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Prompt analysis of condition priority for road improvement planning

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Abstract. The need for quick analysis for road pavement survey is inevitable, especially in a developing country. A new data collection method by using small format photo, which is recorded by drone is developed. The function of drone is not only for photographic purposes, but also developed to measure and record road damage. Digital aerial photogrammetric methods are developed faster than before. A small format areal imagery based on pixel size is developed for this study, so that the degree of road damage can be obtained quickly. In order to obtain a maximum pixel size to detect a maximum damage level of 1 cm, the shooting is done at a height of 24 m drone from the road surface. The result of road damage measured by measuring distance through image is then tested based on the measured sample, directly in the field with a trust level of 97.83%. These results show that the accuracy of road damage measurements made above high resolution photo images is very effective for data collection of road damage. Analysis of Condition Priority can be obtained in one day in complement with contour map and road level, while in previous time it is done within a week without contour map and level.

1. Introduction

There are two types of data used for road management, namely inventory and condition. Inventory is usually used to get the physical element of roads system. While, the condition, in this case is pavement condition data is usually collected at different frequencies, depending on the road class. Main roads and major highways are monitored at frequent intervals, often 1 – 2 years, while minor roads are monitored at 2 – 5 year intervals. The monitoring frequency must be sufficient to identify major changes which that influence the road maintenance decisions. Directorate General Bina Marga of Public Work Ministry has issued the survey guidance for data collection[1].

There are various technologies available and continuously developed for measuring attributes of road network. It is a great opportunity for researchers to find the appropriate equipment, the way in which the data are expected to be used. As it is known that data collection is expensive, then in data collection issues, some considerations are taken, such as deciding what to collect and Information Quality Levels (IQL), sampling interval and sectioning, and survey frequency. Other techniques of measuring the performance conditions of road are evaluated based on the value of NAASRA Rough meter II. The study was to compare the value of IRI from rough meter II tool to the value of IRI using smart phone applications (Roadroid) as a reference in evaluating the functional condition of national roads for efficient and save the national road maintenance budget [2]



In terms of location referencing, there are two types to be considered, namely linear referencing and spatial referencing. Spatial referencing is achieved by using global positioning system (GPS) technologies. The GPS, data collected from satellites are used to generate location information. The accuracy of raw GPS data is approximately 10 meters, most of the time.

Further, remote sensing can offer insights into surface conditions and other aspects that the inspector cannot evaluate except with laborious and destructive testing and field surveys. Field spectra showed that asphalt aging and deterioration produce measurable changes in spectra as these surfaces undergo a transition from hydrocarbon dominated new roads to mineral dominated older roads. Further results of the study showed that several spectral measures derived from field and image spectra correlated well with pavement quality indicators. Some limits to remote sensing based mapping are spectral confusion between pavement material aging and asphalt mix erosion on the one hand and structural road damages (e.g. cracking) on the other. Both the “common practice” methods (Pavement Management System-PMS, in situ vehicle inspections), and analysis using imaging spectrometry are effective in identifying roads in good and very good condition. However, variance and uncertainty in all survey data (PMS, in situ vehicle inspections, remote sensing) increases for road surfaces in poor condition and clear determination of specific surface treatment decisions remains problematic from these methods [3]. This is the first time this issues was presented in this context and further studies are needed to refine to analysis and develop a mapping strategy based on existing technology and in comparison to sensor developments (UAV-based)[4].

Digital Terrain Model (DTM) is a topographic model from the ground, without objects (eg forests) on it. Therefore, accurate DTM can be made in forests where a clear view of the forest is available [5]. Another limitation is that UAV photogrammetric techniques perform poorly in capturing the surface of the terrain beneath increasingly dense canopies in complex tropical rainforests [6].

The accuracy of the DTM originating from the cloud point of the UAV depends on adjusting accurate image UAV bundle blocks, which depend on the configuration and distribution of Ground Control Points (GCP) [7]. Therefore, GCP has a direct influence on UAV-DTM and subsequent tree height estimates.

One of the benefits of UAV compared to Airborne Laser Scanning (ALS) technology is that it can be programmed independently to complete high-precision repetitive missions (Unmanned Aerial Vehicle Systems Advantages of UAVs, 2017). UAVs have the flexibility to carry devices to locations with very short time and, UAVs have repetition and high flexibility in the data acquisition process [8]. The UAV captures images with high spatial resolution, and when equipped with a multispectral sensor, the UAV provides the high spectral resolution images needed for segmenting and identifying tree species. However, multi or hyper spectral sensors are more expensive than the UAV itself. For this reason, most UAVs use low-cost RGB camera sensors, which produce images with high spatial spectrum resolution but are low in terms of altitude data acquisition. Image integration can be a way to increase identification of elevation points with UAV-LiDAR images [9-12].

LiDAR integration and imagery is the process of exploiting the power of two or more images from the same or different sensors to achieve better results. Integration here refers to the addition and final mixing of high points, or the addition of high-altitude layers. Image integration can be expanded into fusion, where relevant information from a set of images is combined and combined into a single image that is more informative and complete [9].

Through a trial of utilizing single frequency GPS KDP with a differential type of mobile positioning, which is used for aerial photography using UAV Photogrammetric, Harianto combines pocket cameras with very high resolution (42 Mpix, 16 bits) utilizing pulse generator and auto facilities trigger exposure for shooting low altitude air (100 m) above sea level. The results obtained from these experiments, produce high accuracy up to 0.010 m and accuracy of the position up to 0.002 m [12].

Roads in Indonesia have many types of damages, from small damage to heavy damage, from crocodile cracking, small holes to big holes. One of the problems is inventory data, time consuming and expensive way to get the data. For road condition survey, most of the cases still use conventional and

manual method to get types, measurements and area of damage. This manual way needs many people, sometimes hundreds people as surveyors. So that the data collections are becoming more expensive.

The advanced technology has enabled researchers to find a new way to collect data. Digital aerial photo can be used to obtain earth surface by using small format aerial photo, with the help of airplane and installing digital cameras. Unmanned Aerial Vehicles (UAV), Drone, which is equipped by camera, sensor, GPS, is used in this research. The picture format RGB (Red, Green and Blue) which is obtained from the attached camera in UAV. Every picture that is caught by camera of UAV needs to be interpreted for observing the shape of damage. The processing of picture RGB is completed with distance information from qualified camera for each picture that will give dimension of length, width of road crack or damage. Based on the developed technologies research is needed to use UAV; which is popular as drone to collect data of road damage. The aims of the study were to get data collection of road damage in a fast, cheap and efficient way and to use those data in the existing program such as Bina Marga and URMS.

2. Methods

Survey location was at H. M. Noerdin Pandji street, a primary collector road, at Kelurahan Kebun Sayur, kecamatan Alang-alang Lebar, Palembang. The survey is done on March 2017. First, the data was collected by using a drone. A manual data collection was done to confirm the data accuracy. The research programme was carried out according to the flow chart in Figure 1.

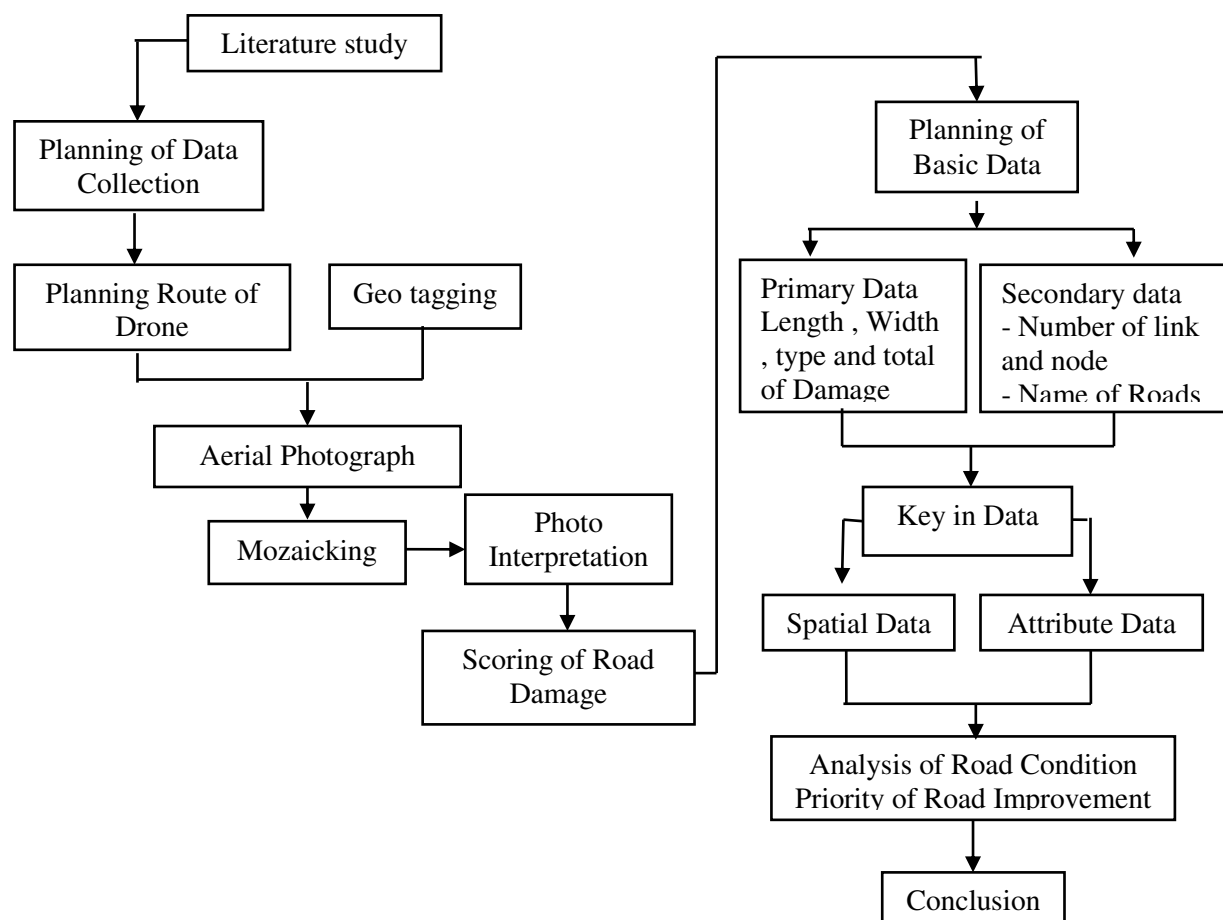


Figure 1. Flow chart of research.

Camera used for this research has photo format 24 x 36 mm, and length of camera focus (f) 18 mm. That specification is used to achieve the height and to find the minimum designed hole of 1cm [3]. Time needed to fly drone and to record the data is 15-20 minute for 600 meter length of road. The road width is 50 meter. For H.M Noerdin Pandji Street, which has 5200 length, it takes 130 minute to take aerial photo. From the survey experience, it can be concluded that the less wide the road, the faster photo recording on the field. To get sufficient coverage and resolution of spatial photo that is able to do interpretation of measurement, types of holes and road damages then the altitude of flying drone is planned initially as the following Figure 2.

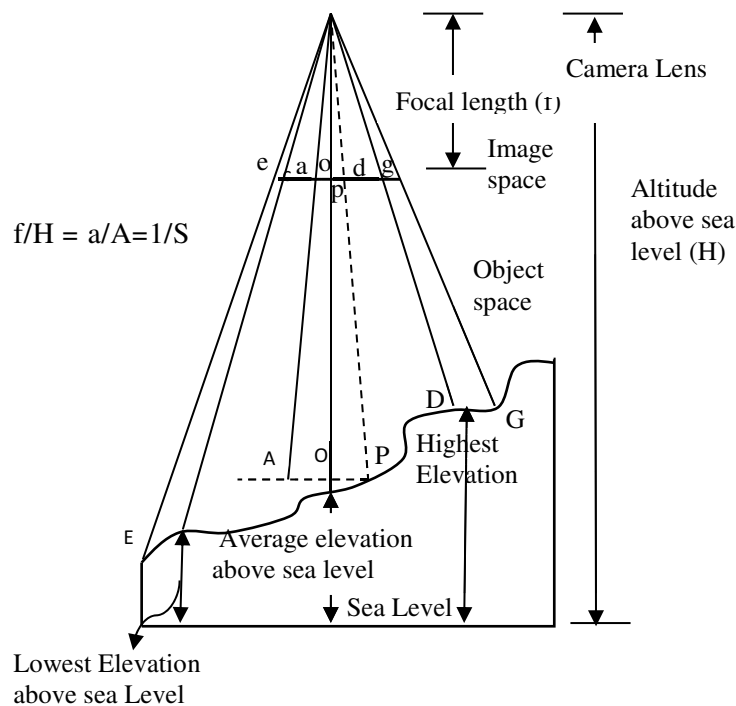


Figure 2. Correlation between Heights of flying, camera focuses and photo coverage.

3. Results and Discussions

Collected Data of Road Damage is described as the following sections.

3.1 Extraction of Digital Elevation Model (DEM) from aerial photo

By using software Arc-GIS 10.3, extraction of aerial photo is carried out with the steps of mozaicking and aerial triangulation as the following Figure 3.

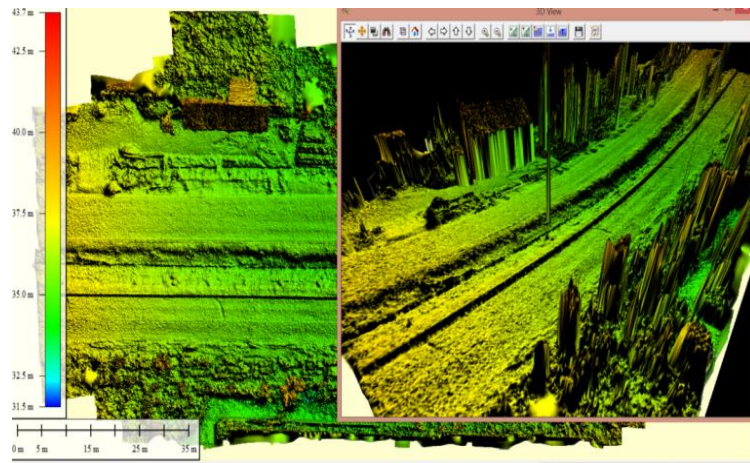


Figure 3. Three dimension of DEM results.

3.2 Identification of road damage

3.2.1 Providing contour line at the road damage. Providing contour line is done in order to get the potholes picture on the road. In this research interpretation is done with 2 cm interval and 10 cm index. The following picture shows the contour of road and side road.

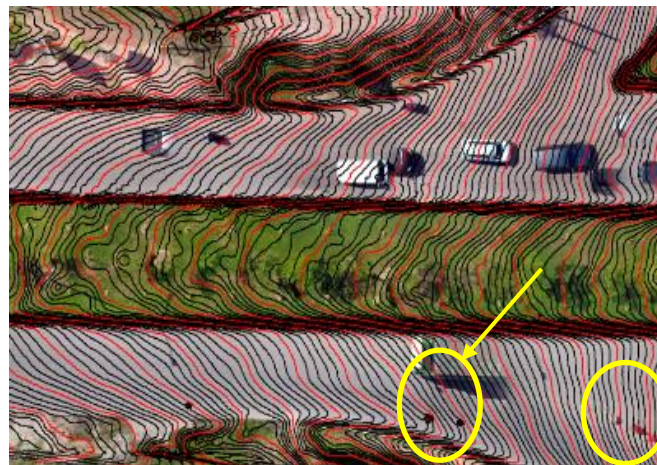


Figure 4. Identification results by Contouring.

The depth of potholes are presented and calculated from the picture, as it is described in Figure 5.

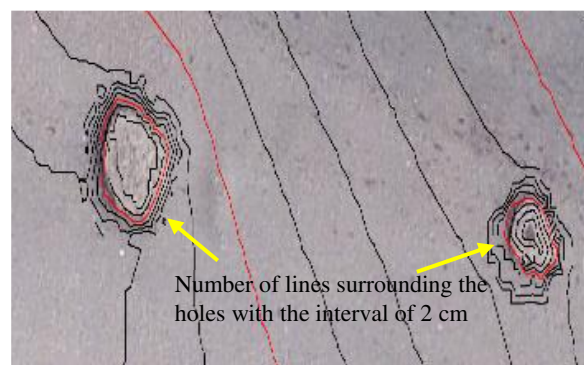




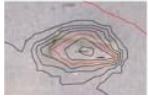



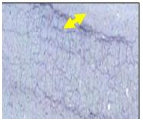

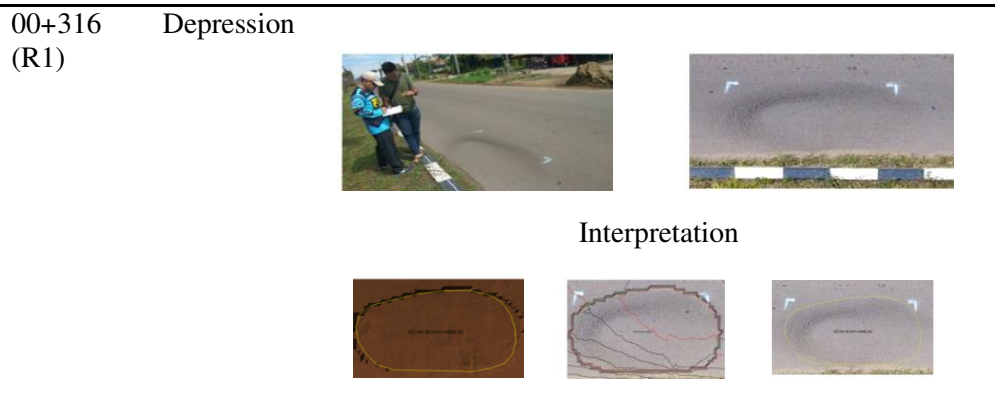


Figure 5. The depth of holes with interval of contour lines.

3.2.2 Types of Potholes. On station, STA 00 + 054 (left picture) after comparison and validation of manual photo and Aerial photo interpretation of potholes it reveals, the area of potholes is 0.054 m², length is 30 cm and width is 18 cm. The comparison can be seen as the following photo inside the Table 1.

Table 1. Comparison of manual photo and Aerial photo interpretation of potholes.

Station	Type of Damage	Manual photo	Aerial Photo
00+054 (L.2)	Potholes		
		Interpretation	
			
			
00+402 (R1)	Alligator crack		
		Interpretation	
			
			



3.2.3 Characteristics of damage condition. Pavement damages in this research are classified into 7 types, namely depressions, potholes, alligator crack, longitudinal crack, slip crack, patching, and reconstruction. Number of damage according to type of damage in the study area is shown in the following Table 2.

Table 2. Number of damage according to type of damage.

Type of damage	Number of points	% damage
Depression	8	7.407
Potholes	14	12.963
Alligator crack	39	36.111
Slip crack	10	9.259
Longitudinal crack	5	4.630
Patching	24	22.222
Reconstruction	8	7.407

3.3 Assessment and evaluation of road damage

3.3.1 Calculation. Road condition per 500 m segment is calculated. Given that the length of street H.M Noerdin Pandji is 5200 m, the width of Area belong to road or daerah milik jalan (Damija) is 40 m. Noted that Damija consist of 2 ways 4 lanes and 2 directions, each lane has 7 m width, and median is 6 m. The results of survey have 96 station, and some of the station recorded is shown in the following Table 3.

Table3. Types of Road damage.

No	Station	Post	Start Point	End Point	Type Of Damage	Code	Length	Width	Height	Area	Volume	Crack Width
1	00+030	L2	00 +030	00+30.3	Potholes	LB	0.30	0.28	0.10	0.08	0.01	
2	00+034	L2	00+034	00+34.4	Potholes	LB	0.40	0.36	0.10	0.14	0.01	
3	00+054	L2	00+054	00+54.3	Potholes	LB	0.30	0.18	0.05	0.05	0.00	
4	00+196	L2	00+196	00+199.0	Longitudinal Crack	RM	3.00	0.60	0.07	0.00	0.00	0.002
5	00+210	L1	00+210	00+212.0	Alligator Crack	RB	2.00	1.00		1.20	0.00	0.4
6	00+242	L2	00+242	00+245.0	Depression	AL	3.00	1.00		3.00	0.00	
7	00+244	L2	00+244	00+249.0	Depression	AL	5.00	1.30		6.50	0.00	
8	00+288	L2	00+288	00+298.0	Alligator Crack	RB	10.00	2.20		22.00	0.00	0.4
9	00+288	L1	00+288	00+292.3	Alligator Crack	RB	4.30	0.84		3.61	0.00	0.4
10	00+300	CL	00+300	00+306.0	Longitudinal Crack	RM	5.00		0.04	0.00	0.00	0.03
11	00+311	L2	00+311	00+314.0	Depression	AL	3.00	1.30		3.90	0.00	
12	00+311	CL	00+311	00+312.2	Longitudinal Crack	RM	1.20		0.04	0.00	0.00	0.02
13	00+348	CL	00+348	00+349.2	Potholes	LB	1.24	0.03	0.05	0.04	0.00	
14	00+354	L2	00+354	00+355.0	Alligator Crack	RB	11.00	5.40	0.04	59.40	2.38	0.4
15	00+360	L2	00+360	00+360.0	Potholes	LB	0.54	0.54	0.05	0.29	0.01	
16	00+484	L2	00+484	00+484.3	Potholes	LB	0.30	0.20	0.05	0.06	0.00	
..												
96												

3.3.2 Method of Bina Marga. From the above data results, it can be described as follows,

- Alligator crack (area = 86.21 m²; width = 4 mm; % area=5 %)
- Longitudinal Road (length = 9.20 m ; width = 3 mm)
- Potholes (area= 0.67 m²; % area= 0.019 %)
- Depression (area = 13.40 m²; % Area = 0.383 %)

Scoring:

A. Cracking

1. Crocodile crack ; score = 5 + 3 +1 = 9

2. Longitudinal crack ; score = 2 + 3 = 5

B. Potholes (area<10% ;score 0 (L=0.019 %)

C. Depression (0-2/100m ; value 1 (L=0.383%)

Total Value = 15

Total score of road condition = 5

Priority = 17-(class of AADT + Road condition score) =7

This means, the road sections need routine maintenance.

3.3.3 Urban Road Management System (URMS). With the same data from aerial photo, URMS method can be applied to get the road priority maintenance. URMS method is published in guidance book for survey of road conditions No. 05/T/BNKT/1991 by directorate general of Bina Marga [13]. The result is the same as previous method, which need routine maintenance.

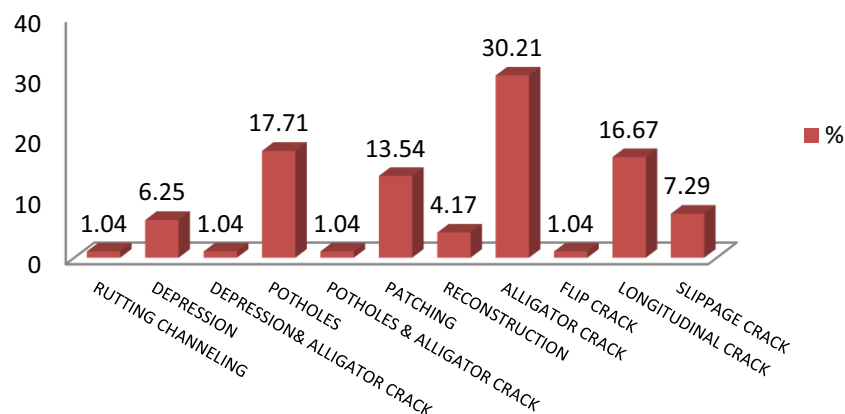


Figure 6. Percentage of number of damages according to damage types.

4. Conclusions

From the above results and discussions, it can be concluded that:

- 1) Road damage data can be obtained from photo interpretation and with good results. The Accuracy result is about 97.83 %.
- 2) Road improvement planning can be done by using of aerial photo interpretation and the existing program Bina Marga, and URMS.

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