DEVELOPMENT OF AN OPTIMAL DRAGONFLY-LIKE FLAPPING WING STRUCTURE FOR USE IN BIOMIMETIC MICRO AIR VEHICLES

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ABSTRACT

Biomimetic Micro Air Vehicles (BMAV) are unmanned, micro-scaled aircrafts that are bioinspired from flying organisms to achieve lift and thrust by flapping their wings. Micro Air Vehicles (MAV) are a relatively new and rapidly growing area of aerospace research. They were first defined by the US Defense Advanced Research Projects Agency (DARPA) in 1997 as unmanned aircraft that are less than 15 cm in any dimension. This allows BMAV to potentially be smaller and more lightweight than the other two types. These characteristics make BMAV ideally suited for flight missions in confined areas (e.g. around power lines, narrow streets, indoors, etc.). Therefore, BMAV structural components must be ultra-lightweight, compact, and flexible. Most past MAV research has focused on fixed wings, which are essentially scaled-down versions of wings on conventional fixed wing aircraft. These wings are unsuitable for BMAV due to their lack of flexibility. So a new type of structural wing design is required for BMAV. In this work, a dragonfly wing structure is mimicked to construct a new BMAV wing design. A dragonfly (Odonata) was selected for biomimicry, because they are highly maneuverable flyers, capable of hovering, rapid forward flight, or reverse flight. Therefore, structurally analyzing these wings could yield results that inspire the design of more effective wings for BMAVs. The overall objective of this research is to develop a simplified wing model for a BMAV, bioinspired from actual dragonfly wings. A simplified model was created using spatial network analysis, a topological optimization method. These simplified wing frame models were then fabricated using seven different types of materials. Stainless steel type 321, balsa wood, red pre-impregnated fiberglass, black graphite carbon fiber, polyvinyl acid, acrylic and acrylo-nitirile butadiene styrene. These wing frame structures were fabricated using laser cutting machine and a 3D printer. These wing frames were then immersed in a chitin-chitosan membrane by a casting method. These wing frames were subjected to
mechanical testing’s such as bending and tensile to study its suitability for use in a BMAV. A flapping mechanism was also created and used to produce flapping motion on these BMAV wings and an actual dragonfly wing (for comparison). The aero elastic properties of both the BMAV and actual dragonfly wings were examined using two high speed frame camera. The bending angle, displaced distance or deflection, wing tip angle, and the wing tip rotational twist speed were analyzed at the flapping frequencies of 10,20, 30 Hz, 60 Hz and 120 Hz.
**ABSTRAK**


DEDICATIONS

d this thesis is dedicated especially

to my beloved father, mother, and husband

Mr. Sivasankaran Nair, Mrs. Santhakumari and Mr. Rajendra Nath

The caring ones,

Kishan Nair Sivasankaran, Rubentheren Viyapuri

Respected supervisors,

Dr. Thomas Arthur Ward

Associate Professor Dr. Mohd Rafie Johan

Thanks for all the support.

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<td>UAV</td>
<td>Unmanned aerial vehicle</td>
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<td>MAV</td>
<td>Micro air vehicle</td>
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<td>BMAV</td>
<td>Biomimetic micro air vehicle</td>
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<td>Hz</td>
<td>Hertz</td>
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<td>PLA</td>
<td>Polylactic acid</td>
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<td>ABS</td>
<td>Acrylonitrile-butadiene styrene</td>
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<td>dpi</td>
<td>Dots per inch</td>
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<td>m</td>
<td>Meter</td>
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<td>μ</td>
<td>Micro</td>
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<td>FEA</td>
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<td>θ</td>
<td>Bending angle</td>
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<td>d</td>
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<td>MPa</td>
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