Minesweepers: Towards a Landmine-Free World

By Alaa Khamis

The aim of civilian demining or humanitarian demining is to find and remove abandoned landmines without any hazard to the environment. According to Landmine and Cluster Munition Monitor report in 2014 [1], there are more than 110 million active mines scattered in 68 countries. These landmines kill or maim more than 5,000 people annually, 46% of whom are children, and they cause 15,000–20,000 injuries each year. Landmines create millions of refugees and internally displaced people. While basic landmine detection and neutralizing theologies remain almost the same, landmine technology improved dramatically. The conventional detection methods make the procedure of removing large numbers of landmines very slow, inefficient, dangerous, and costly. Robotics systems can provide efficient, reliable, adaptive, and cost-effective solutions for the problem of landmines and unexploded ordnances contamination.

Landmines kill or maim thousands of people annually and create millions of refugees and internally displaced people.

Robotic competitions provide inspirational and motivational platforms for students, researchers, and laypersons to present their work to a wider forum with extensive media coverage. To foster robotics research and its applications in the area of humanitarian demining, Minesweepers: Towards a Landmine-Free World was initiated in 2012 as the first outdoor robotic competition on humanitarian demining. In this competition, each participating team constructs a teleoperated/autonomous unmanned ground/aerial vehicle (UGV/UAV) that must be able to search for buried and surface-laid antipersonnel landmines. The position and the type of each detected object are visualized and overlaid on the minefield map. The robot must be able to navigate through rough terrain that mimics a real minefield. The competition contains three main categories.

- ***Minesweepers–Juniors***: For elementary and high school students where only metallic objects are available in the competition arena and only landmine detection is required.
- ***Minesweepers–Academia***: For undergraduate and postgraduate students where only metallic objects are available in the competition arena and landmine detection and minefield mapping are required.
- ***Minesweepers–Industry***: For professional companies where metallic and nonmetallic objects with different dimensions and profiles are available in the competition arena and landmine detection, landmine imaging, and minefield mapping are required.

The fourth edition of the competition was organized in 2015 by the Universidad Católica del Norte in Chile in collaboration with the Chilean Army Forces and with the support of the

Figure 1. The former prime minister of Egypt, assistant of minister of defense, assistant minister of telecommunications, and Egyptian Engineer Syndicate vice chair giving out the best design award in the local round for a system that consists of a UGV for buried mine detection and a UAV for aerial imaging and surface-laid mine detection. (Photo courtesy of the IEEE RAS Egypt Chapter.)

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Special Issue on
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The open-source movement has already revolutionized a number of industries by empowering end-users to contribute to the products that they need and want, and fueling grass-roots development of projects in completely new areas, as well as their continual improvement. While there have been innumerable successes in software and electronics hardware, open mechanical hardware is taking longer to catch on, in large part due to the complexity and expense associated with fabricating mechanical systems. However, rapid fabrication technologies have improved to the point of being able to produce parts that are strong, robust, and precise enough for practical robotic systems and the many of these machines are available in fabrication facilities at most universities. With these and other technologies, users can more easily fabricate and improve upon open-source mechanical hardware without requiring large commitments in terms of cost, time, and domain expertise. This special issue seeks a collection of papers that address topics in open mechanical robot hardware, including issues related to design, fabrication, and dissemination, among others. Lessons learned in both development and in operation are pertinent to the discussion. Experimental results are strongly encouraged.

Topics of interest include but are not limited to:

- Novel open hardware for research, education, or commercial applications that has been specifically developed for easy and widespread fabrication, assembly, customization, and/or repair
- Projects that combine substantial mechanical hardware with open software/electronics hardware
- Research results that strongly rely on open mechanical hardware, such as performance results
- Novel fabrication techniques that facilitate open hardware fabrication and dissemination

Additionally, it is suggested that papers include, in addition to technical content, discussion of challenges and lessons learned as a result of their efforts in open-source or widely disseminated research hardware such that researchers can learn from them for future efforts.

Topics that do not speak to issues specific to open-source mechanical hardware are out of scope, including:

- Projects that are entirely or largely based on open-source software or electronics hardware
- Mechanical hardware that is not open, such as commercial hardware

Traditional mechanical hardware that has not been designed specifically for easy implementation (e.g. requiring extensive machining) is likely to be out of scope (even if the designs have been made publically available), unless there is strong evidence of widespread adoption/implementation and provides insight for other open-source hardware efforts.

Authors of prospective papers are encouraged to send an abstract or description of the work to the special issue editors to discuss its relevance to the SI scope.

Timeline

- April 1, 2016 – Submission deadline
- July 15, 2016 – End of first review round and author notification
- November 15, 2016– Final decisions made
- December 1, 2016 – Final manuscripts due
- March 2017 – Issue in print

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Figure 2. The arena of the final round in the historic ruins of Huanchaca in Antofagasta, Chile. (Photo courtesy of Minesweepers competition volunteers.)

Chilean government. The competition is organized annually under the IEEE Robotics and Automation Society (RAS) Special Interest Group on Humanitarian Technology. An international workshop, "Recent Advances on Robotics and Sensor Technology for Humanitarian Demining," took place as part of the competition. The landmine detection equipment currently used by the Chilean army was also on display in the field of the competition. In total, 94 teams from eight countries signed up to participate. Next, 60 teams passed the eligibility criteria for local rounds (Figure 1) and only six teams from three countries qualified to participate in the final round in Chile (Figure 2). The results of Minesweepers 2015 were as follows. The Elite, Misr University for Science and Technology, Egypt (first place in the Academia Category), Ten In Black, Mansoura University, Egypt (second place in the Academia Category), Most Challenging Team (National Bolivian Team, Bolivia), and the Za3fran Team, IDEL School, Egypt, (Juniors Category) won the "No Pain No Gain" Prize.

In the next editions of the competition, two categories will be added. The first one is to explore the applicability of multirobot systems in mimicking the standard operating procedure commonly used in landmine detection. The second category will be for Robot Operating System (ROS)-enabled mobile sweepers to make use of the interesting open-source modules produced from the Humanitarian Robotics and Automation Technology Challenge [2].

The competition is organized annually under the IEEE RAS Special Interest Group on Humanitarian Technology.

The ultimate goal of the Minesweepers competition is to put into practice the new strategic mission of IEEE, "… to foster technological innovation and excellence for the benefit of humanity," and to serve as an educational and a research forum to provide efficient, reliable, adaptive, and cost-effective solutions for the serious problem of explosive remnants of war. For more information about Minesweepers, please visit http://www.landminefree.org/.

References

[1] Cluster Munition Monitor 2014. International Campaign to Ban Landmines—Cluster Munition Coalition (ICBL-CMC), 2014.

[2] R. Madhavan, L. Marques, E. Prestes, R. Maffei, V. Jorge, B. Gil, S. Dogru, G. Cabrita, R. Neuland, and P. Dasgupta, "2015 Humanitarian Robotics and Automation Technology Challenge," *IEEE Robot. Automat. Mag.*, vol. 22, no. 3, pp. 182–184, Sept. 2015.