Evaluating propellers for noise reduction through component analysis

Christian Neubert

Mentored by Jason Kolligs

Introduction

The purpose of this study was to evaluate the relationship between the physical components of a drone propeller and its noise emission, and force as a measure of lift. The components of camber, pitch, length, width, and material were evaluated to determine which characteristics contributed most to noise emission. Until recently drones have seen limited use outside of military applications, however they have become increasingly popular for consumer/commercial use, posing potential problems with noise pollution, especially in areas of heavy commercial delivery and filming (Goldman Sachs Global Investment Research, 2016). This problem becomes more apparent in areas of high population density such as major cities. Drones, on average, produce as much noise as a garbage disposal. It is preferable to reduce noise passively by changing the propeller, because the weight of an active noise cancellation system can drastically reduce flight time and/or payload. A similar study was conducted on wind turbines where wind farms were causing noise pollution for nearby residents. Researchers in the study had a similar goal of reducing noise without hindering functionality (Oerlemans, Fisher, Maeder, & Köglér, 2009).

Materials and Methods

Logger Pro and Arduino® were used to collect pulse width, noise, and force data. Thirty propellers were tested in a randomized order. Between each test the apparatus was inspected and maintained for accuracy and consistency. Each propeller was cycled ten times between minimum and maximum output at eight seconds per cycle. Data was then exported to and compiled in Excel for analysis.

Results

A linear analysis of variance test was conducted to analyze the relationship between length, width, and pitch on noise emission. Only 27 propellers were tested because of a lack of reliable data for three propellers. The test showed length contributed most to overall noise emission with longer propellers having a higher emission. Length, width, and pitch accounted for 78.24% of the variance in noise. Length was the most influential variable $F(3,25) = 48.93, p < 0.001$. Length and noise were strongly positively correlated $r(25) = 0.878, p < 0.001$. Twenty-five blades with complete data were evaluated with a linear analysis of variance test to show to what extent length, width, and pitch were related to force. The test revealed that length, width, and pitch accounted for 87.29% of the variance in force. Length was the most influential variable $F(3,23) = 77.33, p < 0.001$. Length and force were strongly positively correlated $r(23) = 0.929, p < 0.001$.

Conclusions

The focus of this project was to evaluate the relationships between various physical attributes of propellers, noise emission, and force. Time constraints and sample size led to only length, pitch, and width being evaluated. Length was the most significant variable influencing noise and force. Propeller four exemplifies this finding (Figure 3). Ten propellers, like propeller 30, showed unusual observations where force continued increasing while noise did not (Graph 1). In particular propeller nine had an observed noise of 104.44 dB and force of 5.52 N (Graph 2). These observations suggest that there are other physical attributes of the blade that contribute to noise emission beyond those examined here. Further research into evaluating and manipulating these variables to reduce noise while maintaining force could be performed.

References
