accurate traversal of all the trajectories was the winner.

2) The Microassembly Challenge, in which the microrobots assembled a planar shape out of multiple microscale components. This task simulated anticipated applications of microassembly for medical or micromanufacturing applications.
3) The MMC Showcase and Poster Session, in which each team had an opportunity to showcase and demonstrate any advanced capabilities and functionality of its microrobot system. Each participating team and the MMC organizers received one vote to determine the Best in Show winner.

This year, three teams qualified for the event: the University of Waterloo Nanorobotic Group from Canada, the Exemplary Indians from the Indian Institute of Technology in Patna, and Team UTV Romania from Valahia University of Targoviste. To qualify, the teams had to submit a qualification video to the MMC organizers, demonstrating the ability of their robots to traverse the required sized trajectories, and they had to be able to attend MMC 2016. Out of the three qualifying teams, Team UTV Romania won both the Autonomous Mobility and Accuracy Challenge and the Best in Show, and the University of Waterloo Nanorobotic Group won the Microassembly Challenge.

MMC 2016, as well as previous MMC events, helped to introduce the general audience of the ICRA to microrobotics and to disseminate the excitement of this new and rapidly emerging field to the robotics community. The MMC 2016 organizers, Prof. Igor Paprotny (University of Illinois at Chicago), Prof. Dave Cappelleri (Purdue University, Indiana), and Prof. Aaron Ohta (University of Hawaii), wish to congratulate the winning teams and invite you all to attend MMC 2017 at ICRA 2017 in Singapore!

The 2016 Humanitarian Robotics and Automation Technology Challenge

By Edson Prestes, Lino Marques, Renata Neuland, Mathias Mantelli, Renan Maffei, Sedat Dogru, José Prado, João Macedo, and Raj Madhavan

According to the United Nations Mine Action Service, land mines kill 15,000–20,000 people every year and maim countless more across 78 countries. The cost involved in the demining process is extremely high: in addition to US$300–1,000 per mine, one person is killed and two are injured for every 5,000 mines cleared. Therefore, clearing postcombat regions of land mines has proven to be a difficult, dangerous, and expensive task with enormous social implications for civilians. This scenario motivated the RAS Special Interest Group on Humanitarian Technology (SIGHT) to organize the HRATC. The third HRATC took place at ICRA 2016 in Stockholm, Sweden, on 17–18 May 2016, and it was preceded by almost five months of preliminary practice and test runs for the participating teams.

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The previous two HRATCs took place at the ICRA conferences held in Hong Kong, China, and Seattle, Washington, respectively [1], [2].

Our main goal is to promote global awareness about the land-mine problem and incentivize the robotics and automation community to join our initiative in the development of robotic solutions that can alleviate the consequences caused by buried land mines. To make this challenge viable and more affordable, a robust platform instrumented with several sensors was made available via simulation and (physical) testing phases for anyone interested in joining our effort, i.e., participants around the globe could compete remotely in each phase of the challenge. All teams had access to the codes generated by the previous participants of the HRATC. This enabled the development of algorithmic solutions without reinventing the wheel, and it resulted in more sophisticated methodologies in a shorter duration.

The HRATC 2016 organizers coordinated the simulation phase of the challenge from Brazil while the testing phase was coordinated from Portugal on an outdoor setup complete with mock land mines that the robots were to identify via metal detectors. During the final challenge phase, both teams of organizers in their respective countries worked together to run the challenge held in ICRA 2016 in Stockholm. The HRATC participants had the opportunity to see their code run on the robot located in Portugal in real time. All trials were beamed via a YouTube channel to the conference room through live streaming. After finishing each trial, team scores were determined according to the criteria, which included exploration time, environmental coverage, detection and classification quality, and land-mine avoidance.

At each of the HRATC events, the difficulty level increased compared to the previous one. For the 2016 challenge, the teams needed to sweep an

Figure 1. The HRATC finalists together with Edson Prestes (HRATC co-organizer, fourth from the right) and Raj Madhavan (RAS-SIGHT chair, fifth from the left).

arbitrary area defined by a list of positions provided by the global positioning system in search of land mines placed in a nonuniform distribution. The HRACT 2016 received nine entries from five countries: Bangladesh, France, India, Italy, and the United States. After the simulation and testing phases, four teams qualified for the finals: DISHARI (Bangladesh), Tushar (India), Autobots (India), and MavDetectors (United States) (Figure 1). After two intense days, Team Autobots was declared the grand winner.

We believe that our challenge is a good first step toward a better world without land mines. We are hopeful that, with continuous improvement in each edition, we are on the right path toward a version that could be deployed in real scenarios with real land mines!

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The 2016 Formal Methods for Robotics Challenge

By Vasumathi Raman

Robotic systems demand a high standard of safety and correctness of behavior. There is a large body of algorithmic work addressing the principled design of correct-by-construction controllers for robots, drawing on formal methods for verification and automatic synthesis of transition systems satisfying desired properties. The first of its kind, the FMRC was developed to address the lack of large-scale demonstrations of current capabilities in this domain and of benchmarks and metrics for evaluating novel algorithms.

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At ICRA 2016, teams from four universities—California Institute of Technology (Caltech), Carnegie Mellon University (CMU), Cornell University, and Worcester Polytechnic Institute (WPI)—competed across two problem domains designed to test various challenges faced during the practical deployment of controller synthesis approaches. The first domain involved controlling a dynamical system modeled as a chain of integrators to satisfy a reach-avoid temporal logic specification. This domain was designed to test scalability of the submitted controller synthesis methods on problem instances of increasing dimension and order of highest derivative. The second domain was a road network containing vehicles modeled as Dubins cars. The objective was to control a single "ego" vehicle to achieve safety (i.e., to not collide and to always stay in its lane) and liveness (i.e., to always eventually visit the goal region) specifications while interacting with the remaining vehicles, whose behavior was uncontrolled but simulated subject to certain assumptions (e.g., to always eventually vacate the goal region).

To allow maximum flexibility of solution format, the solutions were evaluated by running them in a black-box fashion rather than requiring, e.g., solutions compatible with