Road Condition Analysis for Accident Assessment Based on Unmanned Aerial Vehicle (UAV) Photogrammetry Using Image Classification

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December 19, 2021

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***Abstract*—In recent years, many people who drove motorcycles died of traffic accidents in the world every year. As for Thailand, here also are the same situation. This paper develops an AI model of the road condition to protect motorcycle drivers by using UAV and image classification. Collect road condition images based on UAV equipment in the city area in Thailand and build the AI models by using Orthomosaic images and digital surface models based on image recognition algorithms. In the algorithm, determining the degree of risk of road conditions is one of the important steps, which used the supervised method by experts for image judgment. Image classification is used to identify the degree of road condition risk, mainly AlexNet, ResNet18 and etc. After completing the model establishment, this research will conduct a test to determine which model is more suitable for analysis by comparing the image predictions and safety factors of the two models. As a result, the RGB model is more suitable for analyzing road conditions than the DSM model and the AlexNet is more suitable for analyzing the DSM model, and the squeezenet1_0 is more suitable for analyzing the RGB model. This study aims to develop an image classification model based on road conditions in Thailand and create a mobile application to give the road condition information based on the GPS location. The model is suitable for utilizing for creating motorbike drivers' safety guidance from UAV data.**

***Keywords*—AI road, UAV data process, road classification, image processing, Aerial data**

I. INTRODUCTION

Recently, the very increase in the number of vehicles has led to frequent traffic accidents all over the world, which not only threatens the lives of people in all countries but also causes greater losses to the economies of all countries in the world. Every year, about 1.35 million people die death due to road traffic accidents worldwide. Road traffic injuries cause huge economic losses to individuals, families, and the whole country [1]. It is reported that motorcycles (including 3-wheelers) account for more than 80% of vehicles involved in accidents (and also about 80% of total casualties), and motorcycles are responsible for a large proportion of traffic accidents in Thailand [2]. We found out that the number of traffic accidents caused by motorcycles is increasing not only in Thailand but also in the Philippines [3].

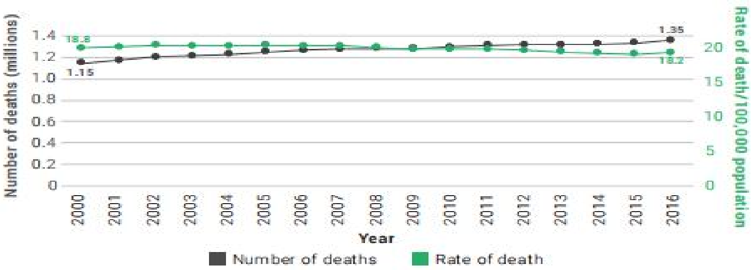


Fig. 1. Number and rate of road traffic death per 100,000 population:2000-2016[1]

There are many reasons for traffic accidents caused by motorcycles. As mentioned above, there will be environmental factors, human factors, and vehicle factors. This research will protect motorcycle drivers through the analysis of road condition models based on UAV and data analysis models.

II. REVIEWS AND BACKGROUND

A traffic monitoring system based on the information captured by UAVs has been proposed in [4]. In the system model, a drone and an onboard camera are used to capture and record traffic videos, and then the captured or recorded information is sent and processed in the cloud server, and the cloud server sends the data to the main server. They evaluated the proposed system by using some parameters (such as queuing and driving time, speed, vehicle count). The system can efficiently allocate vehicles driving on the road.

A system for pit detection and size estimation has been proposed in [5]. The proposed system uses the deep learning-based algorithm YOLO for pothole detection, and the triangle similarity measure based on image processing is used for pothole size estimation. They trained the model for multiple iterations on a custom data set for testing. The system will help reduce manual dependence on road maintenance tasks.

A forest fire detection algorithm by applying YOLO-V3 to aerial images based on drones has been proposed in [6]. First, an unmanned aerial vehicle platform for forest fire detection was developed. Then according to the available computing power of the onboard hardware, a small convolutional neural network (CNN) was implemented with the help of YOLO-V3. First train the model on the desktop, then put the model on the DJI MANIFOLD embedded quadrotor drone for testing. This method has great advantages in the real-time detection of forest fires using drones.

An orthophoto, orthophotograph, or orthoimage is an aerial photograph or satellite imagery geometrically corrected ("orthorectified") such that the scale is uniform: the photo or image follows a given map projection [7]. Unlike an uncorrected aerial photograph, an orthophoto can be used to measure true distances, because it is an accurate representation of the Earth's surface, having been adjusted for topographic relief, lens distortion, and camera tilt.

Zhou S etc.al (2013) researched that the Digital Surface Model (DSM) is a type of 2-D data that reflects the elevation of the earth's surface including all objects on top of it. It is a high-level product of Laser Interferometry Detection and Ranging (LiDAR) [8]. The elevation information of any given area in DSM is represented by the gray value of the specific pixel. Building detection in DSM is one of the most popular topics in the processing of remote sensing images. Because DSM data carries the elevation information of ground surface, the interpretation results of DSM data significantly benefit the post-processing application such as 3D building reconstruction.

III. EXPERIMENTS

In this section, there are mainly the following parts: data collection and processing, build model, test model.

As illustrated in Fig 2, this research has three parts, including data collection and processing, build model, test model. In the first part, this research used the UAV to collect images, then handle data to create RGB and DSM folders. Secondly, it will build RGB, and DSM AI models based on image recognition deep learning algorithms. Finally, it is going to classify the risks and accuracy of the road, and also compare the RGB and DSM models in the same algorithm or different algorithms to get which one is proper to analyse the road to protect motorcycle drivers.

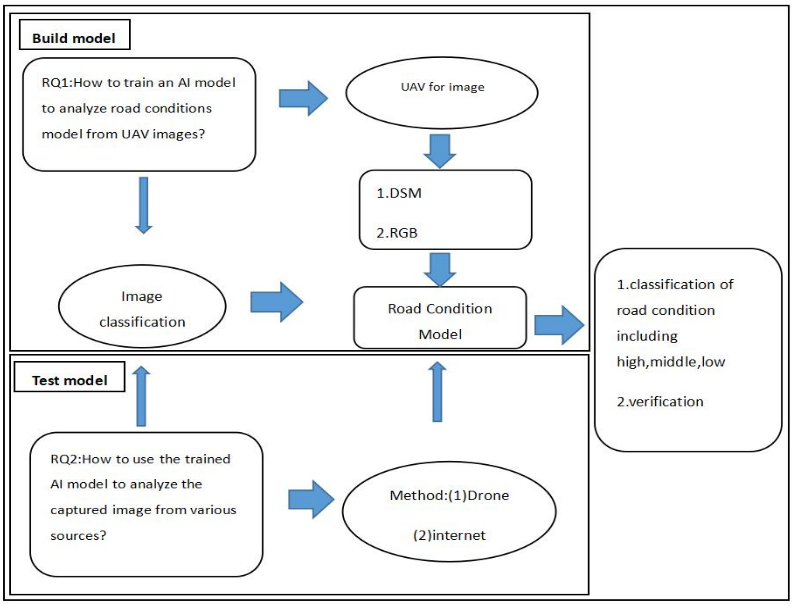


Fig. 2. Conceptual Framework

A. Data collection and processing

This research chooses the traffic situation of a certain city in Thailand as the research object. For example, the research chooses the road condition in the city area in Thailand. The first is to collect images. In this paper, the research chooses to use drones to collect images of road conditions on the ground.

1). Image

The research used UAVs to collect the images, it can take photos about this road, then send them to the computer. In order to ensure the accuracy of the model, this research could collect and process 1000 images with the GSD (Ground Sample Distance) as 10cm/pixels that are taken in the city area in Thailand.

2). Orthomosaic Image

The research used photogrammetry software to create an orthomosaic image because this is to correct the position difference caused by the low terrain height and record the tilt of the camera to modify the position by using the low altitude information of the terrain and refer to the network coordinate system of the world map.

3). Digital surface Image

The research creates DSM by using QGIS. DSM can be used to mark the height of the road surface by colour, which is conducive to the analysis of the road surface.

B. Build model

In the build model, the research has 2 ways to train the model including DSM and RGB. And it labels DSM first, then labels RGB based on data of labelling DSM. When the research finishes label, train the DSM and RGB to build an AI model.

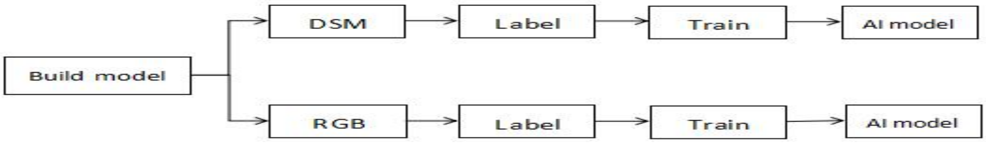


Fig. 3. Build model

1). label RGB and DSM

In the research, we use supervised learning to research the data. First, we find 17 persons who are traffic experts, road condition researchers, road engineers, etc. They can help to divide photos into different risks which are high risk, middle risk, and low risk based on their justify. The main way is a questionnaire that design a form including the road questions to justify the road risk. According to the questionnaire filled out by experts, probability calculations could be carried out in this research.

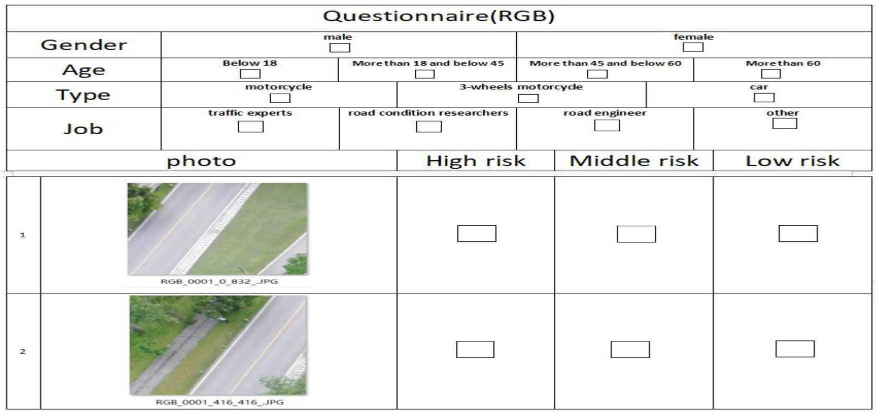


Fig. 4. Part of the questionnaire

When they finished the questionnaire, and divide the data of pictures into different risks, so get the result as the following. When the judgment is different, this research calculates the percentage.

Table I. Image data

Image / *data*	*High-risk*	*Middle-risk*	*Low-risk*	*No-road*
RGB	*300*	*400*	*700*	*1000*
DSM	*300*	*400*	*700*	*1000*

2). Train RGB and DSM model

when we had prepared the trained data that are RGBs and DSMs, we will use image classification algorithms such as RestNet18, AlexNet, SqueezeNet1_1 etc.

C. Test model

1). method of testing model

In this study, images were collected by using drones. Import the collected images into the established model for analysis. And the research uses drones to collect images or research the relevant image on the internet. After this, it also deals two ways to test the AI model, one is DSM, the other is RGB.

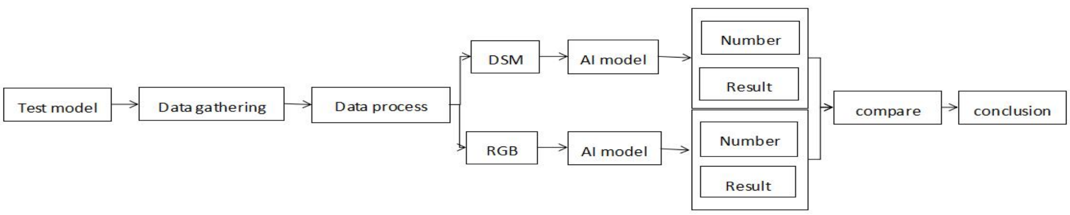


Fig. 5. Test model

2). compare the model

In this study, the models are compared

mainly by analysing five factors such as accuracy, sensitivity, specificity, Matthew's correlation coefficient, and Area Under Curve.

a). Accuracy

The correctness rate is our most common evaluation index. This is easy to understand that is the number of samples to be matched divided by the number of all samples.

$$\text{Accuracy} = \frac{(\text{TP+TN})}{(\text{P+N})} \tag{1}$$

b). Sensitive

It represents the proportion of all positive examples that are matched, which measures the ability of the classifier to recognize positive examples.

$$\text{Sensitive} = \frac{\text{TP}}{\text{P}} \tag{2}$$

c). Specificity

It represents the proportion of all negative examples that are matched, which measures the classifier's ability to recognize negative examples.

$$\text{Specificity} = \frac{\text{TN}}{\text{N}} \tag{3}$$

d). Matthews correlation coefficient

MCC is essentially a correlation coefficient describing the actual classification and the predicted classification. Its value range is [-1,1]. A value of 1 indicates a perfect prediction of the subject, and a value of 0 indicates the predicted result is not as good as the random predicted result. A value of -1 means that the predicted classification is completely inconsistent with the actual classification.

$$\text{Det} = \text{np.sqrt}\{(\text{TP} + \text{FP}) \times (\text{TP} + \text{FN}) \times (\text{TN} + \text{FP}) \times (\text{TN} + \text{FN})\} \tag{4}$$

$$\text{MCC} = \frac{(\text{TP}\times\text{TN})-(\text{FP}\times\text{FN})}{\text{Det}} \tag{5}$$

e). Area Under Curve

AUC is the area under the curve. When comparing different classification models, you can draw the ROC curve of each model, and compare the area under the curve as an indicator of the pros and cons of the model.

Standards for judging the pros and cons of a classifier (predictive model) from AUC:

AUC = 1, is a perfect classifier.

AUC = [0.85, 0.95], the effect is very good

AUC = [0.7, 0.85], the effect is average

AUC = [0.5, 0.7], the effect is low, but it is already very good for predicting stocks

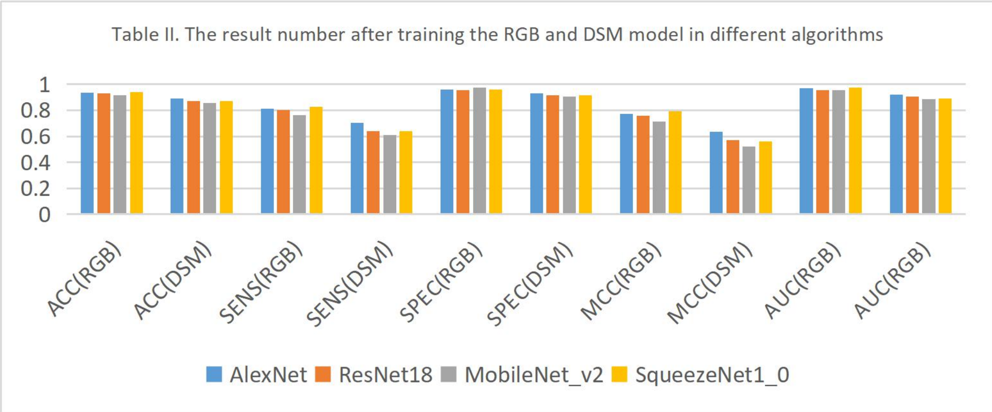
AUC = 0.5, follow the machine to guess the same (for example: lost copper plate), the model has no predictive value.

AUC <0.5, worse than random guessing; but as long as it is always anti-predictions, it is better than random guessing.

IV. RESULT AND DISCUSSION

Furthermore, when getting the result and number, the research can compare the DSM model with the RGB model to get the conclusion. Also, the research uses different image classification algorithms to train and predict. Then compare them in the different algorithms.

After testing, we get the result of the factors as Table II. As the result of the test, we can find: 1. When we use the same algorithm to train and test RGB and DSM, the RGB model is more suitable for analysing road conditions than the DSM model; 2. When we use different algorithms, we can find that AlexNet is more suitable for analysing DSM model, and squeezenet1_0 is more suitable for analysing RGB model.



This APP is road analysis software, which is designed based on the conclusions drawn from the above experiments. The main function is road analysis. The model is derived by using the squeezenet1_0 algorithm to provide the basis for the prediction of the software. The user can take pictures of the road surface through small drone, then import it into the system and the software will give the risk level of the road surface and protection tips.

V. CONCLUSION

This paper develops an AI model of the road condition to protect motorcycle drivers by using UAV and image classification. We used the UAV to collect images and create RGB and DSM folders to train the AI models based on image classification algorithms. As a result, the RGB model is more suitable for analysing road conditions than the DSM model and the AlexNet is more suitable for analysing the DSM model, and the squeezenet1_0 is more suitable for analysing the RGB model. The limitations of the proposed work are as follows: although we can analyse the risk of road conditions, we could not get the result in real-time. Consequently, we will develop a mobile application that using model to tell the road condition based on the mobile GPS data in real-time.

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