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UAV photogrammetry for monitoring changes in river topography and vegetation

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Abstract

This study aims to evaluate the accuracy of digital surface model (DSM) of river-channel morphology, which is derived from the imagery acquired with a low-cost digital camera on board an unmanned multi-copter. UAV photogrammetry at flight altitude of 100 m has been carried out before and after a man-made flood in the Jyoge River in Hiroshima Prefecture, Japan along with ground survey using RTK-GPS and Total Station. The UAV photogrammetry has demonstrated that the DSM reproduces the ground elevation very well with the maximum error of 4 cm over a floodway where the vegetation height and density are low and that the DSM reasonably captures the thick vegetation cover over sandbars. It is also confirmed that the difference in DSM before and after the flood is due to the plant toppling over sandbars.

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Keywords: UAV, photogrammetry, digital mapping, river topography, riverine vegetation

1. Introduction

River geometrical data are of prime importance not only for flood protection planning but also river management. Irrespective of their importance conventional survey in relatively big rivers has been carried out to provide the updated information of specified cross sections at the interval of a few years. The cost for 3D mapping by

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conventional survey or conventional aerial photogrammetry has been huge. This situation has been more apparent and serious with medium and small scale of rivers because their number and longitudinal length are quite large. It is also requested from the standpoint of river environment to regularly monitor river topography and land surface cover including riparian vegetation. Hence a strong need has emerged to develop a new measurement platform for river survey, producing precise georeferenced 2D maps and 3D models.

Unmanned Aerial Vehicles (UAVs) has been attractive in many research fields to obtain the latest information of the target areas, owing its high mobility, high resolution and low cost ([1]-[5]). Nowadays UAV-photogrammetry with autonomous navigation function has reached a level of practical reliability and become a useful platform for spatial data acquisition. Hence it is expected that UAV-photogrammetry can acquire river topographical data in a short time and to generate a high-resolution digital model of complex river environment with required accuracy. However, there has been few reports assessing its accuracy under real conditions.

This study aims to evaluate the accuracy of digital surface model (DSM) derived from UAV-photogrammetry applied to river morphological mapping. For this end we carried out UAV-photogrammetry in the Jyoge River in Japan together with ground survey using RTK-GPS and Total Station.

2. Data acquisition

2.1. Data acquisition and processing

The UAV employed in this study is shown in Fig.1 and its specifications are explained in Table 1. It has six arms and rotors with a GPS and a gyro, which support autonomous flight. The UAV flied over a study area at 100 m above the ground at a speed of 4 m/s. It carried a camera of Sony alpha 7R with a 16 mm plastic lens, 35 mm glass

Fig. 1. UAV used in this study.

Table 1. Specifications of UAV

Item	Specification
Weight	3,800 g
Size	950 mm × 950 mm × 400 mm
Wind resistance	15 m/s
Flight time	30 minutes
Payload	4,000 g

len or a 35 mm glass lens with a polarized lens. The photogrammetry was designed to acquire 90 % forward overlap and 50-60 % lateral overlap. A series of aerial photos were then automatically processed by a photogrammetry software Pix4D Mapper to create orthomosaics, georeferenced Digital Surface Models (DSMs) and 3D mapping.

2.2. Study area

We carried out UAV-photogrammetry in March 2015 before and after a man-made flood in the Jyoge River in Hiroshima Prefecture, Japan. Fig. 2 shows the location of the observation reach located downstream of the Haizuka dam. Fig. 2 explains that the reach consists of a main channel with sandbars covered with dense withered plants and a floodway with short grasses along the left bank. Two small irrigation channels run along the main channel.

The Haizuka Dam, managed by Ministry of Land, Infrastructure, Transport and Tourism (MLIT), has repeated an artificial flood with a peak discharge of 100 m^3/s for fish stocking every March from 2007. The flood has been designed to remove deposited mud and old algae attached to cobbles over the river bed. Since the total volume of water in the reservoir available for the flood is limited, the best practice has been pursued to effectively wash out old algae that juvenile fish does not feed on. We have also observed changes in water level and vegetation during the flood since 2009 and concurrently developed a two-dimensional numerical code for flood flow and sediment