drones

Editorial

Special Issue on Intelligent Image Processing and Sensing for Drones

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1. Introduction

Recently, the use of drones or unmanned aerial vehicles (UAVs) for various purposes has been increasing [1]. Drones can be remotely controlled or programmed to capture scenes from a distance. This capture method is cost-effective and does not require highly trained personnel. Drones are widely used in various applications such as industrial and infrastructure inspections [2,3], agricultural and environmental monitoring [4,5], geographical surveying [6], search and rescue missions [7], security and surveillance [8], and so on.

Multiple sensors can be mounted on a drone. In addition to visible cameras, infrared thermal imaging and multispectral imaging equipment can be mounted on a drone [9,10]. LiDAR and SAR are active sensors that can be used in drones [11–13]. These mobile aerial imaging sensors provide a new perspective on research and development for a variety of applications. However, more challenges are often posed than fixed and ground sensors because of the unique sensing environments and limited resources of drones. Certainly, information acquired by a drone is of tremendous value; thus, intelligent analysis of the data is necessary to make the best use of them.

This Special Issue focuses on a wide range of intelligent processing of images and sensor data acquired by drones. The objectives of intelligent processing range from the refinement of raw data to the extraction and processing of featured attributes and the symbolic representation or visualization of the real world. This can be achieved through image/signal processing or deep/machine learning algorithms. The latest technological developments will be shared through this Special Issue. Researchers and investigators are invited to contribute original research or review articles to this Special Issue.

Eight research papers and two review papers were verified through a thorough review process. Many valuable and recent technologies have been provided in the selected papers to solve real problems. The first volume of this Special Issue on the topic is closed; more in-depth research on the same topic is expected in the second volume of this Special Issue. It is anticipated that the scope of intelligent processing will be even broader in the future.

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2. Overview of Published Articles

This Special Issue was introduced to collect the latest research on relevant topics, and more importantly, to address the current practical and theoretical challenges. In the following, papers are categorized into several subtopics: industrial applications, positioning and tracking, visualization of the real world, and advances in computer vision.

2.1. Industrial Applications

In the first contribution entitled 'Method for Complex Road Cracks Collected by UAV Based on HC-Unet++', Cao, H.; Gao, Y.; Cai, W.; Xu, Z.; and Li, L. proposed a new deep learning network model called HC-Unet++ for the detection and segmentation of road cracks. Their method is based on convolutional neural networks, and they show that UAV aerial photography plays an important role in road maintenance and traffic safety. The new network model can eliminate complex backgrounds, effectively detect cracks of various irregular shapes, and reduce crack discontinuity.

Detection of power lines and transmission towers is critical for the safety of power grid operations. The second contribution entitled 'Transmission Line Segmentation Solutions for UAV Aerial Photography Based on Improved UNet' by He, M.; Qin, L.; Deng, X.; Zhou, S.; Liu, H.; and Liu, K. enhances the UNet algorithm, which is a deep learning segmentation model. The authors improved the UNet algorithm by extracting features using a lightweight backbone structure and then reconstructing them into contextual information features.

Ali, M.A.H.; Baggash, M.; Rustamov, J.; Abdulghafor, R.; Abdo, N.A.-D.N.; Abdo, M.H.G.; Mohammed, T.S.; Hasan, A.A.; Abdo, A.N.; Turaev, S.; et al., in the third contribution entitled by 'An Automatic Visual Inspection of Oil Tanks Exterior Surface Using Unmanned Aerial Vehicle with Image Processing and Cascading Fuzzy Logic Algorithms', proposed a method for visual inspection of external surface defects on oil tanks. Two cascade fuzzy logic algorithms were developed to detect defects and remove noise.

The fourth contribution is a review paper entitled 'An Overview of Drone Applications in the Construction Industry'. Choi, H.-W.; Kim, H.-J.; Kim, S.-K.; and Na, W.S. presented a comprehensive overview of the applications of drones in the construction industry. The introduction of drones into the construction industry has brought about revolutionary advancements in all phases of construction projects. For example, drones equipped with high-resolution cameras in the design phases have revolutionized field surveys and aerial mapping. During the construction phase, drones play an important role in monitoring and inspecting the construction progress and ensuring safety. Drones can also efficiently detect and identify damage, enabling proactive maintenance, cost reductions, and extended asset lives.

2.2. Positioning, Detection, and Tracking

UAV landing technology is a critical tool that allows drones to land without human intervention, improving safety, efficiency, and operability in remote or challenging environments. However, high-precision autonomous landing is still a major challenge. Xu, Y.; Zhong, D.; Zhou, J.; Jiang, Z.; Zhai, Y.; and Ying, Z described, in the fifth contribution entitled 'A Novel UAV Visual Positioning Algorithm Based on A-YOLOX', a UAV positioning algorithm called attention-based YOLOX, which improves the accuracy of automatic landings for UAVs.

While the use of drones offers significant benefits for a variety of applications, it also presents a number of hazards. These hazards range from concerns about privacy and security to risks of physical injury and environmental impacts. In the sixth contribution entitled 'Non-Linear Signal Processing Methods for UAV Detections from a Multi-Function X-Band Radar', Kumar, M. and Kelly, P.K. developed a nonlinear processing technique for UAV detection using a portable radar system.

Drones have become an invaluable tool in search and rescue (SAR) missions. In the seventh contribution entitled 'Thermal Image Tracking for Search and Rescue Missions with a Drone', Yeom, S. developed an effective thermal image tracking method. His method shows promising results for handling challenging environments such as complex backgrounds, heavy occlusions, and complex maneuvering of drones.

2.3. Visualization of the Real World

Amala Arokia Nathan, R.J.; Kurmi, I.; and Bimber, O., in the eighth contribution entitled 'Inverse Airborne Optical Sectioning', presented inverse airborne optical sectioning, an optical analogy to inverse synthetic aperture radar. Moving targets, such as walking people, that are heavily occluded by vegetation can be made visible and tracked using cameras on drones hovering over forests. They introduced the principles of inverse synthetic aperture imaging and suppressed the signal of occluders by filtering the Radon transform of the image integral.

The development of UAVs has significantly increased the type and number of datasets available for image synthesis. An improved image synthesis model, SYGAN, was proposed in the ninth contribution entitled 'Improved Image Synthesis with Attention Mechanism for Virtual Scenes via UAV Imagery' by Mo, L.; Zhu, Y.; Wang, G.; Yi, X.; Wu, X.; and Wu, P. A spatial adaptive normalization module and a sparse attention mechanism were introduced on the basis of a generative adversarial network (GAN) for image synthesis.

2.4. Potentials of Drones in Computer Vision

Vision transformers can be used for various computer vision applications, including image classification, object detection, image segmentation, image compression, image super-resolution, image denoising, anomaly detection, and drone imagery. In the tenth contribution entitled 'A Comprehensive Survey of Transformers for Computer Vision', Jamil, S.; Jalil Piran, M.; and Kwon, O.-J. reviewed the state of the art and compiled a list of available models and discussed the pros and cons of each vision transformer model.

3. Conclusions

This Special Issue covers various applications of images and signals acquired by drones. It also shows a wide range of potential as well as the versatility of drones in the near future, encompassing a richness of research fields. This is reflected in the wide range of methodologies adopted in the studies, including deep learning, traditional machine learning, signal and image processing, and estimation theory. From a methodological perspective, deep learning appears in five of the eight research papers (Contributions 1, 2, 5, 7, 9). Among them, a deep learning method was combined with estimation theory in Contribution 7. Two papers (Contributions 6 and 8) take advantage of methods using the signal processing regime, and one paper (Contribution 3) combines image processing with machine learning algorithms. It is anticipated that research in the field of deep learning will increase further, while different approaches can potentially be combined with one another in this era of rapid change and development.

As a final note, I would like to thank all the authors contributing to this Special Issue. I also appreciate the dedicated reviewers and editors for their efforts and expertise. I sincerely hope that readers will find great inspiration from current and future technologies related to drones in this Special Issue.

Conflicts of Interest: The authors declare no conflict of interest.

List of Contributions

1. Cao, H.; Gao, Y.; Cai, W.; Xu, Z.; Li, L. Segmentation Detection Method for Complex Road Cracks Collected by UAV Based on HC-Unet++. *Drones* **2023**, *7*, 189. https://doi.org/10.3390/drones7030189.
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