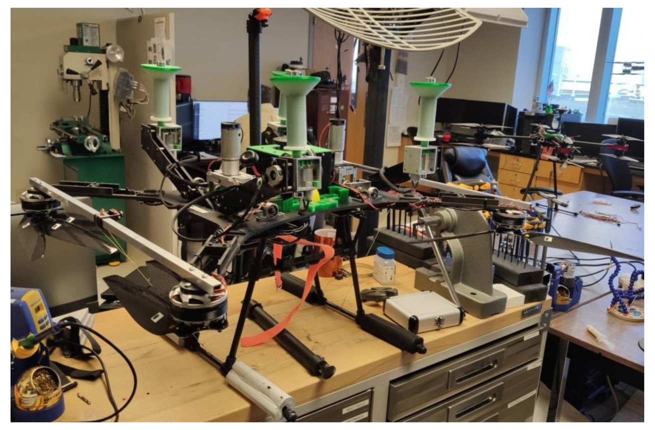
UAV Aerodynamics Simulation: Model Building and Analysis

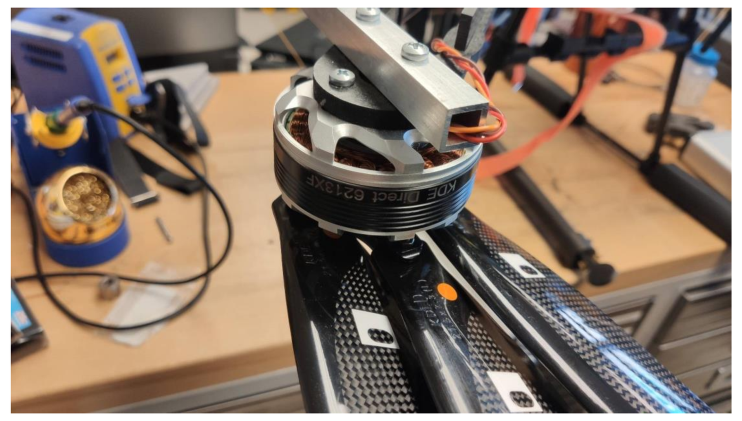
Pu Jiao, Genda Chen

INTRODUCTION

This is a CFD simulation for the UAV designed by Missouri S&T. This UAV is able to inspect the bridge closely using its rollers to moving along the bridge girders, which is expected to provide longer operation time and steady sensing results. The CFD simulation aims to help to optimize the control system and the configuration of the whole UAV system.



UAV Prototype

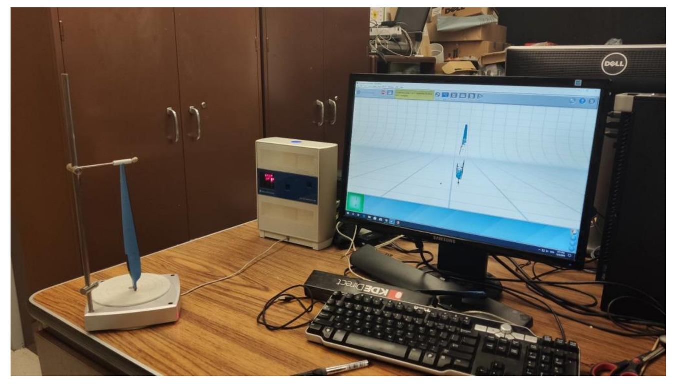


Motor and Propeller Blades

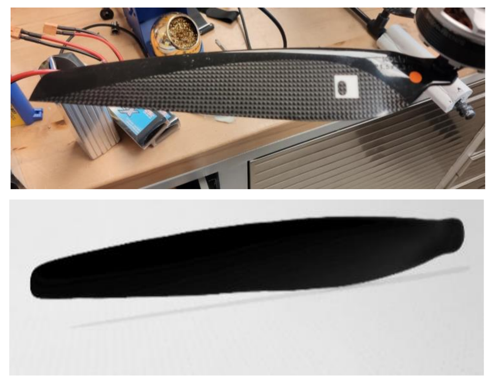
METHODS

(1)3D Laser Scanning

In the model building step, the propeller blade's shape is acquired using 3D laser scanning for more accurate representation of the blades.



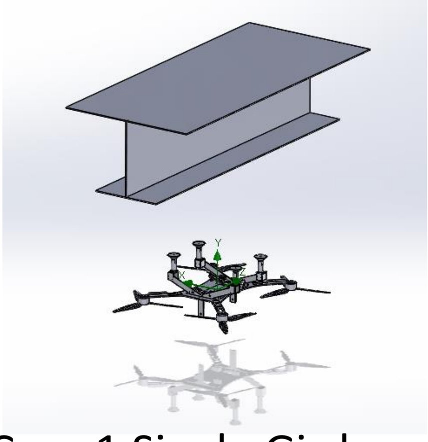
Scanning equipment



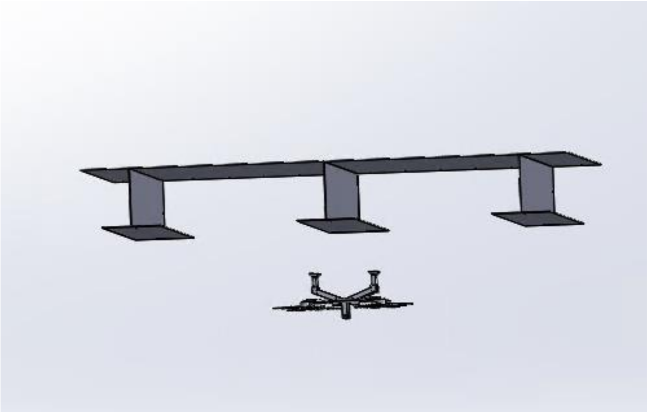
Prototype and scanning result

(2) CFD Simulation in SolidWorks

SolidWorks Flow Simulation is used as CFD solver.

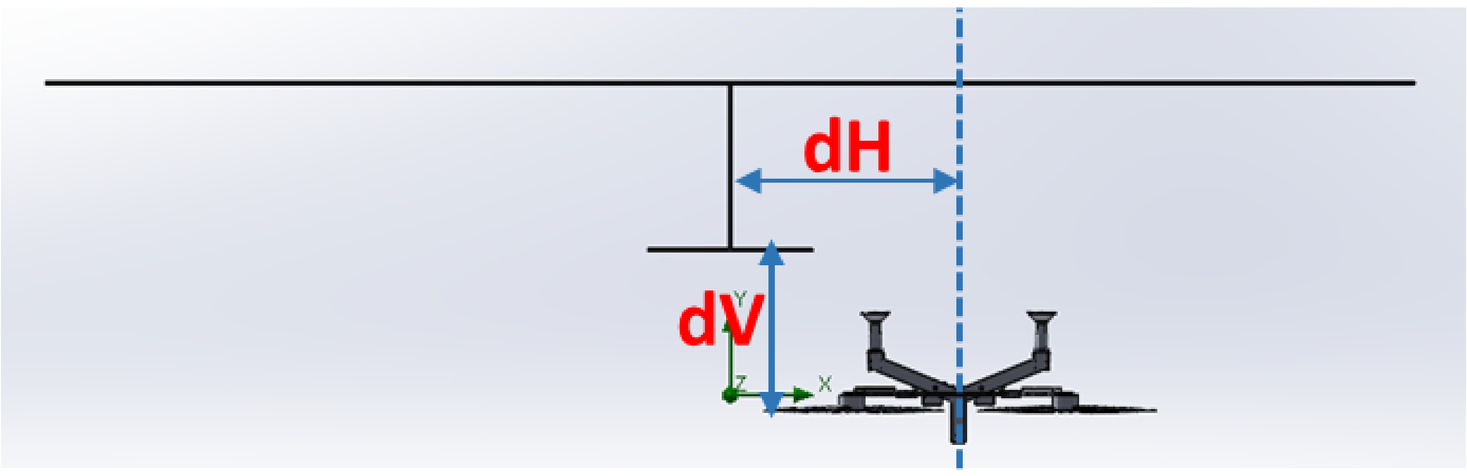


Case 1 Single Girder



Case 2 Three-Girder

(3) Parametric study



Two parameters are considered to simulate the approaching process and monitor the variation of pressure distribution, flow trajectories and etc.

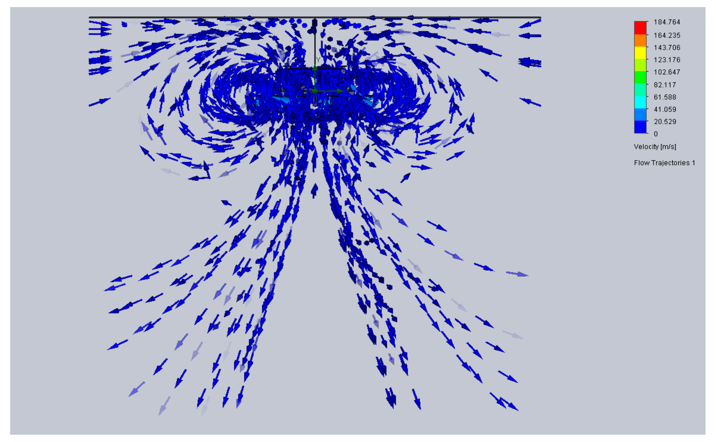
dV: vertical distance between the UAV and the girder bottom.

dH: horizontal distance between the center of UAV and the center of girder in X direction.

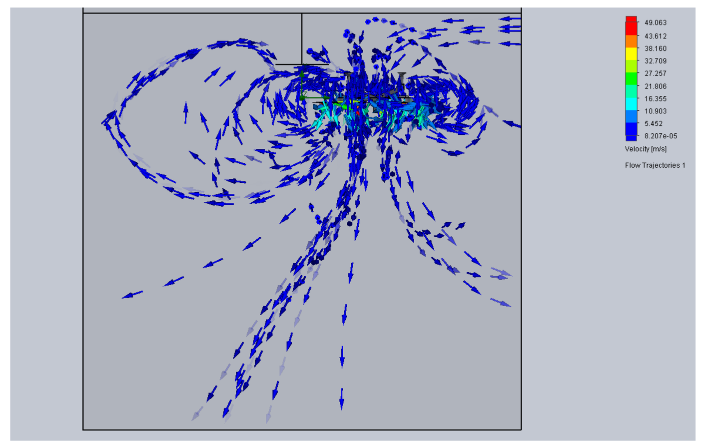
RESULTS

Case 1: Single girder with UAV

Two parameters are considered for this case: the vertical beam-to-UAV distance and horizontal UAV shift.



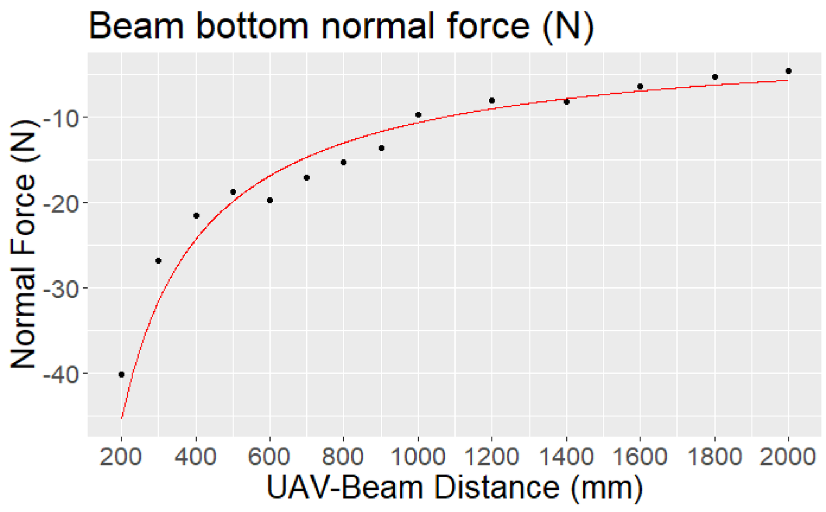
V-diatance= 200 mm
H-shift = 0



V-diatance= 200 mm
H-shift = 635mm (25in)

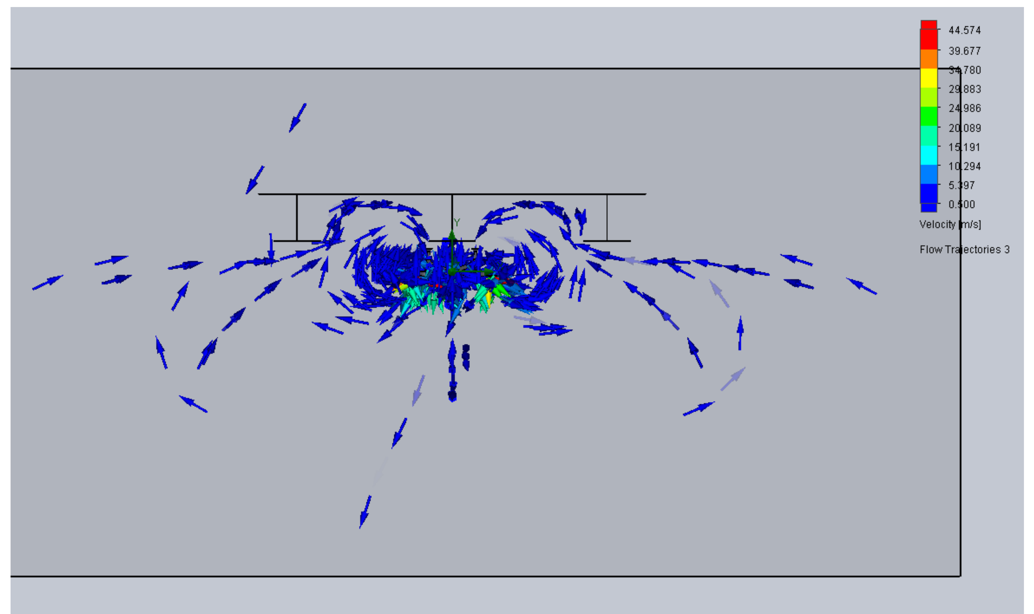
Flow trajectory results example

For the first case, a parametric study for the vertical beam-to-UAV distance is performed to get the relationship between the bottom face normal force and the distance.



The figure shows the data point as well as a regression line for the data points. It can be obtained from the regression line and the tendency that the normal force on the girder bottom face increase significantly as the UAV approaches it with a steady working rotation velocity.

Case 2: Three-girder deck with UAV (in progress)



Flow trajectory results

FUTURE PLAN

1. Choose parameters to describe the non-uniformity of pressure distribution on target surfaces.
2. Select representative cross-sections to describe the dynamic performance of the model.
3. Change the rotation speed at certain positions to check its influence on the of the model performance.
4. Port the critical aerodynamics behavior in control design process for comprehensive simulation.

ACKNOWLEDGEMENTS

Financial support for this study was provided in part by the Federal Highway Administration (FHWA) Innovative Bridge Research and Construction (IBRC) Program, by Washington County, MO, and by the U.S. Department of Transportation under the auspices of the Center for Transportation Infrastructure and Safety at Missouri S&T.