

GUEST EDITORIAL

Robotics and Sensing for Humanitarian Demining

Although demining has been given priority, current operations dealing with mine clearance are labor-intensive, time consuming, very dangerous, expensive, and low technology operations. In the context of humanitarian demining it is essential to have a reliable and accurate sensor to detect or locate landmines, or to have integration of heterogeneous/ homogeneous sensors with efficient and reliable data fusion and processing techniques to achieve the same purpose. In addition, it is important to overcome the constrain on the resources by developing innovative, cost effective and practical technology inspired by local environment and the needs of real minefield to help in speeding up the demining process and in enhancing accuracy, productivity, operation and personnel safety, achieve higher quality of service, and contribute to local economy of mine inflicted countries.

Technology has become solution to many long-standing problems, and while current mine detection and clearance technologies may be effective, it is far too limited to fully address the huge complex and difficult landmine problem facing the world. The challenge lies in finding creative, reliable and applicable technical solutions in such highly constrained environment. Applying technology to humanitarian demining is by itself a stimulating objective.

In order to have effective approach in tackling this complicated problem, with aims to accelerate the demining process, increase daily performance, improving productivity and accuracy and to achieve cost effective measures, there is a need to have innovative technology and techniques within the following areas, Demining is very costly and searching an area that is free of mines is adding extra high cost and wasting resources. Hence, to avoid that, the first essential objective in the demining process should be to identify efficiently what areas are polluted by mines. Locating the contaminated land helps to separate the danger from people and makes the uncontaminated land available for use immediately. New demining methods are urgently needed to detect minefields over large and varied tracts of land in a much more cost effective, efficient, safe and reliable manner. It is important to have reliable methods that can reduce mine suspected areas. Unmanned Aerial Vehicles (UAVs) and Airships are integrated with remote sensing technology and sensor fusion techniques to help reducing mine suspected area and isolate the danger of mines while producing viable risk assessment maps.

The critical element to humanitarian demining is the detection and location of every single mine. Mine detection represents the slowest and the most important step within the demining process, and the quality of mine detector affects the efficiency and safety of this process. Hence, there is a need to have practical and reliable technology that can single out mine from other objects and natural clutters, and work under different climates and terrains, while it should be possible to efficiently perform without cutting vegetation.

It is necessary increase productivity and efficiency by having reliable and cost effective humanitarian mine action equipment with flexible mechanism and adaptable mobility, multiple operational modes, and some level of decision making capabilities. Such equipment should have selectable sets of mine detectors and work to locate and mark individual mines precisely, and at a later stage to neutralize the detected mines. Mobile robots can be useful to quickly verify that an area is clear of landmines so that manual cleaners can concentrate on those areas that are most likely to be infested.

It is important to remind ourselves that there is little value in a system that makes life safer for the operators but will be less effective at clearing accurately and reliably the ground.

The development of such systems should be done with close cooperation and interaction with deminers in the field, and the resultant systems must be inexpensive with possible use of locally available materials as possible, and easy to use with minimal training by locals. In addition, these systems must be flexible and modular with proper logistical consideration to address a variety of clearance tasks and for case-by-case scenarios.

In this Special Issue, there are eight full papers and two short papers. These papers offer recognizable contributions from enthusiastic researchers whom are aiming to develop new sensors and robotics technologies that help to progress the field of humanitarian demining. The papers are divided into three groups.

The first group includes one paper titled: "Humanitarian Demining: Reality and the Challenge of Technology - The State of the Arts" by Maki K. Habib. It describes the problem, difficulties, reality and challenges, adopting realistic vision for solutions, and the need for innovative technology. It presents and evaluates key technologies applied in the field of humanitarian demining from mine detection, mechanization of demining process and robotization aspect with clear focus on effort related to the development of robots for demining. The development of robotic systems for demining has always represents a big challenge to researchers due to the complex issues involved.

The second group of papers focuses on sensors development for mine detection and reduction of suspected mine area. It includes three papers. The first paper titled: "Multisensor Data Fusion for Spaceborne and Airborne Reduction of Mine Suspected Areas", by Isabelle Bloch et al. The paper focuses on mined area reduction in a post-conflict situation, using aerial and satellite data through different sensors, and it presents the development of classification and data fusion tools based on the belief function framework and fuzzy sets theory. The second paper titled: "A Biologically Based Chemo-Sensing UAV for Humanitarian Demining", by Sergi Bermúdez i Badia et al. They authors have investigated the use of a chemo-sensing Unmanned Aerial Vehicle (cUAV) for demining tasks, and developed a blimp based UAV that is equipped with a broadly tuned metal-thin oxide chemo-sensor. The third paper titled: "GPR Signal Processing with Geography Adaptive Scanning using Vector Radar for Antipersonnel Landmine Detection", by Toshio Fukuda et al. The paper tries to overcome the problems associated with Ground Penetration Radar (GPR) by modifying Kirchhoff migration so as to account for not only the variation of position of the sensor head, but also the antennas alignment of the vector radar.

The third group of papers focuses on the development of robotic systems for demining. It includes six papers (Four are full papers and two are short papers). The first paper titled: "Sustainable Robots for Humanitarian Demining", by Pedro F. Santana et al. The paper proposes a roadmap for the application of advanced technology, in particular robotics, for the humanitarian demining domain. The second paper titled: "Integrated robotic systems for Humanitarian Demining" by E. Colon et al. The paper introduces Hudem project and summarizes the main results of 10 years of research and development in Humanitarian Demining. The third paper titled: "Development of Mine Detection Robot System", by Hajime Aoyama et al. The paper describes the development of a robot vehicle with four crawlers and integrated with two robotic arms and sensor for mine detection. The fourth paper titled: "Controlled Metal Detector Mounted on Mine Detection Robot", by Seiji Masunaga et al. The paper describes the development of a Controlled Metal Detector (CMD) for controlling the gap and attitude of the sensor head with respect to ground surface during scanning. The fifth is a short paper titled: "Research on Semi-automatic Bomb Fetching for an EOD Robot", by ZENG Jian-Jun et al. The paper presents techniques to improve the operation performance of bomb fetching function of EOD robot. The sixth and last short paper titled: "Power tillers for demining: blast test", by Emanuela Elisa et al. The paper presents a demining machine composed by a tractor unit, a ground processing tool and a vegetation cutting tool with results obtained from the first blast test.

Finally, I would like to appreciate and thank Editors in Chief for their effort in making this Special Issue possible. In addition, I would like to thank all reviewers for their time, efforts and valuable and constructive comments. Finally, special thanks to all contributors of this Special Issue on Robotics and Sensing for Humanitarian Demining.

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