Editorial: Special Issue on Field and Service Robotics

We are delighted to present this Special Issue containing a selection of ten extended papers originally presented at the Tenth Conference on Field and Service Robotics (FSR'15). FSR is a biennial, single-track meeting that emphasizes the quality of the contributions and fosters an atmosphere of discussion and interaction among participants. In 2015, the conference was held in Canada for the first time, at the University of Toronto from June 24–26. Previous FSR conferences have been hosted successfully all around the world, in countries carrying out leading-edge robotics research, including Australia, Finland, France, Japan, and the United States. The conference will move to Switzerland in 2017.

The goal of FSR is to report on and encourage the development of field and service robotics. These robots are typically mobile, unlike their factory counterparts, and must operate reliably in dynamic and complex environments. Application areas for field robots include agriculture, mining, construction, forestry, cargo handling, and a myriad of other domains. Field robots may operate on the ground (either terrestrially or on other planetary bodies), underground, underwater, in the air, or in space. Service robots work closely with humans, including the elderly and the sick, to assist them with their daily lives and activities.

The papers that appear in this Special Issue were invited based on conference review scores, quality of presentation, and discussion amongst the technical program committee members. Authors of nominated papers were asked to submit extended articles, which then underwent the regular JFR review process. The selected papers underscore the diversity, complexity, and growing maturity of field robotics. Articles were grouped into three different categories based on the targeted operating environment of the system described in each submission: air and space, ground, and water.

1. AIR AND SPACE

The first article, "Design, Control, and Experimentation of Internally-Actuated Rovers for the Exploration of Low-gravity Planetary Bodies," by Hockman et al., describes a unique hardware system for rover navigation and exploration of small extraterrestrial bodies, where very low gravity brings interesting challenges. The authors propose a novel hopping mechanism based on flywheels that enables coverage of asteroids, comets, and small moons. The actuation mechanism is validated using a microgravity test bed built on a powered gantry crane.

The second article, "Robust Autonomous Flight in Constrained and Visually Degraded Shipboard Environments," by Fang et al., addresses the problem of autonomous micro air vehicle navigation for inspection and damage assessment in confined and cluttered shipboard spaces. In such environments and under degraded conditions, including fire and smoke, existing 2D lidar and visual navigation methods fail. To enable reliable flight in these situations, a robust two-layer sensor fusion algorithm is developed; the fusion algorithm is then coupled to a receding horizon controller that incorporates trajectory optimization for fast obstacle avoidance. Experimental evaluation is carried out in the laboratory and through field demonstrations at a shipboard site where navigation hazards are present.

2. GROUND

The third article, "Background Appearance Modeling with Applications to Visual Object Detection in an Open-Pit Mine," by Bewley and Upcroft, couples deep convolutional networks with cluster-based analysis in order to better detect personnel and vehicles that may interfere with autonomous agents. The camera-only solution is benchmarked using images collected in a real open-pit mine under varying lighting conditions.

Also relying on a single camera, Clement et al. propose a navigation solution for ground vehicles in "Robust Monocular Visual Teach and Repeat Aided by Local Ground Planarity and Color-constant Imagery". Their system leverages approximate knowledge of camera geometry to enable monocular teach and repeat with an accuracy comparable to stereo implementations; validation testing is performed through a series of large scale experiments in varied environments and under different lighting conditions.

The fifth article, "Expanding the Limits of Vision-based Localization for Long-term Route-following Autonomy," by Paton et al., demonstrates that the use of multiple channels of visual information, including multiple stereo cameras and images that are resistant to lighting variations, can enable highly robust route following under extreme appearance changes. They present results from an extended field deployment spanning 26 km of driving with an autonomy rate greater than 99.9%.

Moving from perception to control, the sixth article by Dobson et al., "Admittance Control for Robotic Loading: Design and Experiments with a 1-Tonne Loader and a 14-Tonne Load-Haul-Dump Machine," describes an admittance-based autonomous loading control framework for robotic excavation. The work is motivated by the desire to automate the repetitive load-haul-dump (LHD) cycle in mining, which is potentially dangerous for human operators. Results from experimental trials with a surface

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robotic loader and a large underground LHD vehicle show that the proposed controller increases payload yield by between 18% and 39% compared to manual loading, as well as reducing loading time.

3. WATER

Water body monitoring and in situ assessment plays a key role in the following papers. In the work of Dunbabin and Grinham, entitled "Quantifying Spatiotemporal Greenhouse Gas Emissions Using Autonomous Surface Vehicles," a fleet of robots is used to monitor methane production in water reservoirs. A comprehensive review of current autonomous surface vehicles is presented, along with a novel methane flux measurement system. The eighth paper, "Robotic Coral Reef Health Assessment Using Automated Image Analysis," by Manderson et al., provides details on an image-based classifier to identify healthy regions of a Caribbean coral reef. The classifier solution is compared against a recently-released, publicly available data set, where manual classification from an expert marine biologist is available.

Longer-term monitoring of surface and subsea phenomena presents its own set of unique challenges, including significant environmental change over time and the general difficulties of extended robot operation. In the ninth article, "Survey Registration for Long-Term Natural Environment Monitoring," by Griffith and Pradalier, a visual registration framework is developed to assist with recurrent inspection tasks such as lakeshore surveying. The framework operates in a coarse-to-fine manner, providing pixel-level registration of images acquired across seasons and enabling rapid change detection. Results from experiments involving an autonomous surface vessel traversing a 1 km lakeshore perimeter over 14 months are provided,where the registration framework enables detection of several important changes that would otherwise not have been identified.

Finally, the tenth paper, "A Parameterized Geometric Magnetic Field Calibration Method for Vehicles with Moving Masses with Applications to Underwater Gliders," by Claus and Bachmayer, develops a method for calibration of magnetometers that incorporates knowledge about the presence of nearby moving ferrous masses. The work is targeted at underwater gliders, which typically rely on dead reckoning and magnetometer readings for navigation while submerged; accurate magnetometer calibration is critical, as measurements of the Earth's magnetic field provide the only source of absolute heading information while below the surface. The parameterized calibration method is evaluated using data from field trials with an underwater glider operating off the coast of Canada in 2013 and 2014.

Together, these ten articles provide a broad survey of field and service robotics research, highlighting successful implementations that solve real-world problems. Importantly, the results in each paper have been derived through extensive field testing, which is a difficult and time-consuming, but necessary, process to assess the value of these solutions.

We hope that you find these articles pertinent to your own research work and that they motivate you to participate in future FSR conferences. Finally, we would like to thank the program committee, all the authors, and the reviewers for their fine efforts and contributions.

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