UNIVERSITI TEKNOLOGI MARA

PHOTOGRAMMETRIC LOW-COST UNMANNED AERIAL VEHICLE FOR POTHOLE DETECTION MAPPING

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ABSTRACT

Types of pavement distress include potholes, cracks and rutting. The most dangerous and common form of road defect is the pothole. Effective data collection of pothole geometry information can assist in road maintenance project. It is necessary in estimating a logistic need which can help Authorities in distribute their budget projection. Pavement damage involving spectral features has limitations with the RGB format. In the field of remote sensing, road distress in the form of spectral features has been characterised by Multispectral (MS) images that have coverage with broad wavelengths. This study extracted pothole area and volume information from fusion of Digital Elevation Model (DEM) and classified MS image. The study set four main objectives to achieve its aim: (1) To analyse RGB and multispectral sensor calibration, (2) To evaluate the optimal flight parameters for pothole modelling production using RGB imagery, (3) To investigate various classifier algorithms and band combinations for pothole region areas using multispectral imagery and (4) To validate geometric information from the extracted pothole. Three (3) chequerboards were used in camera calibration to find an optimal camera parameter. 50mm size of chequerboard pattern yielded the lowest pre-projection error while there's no guaranteed in having better projection by increased the focal length of the camera. Meanwhile, nine (9) classifier algorithms and forty (40) band stack combinations were deployed to classify the pothole edge. The most significant classifier algorithms to distinguish a pothole defect is Maximum likelihood with 29 over 40 band combination win rate. The lowest error of pothole polygon classification is 0.016m² from classification of Mahalanobis distance algorithm with NIR + red edge + red or Green + red edge + red combination. For volume estimation purpose, a Digital Elevation Models (DEM) were generated from photogrammetric method with flight parameters of three (3) different camera focal length and ten (10) UAV altitude. The optimal flight parameters for accurate fill-in volume estimation is at 8 m and 10 m flight altitude, with the 3.61 mm and 8.8 mm of focal lengths, respectively. These results confirmed that the UAV is a very useful form of technology in road maintenance applications, at the same time, contributing in alternative method of pothole information extraction. The information gathered is useful for Authorities, concession expressway company and interest party for better road maintenance implementation.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Types of pavement distress include potholes, cracks and rutting. The most dangerous and common form of distress is the pothole. Many factors can affect the pavement integrity, such as temperature, moisture, weathering and load. A pothole is a small, bowl-shaped depression in the pavement (Buza et al., 2014). Small potholes can be defined as having a depth of 25 mm and a width of 200 mm wide, while large potholes have depths of over 50 mm and widths of over 500 mm (Naveen et al., 2018). Last year alone, JKR said a total of 168,003 potholes were patched along the 14,385km of federal roads in Peninsular Malaysia. Pothole repair is necessary; otherwise, safety and pavement ride-ability are compromised. To patch up a pothole, it reflects to the budget preparation as the asphalt used for pothole pavement is expensive and cannot be wasted. Thus, an accurate estimation of asphalt used for pothole patch is important by acquiring a pothole's measurement such as area and volume. The data collection process and analysis phases are crucial to effective pavement maintenance approaches (Ragnoli et al., 2018). They are also fundamental in road management (Poon et al., 2005; Zhang, 2006; Kumar & Angelats, 2017).

A study was carried out to find an optimal solution in acquiring measurement method of a road. The current study presents a method of pothole detection using 3D reconstruction (Jog et al., 2009; Saad & Tahar, 2019), single RGB image processing (Hoang, 2019 and Gao et al., 2020), remote sensing classification (Abdellatif et al., 2019; Pan et al., 2018) and vehicular sensors (a mobile phone, vibrator or gyroscope) (Gunawan, 2018). Outputs from the proposed detection method are mostly presented as pothole numbers with georeferenced tags (Jo & Ryu, 2015), especially from single RGB image processing and sensorial method. Meanwhile, the 3D reconstruction method, stereovision and classification from calibrated images offer added value, such as a pothole's measurement information (i.e., its width, length and depth) (Zhen et al., 2014; Saad & Tahar, 2019).