

Aerial and Underwater Robots in Competition

By Gabriele Ferri, Fausto Ferreira, Antidio Viguria, and Francisco Perez-Grau

The European Robotics League (ERL) is a novel pan-European competition format that aims to provide a platform for developing, benchmarking, and showcasing challenging robotics technologies, bridging the gap between industry, research, and the general public. It builds on the success of important European competitions and on several EU-FP7/H2020 projects. The main goal is to foster scientific progress and innovation in robotics.

International teams, from both academia and industry, compete in three leagues touching on different aspects of robotics: consumer, professional, and emergency service robots. These competitions target three main objectives: meeting the European societal challenges of an aging population, strengthening the European robotics service industry, and assisting the effort to push state-of-the-art features in autonomous systems for emergency response. The league season runs from April to February and ends with an awards ceremony at the European Robotics Forum. In addition to the annual competitions, there is a new biennial ERL Smart Cities challenge (also known as the *SciRoc Challenge*) that will be held in smart cities across Europe. In this challenge, robots from all three categories will come together to interact with the smart infrastructure in familiar urban settings.

ERL Local Competitions: Underwater and Aerial Robots in Action

In addition to the major emergency robot tournaments, several local tournaments are organized each year. In July 2018, the NATO Science and Technology Organization's Center for Maritime Research and Experimentation hosted a local tournament of the ERL Emergency Robots League in La Spezia, Italy. For this competition, land and marine robots were challenged with a simulated incident in a harbor.

In February 2019, the Center for Advanced Aerospace Technologies (CATEC) will host a second local tournament in Seville, Spain, with aerial robots from different teams, together with mobile manipulators, competing to handle emergency situations. In such situations, robotic systems play a key role by enabling rescue teams to sense and act at a distance away from actual emergency sites. The main goal of these challenges is to push robotic developments toward autonomous capabilities that can help rescue teams work safely and more efficiently. These capabilities include surveying the disaster area quickly and providing map representations of it or finding missing persons and autonomously delivering first-aid kits. But what are the main challenges that participants have faced, or will face, in these two tournaments of the ERL Emergency Robots League?

Emergency Robots League Local Tournament 2018 (La Spezia, Italy)

The tournament was held during July 2018, with participants from various

organizations competing to solve a simulated incident in a harbor. The proposed tasks (for the marine segment of the competition) involved autonomous navigation, piping-assembly inspection, recognition of underwater buoys, and identification of underwater images/numbers.

Main Challenges Experienced

Participants faced challenges that went beyond the merely technical. Managerial skills were, in fact, needed to organize the teamwork and handle robot preparation under stress conditions and within the short available time. These challenges teach teams the importance of organization and division of roles, along with how a rational robot design can be a key point in addressing unavoidable technical issues. Certainly, teams that participated several times in the competition showed significant improvements in their performances.

Technological Gaps in Underwater Manipulation

One important consideration in terms of this local tournament was that no robotic challenges involving underwater manipulation were presented. The reason is that underwater manipulation, from floating-based systems, remains a premature technology for autonomous

The main goal is to foster scientific progress and innovation in robotics.

robotic challenges. To attempt autonomous manipulation, teams would need specifically designed platforms endowed

International teams, from both academia and industry, compete in three leagues touching on different aspects of robotics.

with hovering capabilities and able to operate robotic arms. So far, only general-purpose autonomous underwater vehicles have been used in the competitions. In addition, the task necessarily becomes more complex in real-

istic environmental conditions, e.g., having a very limited visibility.

A Thought on the Final Results

The results highlight the fact that teams having participated in the competition several times before achieved major improvements and the best scores. This demonstrates that participating in the competitions multiple times is, in general, the way for teams to increase their technical and, above all, management skills. In this year's local tournament, no team completed all the proposed tasks, but three achieved good results with the most important task (e.g., the inspection of the piping-assembly structure). One of the teams was also severely hindered by damage to its Doppler velocity log sensor. The top-scoring teams showed good robustness in mission planning and in the execution of the preplanned area survey, with perception algorithms working in an appreciable way.

Outlook for Possible Future Underwater Manipulation Challenges

Future challenges involving underwater manipulation will be interesting to design to further attract attention on the topic. However, given the demanding subject, any competition should be of the "grand challenge" type, with large monetary prizes and funding opportunities used to attract teams solving a specific scientific/technological challenge.

An important consideration such a competition might address is developing adaptive mission planning in reaction to real-time sensing. In fact, autonomy and multirobot operations are key points for the future of underwater robotics, and the rate of development of such robotic systems depends largely on the proper design of challenges that will bring together industry and academia to compete in solving highly challenging technological tasks.

ERL Emergency Robots League 2019

The February 2019 local tournament will be hosted by the CATEC in Seville and will involve aerial robots. The main goal will be to push robotic developments for autonomous capabilities that can help rescue teams work safely and more efficiently. As in earlier competitions, these capabilities will include surveying the disaster area quickly and providing map representations or finding missing persons to autonomously deliver first-aid kits.

Expected Main Challenges

Besides organizational challenges, one of the greatest envisioned technological challenges for teams is dealing with the lack of a communication infrastructure and often even access to Global Positioning System signals. This is a major problem in most current state-of-the-art robotic solutions; therefore, the 2019 local tournaments will foster advanced developments of autonomous capabilities and seamless outdoor/indoor navigation for air and land robots. These are, in fact, important milestones to achieve for emergency robotic systems, as emergencies can take place in any scenario, making robot autonomy key for the proper operation of robotic technologies.

Technological Gaps in Aerial Floating-Base Manipulation

Even though competitions involving aerial robots are becoming more popular, the state of the current platforms with respect to autonomous operation lags behind as part of the novel research field of aerial manipulation. The control

problem largely depends on the manipulator and its configuration within the aerial platform, which increases development costs because there are many different ways of performing aerial manipulation. Standardizing the technological components that constitute the basis of aerial manipulation could lead to an evolution in the commercial market, with more people being able to access the technology, thus making it suitable for a robotic competition. Because of these gaps, the design of robotic competitions focused on aerial manipulation are still premature with respect to the current state of technology.

Expectations for the 2019 Local Tournaments

Although it is hard to foresee the results of the competition, looking to the past, it is possible to forecast the type of participant teams. The competition is open to international participation of any nature. That said, as has happened in previous competitions, most participants are academic, coming from universities or technological centers.

Robotic competitions meet educational needs and can serve as an excellent platform for developing the skills of future engineers and scientists, contributing to student awareness and understanding of applied research and development in robotics. We expect to see interesting customized solutions, especially regarding aerial robots, because recent developments in this field can help teams focus more on the application, rather than on the operational aspects of the platforms.

BA

Correction

The "Competitions" column in the June 2018 issue of *IEEE Robotics and Automation Magazine* (vol. 25, no. 2) omitted two of the authors. They are Si Jung Kim and Hyunchul Shim.

BA

Digital Object Identifier 10.1109/MRA.2018.2873261
Date of publication: 12 December 2018