Foreword to the Special Issue on Unmanned Airborne Vehicle (UAV) Sensing Systems for Earth Observations

THIS SPECIAL Issue of the IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING is dedicated to Unmanned Airborne Vehicle (UAV) Sensing Systems for Earth Observations. UAVs have received early, rapid, and widespread adoption for military purposes. As these military systems grow in maturity, a number of types of UAV systems with various onboard sensors have been developed for civilian applications such as homeland security, forestry fire monitoring, quick response measurements for emergency disaster, Earth science research, volcanic gas sampling, humanitarian observations, biological/chemosensing/demining tasks, and monitoring of gas pipelines. Recent developments in the vehicles themselves and associated sensing systems make these platforms increasingly attractive to the geoscience community. UAV platforms and imaging and sensing systems that are adaptable to these platforms facilitate unique capabilities in Earth observation for both research and operational monitoring purposes. This special issue focuses on developments and advances in UAVs and associated sensors and sensing systems for Earth observation. It provides a forum for high-quality peer-reviewed papers that broaden awareness and understanding of UAV developments, applications of UAVs in Earth observation, and associated developments in sensor technology, data processing and communications, and UAV system design and sensing capabilities. The target audience includes those members of the remote and *in situ* sensing Earth science communities with interests in applying UAV technologies to Earth observation.

In this Special Issue, seven high-quality papers have been accepted for publication. Five papers describe UAV sensors and sensor systems. Wang *et al.* suggest a technique of waveform diversity-based millimeter-wave UAV SAR imaging system design. The corresponding imaging algorithm is validated using computer simulations. A parallel direct digital synthesizer driven phase-locked loop synthesizer with adaptive nonlinearity compensation has been validated. Nagai *et al.* propose a UAV-based laser scanner in combination with charge-coupled device (CCD) cameras, inertial measurement unit (IMU), and GPS for 3-D mapping. The method of direct georeferencing by the combination of bundle block adjustment and Kalman filtering is developed and validated. Gurtner *et al.* investigated the application of fisheye lenses for small UAV remote-sensing missions. Their detailed study covers fisheye lens distortion in relation to image registration. Berni *et al.* demonstrate the ability to generate quantitative remote-sensing products by means of a helicopter-based UAV equipped with inexpensive thermal and narrowband multispectral imaging sensors. Zhou designed and developed a low-cost moderately functional small airborne platform with onboard color CCD camera, GPS, and IMU for video flow data collection. In UAV-based data aspect processing, Mukherjee *et al.* developed algorithms to extract multiscale points of interest from UAV hyperspectral imagery in which structural information is distributed across several spectral bands. A spectral distance measure is used to estimate spatial relations between neighboring hyperspectral pixels. Laliberte *et al.* determined the most suitable texture measures and the optimal image analysis scale for UAV imagery. A decision tree was used to determine the optimal texture features for each segmentation scale. The inclusion of texture measures increased classification accuracies at nearly all segmentation scales, and entropy was the texture measure with the highest score in most decision trees. Zhou presents near real-time UAV image flow data processing for georeferencing. A mathematical model for directly geolocation of video data is developed for simultaneously solving the video camera's interior orientation parameters (including lens distortion) and the exterior orientation parameters of each video frame. The accuracy of orthorectified video flow can reach 1–2 pixels. Gurtner *et al.* developed a camera calibration for fisheye lenses onboard a small UAV system. From the standpoint of applications, Berni *et al.* applied UAV-based high-resolution (40 cm) multispectral imagery (400–800 nm) for estimating biophysical parameters using vegetation indices Normalized Difference Vegetation Index, Transformed Chlorophyll Absorption in Reflectance Index/Optimized Soil-Adjusted Vegetation Index, etc. These data are used for agricultural monitoring. Laliberte used a low-cost UAV system for vegetation rangeland monitoring, while Zhou demonstrated a low-cost small UAV system for wildfire monitoring. In summary, this IEEE TGRS special issue collects seven papers, grouped into five categories: UAV platforms and platform systems, UAV sensors and sensor systems, UAV data processing, UAV telemetry, and UAV applications.

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