ABSTRACT

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Title: An Obstacle-Avoidance Course to Test Unmanned Aerial Systems Navigation Capabilities in Inspection of Structures

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Civil engineering structures must provide an adequate and safe performance during their time of service, and the owners of these structures must have a reliable inspection strategy to ensure time-dependent damage does not become excessive. Visual inspection is the first step in every structural inspection; however, many elements in the majority of structures are difficult to access and require specialized personal and equipment. In an attempt to reduce the risk of the inspector and the cost of additional equipment, the use of Unmanned Aircraft Systems (UAS) has been increasing in the last years. The absence of standards and regulations regarding the use of UAS in inspection of structures has allowed the market to widely advertise Unmanned Aerial Vehicles (UAV) without protocols or qualifications that prove their effectiveness, leaving the owners of the structures to solely rely on claims of the vendors before deciding which technology suits their particular inspection needs. Focusing primarily on bridge inspection, this research aimed to address the lack of performance-based evaluation and standards for UAS, developing a validation criterion to evaluate a given UAS based on a repeatable test that resembles typical conditions in a structure.

Current applications of UAS in inspection of structures along with its advantages and limitations were studied to determine the current status of UAS technologies. A maximum typical rotor-tip-to-rotor-tip distance of an UAV was determined based on typical UAVs used in bridge inspection, and two main parameters were found to be relevant when flying close to structures: proximity effects in the UAV and availability of visual line of sight. Distances where proximity effects are relevant were determined based on several field inspections and flights close to structures. In addition, the use of supplementary technologies such as Global Positioning System (GPS) and Inertial Measurement Units (IMU) was studied to understand their effect during inspection.

Following the analysis, the author introduces the idea of a series of obstacles and elements inside an enclosed space that resemble components of bridge structures to be inspected using UAVs, allowing repeatability of the test by controlling outside parameters such as lightning condition, wind, precipitation, temperature, and GPS signal. Using distances based on proximity effects, maximum typical rotor-tip-to-rotor-tip distance, and a gallery of bridges and situations when flying close to bridge structures, a final arrangement of elements is presented as the Obstacle Course. Components inside the Obstacle Course include both "real" steel and concrete specimens as well as those intended to simulate various geometric configurations on which other features are mounted. Pictures of damages of steel and concrete elements have been placed in the internal faces of the obstacles. A detailed comparison between the objectives of this research project and the results obtained by the Obstacle Course was performed using visual evaluation and resolution charts for the images obtained, the availability of visual line of sight during the test, and the absence of GPS signal.

From the comparison and analysis conducted and based on satisfactory flight results as images obtained during flights, the Obstacle Course is concluded to be a repeatable and reliable tool to apply to any UAS prior to inspect bridges and other structures, and the author recommends to refrain from conducting an inspection if the UAS does not comply with the minimum requirements presented in this research work. Additionally, this research provided a clearer understanding of the general phenomenon presented when UAVs approach structures and attempts to fill the gap of knowledge regarding minimum requirements and criterion for the use of UAS technologies in inspection of structures.