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Master's Dissertation 2014

Design and Evaluation of Improved Weighted Objectives Method to Introduce New Technology for Ornithopters

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SUMMARY OF MASTER'S DISSERTATION

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Title

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Abstract

In recent years, there has been a growing interest in an ornithopter that is one of the unmanned aerial vehicles (UAVs) with flapping wings and imitate the maneuverability of insects and birds. Ornithopters are a relatively new technology because they can achieve maneuvers that cannot be accomplished using conventional UAVs, and their mission design is still an unexplored field. To widen the utilization of ornithopters, missions that can take advantage of ornithopters' characteristics are required.

A common approach in design methods, such as Quality Function Deployment (QFD) and the Pugh's method, is to gather customer requirements and needs based upon missions or operational scenarios; these requirements and needs lead to objectives that are useful in concept selection methods. However, when introducing new and cutting-edge technology, it is extremely hard for researchers or developers to gather customer requirements because customers do not fully understand or are not familiar with the capabilities of the new technology.

In this type of situation, a more developer-oriented method that can make up for inadequate customer requirements and describe missions that would best suit a bird-scale ornithopter is required. Thus, the author has designed an improved Weighted Objectives method. The Weighted Objectives method typically uses a set of objectives with user-defined importance weights to aid in the selection of a concept that best meets the objectives; in this study, the author applied this method "in reverse" to determine the importance weights of the objectives so that the ornithopter concept becomes the preferred concept. This method can extract important objectives that a designer can then develop into an operating mission or scenario.

In this paper, this method is evaluated in two ways. First, a potential mission is created that requires highly ranked objectives; then, an ornithopter that can be used for the mission is developed. For the first step, the author designs an airfoil that works efficiently with a low Reynolds number. The author also develops flapping mechanisms with independently controllable wings and a new conceptual ornithopter using 3D CAD. In addition, flight experiments of the small ornithopter using the Vicon system are conducted. Next, a numerical approach to evaluate repeatability of the improved method in case of method users' inputs including errors is employed. This approach indicates that the results of this method are reliable and repeatable.

From these results, the improved Weighted Objectives method can compensate for inadequate customer requirements for new technology and make it possible to select technology concepts when designing a mission for new technology, such as bird-scale ornithopters. Future works include increasing application examples of the improved method, surveying design methods experts and to complete the development of a novel ornithopter.

Key Words (5 words)

Ornithopter, UAV, Concept Selection Method, Weighted Objectives Method, New Technology