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EDITORIAL

Special issue on recent advances in field and service robotics: handling harsh environments and cooperation

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Abstract
This Special Issue of the *Robotica* is on recent advances in field and service robotics with a focus on the use of robotic and autonomous technologies to handle tasks in harsh environments and tasks that involve the multirobot cooperation and human–robot interactions.

1. Introduction

Field robots are mobile robots, deployed to work in dynamic, unstructured environments under changing and complex conditions. The working environment for field robots is often dirty, distant, harsh, and even hostile for humans. On the other hand, service robots can assist human beings for tasks that are repetitive, difficult, or sometimes dangerous. While field robots have proven their key role in autonomous operations in areas such as agriculture, ranching, construction, and mining, service robots are emerging to address industrial needs in manufacturing, human demands from domestic tasks to entertainment, elderly, and handicap assistance, as well as home security and surveillance.

With growing requirements for performance and autonomy level in various applications, advanced technologies are required for these robots to deal with harsh and difficult conditions as well as changes in the workspace. In this regard, there has been increasing interest in research and development for robotic and autonomous systems to enable their operation volatile environments and to enhance the teaming capability of their cooperation. These technologies and systems cover such areas as perception, localization, locomotion and navigation, communication and cooperative control and interactions.

Recent advances in system architecture, design, vision, and data technologies such as artificial intelligence, the Internet of Things, communications, and signal processing have fostered the development of more advanced and intelligent robotic systems. This Special Issue in the "Robotica" aims at putting together some novel contributions on field and service robotics where the emphasis is placed on robotic autonomous systems (RAS) operating in harsh conditions or volatile environments as well as on the teaming capacity of RAS.

Given a limited time for the preparation of this Special Issue, only eight contributions are selected here, reflecting some aspects of the current focus. The remainder of this Editorial provides a summary of each article presented in the issue, followed by a conclusion.

2. Special Issue Summary

Construction and mining are the industrial sectors that have been using many advanced technologies in field robotics, particularly for earthmoving processes. Autonomous systems have been increasingly applied to such equipment as haul trucks, excavators, bulldozers, loaders, telehandlers, graders, and compactors that present robotic platforms operating in various modes of autonomy. The literature survey by Nguyen & Ha provides a comprehensive review of significant contributions and recent advances using robotics and automation technologies, with an emphasis on operations in volatile environments and on the collaboration of those platforms [1].

For onsite execution of robotic tasks, ground-based platforms are often required to navigate in offroad, unstructured environment subject to terrain constraints and dynamic obstacles, such as in emergency robotics, search and rescue, agriculture, forestry, or in military operations. For unmanned ground vehicles autonomous operating in these conditions, a 3D navigation system is proposed by Zhou, Yi *et al.*, using an octree-based terrain constraint analysis module with an octomap library for path planning and trajectory generation to enable mapless navigation with negative obstacles [2].

For the sake of enhancing work capacity and task efficiency in industry, research attention has been paid to the interactions, either among machines or between machines and humans. Addressing this problem for robotic collaboration with manipulators, Kanik, Ayit *et al.* propose an admittance control scheme for human–robot interface via a shoulder haptic device [3]. The dynamics ratio of the end-effector's velocity and the interaction force change is controlled to follow a desired admittance function while avoiding the obstacles and driving the trajectory tracking error to zero with a PI controller. The results are promising in the context of achieving high performance and safe collaboration between a human operator and robots.

In dealing with interactions between the robot's end-effector or platform's tool and the environment, the fourth paper of this special issue by Muñoz, López *et al.* presents a new approach to geometrically constrained path planning for robotic grasping using fast marching square (FM^2) and differential evolution (DE) techniques [4]. For this, geometrical constraints imposed by the robot arm and hand are coded in some cost functions correspondingly for the optimization purpose. The FM^2-based path planning DE-based evolutionary algorithms are then applied to obtain an optimal path for a certain grasping task.

Addressing also the robotic grasping problem, Lu, Cai *et al.* propose a target-oriented push-grasping system to sort and pick out impurities in a dense environment using the synergy between pushing and grasping strategies [5]. An attention module is first developed using a vision-based algorithm for target saliency detection and density-based occluded-region inference. The identified targets are then picked out by a push–grasp synergy framework incorporating a convolutional network to enable the robot's ability to learn pushing actions and isolate the target for grasping.

To improve the grasping capacity of robots, a new self-adaptive underactuated robot hand with rigid-flexible coupling fingers is designed, as reported in Su, Wang *et al.* [6]. The robotic hand, driven by four servomotors, consists of three fingers with seven degrees of freedom. As per the design, it can perform flexion and extension motion to present a four-bar linkage. A belt is fitted in the inner direction of the finger to make it flexible while maintaining a rigid structure in the outer direction. This rigid-flexible finger is aimed at grasping objects of different shapes, sizes, and hardness.

To manage such tasks as delivering components in an uneven environment, some service robots are required to possess the capability of walking as humans or animals besides scooting along on wheels. Motivated by advances in wall-climbing robots, Bisht, Pathak, and Panigrahi present the work on modelling, simulation, and experimental validation of wheel and arm locomotion for wall-to-wall transition, obstacle avoidance, and uneven surface navigation [7]. The robot consists of two mobile modules connected with an inchworm-inspired robot arm mechanism. Particle swarm optimization and PID control algorithms are used to effectively control the process of switching between arm and wheel configurations to accommodate the wall-climbing navigation of the robot.

The last paper of the issue is by Le, Vu, and Vo, devoted to the development of an access control system using 3D face recognition. Unlike 2D face recognition, the 3D recognition algorithm can identify features with improved robustness against variations in pose and illumination conditions as well as facial expressions [8]. Covering preprocessing, feature extraction, and classification stages, the proposed algorithm combines the principal component analysis and linear discriminant analysis for feature extraction and *k*-nearest neighbour for classification. The resulting access control system may find many applications in enhancing security in a variety of work environments.

3. Conclusion

In conclusion, it is expected that the trends on dealing with environmental volatility and robot cooperation in field and service robotics will be further explored in the robotics research community. In this regard, we hope that the readers will find this Special Issue inspiring.

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