UNIVERSITI TEKNOLOGI MARA

PHOTOGRAMMETRIC UNMANNED AERIAL VEHICLE FOR DIGITAL TERRAIN MODEL ESTIMATION UNDER OIL PALM TREE CANOPY AREA

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Thesis submitted in fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Design and Build Environment)

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Postgraduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Digital terrain model (DTM) is used to get the information of the earth's surface for scientific and commercial purposes. Currently, there are many attempts to use unmanned aerial vehicle (UAV) technology for the DTM generation. UAV perceived an increased usage for high-resolution mapping, but as debated in the literature, it is nearly impossible for the UAV aerial photogrammetry to be used for penetrating a tree canopy in dense areas. This study aims to fill the gap by focusing on the production of DTM estimation under tree canopy area through photogrammetric processing, acquired with the UAV technology. The study has specifically developed four main objectives to achieve its aim, namely: (1) to identify camera internal geometry of UAV for DTM production under tree canopy conditions, (2) to identify appropriate methods for the tree height estimation based on tree crown delineation, (3) To formulate a new methodology for estimating DTM production under tree canopy conditions - (Under Oil Palm area), and (4) to validate the accuracy of DTM result based on in situ measurement. In this study, data acquisition was carried out using UAV images involving simulation and real site studies under oil palm area based on the different flying heights. The experiments were performed in both simulation and real site studies based on four algorithms namely inverse watershed segmentation (IWS), object-based image analysis (OBIA), watershed segmentation (WS) and seed generation (SG). At this stage, this study has formulated a new methodology for estimating DTM production under tree canopy conditions based on tree crown estimation produced from the digital surface model (DSM) and subsequently, the tree height estimation was determined as the final process in the DTM implementation. The DTM estimation was retrieved from the difference between DSM and tree height. The accuracy of the DTM was further tested based on in situ experiments and analysed based on RMSE. Following the application of a new methodology on the real site, the result indicated the consistency of DTM values of all the algorithms at different flying heights but there were relatively small differences between all the algorithms used. It was found that WS algorithm recorded the lower RMSE value of 2.824m at 40m flying height, IWS algorithm obtained a lower RMSE value of 2.879m at 80m flying height, OBIA and SG algorithms obtained a lower RMSE value of 2.246m and 2.182m respectively at 100m flying height. With these results, this study confirmed that UAV is a very useful technology in obtaining aerial photograph especially under tree canopy area. Thus, this is a major contribution towards photogrammetric mapping and other applications in this area.

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