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Book Review

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Cooperative Path Planning of Unmanned Aerial Vehicles

Antonios Tsourdos, Brian White, and Madhavan Shanmugavel, Wiley, New York, 2011, 214 pp., $125

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ALL three authors are well-recognized experts in the intelligent robotics community. Their view of the scope of autonomous aerial applications and the critical issues associated with UAV (unmanned aerial vehicle) platforms, sensors, and operational considerations are genuine, accounting for approximately a decade of rapid theoretical and instrumentation development. The authors' expertise is well rooted in the guidance, navigation, and control (GNC) community, which is positively reflected in the style of the material presentation; there is no "learning curve" necessary to become familiar with the terminology and the key GNC concepts.

The primary scope of the book is accurately formulated in the title; namely, it focuses on the feasible path planning for safe operation of multiple UAVs. The key advantage of the book is that it considers the multiple-UAV path-planning task that is subject to real-life constraints, given in terms of both the realistic UAVs operating in a bounded operational environment as well as limited computational, sensory, and communication capabilities of the onboard avionics. The beneficial impact of this system-engineering approach cannot be overestimated, especially considering the manpower resources required to operate the multiple UAVs. While the majority of the operational UAV platforms nowadays require large crews to operate a single UAV, the approach presented by the authors inverts the ratio, thus enabling multiple UAVs to be controlled by a single operator.

The book starts with the path planning in 2-D and considers three simple classical algorithms: Dubins path, Pythagorean hodograph, and Composite path. These three approaches are the key building blocks for the entire book. In discussing their advantages, the book logically extends the Dubins and Pythagorean algorithms to the case of three dimensions. Advantages of the presented methods are fully revealed by their ability to account for the static and dynamic obstacles. While the presented obstacle-detection approach resembles the simple geometry-based ideas, the book gives a sufficient overview of existing concepts from the point of view of modern sensory capabilities. When a feasible path is developed, the book presents two classes of path-following control algorithms capable of accounting for possible collision avoidance with another noncooperating UAV. The first is a simple linear algorithm and the second is the nonlinear dynamic inversion-based algorithm. Finally, the authors address the area of a coordinated path following of multiple UAVs and considers a simplified case of simultaneous arrival of multiple agents to the prior given final conditions. The approach constructs a set of nonintersecting paths of equal length that are to be followed by agents flying at the same constant speed.

Unfortunately, the Dubins path and the Pythagorean hodograph are the only key building blocks for the entire book. Although they might represent the underlying idea of path generation and fully support the navigation and control parts of the framework, this is an essential limitation of the book. A need for significantly wider representation of path-planning and path-generation methods is obvious, especially in the context of the book addressing the path planning for multiple intelligent agents. It is also unfortunate that the path planning for multiple UAVs considers only the case of nonintersecting paths. A coordinating capability of multiple UAVs is only mentioned in the final chapter but is not used to design the coordination control laws such that the paths might be intersecting with guaranteed collision avoidance that is achieved by varying speed profiles of the UAVs.

The book is well suited for upper-undergraduate and graduate-level students specializing in mechanical and aerospace engineering and closely related disciplines. The key concepts used by the authors are rooted in kinematics, dynamics, principles of feedback control theory, and elementary navigation. The book provides some necessary preliminaries in differential geometry. The material can be considered a shortcut to the area of path planning of multiple agents. It provides necessary knowledge for the design of verifiable and implementable real-time path-planning and path-following algorithms. Students and researchers can significantly shorten the time in preparing the algorithmic framework by implementing these algorithms onboard.

The authors' GNC expertise, industrial experience, and academia exposure make this book not only technically accurate but also very well organized from the teaching perspective. The theoretical development is

well balanced, and required background and additional recommended reading is well referenced. All the chapters provide a thorough review of the prior key developments in the specific areas of discussion. The book is well illustrated, and appropriate graphs and diagrams are used wisely in support of intuitive presentation of more complex theoretical concepts.

With the rapid development of theoretical ideas of intelligent autonomy, the material presented in the book can serve as a thorough introduction to the field of multi-agent operation. Although the reader is provided with an impressive number of most recent relevant references of the last decade, it is reasonable to assume that new developments will emerge in the nearest future. However, the book will certainly serve as a perfect survey reference for the next 3–5 years.

In conclusion, there is one more note. With the variety of models presented and discussed in the book, it would be highly desirable and beneficial for any reader to have a CD supplement accompanying the manuscript with the software implementations (for example, in MATLAB/Simulink) of the presented algorithms. Time spent on coding the algorithms presented in the book can be better used to experiment with the algorithms, thus providing more insight to the performance of the proposed solutions.

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