Analysis of a data-driven planar drone model

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Abstract. The main aim of this paper is a new data-driven aerodynamical model for multi-rotor drones and helicopters. The training dataset was created by validated CFD simulations utilizing the virtual blade model. A regression algorithm was used to develop the data-driven model, resulting in a simple model in a short amount of time. Using the data-driven model, the generated forces and moments by the rotating blades can be modeled with high accuracy when the motion state of the structure is known. The result of the paper is a nonlinear drone model whose control algorithm can consider the nonlinear aerodynamical effects. With the help of this model, the maneuverability and precision of drones can be increased in the future.

Introduction

Unmanned aerial vehicles or drones are increasingly common for various tasks, as they have some distinct advantages over conventional aircraft. One of these is that they are much more agile than their traditional counterparts, which stems from the fact that they are much smaller, and human limits do not have to be considered [1]. One popular type of drone is the quadcopter with four rotors, where control is achieved by varying the rpm of the individual rotors only. However, these drones are inherently unstable and exhibit strongly nonlinear, coupled, and underactuated dynamics. For this reason, an accurate aerodynamic model is important to design control algorithms [2].

In this study, the lift of a single propeller was computed using CFD simulations for several different flight conditions. The virtual blade model [3] was applied to reduce the computational cost. From the results of the simulation, an aerodynamic model was built for the lift of a propeller which takes into account the velocity and the angular velocity. This model was applied to a planar quadcopter model [4] and it was compared with a simpler aerodynamic model which only considers the angular velocity.

Results and discussion

To compare the two models, an identical PD controller was used and identical trajectories were prescribed. In most of the cases involving smooth trajectories, the main difference between the models is the resulting angular velocities of the rotors. However, in some cases, especially when the prescribed trajectory is discontinuous, there can also be significant differences in the resulting trajectories. An example is shown in Figure 1, the model based on the CFD simulations is shown in blue, the simpler model by dashed green, and the prescribed trajectory in dotted red.

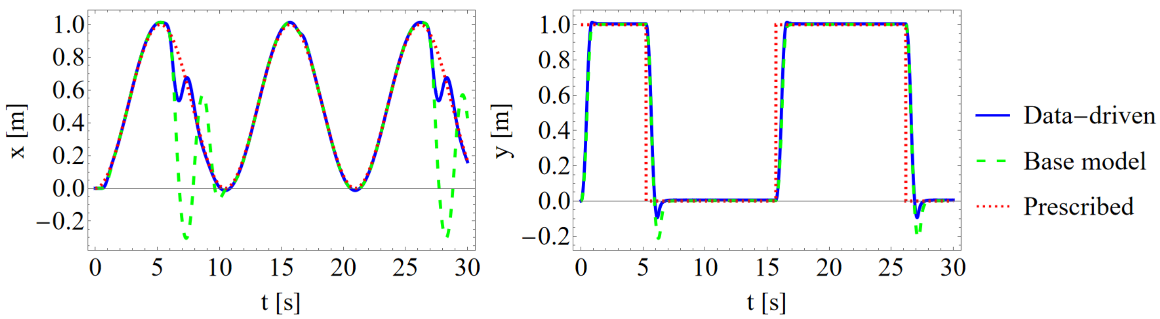

Figure 1: The resulting horizontal and vertical displacements for the two models compared with the prescribed trajectory.

From Figure 1 it can be observed that in the vertical direction, the trajectory is followed more accurately than in the horizontal direction. In the horizontal direction, the trajectory that results from using the base model deviates significantly from the prescribed trajectory.

The result of this investigation is a nonlinear drone model whose control algorithm considers the nonlinear aerodynamical effects. With the help of this model, the maneuverability and accuracy of drones can be increased in the future.

References

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