PROJECT TITLE: USE OF DRONE IN ABC CONSTRUCTION

Quarterly Progress Report
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Submitted by:

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1. Background and Introduction

In recent years, drone technology has entered many industries and applications, greatly impacting and revolutionizing their processes. It is strongly believed that drone technology has also an important role to play in ABC construction, especially when geometry control, inspection, and surveying/mapping are concerned.

The recent researches [1-4] on effectiveness and applications of drones have demonstrated the great potential for drones in inspection of hard to reach bridges, but at the same time pointed to technological limitation of existing drone designs preventing their full implementation. A comprehensive and up-to-date knowledge of drone technology is very essential in addressing these limitations. The current commercially available rotorcraft drones are designed for general-purpose application but successful implementation of such systems in ABC requires certain technical considerations.

The ABC Drone (ABCD) project will provide guidelines to overcome the many challenges of using drones for inspection and construction programs. Aircraft's stability at the inspection site due to gust, wind driven rain, unsteady turbulent flow or induced airflow (from the blades) when flying close to the bridge, aircraft overall efficiency for longer endurance, balancing and fast setup, track control sensor communication, inspection instrumentation setup, software and hardware integration of the data acquisition systems with wireless communication capabilities, tolerability to impact of inappropriate landing are among issues that need to be addressed in application of drones.

2. Problem Statement

One of the main challenges in ABC construction is geometry control at fabrication and construction stages, especially during installation and erection of prefabricated large elements. Also, as it is concerned with the rehabilitation projects, inspection for detection of damages, and survey and mapping of the affected areas necessary for design and construction has required costly operation and traffic interruption that is in contrast with ABC objectives.

This study therefore will include identification of tasks and processes in ABC that can benefit from drone application, and development of preliminary drone systems that would best serve these processes. The study will also provide parameters and hardware/software requirements; identify the existing drone systems that readily are applicable and those that would require adaptation or new designs. An implementation demonstration for conceptual verification will be performed for selective identified process(es) and application(s), and compare them with the current practices.

3. Research Approach and Methods

The overall approach of this project will be organized in three basic stages; search of background information for identification of processes within ABC construction where drone application would be beneficial, and development of appropriate drone systems through determination of important parameters for applicable drones and necessary hardware and software, and finally verification of the concepts through experimental trials within the scope and budget limitation.

4. Description of Research Project Tasks

The following is a description of tasks carried out to date.

Task 1 – Identification of ABC processes benefiting from drone application

A review of available literature and data is performed to study various processes and operations carried out for an ABC bridge construction, for both new construction and rehabilitation of existing construction. These processes are categorized based on how they would benefit from drone application.

Task 2 – Review of drone technology and its application in construction industry

Available drone technologies are reviewed within construction and other industries, and general applications benefiting the construction industry. Also, the most suitable drone system is identified to be used in the experiments.

Task 3 – Determination of drone design parameters for application to ABC

The drone parameters required for adaptation to ABC processes are identified. Flight requirements for different ABC mission, design and automation of the aircraft's control system requirements, wireless data acquisition system requirements for inspection are determined through a comparative study between drone flight characteristics and current customary inspection methods.

Task 4 – ABCD Hardware and software assembling and integration

A wooden model (box and arm) was manufactured and mounted on a drone. This combination represents a Magnetic Flux Leakage Sensor (MFLS) that needs to touch the surface for inspection. See Fig. 1.

Task 5 – Experimental Concept Verification

The model sensor mounted on the drone creates an asymmetric loading condition. This condition requires asymmetric trim and flight control to maintain stable flight.

Experiment was carried out with student's drone and the main purpose was to investigate the feasibility and possibility for use of MFLS with drones for bridge inspection; see figure 1.

<table>
<tr><td>(a)</td><td>(b)</td></tr>
<tr><td>(c)</td><td>(d)</td></tr>
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Fig 1. A bridge inspection drone prototype (a) the sensor model mounted on the drone and ready for take-off (b) drone performing stable flight with asymmetric payload (d) investigating the effect of impact on flight stability (d) investigating the effect of gust loads on inspecting drones with asymmetric loading

The results reveals that (a) the blade downwash (aerodynamic forces) will make the aircraft unstable as the aircraft flies close to the surface, (b) the drone for such like maneuver require an automatic flight control that take into account the effects of the wall impact as well as the inflow downwash, (c) the asymmetric configuration of the combination of the aircraft and sensor results in sever difficulty to trim and maintain the stability of the aircraft during inspection, and (d) these instabilities are significantly aggravated during gust loads.

Task 6 – Final (Draft and Revised) Report submission
A final report is being drafted and will be submitted by the project end date.

5. Expected Results and Specific Deliverables

This research identified the ABC processes that will benefit from drone application, provided parameters and hardware/software requirement for drone application to these processes, identified the existing drone systems that readily are applicable and those systems that would require adaptation or new designs.

An implementation demonstration for conceptual verification is performed for selective identified processes and applications, and it shows the importance of gust and impact load suppressions.

PHASE	RESEARCH TASK	2017										2018								
		M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
I	Task 1 – Identification of ABC processes benefiting from drone application	▮	▮	▮	▮	▮														
	Task 2– Review of drone technology and its application in construction industry.	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮									
	Task 3 – Determination of drone design parameters for application to ABC.								▮	▮	▮	▮	▮	▮	▮	▮				
	Task 4 – ABCDHardware and software assembling and integration.											▮	▮	▮	▮	▮	▮			
II	Task 5 – Experimental Concept Verification															▮	▮	▮		
	Task 6 –Final (Draft and Revised) Report submission.																		▮	▮

6. References

[1] Unmanned Aerial Vehicle Bridge Inspection Demonstration Project, Final Report 2015-40, Office of Bridges and Structures, Minnesota Department of Transportation, July 2015.http://www.dot.state.mn.us/research/TS/2015/201540.pdf

[2] Will Drones Transform Bridge Inspection? Roads and Bridges, September 6, 2016. https://www.roadsbridges.com/will-drones-transform-bridge-inspection

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[4] Murphy, Robin R., et al. "Robot-assisted bridge inspection." Journal of Intelligent & Robotic Systems 64.1 (2011): 77-95.