Editorial
Special Issue on Innovative Approaches for Mearsurements in Small Aerospace Platforms - 2020 MetroAeroSpace Workshop

THIS Special Issue reports some papers in the extended version originally presented at 2020 IEEE International Workshop on Metrology for Aerospace (www.metroaerospace.org)—MetroAeroSpace. The papers are related to the measurement methods and instruments for aerospace applications. This field of measurement science and technology is exciting for its rapid development and the opportunities given for broken the borders of the knowledge, in particular, for space exploration.

Since the first edition, the MetroAeroSpace represents an international meeting place in the world of research in the field of metrology for aerospace involving national and international institutions and academia in a discussion on the state-of-the-art concerning issues that require a joint approach by experts of measurement instrumentation and industrial testing, typically professional engineers, and experts in innovation metrology, typically academics.

The increasing number of scientists attending the 2020 edition of MetroAeroSpace and coming from fields that can be very far from engineering, led to a positive hybridization of the conference that now presents the state of the art of the research in measurement for aerospace. The community joining the MetroAeroSpace year after year, in fact, has in common the interest in measurements and instrumentation, although from different points of view. Attention was paid, but not limited to, new technology for metrology-assisted production in the aerospace industry, aircraft component measurement, sensors and associated signal conditioning for aerospace, and calibration methods for electronic test and measurement for aerospace.

The papers deal with J-MASS topics covering the rapidly evolving field of small air and space systems, such as small satellites and drones.

The first group of papers includes the efforts carried out at world level for the development of new methods and technics for satellites.

The problems of autonomous digital control of a spacecraft orientation and checking the operability of its attitude control system in the initial orientation modes are investigated in "Health Checking Autonomous Attitude Control System of Earth-Observing Miniature Satellite in Initial Orientation Modes," by Somov *et al.* The developed methods, algorithms, and simulation results for a miniature Earth-surveying satellite in a Sun-synchronous orbit are presented. Autonomous angular guidance and modularly limited vector digital control using a vector of the modified Rodriguez parameters are applied to bring the spacecraft's orientation from completely arbitrary to the required one. The health check of the mini-satellite's attitude control system, as well as the proposed discrete algorithms for onboard diagnostics of faults based on computer processing of available measurements and explicit relations are discussed.

"Small Satellite Orbit Determination Methods Based on the Doppler Measurements by Belarusian State University Ground Station," by Spiridonov *et al.* reports the Doppler measurements of the small satellites carried out using Belarusian State University ground station. Measurements of a telemetry signal for the several satellite orbits with a limited number of data on one pass were performed. Two methods for orbit determination of a small satellite are considered. The first method is based on the perturbed circular motion prediction model for the satellite orbit with experimental data from radio signal processing. It does not require additional information from the NORAD database of satellite orbital parameters. Using predicted data of the tracking angles of antenna systems and the Doppler frequency shift of the telemetry radio signal, the ground station of the Belarusian State University received and successfully decoded telemetry packets from an unknown small satellite LUOJIA-1 01. The second method is based on the SGP4 model and requires additional information from the NORAD TLE catalog of the satellite orbital parameters. An unknown small satellite LUOJIA-1 01 was identified using the NORAD TLE catalog based on a probabilistic estimation of the elevation angle and the Doppler frequency shift of receiving telemetry signals.

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Payloads left in space at the end of life create debris. A high number of space debris surround our planet and within a few years, experts argue, it will no longer be possible to send payloads safely into space. "Tethered Satellite-Controlled Re-Entry Dynamics From the International Space Station," by Brunello *et al.* strives to demonstrate the ability to bring a payload back to Earth without the use of active propulsion system in close proximity of the ISS. The use of a classical chemical propulsion system near sensitive and inhabited space areas is risky and causes contamination due to the fuel ejection. Consequently, the design of a passive but controlled vehicle, that satisfies safety and free-pollution requirements, needs a new propulsive technology. A possible solution is using a Tether Subsystem, mounted onboard a re-entry capsule, employed to execute the first phase of the release/deployment maneuver. The tether deployment trajectory must be controlled in order to provide a large libration angle of about 40° and a radial velocity near zero at the end of tether deployment. The control algorithm adopted is based on reliable and easy to measure dynamics parameters: the deployed length and length rate are the inputs of the control loop that forces the tethered capsule to follow a predetermine reference trajectory during deployment. Relevant details of the IR sensors (i.e., photocells) that are planned for measuring the input parameters are also presented. The aim of the study is to propose a safe and pollution-free solution for separating small satellites from the ISS, preventing hazards, and minimizing external contamination.

The second group of papers deals with the challenges in the design of new testing methods and equipment for aeronautic applications.

The recent developments in rechargeable energy storage system, and particularly in lithium-ion (Li-Ion) technology concerning electrochemical storage, has played a crucial role in pushing the market toward transport electrification, in particular in the field of drones. The article "Capacity Fade and Aging Effect on Lithium Battery Cells: A Real Case Vibration Test With UAV," by Caposciutti *et al.* presents an analysis of the capacity and the state of health (SoH) of 3-Ah lithium battery cells operating in a real case vibration stress scenario based on drones. An unmanned aerial vehicle (quadcopter) is adopted to acquire real vibration profiles during different phases of flight. First, the possible capacity fade and aging effect on lithium cells are investigated by considering vibrations applied to the radial and longitudinal battery axes with both short-term and long-term (aging) tests. Then, the cruise-flight vibration profiles are applied and characterized. A comparison with standard (no vibrations) cycling aging is also presented and discussed. Experimental results show that no significant effect on capacity fade can be observed between standard and real case vibrating operating conditions.

Applicability of the whispering gallery mode sensor in the form of the multiresonator imaging device for the atmospheric relevant parameters monitoring has been demonstrated in "Multiresonator Imaging Sensor for the Aerial Parameters Detection," by Saetchnikov *et al.* The sensor design and the appropriate techniques for sensing data collection have been discussed. The sensor performance has been numerically and experimentally studied on examples of the temperature variation detection and the monitoring of small spherical microparticles (<3 μm) that have been used to mimic the particulate contamination of the environment. The thermal sensitivity of the sensor on the level of 8.6 pm/°C has been experimentally demonstrated. The experimental results on the distinguishing of the microparticle concentrations (0.5% and 1%) via the wavelength sweeping technique and the results on the single-particle detection under illumination at the fixed wavelength have been shown.

Purpura, in the article "Methods for the Material Spectral Emissivity Evaluation by Dual-Color Pyrometer in a Hypersonic Plasma Test Facility," deals with the investigation of the physical properties of the materials used as thermal protection systems (TPSs). This examination is mandatory in the aerospace applications. One of the most important material properties involved in the prediction and measurement of the aerothermal loads is the material surface emissivity. In fact, to set properly optical devices operating in the infrared region of light it is necessary to know the material emissivity for the measurement of the temperature at the surface. In order to perform such analysis during the development of a test in a hypersonic plasma ground simulator, like the CIRA-PWT SCIROCCO and GHIBLI facilities, the INPP laboratory developed techniques for the investigation of the spectral emissivity by properly using dual-color pyrometers. Those techniques have been applied during tests carried out in the SCIROCCO and GHIBLI facilities on materials candidate for TPS of re-entry space vehicles.

The object tracking alongside the image segmentation has recently become of particular significance in satellite and aerial imagery. The latest achievements in this field are closely related to the application of the deep-learning algorithms and, particularly, convolutional neural networks (CNNs). Supplemented by the sufficient amount of the training data CNNs provide the advantageous performance in comparison to the classical methods based on Viola–Jones or support vector machines. However, the application of CNNs for the object detection on the aerial images faces several general issues that cause classification errors. The first one is related to the limited camera shooting angle and spatial resolution. The second one arises from the restricted dataset for specific classes of objects that rarely appear in the captured data. "Object Detection for Unmanned Aerial Vehicle Camera via Convolutional Neural Networks," by Saetchnikov *et al.* represents a comparative study on the effectiveness of different deep neural networks for detection of the objects with similar patterns on the images within a limited amount of the pretrained datasets.

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