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EDITORIAL

Focused section on robotics and autonomy for sustainability

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Recent advances in aerial, maritime and ground robotic systems suggest that robots can be used to render a sustainable future for human society. Potentials of such robotic systems are highlighted by green and innovative design, development and deployment in industrial and field applications such as environmental protection, clean energy, transportation, agriculture, aquaculture, and supply chains. Key features in localization, navigation, perception, planning, and control enable the long-term autonomy of robots in sustainable operations. This perceivable trend calls for attention from academic and industrial researchers to develop innovative concepts and unconventional systems. The primary objectives of this focused section are dedicated to solicit the state-of-the-art and novel results addressing robotics for sustainable operations and/or sustainability applications in all domains in the air, in the water, on the ground, or in manmade infrastructures. We have assembled a collection of papers that contain theoretical and/or experimental results of robotic systems that are applied to underwater operation, radioactive environment, agriculture fields and construction sites.

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The first three papers in this focused section reports recent progresses of intelligent robotic systems research within the context of underwater environment. Most underwater operations are very challenging for humans. Robotic technology has long been considered a key enabler in this important application area. In offshore energy industry, operating a handwheel normally requires tremendous force with accurate motion. It would be a big challenge for mobile robots, especially those deployed on offshore oil platforms. The paper (Zuo et al. 2023a) addresses this challenge by designing tools for a mobile robot to manipulate handwheels on two of the most common types of equipment in offshore oil platforms; a watertight door and a gate valve. The operating methodology and the tool design are examined in experiments using real industry equipment and commercially-available lightweight robotic arm. The toolset also collects data and use deep learning technology to monitor the sealing of a valve. Overall, this study demonstrates the feasibility of using the tool to operate handwheels to expand the robot's operating range and functionality, as well as to provide a low-cost high-accuracy approach for robot-enabled inspections for oil and gas industry.

Water current is an important factor in the operation of marine robotic vehicles (MRVs). When cruising in a confined area, the perception of the flow field of this area greatly helps MRVs in path planning and improves energy efficiency. Traditional current observations rely on information obtained through buoys and satellites which may be costly. Motion tomography is a method that uses vehicle navigation information to estimate current-induced flow and generate a flow field map. This method provides a time-efficient and convenient way to monitor water currents. The paper (Zuo et al. 2023b) realizes motion tomography method on bio-inspired robotic fish, which is an ideal agent for shallow water environmental sensing tasks due to its high maneuverability in grassy environments, low noise propulsion, and multi-functional capabilities. To improve the estimation accuracy, an active heading control (AHC) is realized to moderate the passive heading change caused by the flow field. With the position and direction data collected from multiple segments of the vehicle trajectories, a vectorized flow map could accurately estimate the flow field.

Underwater optical images are becoming more important for marine exploration. The weak lighting causes challenges including noise, low brightness, strong blue−green background color, and blurred images. These characteristics causes inconvenience to marine exploration tasks. Most of the existing underwater image enhancement methods mainly solve the problem of the overall denoising and brightness enhancement of the underwater image while ignoring the partial denoising of the image. To solve these problems. The paper (Li et al. 2023) proposes an improved generation adversarial network (GAN) to achieve clearer processing of underwater images. Extensive experimental results show that the proposed model is superior to the comparison method in both quantitative and qualitative experiments.

Similar to the underwater environment, nuclear power plants and radiation environment are restricted for access by human operators. In order to protect human from nuclear radiation, nuclear emergency robots are widely used in radiation environment. These robots need to consider the radiation quantity (or dose rate) and navigate complex landscape. The paper (Huang et al. 2022) provides an autonomous navigation method for nuclear emergency robots. A multi-layer costmap, which includes the costmap of radiation and the costmap of traversability, is proposed as the input to the path planner. Then, an A* algorithm with heuristic function of distance, radiation and slope is employed to search the global path. Finally, a multi-sensor data fusion algorithm is implemented for the real-time localization and motion control of the robot. Both simulation and real-world experiments demonstrate that the proposed autonomous navigation method can plan a reasonable path and control the robot to reach the target safely in a complex radiation environment.

The agriculture industry is increasingly in need of robotic technology to reduce the labor intensity and to cape with the lack of human workers. Robots can be used to patrol and monitor the healthiness of crops. Unidentified crop diseases can cause significant losses in the agriculture sector, thus they must be recognized and detected in a timely fashion. Due to the appearance differences and crowded backdrop among crop illnesses, automatic crop disease detection in the wild is a challenge for intelligent agriculture. The paper (Farooqui et al. 2022) implements a novel deep learning model for crop disease classification. During the data collection phase, a benchmark dataset is used, which is pre-processed by median filtering, and contrast enhancement techniques. Once the image is pre-processed, the abnormality segmentation from the leaves of crops is performed by a method named Optimized Fuzzy C-Means Clustering (FCM), which is further improved by a hybrid meta-heuristic algorithm. From the segmented images, the texture, geometry, color features, as well as features from the deep neural networks are combined. Then a modified Long short-term memory (LSTM) network is used to classify the types of diseases from different plants. When compared to traditional approaches, the suggested methodology obtains improved classification accuracy.

While robotics has caused leaps in productivity and safety enhancements in several industries, its adoption in construction has been slow due to its perceived complexity and the high cost of implementation. Recently, however, there has been a high level of research and development work in this domain. This focused section selected two review papers on this trending topic.

The paper (Attalla et al. 2023) presents a review of recent publications about new advances in construction robotics. The survey revealed that several technologies (e.g., additive manufacturing; automated installation systems) are being implemented in structural works, interior finishing, exterior finishing, site preparation, lifting, repairs, and drilling. The paper identifies the key efforts that used intelligent tools to allow robots to increase productivity, quality, and safety on construction sites. The paper examines the benefits, the effort it takes, and how intelligence was implemented in various research efforts, as well as identifies common and future. The paper (Tehrani et al. 2022) proposes a mapping system that connects the identified robotic systems to offsite assembly and onsite installation tasks of industrialized construction. The study results revealed that robotics in industrialized construction is considerably under-researched, leaving significant room for improvement. Indeed, only six out of the twenty-five identified industrialized construction tasks, namely panel framing, boxing station, drywall installation, inspection, excavation/site rough grading, and surveying, have been sufficiently explored in the literature. Both review papers provide a value source of information to educate and inform construction practitioners about the potential integration of existing robotic systems into industrialized construction.

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