SAR 4.0: Leapfrogging to a New Paradigm in Cooperative Human-Robot Cyber-Physical Systems for Search and Rescue

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Project Mission

Developing new collaborative Search & Rescue (SAR) support technology where heterogeneous robotic teams, sensor networks, communication systems and deployed artificial intelligence (AI) produce seamless, transparent, fluid, and adaptive support to the responders with the ultimate goals of optimizing SAR efficiency and minimizing mission-associated risks.

Research Challenges

1. **Develop specific interoperability requirements** to enhance adaptability to SAR mission specifications, reduce integration risks and implementation time, enable rapid deployment, and simplify complexity for all involved actors (from end-users to maintenance teams).

2. **Define a distributed IoRT architecture** to integrate all agents in a SAR mission, including heterogeneous mobile robots (UGVs and UAVs), wireless sensor networks, and remote computing (cloud or edge), using either commercial or ad hoc communication networks.

3. **Create a smart space with ambient intelligence** in disaster scenarios, utilizing a deployable hybrid sensor network with fixed and mobile nodes, special sensor deployment mechanisms, telepresence, multimodal object recognition for victim detection and scene understanding, as well as wearable sensors to monitor and diagnose victims and track responder stress levels and activity.

4. **Develop novel robotic intelligence methods** for SAR missions, including a strategic mission control system, trajectory planning algorithms for realistic environmental conditions, strategies for swarms or fleets of heterogeneous robots, and collaborative 3D localization and mapping.

5. **Validate and test the SAR4.0 system in realistic field exercises** with professional rescue teams, providing valuable insights into its applicability, open datasets for the international disaster robotics community, and dissemination opportunities for emergency response stakeholders.

1. Interoperability Highlights

- **Definition of interoperability requirements.**
- **Migration to ROS2** of UGV and UAV platforms, control center and communication systems.
- **Hardware redesign** of UAV and UGV platforms.

2. Distributed Architecture Highlights

- **Bayesian architecture** for real-time sensory anomaly detection and recovery.
- **Leveraging Smartphones** for Sensor Integration and Connectivity in Field Robotics
- Integrating ROS and Android for Rescuers in a Cloud Robotics Architecture
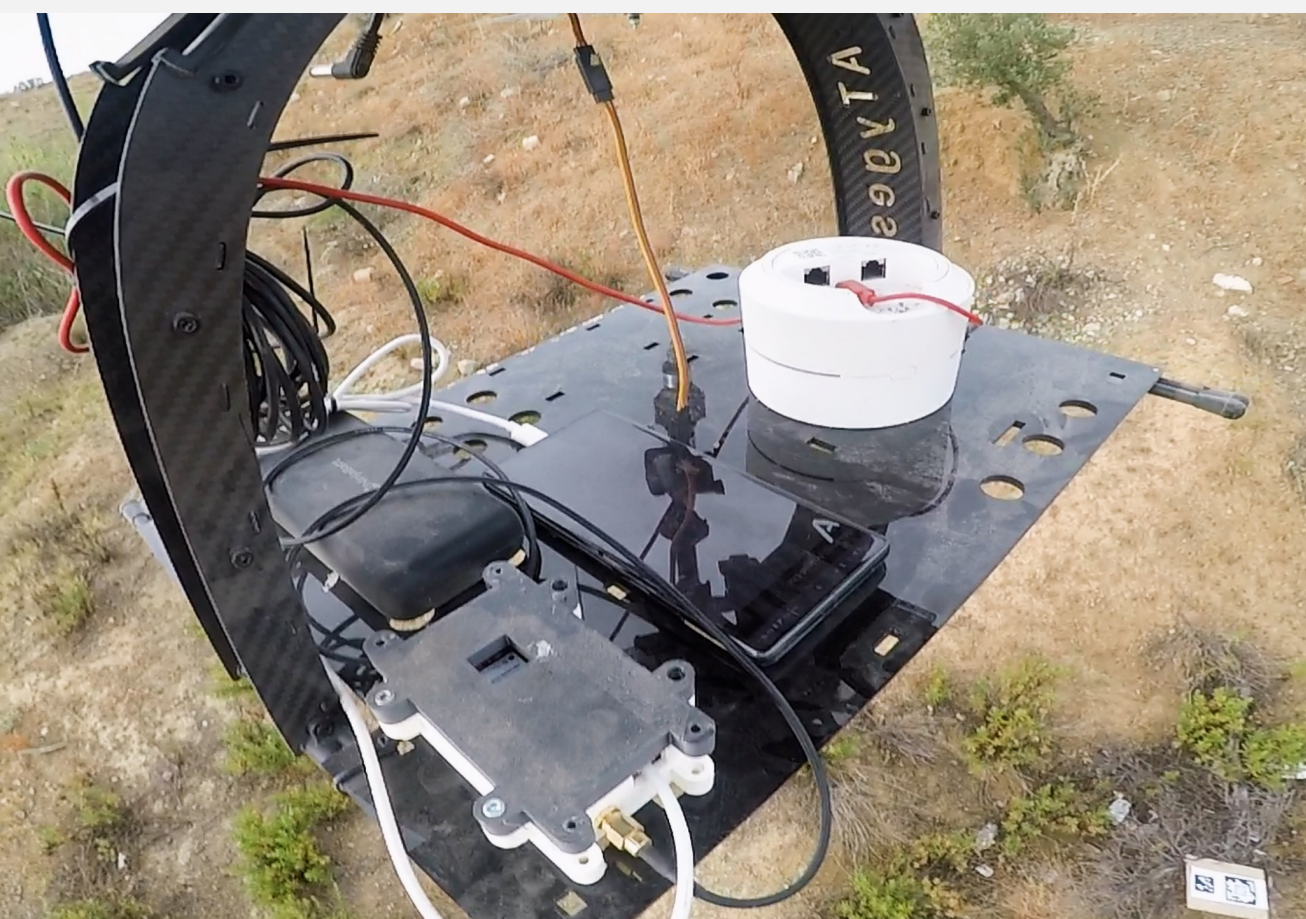
## 3. Ambient Intelligence Highlights

- **Entropy-Based Exploration** for Efficient Search and Rescue in Disaster Environments.
- **Remote Responder Bio-Signal** Monitoring and modeling.
- **Bluetooth-Based Victim Detection** for SAR Using Terrestrial and Aerial Robots.
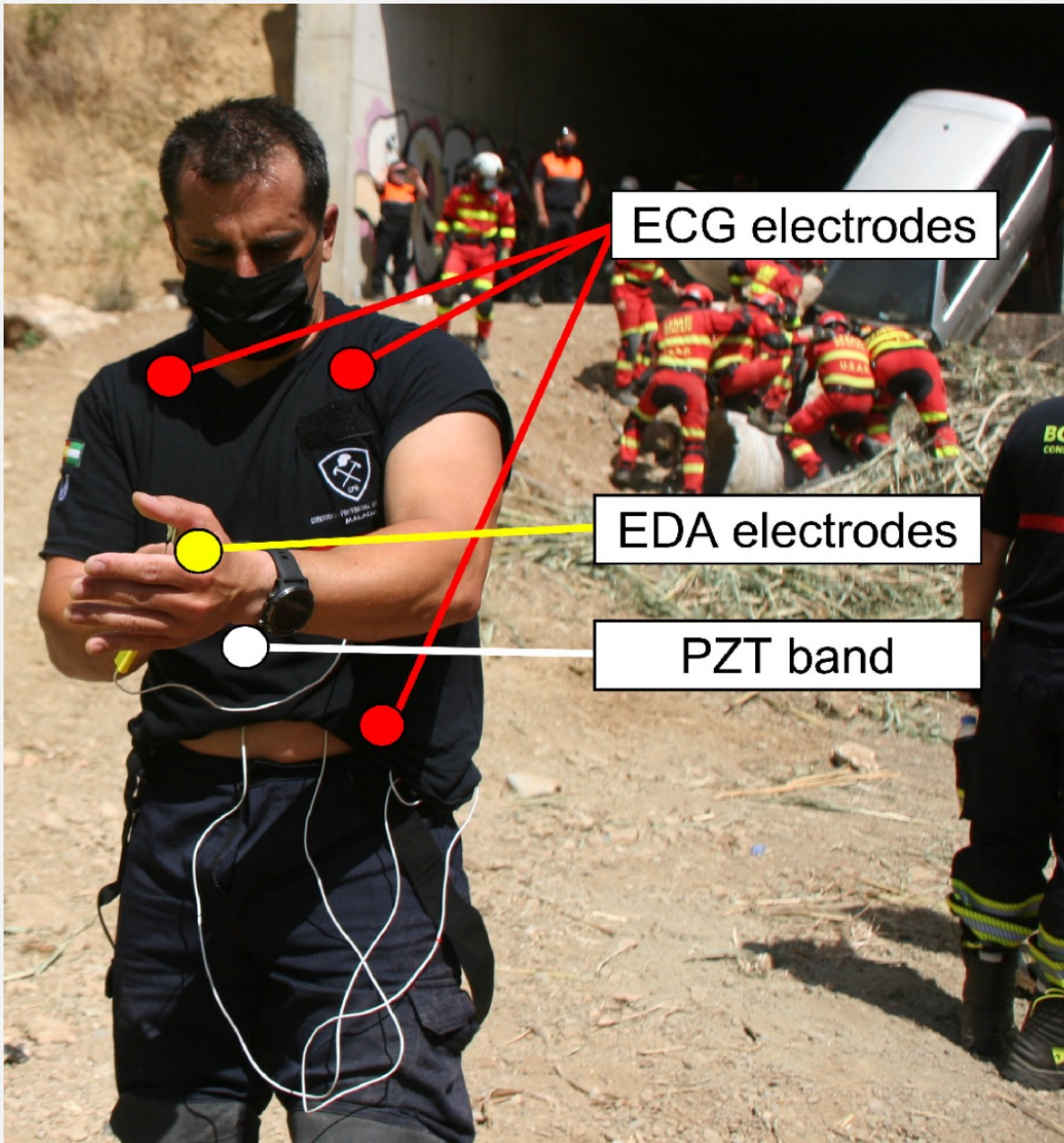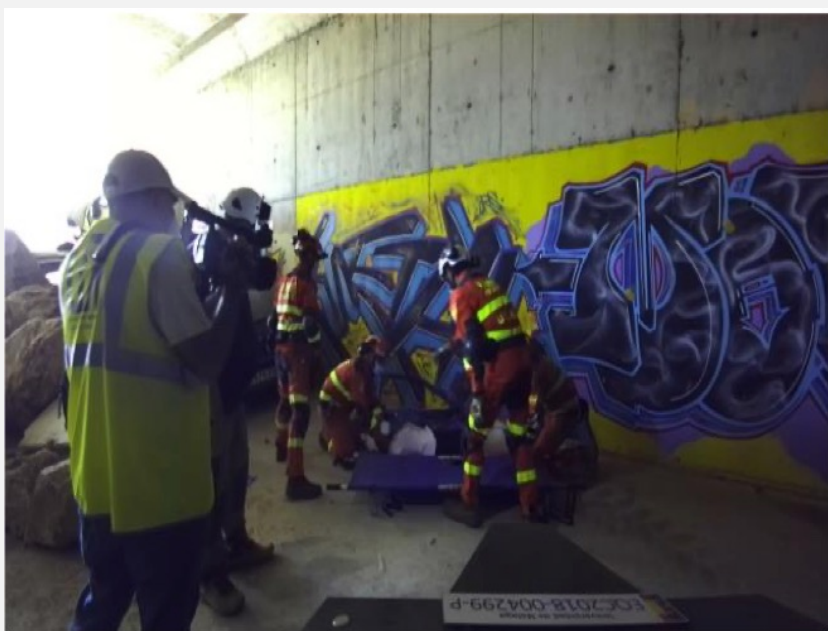
- **Semantic segmentation** in SAR imaging.

4. Robotic Intelligence Highlights

- **Strategic Planning.** LTL trajectory planning with motion constraints on rough terrain.
- **Trail detection and** planning from satellite images.
- **Deep Reinforcement Learning** for UGV Off-Road Navigation with 3D LiDAR
- **Gain optimizer for Fuzzy UAV control**
- **Autonomous Wristband Placement** in a Moving Hand from a UGV.
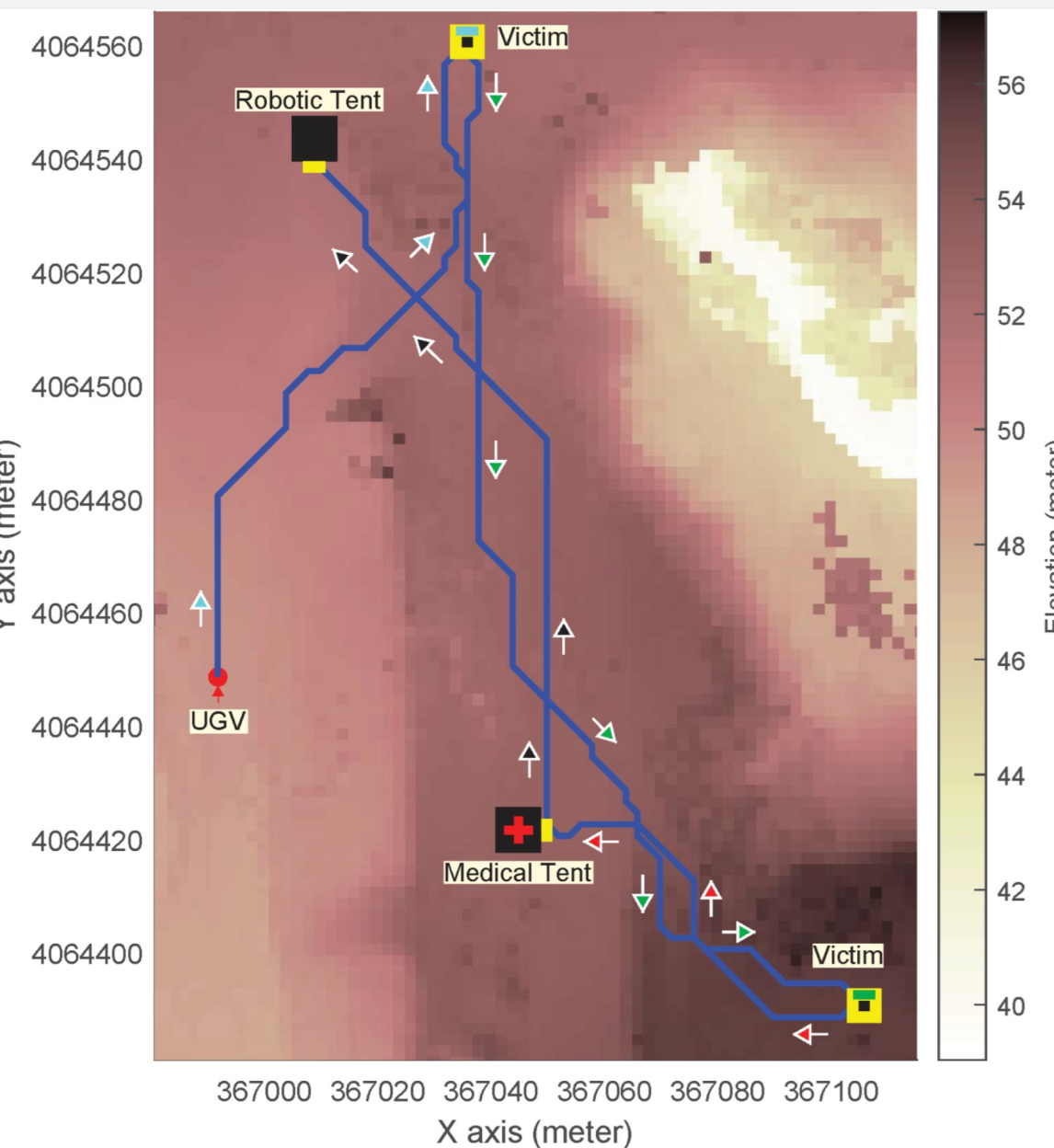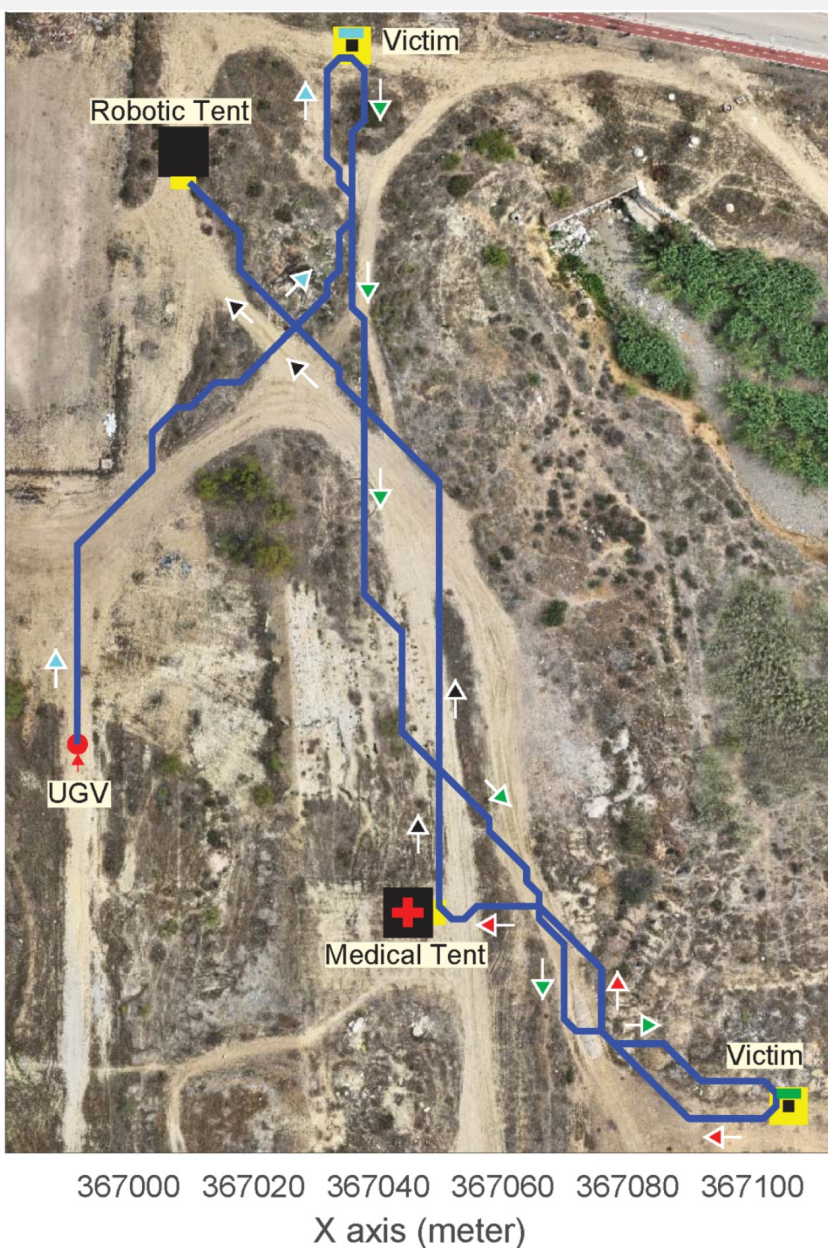
5. Field Exercises Highlights

High-fidelity exercises. Annual testing and validation at the LAENTIEC experimental area for emergency response (Málaga, Spain). These joint exercises involve real-life responders, including UME, Málaga Province Firefighters, the Spanish Legion, and others.

Further Info

Visit the SAR4.0 website for open access publications, videos, datasets and other information:

www.uma.es/sar4point0