Drone vision-based clamping strategy for bridge inspection

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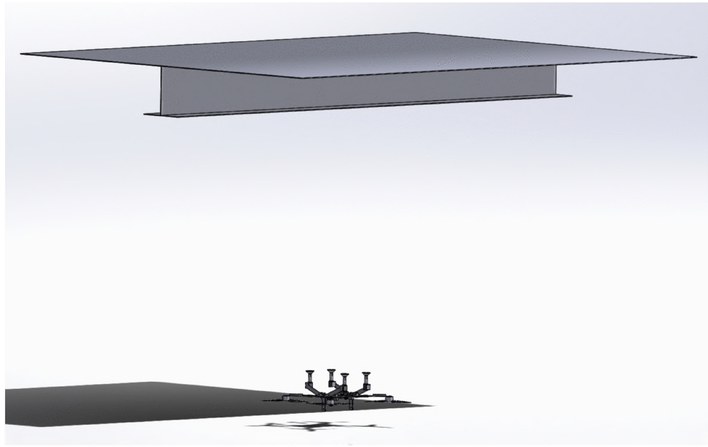
INTRODUCTION

Most bridges in the United States are near their designed lifetime. So, policy needs bridges to be inspected every two years. Currently, most of those inspections are done by human which needs to block the traffic and can cause injury. MST INSPIRE-UTC's project Bridge Inspection Robot Deployment Systems (BIRDS) tries to develop a flying and climbing platform that has the following benefit:

- Capturing high quality data for inspection without vibration;
- Free of blocking traffic;
- Operator and inspector are safe.



Operational features of Bridge Inspection Robot Deployment Systems (BIRDS): Approaching, clamping, traversing, detaching.

METHODS

Technologies/Tools used in this research include:

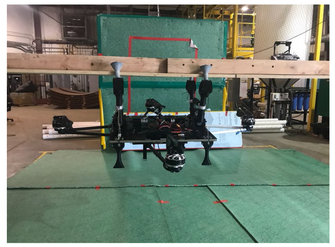
- Mechanical and electronical design;
- Embedded system/Linux development;
- Computer vision;
- Robot Operating System (ROS)

RESULTS

A platform that can fly, clamp and traverse is developed. Girder detection algorithm is transferred to this platform. Subsystem tests have been implemented.
Manual flight tests show BIRDS can balance itself. LOITER mode flight tests show that BIRDS can hover stably with visual inertial odometry data from an Intel RealSense tracking camera:

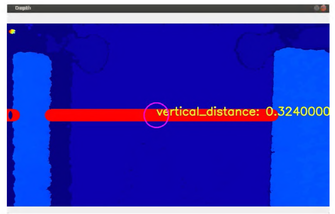
Clamping tests show that arms on top of BIRDS can clamp on a girder above and the clamping mechanism can hold the total weight of BIRDS:

Arms open



Clamped on girder

Arms closed



Girder detection

Girder detection algorithm can detect a girder above the BIRDS farther than 0.3 meters.

CONCLUSIONS

The results from flight tests, clamping test and girder detection algorithm evaluation show that the goal of this project has a great potential to be reached. Those tests lead to the following conclusions:

- GPS signals can not be received stably under bridges. Currently GPS-denied navigation is still challenging. Even though Visual-Inertial Odometry (VIO) based method is sensitive to direct sun light and rely on enough visual features, it has the benefits of not relying on pre-installed/calibrated bacons.
- Even though current 3D printed clamping and traversing design is not super strong, it shows the feasibility of the concept and leads to necessary demonstration videos for applying patents. More professional efforts are needed to eventually convert this concept to a commercial product that can make profits.
- Current girder detection algorithm only used traditional computer vision techniques. Further research could include machine learning based methods to improve its robustness.
- Current prototype can fly about 10 minutes. Adding another battery or using carbon fiber to build motors can increase the operation time.

REFERENCE

Reven, A., Frische, C., and Chen, G (2019). Unmanned Aerial and Traversing Robot as Mobile Platform for Bridge Inspections, Presented at the 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure, St. Louis, MO, August 4-7, 2019.
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