

# Preface

In recent years, research and development of unmanned systems have gained much attention in the academic and military communities worldwide. Topics like unmanned aircraft, underwater explorers, satellites, and intelligent robotics are widely investigated as they have potential applications in the military and civilian domains. They are developed to be capable of working autonomously without the interference of a human pilot. The challenge is that they need to deal with various situations that arise in very complicated and uncertain environments, such as unexpected obstacles, enemies attacking and device failures. Besides, they are required to communicate with technical personnel in the ground station. Consideration of a wide range of factors needs to be taken. Control systems for the unmanned vehicles are required to integrate not only basic input-output control laws but also high-level functionalities for decision making and task scheduling. Software systems for unmanned vehicles are required to perform tasks from hardware driving to the management of device operations, and from traditional input-output control law implementation to task scheduling and event management.

In this monograph, the authors aim to explore the research and development of fully functional miniature unmanned-aerial-vehicle (UAV) rotorcraft, which consist of a small-scale basic rotorcraft with all necessary accessories onboard and a ground station. The unmanned system is an integration of advanced technologies developed in the communications, computing, and control areas. It is an excellent test bed for testing and implementing modern control techniques. It is, however, a highly challenging process. The flight dynamics of small-scale rotorcraft such as a hobby helicopter is similar to its full-scale counterpart but owns some unique characteristics such as the utilization of a stabilizer bar, higher rotor stiffness, and yaw rate feedback control. Besides these, the strict limitation on payload also increases the difficulty in upgrading a small-scale rotorcraft to a UAV with full capacities. Based on its various characteristics and limitations, a lightweight but effective onboard avionic system with corresponding onboard/ground software should be carefully designed to realize the system identification and automatic flight requirements. These issues will be addressed in detail in this monograph. Research on utilizing the vision-based system for accomplishing ground target tracking and following, cooperative control, and flight formation of multiple unmanned rotorcraft is also highlighted.

The intended audience of this monograph includes practicing engineers in rotorcraft industry and researchers in the areas related to the development of unmanned aerial systems. An appropriate background for this book would be some senior level and/or first-year graduate level courses in aerodynamic engineering, control engineering, electrical engineering, and/or mechanical engineering.

The authors of this monograph are thankful to the whole UAV Research Team at the National University of Singapore. We would like to thank Dr. Feng Lin, Dr. Biao Wang, Dr. Kemao Peng, Dr. Miaobo Dong, Dr. Ben Yun, Xiangxu Dong, Xiaolian Zheng, Fei Wang, Shiyu Zhao, Swee-King Phang, Kevin Ang, and Jinqiang Cui for their help and contributions. We are particularly thankful to Dr. Feng Lin for his contribution to the results presented in Chap. 11 and to Dr. Biao Wang for his help to the material given in Chap. 10 of this monograph. We would also like to extend our thanks and appreciations to Ms. Charlotte Cross, Editorial Assistant of Springer, for her kindly help and assistance, and to the Springer's copy editor and series editor for their careful reading of the entire manuscript and their invaluable comments.

We have had the benefit of the collaboration of several coworkers and discussions with international visitors, from whom we have learned a great deal. Among them are Dr. Kai-Yew Lum and Dr. Hai Lin of National University of Singapore, Dr. Chang Chen and Dr. Rodney Teo of the DSO National Laboratories of Singapore, Professor Da-Zhong Zheng of Tsinghua University, Professor Clarence de Silva of the University of British Columbia, Professor Frank Lewis of the University of Texas at Arlington, Professor Lihua Xie of Nanyang Technological University, Professor Delin Luo of Xiamen University, Professor Hai-Bin Duan of Beijing University of Aeronautics and Astronautics, Professor Wei Kang of the Naval Postgraduate School, USA, and Dr. Siva Banda of the Air Force Research Laboratory, USA. We are indebted to them for their valuable contributions and/or comments.

The second author would like to thank particularly the Defence Science and Technology Agency (DSTA), Singapore, for granting him the Temasek Young Investigator Award in 2003 to initiate his research on unmanned systems. We would also like to acknowledge Temasek Laboratories and the Temasek Defence Systems Institute, the National University of Singapore, for their financial support and research funding over the years. We are thankful to the Department of Electrical and Computer Engineering and Temasek Laboratories, the National University of Singapore, for providing us generous laboratory spaces for housing our unmanned aircraft and related research activities.

Last, but certainly not the least, we owe a debt of gratitude to our families for their sacrifice, understanding, and encouragement during the course of preparing this monograph. It is very natural that we dedicate this work to our families and to our whole UAV Research Team.

Singapore, Singapore

Guowei Cai  
Ben M. Chen  
Tong H. Lee

<http://www.springer.com/978-0-85729-634-4>

Unmanned Rotorcraft Systems

Cai, G.; Chen, B.M.; Lee, T.H.

2011, XIX, 270 p. 167 illus., 140 illus. in color.,

Hardcover

ISBN: 978-0-85729-634-4