative adaptive and soft effectors, autonomous collaborative robot for victim manipulation from a UGV, and novel intelligent UAV solutions for placing biomedical sensors on the victim.
4. Resilient multi-robot cooperation based on new methods for high-level mission specification, validation and coordination in the face of environmental and temporal uncertainty as well as distributed bio-inspired capabilities for formation dispersion and regrouping.
5. Integration of the resulting multi-robot system in realistic field exercises with professional rescue teams. In addition to evaluating and demonstrating the project results, field exercises are expected to provide valuable applicability insights and data-sets for the international disaster robotics community.

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References

- [1] UMA. *TRUST-ROB Project website*. Accessed: September 3, 2022. URL: <https://www.uma.es/robotics-and-mechatronics/info/124560/TRUST-ROB/>.