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## Preface

The DelFly project that is at the heart of this book has its origins in 2005 as a design synthesis project for students. The goal of the project was to ‘design a flapping wing UAV of <50 g with on-board camera that will impress the jury of the European Micro Air Vehicle conference and competitions 2005’. After flying the 35 cm wing span and 21 g DelFly I at the EMAV 2005, winning the prize for ‘most exotic MAV’, the DelFly project was continued by the faculty of Aerospace Engineering of Delft University of Technology. It resulted in the creation of the Micro Air Vehicle Laboratory, which focuses on the design and study of all types of autonomous MAVs.

In 2006, with financial support of TNO (Netherlands Organisation for Applied Scientific Research), the DelFly II project was defined: this time the goal was to make a flapping wing MAV which would fit in a sphere with a diameter of 30 cm. The DelFly II was presented one year later in 2007. It surpassed the project’s goals: besides reducing the wing span to 28 cm, the flight envelope was considerably increased. The DelFly II is able to fly forward at 7 m/s, hover, and even fly backward at  $-1$  m/s.

DelFly II’s broad flight envelope and on-board camera have made it a desirable study object both for investigating the airflow around the flexible wings and for achieving autonomous flight capabilities. The insight into the structural and aerodynamic properties of the DelFly II first led to the successful design of the DelFly Micro, presented in June 2008. The DelFly Micro is currently still the smallest (10 cm wing span) and lightest (3.07 g) flapping wing MAV in the world that carries both a camera and a video transmitter—a fact mentioned in the Guinness Book of Records 2010. Concerning autonomous flight, we have developed algorithms to continually increase the capabilities of the DelFly. We did not only apply these techniques to a laboratory setting, but have been demonstrating these techniques also in the IMAV competitions. The DelFly II was the first IMAV entry ever to perform autonomous flight indoors, successfully flying an 8-shape figure in the indoor dynamics mission at the EMAV 2008. At the IMAV 2010 in Braunschweig, Germany, the DelFly II was the only MAV that flew autonomously during the dynamics competition and it won the general first prize (beating all other types of MAVs) in the exploration competition. At the end of 2013 improvements to the motor and wings have allowed the design of the DelFly Explorer, the world’s first

fully autonomous flapping wing MAV. The DelFly Explorer carries a 4 g stereo vision system. It can take-off, keep its height, and avoid obstacles for as long as its battery lasts—with all sensing and processing performed on-board.

The design of an autonomously flying flapping wing MAV requires knowledge and expertise in various areas, including materials, aerodynamics, electronics, propulsion, flight control, and artificial intelligence. This book intends to convey the knowledge we gained in these areas to researchers, students, or enthusiasts that are interested in flying robots in general or flapping wing MAVs in particular. The main body of the book explains the scientific and engineering work performed to arrive at the current design and capabilities of the DelFly, always putting it in the perspective of other work on (flapping wing) MAVs. The in-depth chapters include a general introduction so that readers familiar with one of the mentioned domains will be able to follow the research in the other domains as well.

We hope that the ensemble of scientific, engineering, and practical insights contained in this book will further stimulate the research on flapping wing Micro Air Vehicles.

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The DelFly

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