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A height measurement uncertainty model for archaeological surveys by aerial photogrammetry

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Abstract

In this paper, an uncertainty estimation model for object height measurement by aerial photogrammetry using Unmanned Aerial Vehicles (UAVs) is proposed. In particular, a procedure to evaluate the height measurement uncertainty and its sources has been designed. In order to evaluate the uncertainty values related to height measurements, experimental tests to obtain repeated measurements have been conducted. Furthermore, an uncertainty propagation model has been developed considering the uncertainty sources affecting the measurement process. An evaluation of each uncertainty source contribution has been obtained by comparing the results of the experimental investigation and the estimation provided by the proposed propagation model. The 3D maps, which provide object height measurements, are generated by a commercial aerial photogrammetry application, the Pix4Dmapper Pro, and a 3D reconstruction application developed ad hoc. The obtained results and a discussion related to each uncertainty source contribution are presented.

Keywords: aerial photogrammetry, UAV, stereoscopic measurement, measurement uncertainty.

1. Introduction

Nowadays, the use of light Unmanned Aerial Vehicles (UAVs), also known as drones, is growing in civilian scenarios due to the characteristics of such vehicles, e.g. low weight, small size, low cost and easy handling. UAVs are platforms able to survey wide areas and reach human-hostile environments. Furthermore, several kinds of sensors can be embedded on them, converting UAVs into mobile measurement platforms. According to the sensor typology, they are suitable for several application fields [1].

UAVs in archaeology are used for accurate documentation of archaeological sites. This documentation consists of 3D maps, orthophotos, and thermal images obtained by the on-board sensor measurements during the site surveys. In particular, in order to provide 3D maps, mainly the following measurement techniques can be used: (i) aerial laser scanning (ALS), and (ii) aerial photogrammetry.

ALS systems consist of: (i) a Light Detection And Ranging (LiDAR) system, (ii) an Inertial Measurement Unit (IMU), (iii) an on-board GPS receiver, and (iv) a ground GPS receiver. The LiDAR technology is based on the time of flight measurement. A LiDAR system consists of a laser transmitter that emits short pulses of laser light, and an optical receiver to detect backscattered laser radiation. By measuring the travel time of the pulses, it is possible to measure the distance between the laser transmitter and the target. In order to collect 3D data, the LiDAR system requires the laser beam steering. For an UAV system, the forward motion of the aircraft provides one direction of scanning motion. The second dimension is implemented due to the use of the mechanical motion of a scanning mirror. In [2], a UAV-borne