



Editorial for Special Issue on Selected Papers from IMAV 2021

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Several factors have boosted the development of Micro Aerial Vehicles (MAVs) in recent years. On the one hand, the availability of more powerful miniature computers has permitted the implementation of more sophisticated flight controllers. On the other hand, the use of lightweight on-board cameras and depth sensors has leveraged the data processing capabilities of the MAVs by allowing them to perform closer to aerial robots rather than just passive aerial vehicles capable of following GPS-guided trajectories. There is no doubt that these advancements are contributing to the development of the next generation of MAVs.

The International Micro Air Vehicle Conference and Competition (IMAV) is an ideal forum to learn about the latest developments on MAVs. Every year, the IMAV offers a pioneered event format that has become a standard practice in other scientific conferences today; this is, the IMAV runs a scientific conference in tandem with competitions. The conference includes presentations of peer-reviewed scientific papers and technical reports in addition to keynote presentations delivered by top-notch personalities in the fields of uncrewed aerial systems, aeronautics and aerial robotics. A selection of the best papers receives an invitation to be published in journal special issues. The competitions are split into two categories: indoors and outdoors. Teams participating in these categories face challenges where MAVs have to be used to resolve a task, for instance: package delivery, endurance flight, heavy lifting, autonomous exploration and collaborative flight, among others.

Due to the pandemic, the IMAV 2020 had to be postponed to the next year. Unfortunately, in 2021, restrictions for social gatherings and traveling were still high. Seeking to abide by these restrictions while avoiding missing another year of this important event, the IMAV 2021 was run virtually from November the 17th to the 19th of 2021, virtually held in Puebla City, Mexico. For the first time ever, the IMAV 2021 was organized by Latin American institutions: the Instituto Nacional de Astrofísica Óptica y Electrónica (INAOE), the Universidad de Las Américas Puebla (UDLAP), the Benemérita Universidad Autónoma de Puebla (BUAP)

and Centro de Investigación y de Estudios Avanzados (CINVESTAV), all of these located in Puebla City.

A total of 27 peer-reviewed papers were presented at the IMAV 2021. Awards were granted to the Best Conference Paper, Best Technical/Application Paper and Best Student Paper. For each day of the conference, two keynote presentations were delivered, summing up a total of six keynote speakers from Mexico, the Netherlands, the USA, the UK and France. Also, two special panels were hosted during the conference. These panels included former IMAV General Chairs and co-Chairs from the IMAV 2014, IMAV 2016, IMAV 2017 and IMAV 2018. They shared their experience in organizing these events, together with anecdotes and lessons learned from competitions and scientific contributions made in these IMAV events. On top of this, the virtual format allowed people worldwide to join the presentations, keynotes and panels, which were publicly streamed using social network platforms.

This special issue includes a selection of scientific and innovative works that represent open challenges and avenues of research involving MAVs. Furthermore, these works are extended versions of the papers presented at the IMAV 2021 conference, except the last one, which reports the system developed to address the warehouse inspection challenge of the indoor competition at the IMAV 2019 held in Madrid, Spain. This work received the Special Award: “Best Flight Performance” of the competition and it was invited to undergo a peer-review process whose decision recommended its publication in this special issue.

The first two works in this issue are developed in the context of Autonomous Drone Racing (ADR), which has become a research topic that has attracted significant attention recently. This challenge calls for the development of an autonomous MAV that can compete and beat a human. In this spirit, the article “Efficient bang-bang model predictive control for quadcopters” by Jelle Westenberger *et al.* presents a simplified model predictive controller that can run onboard a commercial MAV while approaching time-optimal control principles. This approach is a step forward

to achieving a fast and agile flight for MAVs with limited computational resources. Arguing the need for tools to assess proposed strategies for ADR, the article “Framework and evaluation methodology for Autonomous Drone Racing” by Miguel Fernández-Cortizas *et al.* introduces a modular methodology, where each component in a solution can be evaluated, namely, control technique, learning-based gate estimation and visual methods for MAV localization, among others.

The following articles in this issue explore control techniques using nonconventional positioning systems such as GPS or motion capture systems. Such is the case in the article “Position controller for a flapping-wing drone using UWB”, by Guillermo Gonzalez *et al.*, where an ultra-wide-band (UWB) indoor positioning system is used to localize and control a micro flapping wing vehicle, particularly challenging given the small size of the vehicle and its limited battery life. Nevertheless, this work offers an interesting approach to addressing expected control problems for autonomous navigation using the UWB positioning system. The article “An immersion and invariance controller for aerial manipulation” by Aaron Lopez *et al.* also deals with control positioning without GPS in outdoor scenes for another nonconventional MAV, this time, a small quadcopter with a robotic arm attached to it and decoupled from the quadcopter’s controller. In this work, the authors present a study on the immersion and invariance control technique for nonlinear systems but applied to the aerial manipulation case, where the robotic arm behaves as an external perturbation to the system.

The last two articles deal with two hot topics in the MAV field: endurance and autonomy. Regarding the former, the article “Developing a modular tool to simulate regeneration power potential using orographic wind-hovering UAVs” by Midas Gossyea *et al.* introduces a model to identify hovering locations and their potential for battery recharge during these locations for fixed-wing vehicles. This approach joins other efforts to build MAVs with long-term flight capabilities, which are very useful in exploration, monitoring and surveillance applications with MAVs. The last article, “Warehouse inspection with an autonomous micro air vehicle”, describes a system developed to enable a MAV to perform indoor autonomous flight while seeking out a set of packages located on shelf racks. This system only uses vision-based methods to identify QR codes used to label the packages and estimate the MAV’s position using monocular SLAM. All computations are processed onboard the MAV, which is an essential feature to achieve truly autonomous behavior.

Therefore, we expect this special issue to convey exciting ideas and exemplary solutions to real problems faced when using MAVs in indoor and outdoor scenarios. We are also hopeful that each article in this issue will influence the future research that will enable MAVs to become safer, more robust and more amicable to be deployed in several civilian applications for the benefit of society.

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