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Implementation of CSP1 Matrix Application for Roof Defects Inspection: Case Study in F2 Examination Hall UTHM

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Abstract: The roof is a component of the structure's covering and usually it's place in a higher place that need to use ladder to see the condition. Furthermore, because of the risks posed by these characteristics, roof inspectors have difficulties completing rooftop inspections owing to the high roof structure and assisting it if it runs on it. The goal of this research is to use a UAV to enter faulty structures for visual inspection and to categories roof building problems using the CSP1 Matrix as a technique of evaluation and ultimately acquire the condition of the roof condition between the main hall of Universiti Tun Hussein Onn Malaysia. The main hall was elected in the UTHM area namely the examination hall (F2) UTHM. Unmanned Ariel Vehicles (UAV) was used for visual monitoring and Condition Review Protocol (CSP) 1 Matrix was used to analyze the assessment of building roof conditions and to identify the seriousness of defective buildings detected for the roof's hall. Therefore, 19 defects for F2 examination hall UTHM have been recorded on the roof surface and the overall roof condition is calculated is 2.4 (Green). The result indicates that the state of the roof for F2 examination hall UTHM is in a fair condition (score 1-4) by referred to overall roof rating by CSP1 Matrix. Total defects in research studies are 46. Researcher conclude that, UAV is recommended for visual inspection and CSP 1 Matrix is really helps in evaluate the extent of the defects of roof structures. All the suggested maintenance work needs to be discussed and verified by the professionals

Keywords: Visual Inspection, Spatial Data, CSP1 Matrix, UAV, Roof State

1. Introduction

CSP1 Matrix method is usually implement for building façade. This research if focus on implementing CSP 1 Matrix for roof monitoring since roof is a component of the structure's covering and it is usually placed in a higher place that need to use ladder to see the roof condition. When it comes to building maintenance issues and problems, researchers have identified some issues, particularly from

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management and the general public. Furthermore, there is no single, systematic framework that can assist the maintenance team in planning, executing, controlling, and evaluating a building's maintenance performance [1]. The building's height, as well as the need to cover the entire city, should be taken into consideration. Aside from the safety considerations, the time needed for the inspector to complete his work has increased. if the building is more than 5 storey high or higher, it is nearly impossible to climb using a ladder to reach the roof. As technology advances, so does the desire for components to be produced at a lower cost and at a quicker rate. For component remodel, photogrammetry technology is applied. Photogrammetric data acquisition is based on the principle of non-contact passive data collection. Aerial photogrammetry is the process of collecting images of large areas from the air. Photographs of an object are the subject of terrestrial photogrammetry [2]. A proper and efficient ways to inspect roof which is by using Unmanned Aerial Vehicle (UAV) must be taken to lower down the risk of getting disability or death cases cause from roof inspection incidents. Because of their growing recognition among the general public, unmanned aerial vehicle (UAV) have become useful tools in a variety of businesses throughout the world [3]**.** UAV have a variety of uses in the facilities industry, including monitoring and inspecting various components of a building and sites [4].

The use of unmanned aerial vehicles (UAVs) is a recent addition to the Computerized Maintenance Management System (CMMS). One of the most essential approaches for determining if a roof has faults is to conduct a visual assessment using a UAV [5]. The goal of inspection, according to [6], is to offer to advice on the state of the inspected area at the time of inspection. The significance and impact of this research will assist organizations and building owners in avoiding losses in building maintenance work as well as increasing the value of their building investment. The scope of this study is by using Pix4Dmapper, create complete high quality images of the surface of the roof structure of the F2 examination hall UTHM from the air to locate and evaluate the extent of defects of the roof structure by refer to JKR specifications of types of defects and refer to Condition Survey Protocol (CSP1) Matrix method to classify the overall rating of the roof structure.

Building inspection rating criteria are constantly being established. The first to contribute was Pitt, followed by Alani et al., Adi Ifran Che-Ani et al., Mahmood, and RICS [7], [8], [9], [10], [11]. N.Hamzah and Alani et al., provided rating standards that may be used to evaluate any form of structure [12][8]. The CSP1 matrix is used to assign a grade to the best property condition evaluation. Because the information input facts are dependent on the state and damage evaluation, this grid may be used for a variety of constructions. Even though damage to each structure is small, the work on the roof may change. The grid format cannot demand any overview of work circumstances [13].

Inspections were carried out on the roofs of F2 examination hall Universiti Tun Hussein Onn Malaysia. Researchers need to find defects on each roof surface structure. Following the discovery of defects, the researcher will use the CSP1 Matrix approach to determine the defect type and suggestion for improvements.

2. Monitoring of roof defect using ariel photography

Focusing technique in data acquisition, which has been thoroughly documented throughout numerous phases. This paper's critical path is data acquisition and data processing. The method and procedure for obtaining photogrammetry from an unmanned aerial vehicle (UAV), the planning of flights and The CSP1 Matrix method for condition assessment.

In general, the method is followed by the phases given in (a,b,c,d) in the first paragraph. For investigating and attaining the goal, several methodological phases have been devised, including data quality, software discovery, data processing, data collection, and data analysis. This methodology will be used in this project.

a) Phase I – Research Plan and Literature Review
b) Phase II – Data Acquisition
c) Phase III – Data Processing
d) Phase IV – Result and Analysis

2.1 Data acquisition and visual inspection

The first step in data acquisition was visual inspection which required flight person to setting up and fly the UAV and the use of Pix4DCapture software to plan the UAV route, as seen in Figure 1 and Figure 2 respectively. It is critical to prepare thoroughly and precisely before start the data collecting procedure. The goal of this part was to use Pix4DCapture for DJI devices to build a UAV route, project scale, overlapped, height, speed, and sensor coordination system. Overlapped will be set at 60%, in order to create a good quality images for this project. This part must prevent any UAV issues throughout the flight. The operator must calibrate the remote controller and the UAV internal GPS observation signal to ensure it is ready to fly with the coordinates pre-set in flight planning.

Figure 1: Researcher fly the UAV DJI Phantom 4 Pro

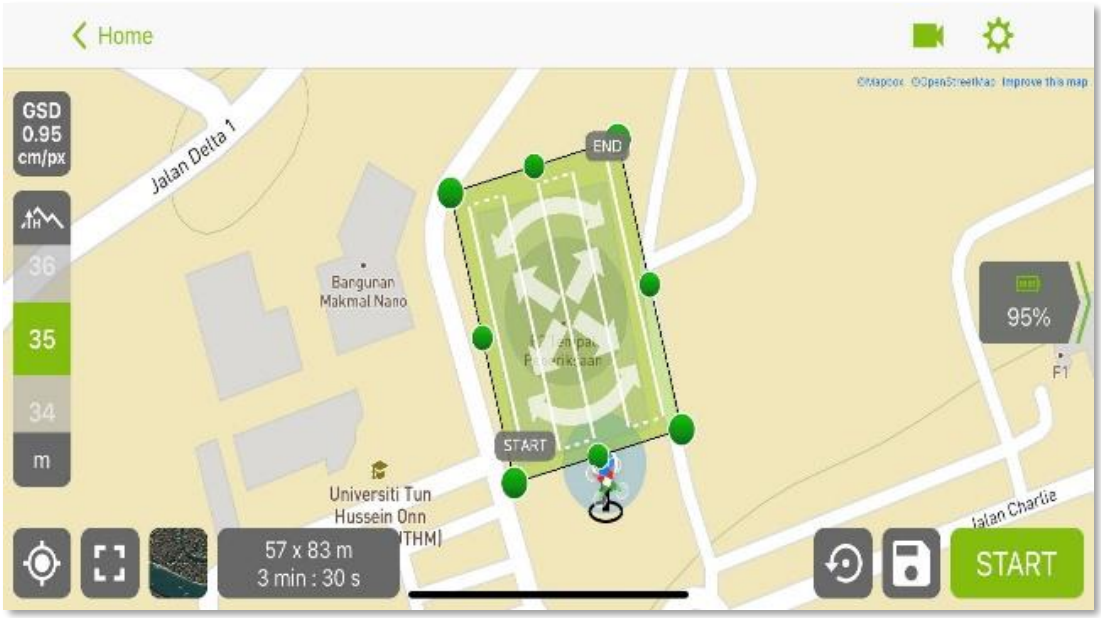

Figure 2: Interface for Pix4D Capture apps for flight planning

For Image processing the photography process was done using Pix4dmapper software (Figure 3) which the batch of images to Pix4dmapper was uploaded. This image processing involved 3 phases which is Initial Processing, Point Cloud and Mesh and DSM, Orthomosaic & Index.

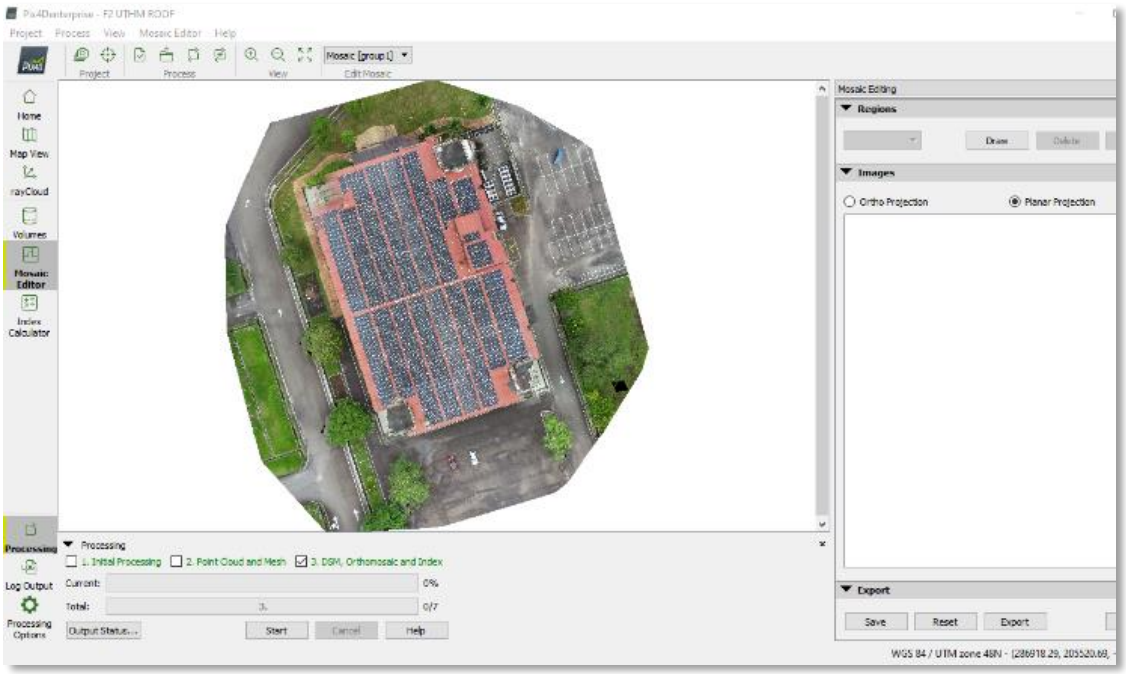

Figure 3: Interface for Pix4D Mapper image processing

The entire area of the roofs of examination hall at block F2 UTHM was image processed to generate an orthophoto with Pix4d Mapper to display the full area and high quality images of F2 examination hall UTHM (Figure 4). The stages in this method are to upload a photo to Pix4D Mapper, order it in one photo, and then open it in Adobe Photoshop to labelled picture flaws. The image produced must fulfil the criteria which is must be clear, not blurry and bright, the images overlapped more than equal 60%.

Figure 4: Steps of image processing F2 examination hall UTHM

The image will be magnified to clearly reveal faults, and the brightness and contrast will be modified to improve picture outcomes. DJI is a code that obtained from the drone's initial name which is DJI Phantom 4 PRO and the number afterwards is the number of the individual picture.

2.2 Condition evaluation by using CSP1 Matrix

The data required for the CSP 1 Matrix are the condition and priority assessments, as shown in Tables 1 and 2. A scale value and description are provided for each numerical score (1–5). This will certainly help surveyors rate a building's faults, which will subsequently establish the exact condition represented by the scale valves [14].

Each flaw is assigned a condition and a priority grade. The overall score for each flaw is then calculated by multiplying each rating. The scores varied from 1 to 20, with the colour (green, yellow, or red) applied to each of the three characteristics to denote the score: Maintenance should be planned (1 to 4), Condition Monitoring (5 to 12) and Serious Attention (13 to 20). This method made determining the severity of each defect discovered during the building inspection much easier [3].

To prevent the risk of surveyors/clients misinterpreting the amount of defects, maintenance standards and/or definitions of defects must be allocated carefully for each rating. It is critical to address red-coded defects first, as they may have an impact on the overall state of the building, in addition to posing a risk to those who are currently using it. Aside from that, surveyors may be able to supply clients with well-informed defect reports as a result of this [12].

Table 1: Condition Assessment Protocol 1 (CSP1)

Condition	Description	Scale
1	Good	Minor work
2	Satisfactory	Minor Repairs
3	Poor	Major Repairs / Replacement
4	Very Poor	Damage
5	Dilapidated	Damage / Replacement of Missing Parts

Table 2: Priority Assessment

Priority	Level	Description
1	Normal	Functional: Cosmetic defects only
2	Routine	Minor defects, but can be serious if left unattended
3	Urgent	Serious defects, not functioning to acceptable standards
4	Emergency	Elements / structures not functioning at all: OR indicates a risk of death and / or injury

3. Analysis of CSP1 Matrix

The CSP1 matrix concept was used in this research to produce a reliable and accurate outcome. Matrix Assessment and Planned Maintenance were used in this study, as shown in Tables 3 and 4.

Table 3: Matrix assessment (CSP1 Matrix Method) [9]

Scale		Priorities Assessment			
		E4	U3	R2	N1
Conditions Assessment	5	20	15	10	5
	4	16	12	8	4
	3	12	9	6	3
	2	8	6	4	2
	1	4	3	2	1

Table 4: Maintenance Plan (CSPI Matrix Method) [9].

No	Matrix	Score
1	Planned Maintenance	1 to 4
2	Condition monitoring	5 to 12
3	Serious attention	13 to 20

Upon scoring of each defect, the overall building rating is produced, which summarises the state of the building. The overall building rating is calculated by adding the scores of each defect and dividing them by the total number of faults.

The building is then rated Good, Fair, or Dilapidated based on the score (out of 20); Table 5 gives the overall building ratings [6-7]. The Schedule of Building Condition form records all of the information acquired for the CSPI Matrix. The CSP1 Matrix includes an image box, a defect plan tag, and an executive summary for reporting purposes, as illustrated in Figures 2 and 3. Figure 4 depicts the findings of all defects on the F2 examination hall and figure 5 depicts the analysis between condition and priority assessment.

Table 5: Overall building Rating (CSPI Matrix Method) [9]

No	Matrix	Score
1	Good	1 to 4
2	Fair	5 to 12
3	Dilapidated	13 to 20

Details	Location of defect image	Enlarged image
Defect position: 1 (Figure 4.2) Condition: 2 | Priority: 2 | Matrix: 4 | Colour Element/components: EL/CS 15: Roof Defect information: DS/CS 27:Vegetation growth Suggestions for improvement: Remove the vegetation growth and resolve the cause of the vegetation growth.		

Figure 5: Example of defects (vegetation)

Defect position: 16 (Figure 4.2) Condition: 2 | Priority: 1 | Matrix: 2 | Colour Element/components: EL/CS 15 Roof Defect information: DS/CS 21: Rust Stain Suggestions for improvement: Remove the rust stain using rust removing solutions and resolve the cause of the rust on the steel roof.		

Figure 6: Example of defects (rust stain)

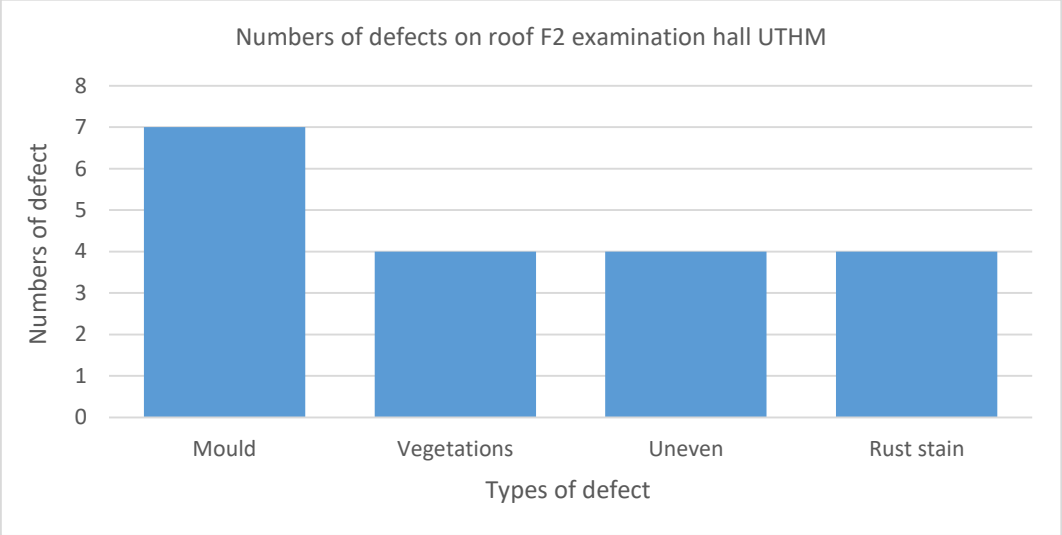

Figure 7: Numbers of Numbers of defects on roof F2 examination hall UTHM

Total = 46 Total mark, d = 46 Defects numbers, e = 19

Total score, d/e = $\frac{46}{19}$ = 2.4

Assessment overall building = good

Maintenance Plan = Planned maintenance

4. Conclusion

In conclusion, it was determined that UAV offers benefits in doing low-slope roof assessment inspections. The overall safety of the inspector, as it could eliminate the need to physically walk the roof, any damage caused to the roof by the inspector during the inspection walk and the time spent is excessive, especially during site inspections. So, the roof of F2 examination hall is in a good condition since majority of the roof are using galvanized zinc roof sheets. It is just quite poor condition on the slab roof of stairs of F2 examination hall. Therefore, it is recommended that periodical inspections be carried out on this roof's building and that any actions recommended by this report are carried out to prevent further dilapidation to the building.

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