DEVELOPMENT OF INTEGRATED 3-DIMENSIONAL AND VIRTUAL REALITY DIGITAL OUTCROP MODEL OF SEDIMENTARY ROCK SLOPE

MUHAMMAD AFIQ NA'IMULLAH BIN ALLIAS

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By

MUHAMMAD AFIQ NA'IMULLAH BIN ALLIAS

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Name of Student: **MUHAMMAD AFIQ NA'IMULLAH BIN ALLIAS**

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

Signature: Approved by:

(Signature of Supervisor)

Date : 10 / 08 / 2022

Name of Supervisor : Assoc. Prof. Ir. Dr. Mohd Ashraf Mohamad Ismail

Date : 10/8/2022

Approved by:

(Signature of Examiner)

Name of Examiner : Ts. Dr.Mastura Azmi

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ABSTRAK

Semasa Revolusi Perindustrian Keempat (IR 4.0) ini di mana kemajuan dalam teknologi berada di kemuncaknya, beberapa perkara menjadi menjadi lebih mudah dan senang. Dengan melaksanakan teknik fotogrametri udara dengan bantuan Unmanned Aerial Vehicles (UAV), khususnya menggunakan dron DJI Phantom 4 Pro, model singkapan digital 3 dimensi boleh dihasilkan oleh hujung jari sahaja. Model singkapan digital kemudiannya akan dinilai untuk mengumpul ciri geologi bagi singkapan cerun batuan menggunakan teknik pemetaan geologi konvensional dan model 3D. Dalam kajian ini, model singkapan digital 3D dibangunkan menggunakan perisian pemetaan dron dan output akan dianalisis selanjutnya menggunakan perisian geologi seperti Perisian Virtual Reality Geological Studio (VRGS) untuk menilai secara digital dan melakukan beberapa tafsiran geologi bagi model singkapan cerun batu. Bagi ahli geologi dan jurutera batu, fotogrametri digital ialah alat yang berguna dalam teknik pencirian jauh di mana mungkin terdapat beberapa had dan kesukaran untuk penilaian ketakselanjaran fizikal dilakukan. Kaedah pengumpulan data dan ketepatannya daripada kerja lapangan konvensional mungkin juga tidak mencukupi kerana batasan sebelumnya ditambah kerja lapangan konvensional mungkin memerlukan masa dan penggunaan tenaga. Perbandingan tentang keupayaan dan batasan antara data analisis digital dan data kerja lapangan konvensional akan diterangkan semasa kajian ini dan juga batasan setiap perisian individu yang digunakan dalam mendapatkan sifat ketakselanjaran jisim batuan. Kestabilan kinematik menggunakan stereonet akan diterangkan lebih lanjut untuk menentukan kemungkinan jenis kegagalan tapak singkapan cerun batuan sebenar.

ABSTRACT

During this Fourth Industrial Revolution (IR 4.0) where the advancement in technology is at its peak, some things just becoming to get much easier and simpler. By implementing aerial photogrammetry techniques with the aid of Unmanned Aerial Vehicles (UAVs), specifically using DJI Phantom 4 Pro drone, a 3-dimensional digital outcrop model could be generated by your fingertips. The digital outcrop model would then be evaluated to gather geological characteristics of the rock slope outcrop using the conventional geological mapping technique and 3D model. In this study, 3D digital outcrop models are developed using drone mapping softwares and the output will be further analyze using geological softwares such as Virtual Reality Geological Studio (VRGS) Software to digitally evaluate and do some geological interpretations of the rock slope outcrop models. For geologists and rock engineers, digital photogrammetry is a helpful tool in remote characterisation technique where there may be some limitations and difficulties for a physical discontinuities evaluations to be done. Data collection method and its accuracy from conventional fieldwork may also not sufficient enough due to previous limitations plus conventional fieldwork may be time and energy consumption to be done. Comparison about the capabilities and limitations between the digital analysis data and conventional fieldwork data will be explained during this study and also the limitations of each individual softwares used in obtaining the nature of discontinuities of a rock mass. Kinematic stability using stereonet will be further explained to determine the possible failure types of the real rock slope outcrop site.

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LIST OF ABBREVIATIONS

2D	Two - Dimensional
3D	Three - Dimensional
DOM	Digital Outcrop Model
VR	Virtual Reality
UAV	Unmanned Aerial Vehicle
SfM	Surface from Motion
DEM	Digital Elevation Models
DSM	Digital Surface Models
GIS	Geographic Information System
RGB	Red, Green, Blue
ISO	International Standards Organization
ISRM	International Society for Rock Mechanics
JRC	Joint Roughness Coefficient
VRGS	Virtual Reality Geological Studio
TVT	True Vertical Thickness
UCS	Uniaxial Compressive Strength

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Outcrop is an area where a large formation of rock were exposed on the surface of the earth. This phenomena occur when the mantle of soil and vegetation which covered the bedrock is separated through erosion and rapid weathering which often occur on steep hillsides area and mountain ridges. This outcrop may also happens during excavations for quarrying and others activities which were done by human ourselves. From the outcrop, the rock formation could be observed clearly in situ for further analysis the rock behavior and also study the slope stability of the outcrop itself. For this particular studies, a 3D outcrop model will be created from a set of aerial photogrammetry that was taken by a drone from the air. Digital Outcrop Model (DOM) or spesifically known as virtual outcrop model is when the outcrop model is represented into a digital 3D model which textured in polygon mesh form. DOM can be used to interpret in details all the geological features such as the orientation of the geological surfaces, and also the properties of the layers.

To achieve the highest accuracy of the measurable geological features, the resolution of the outcrop model and its accuracy should be elevated to its fullest. Some of the key advantages of Digital Outcrop Model is that these digital model could cover inaccessible areas such as high cliff walls or dangerous slope failure areas through remote sensing devices such as Unmanned Aerial Vehicle (UAV) or commonly known as drone. Unmanned aircrafts offer low risk and high efficiency in its mission to capture photos which later would be stitched together using SfM to generate a high-resolution DEM (Trembanis et al., 2021). Furthermore, all the data from the outcrop model could be collected in short period of time compare to the conventional fieldworks which may be risky and time consuming. Digital outcrop model could be

georeferenced which allows for intergration with other spatial features and produces digital geologic mapping and also Geographic Information System (GIS) database. The textured 3D outcrop models may also be visualised using a point cloud data which will enhance the outcrop aerial images thus making the topography of the outcrop accurately visualised and facilitates the geological interpretation. Structure from Motion(SfM) photogrammetry has been a good initiative and efficient method to reconstruct a highly resolved and accurate 3D Digital Outcrop Model(DOM) from set of images (The point cloud derived from Surface from Motion (SfM) is created from images and always comprises of red, green and blue (RGB) band attributes (Guo et al., 2019).

Although DOM can be used to observe the geological features of an outcrop, the 2 dimensional viewing method will have its limitations to better understand the 3D geometry and the outcrop scale itself. One of the way to overcome this limitation and provide a better interpretation of the DOM is by integrating it into a Virtual Reality(VR) environment. The users are enable to experience a real scale and much realistic observation of the actual remodelled geological features. VR could enable a much more precise interpretations and characterization that are almost similar to the real conventional fieldwork.

1.2 Problem Statement

Conventional fieldworks of gathering geotechnical information from an outcrop is crucial as it is the only way of gathering in-situ geological data back in the days. However, this method may have some reachability limitations as the exposed rock outcrops site is usually near the slope. The safety measures and risk assessment are also crucial throughout the conventional fieldworks to prevent any potential accidents from occur. By integrating Virtual Reality in the current method, it could enable and enhance the interpretations and characterizations of the outcrop which are alomost as similar as the real conventional fieldwork. In addition, the accuracy of the final findings may also be compromised if the structure is disrupted thus affecting the integrity of the sample itself. Furthermore, the manual data collection may also differ based on the visual perception of various individuals making the informations obtained from the observations to differ thus the critical informations needed may be amiss. The accessibility and reachability of the conventional fieldworks could also be beyond the standard height of reach unless some advanced photogrammetry technology is used to cover those inaccessible areas. Last but not least, the overall process of conventional fieldworks may be time and energy consuming to obtain the final findings compare to image analysis technique. In short, the implementation of DOM could be a solution for the limitation and restictions from the conventional fieldworks which are very risky plus time and energy consuming.

1.3 Objectives

The main purposes of this study are as follows:

I. To develop a 3D model of the rock slope outcrop using UAV-SfM photogrammetry technique.

II. To evaluate the geological characteristics of the rock slope outcrop using the conventional geological mapping technique and 3D model.

III. To integrate the rock slope outcrop model analysis into the virtual reality environment.

1.4 Scope of works

1) Three simulated digital outcrop model full with geological interpretations shall be presented in the virtual reality environment using Meta Quest 2 VR Headset with the help of Virtual Reality Geological (VRGS) Software.

2) Discontinuities orientation, scale measurement, discontinuities mapping, and stereographic projections analysis should be included in the digital outcrop model final output.

3) Discontinuities orientation comparison between VRGS software, CloudCompare, and geological compass.

1.5 Dissertation Outline

This dissertation paper has been broken into numerous chapters for a better understanding of this analysis. The chapters are listed as follows.

Chapter 1: This chapter summarises the key findings of the study and gives an overview of its contents. In this chapter also would provides a conceptual framework for the researcher's research, including scientific challenges, hypotheses, and basic research organisation.

Chapter 2: This chapter would compile and details all similar case for analyzing research topics and formulating a research methodology. It covers the topic, the primary research problem, the question(s), and the design elements and also the theoretical framework for the thesis.

Chapter 3: This chapter mainly describes the dissertation's research methodology. This chapter delves deeper into the study technique, research methodology, data collection methods, dataset preparation, research procedure, data analysis format, ethical issues, and project research limits.

Chapter 4: This chapter would summarise all the information gathered, analyse it, and present the findings.

Chapter 5: This chapter gives a thorough review of the context of the analysis. This chapter will make assumptions, implications, and suggestions.

1.6 Expected Outcomes

The finished 3D Digital Outcrop Model will provide a detailed visualization of the outcrop 3D model in Virtual Reality (VR) environment. This model will also provide results of structural interpretations of the virtual outcrop model and characterized the discontinuities and dip and dip direction of faults, fractures or beds.

1.7 Importance and Benefits

Virtual digital outcrop model will assist people to have proper visualization and understanding about geological features of the rock formations without having to physically be on site. This model will act as an alternative for those whom have limitations and restrictions to be on site due to site inaccessability and safety reasons.

CHAPTER 2

LITERATURE REVIEW

2.1 Chapter Overview

In this chapter all the primary parameters which were covered in the previous researches that have been done prior to the study would be highlighted. A comparison of some definitions, parameters, methodology, results and discussion and lastly conclusion and also limitations will be highlighted as a part of summary. Some of the topics include are rock discontinuities and its orientation, Digital Outcrop Model(DOM), Virtual Reality(VR) outcrop.

2.2 Discontinuities of Rock

As a solid mechanical behaviour, it is okay to assume that they are homogeneous, isotropic, and continuous. But, since rocks consists of discontinuities, this will make them different from other engineering materials. In result, a strong distinction must be made between the rock material and also the rock mass (ISRM, 1979). Rock material is a continuum or polycrystalline solid between discontinuities composed of mineral aggregated or grains while rock mass is an assemblage of rock blocks separated by various types of geological discontinuities (ISRM, 1979).

Discontinuity can be referred as any distinction in a rock mass with poor tensile strength. Discontinuities collectively includes weak bedding planes, weak zones, faults and most types of joints (Palmstr, 2006).

The following table is list of the commonly known discontinuities with its respective descriptions of their individual engineering properties.

Table 2.1 : Common Discontinuities with its Description

Type	**Description**	**Source**
Faults	- discontinuities with identifiable shear displacement - pervasive characteristics that span a wide area or relatively limited to a local extent - often occur in echelon or in groups	(Palmstr, 2006)
	- a fracture or a fracture zone where there has been distinguishable displacement - walls are polished due to shear displacement - shattered and weathered sides of faults result in fillings	(ISRM, 1979)
Bedding planes	- classify sedimentary rocks into strata or beds - may contain different grain sizes of parting material with cohesion between beds	(Palmstr, 2006)
Joints	- a geologically induced break in the continuity of a body of rock along which no apparent displacement occurred - set: a group of parallel joints; joint system: intersection of joint sets - form parallel to bedding planes, foliation and cleavage	(ISRM, 1979), (Palmstr, 2006)

2.2.1 Discontinuities Parameters of Rock Mass

The primary parameters of discontinuitie is orientation. Orientation is the attitude of discontinuity in space and can be described with dip value dip direction or called azimuth which is the line of the steepest declination in a plane of discontinuity.

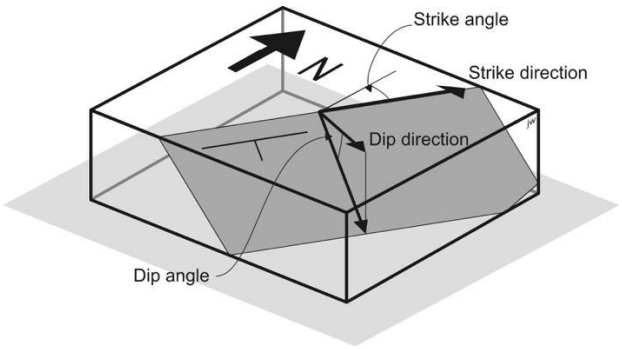

Figure 2.1 : Dip, and dip-direction of a plane with strike angle (Waldron & Snyder, 2020).

Next, spacing refers to the perpendicular distance between the adjacent discontinuities and usually refers as the mean of a set of discontinuities.

Roughness is the inherent surface waviness relative to mean plane of the discontinuities. It may contribute to the shear strength and coul alter the dip locally under a large scale waviness.

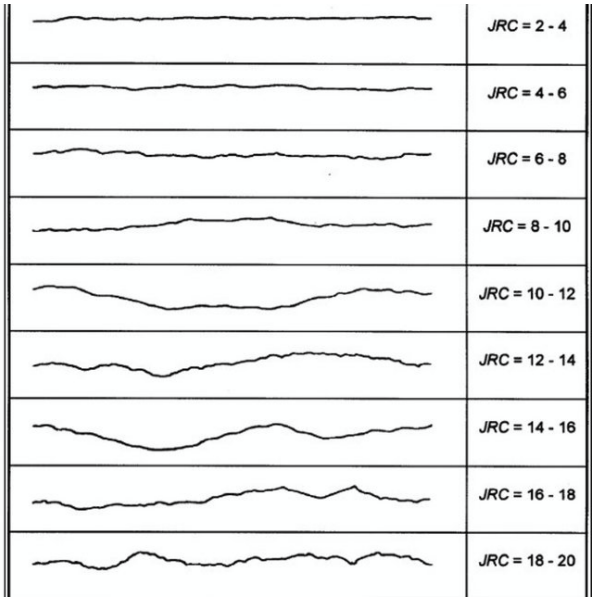

Figure 2.2 : Joint Roughness Coefficient (JRC) (Serasa et al., 2017)

Number of sets is the number of discontinities set from the similar discontinuity system. Rock mass may be further divided according to each respective discontinuities. . The most important parameters of discontinuities including dip, dip direction, extension, infilling materials and percentage of infilling, roughness, and joint compressive strength are measured (Mohebbi et al., 2017)

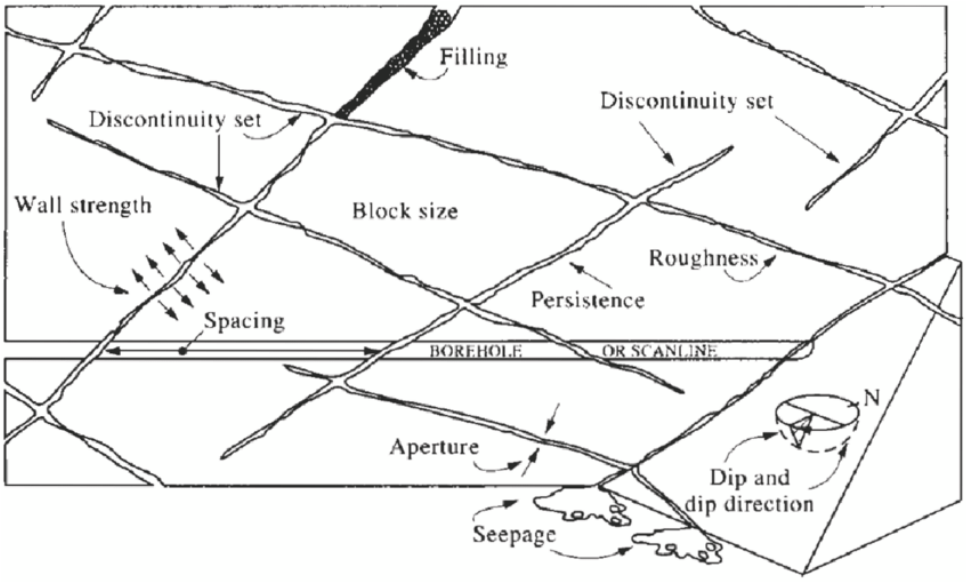

Figure 2.3 : Discontinuity parameters of a rock mass (Singh et al., 2019)

2.3 Rock Outcrop Model

Unmanned aerial vehicles (UAVs) and digital photogrammetry are useful for detecting discontinuities in areas where field mapping, terrestrial photogrammetry, or laser scanner surveys cannot be used because the slope is dangerous, inaccessible, or has complex geometry with areas that are not visible from the ground. The acquired images can be used to create a 3D texturized digital outcrop model (TDOM) and a detailed point cloud representing the rock outcrop using the Structure-from-Motion method (Menegoni et al., 2019). Structure from Motion(SfM) photogrammetry has been a good initiative and efficient method to reconstruct a highly resolved and accurate 3D Digital Outcrop Model(DOM) from set of images (The point cloud derived from Surface from Motion (SfM) is created from images and always comprises of red, green and blue (RGB) band attributes (Guo et al., 2019).

2.4 Image Analysis Technique

Recent advances in discrete element modelling and computer power have enabled the creation of detailed simulations of jointed rock masses. In order to model a realistic jointed rock mass, the numerical approach used must have two characteristics: it must include a realistic geometric model of fracturing and it must capture rock block breakage through fracture growth (Gao & Kang, 2016).

In the photogrammetric remote sensing section, the SfM-MVS technique reconstructs the 3D virtual slope with high resolution and accuracy in the form of both 3D point clouds and photorealistic 3D mesh models based on multiple UAV imagery of the rock slope (Y. Zhang et al., 2019). The DSE, qFacet FM, and qFacet KD-tree methods were used to perform semi-automated discontinuity mapping using the point cloud on the same 3D model (Menegoni et al., 2019).

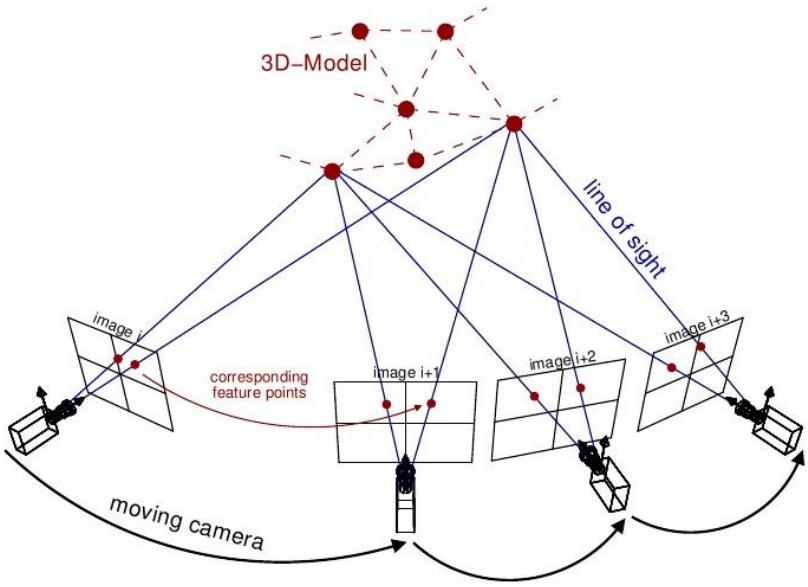

Figure 2.4 : Surface from Motion Photogrammetric Model (Riel, 2016)

Complex landscapes with high topographic relief and intricate geometry present challenges for complete and accurate mapping of both lateral (x, y) and vertical (z) detail without deformation (Nesbit & Hugenholtz, 2019). Latest remote sensing techniques such as

Surface from Motion (SfM) and Terrestrial Laser Scanner (TLS) 3D-laser scanning allow discontinuities to derive both the strike and dip direction (Riquelme et al., 2017).

2.5 Photogrammetry Technique

The detailed 3D outcrop models serve as the fundamental data foundation that governs the susceptibility analysis's resolution, precision, and reliability. Close-range remote sensing technologies, such as LiDAR and photogrammetry, are revolutionising the acquisition of 3D virtual outcrops of rock slopes with high resolution and precision for susceptibility analysis, far outperforming traditional survey methods of fracture windows sketching and the assumption that simplifies the entire slope with a uniform dip and dip direction (Y. Zhang et al., 2019).

The photogrammetric method is an estimation method for obtaining 3D object metric data (shape, position, and size) by estimating the spatial coordinates of each point in photos. Because each snapshot only contains 2D coordinates, estimating 3D coordinates of locations necessitates at least two overlapping photographs taken from different angles of view (Corradetti et al., 2017). This method uses advanced technologies to obtain morphological data via remote acquisition, which is typically represented by images with 3D point clouds, and can supplement and, in some cases, replace traditional engineering-geological surveys for characterization of rock outcrops. These processes allow data to be collected from a certain distance away from the rock face, depending on the instrument requirements and the required data resolution or outcome information, thereby reducing acquisition time and improving worker safety (Salvini et al., 2020)

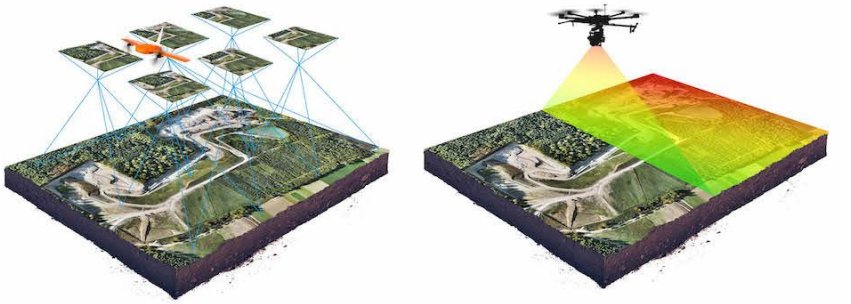

Figure 2.5 : Photogrammetry Model (Source: Website at Wingtra.com)

UAV photogrammetry has enabled the collection of DEMs and orthophotos in a cost-effective and realistic manner. However, it is critical to ensure that the data is accurate and within acceptable limits. GCPs must be placed on the outskirts of the study region in order to achieve optimal results solely in planimetry. However, if total accuracy, including horizontal and vertical components, is required, the best accuracies are obtained by placing GCPs around the edge of the study area, but stratified distribution of GCPs within the study area is also required to maximise vertical accuracy (Martnez-Carricondo et al., 2018).

2.6 Virtual Reality Technology

Virtual Reality (VR) implementation in planetary sciences is not a recent idea (McGreevy, 1993) but the advancement of hardware and software as well as democratization of powerful computing units have made it more reachable in the community. Currently, there are a few low-cost solutions which enable the VR experience using publicly available dedicated game-based engines (Mat et al., 2014; Murray, 2017) which provide a solution to produce VR scene and environment. To produce simulated virtual reality outcrop experience, the main component needed is the high resolution DOM that were produced by ground or aerial images.

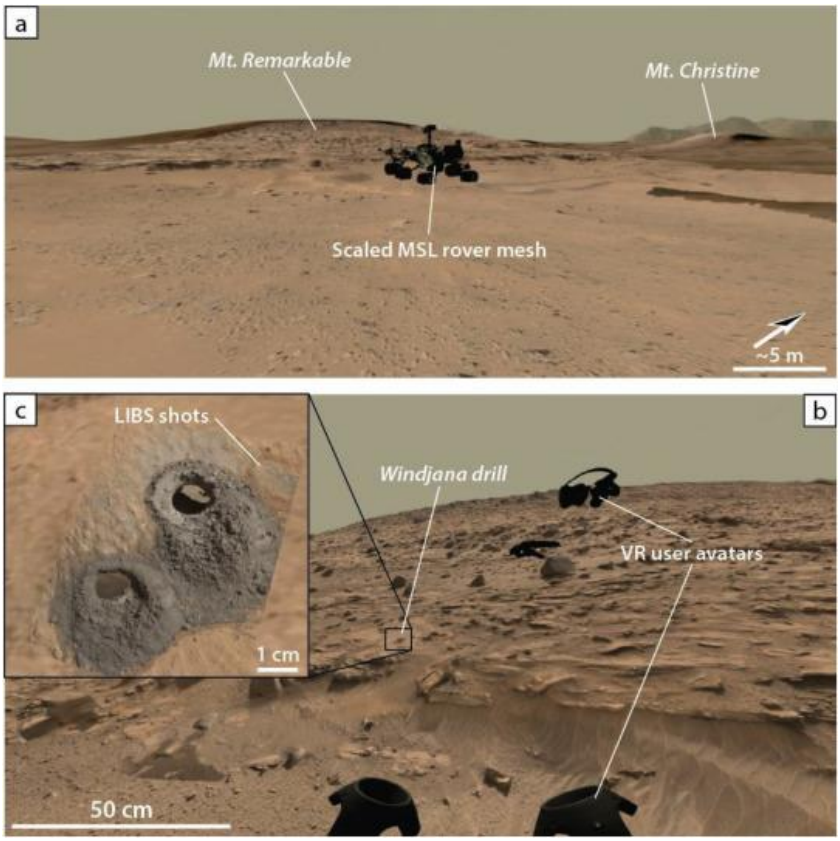

Figure 2.6 : Kimberly Simulated Outcrop in VR Environment (Caravaca et al., 2020)

Some of the key benefits of VR over conventional viewing methods is the ability to observe real geometry of several geological structures such as ripples and cross stratifications. While 3D model gives a better characterization of the 3D shape, structures and geometry than 2D panoramic images, VR could enables a real scale experience of the simulated outcrops that is useful in replacing geological features as well as allowing different projection ranges and with the ability to change the user's point of view. VR implementation therefore could represents an advancement for the in-situ analysis of remote rock slope outcrop.

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter will go over all the procedures that must be followed in order to replicate the 3D rock outcrop models to achieve the study's goals which was described in Chapter 1. The sequential flow starting from the selection of the study area into the in-situ data acquisition, Unmanned Aerial Vehicle (UAV) photogrammetry and 3D modelling and also image analysis procedures would also be explained in details in this chapter.

3.2 Case Study Flowchart

Figure 3.1 shows the overall flowchart which represents all the steps in graphics for this case study starting from the in-situ data acquisition up until the 3D modelling and image analysis processes. The process begin with in-situ data acquisition where all the physical data for rock characterization and rock analysis, discontinuities orientation, and also Unmanned Aerial Vehicle (UAV) aerial images collection were obtained on site. Next, software based methods would be utilised to complete this study and achieve the remaining objectives. To achieve objective 1, all the aerial images taken would be inserted into image photogrammetry softwares to produce a digital 3D point clouds and 3D models. Once the 3D models are generated, it will then be used in another geological based software to further interpret the outcrop model and compares it with the conventional data taken on site to achieve objective 2. Finally, to accomplish the third objective, the finished model full with interpretations and other multimedia will be shown into the virtual reality environment to get a full simulated outcrop experience.

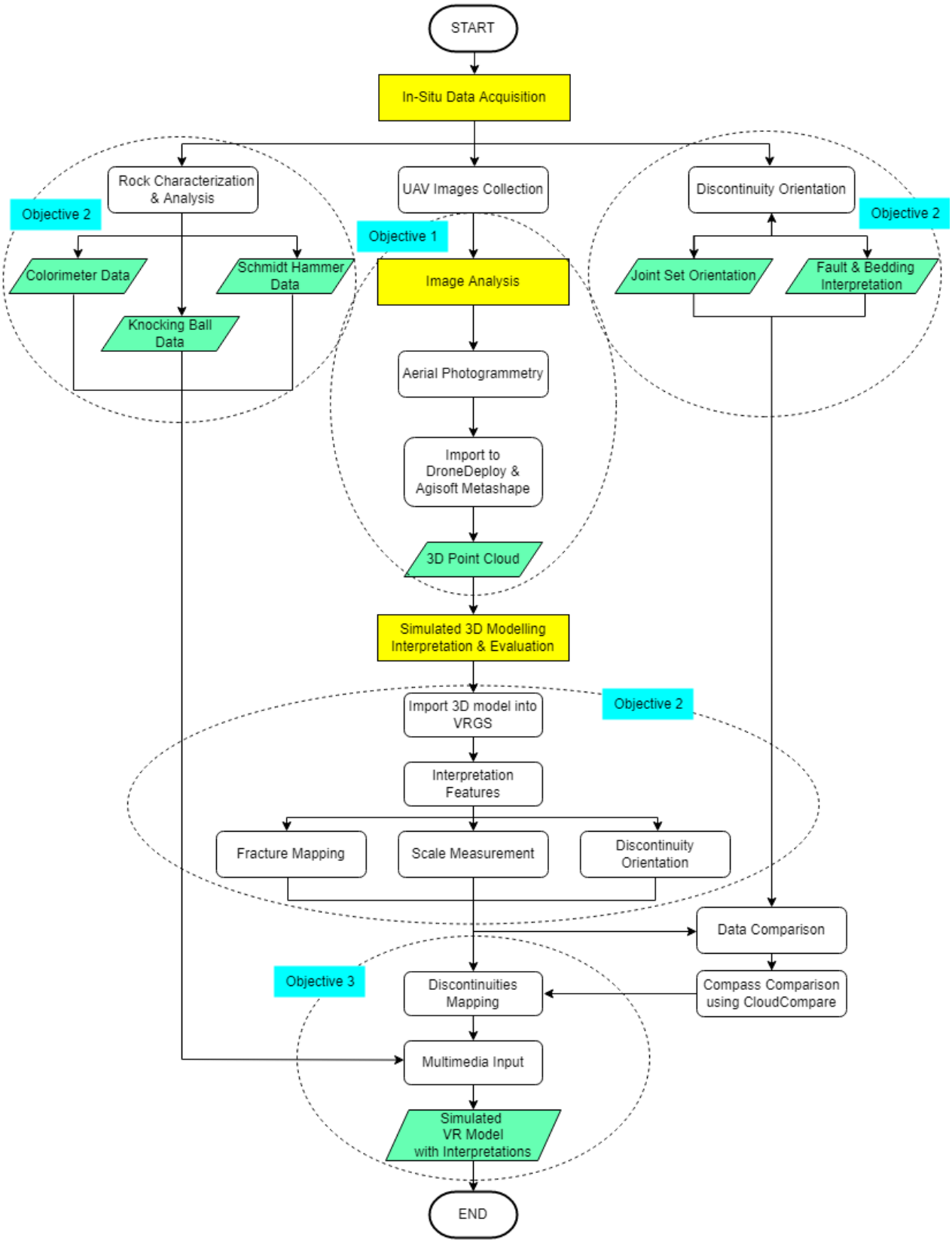

Figure 3.1 : Overall Case Study Flowchart

3.3 Backgorund of Study Area

In this topic, the site selection to conduct this research studies will be further discussed to better understand the study area and its geological conditions. The study area that was allocated to this study is picked based on the uniqueness of the rock slope outcrop outcrop with its distinctive rock characteristics.

3.3.1 Location of Study Area

Two rock slope outcrop location were picked during this research study. Both of the locations is located in the northern side of peninsular Malaysia which are in Kedah and Perlis. These locations will be further discussed in the subtopic in term of the site location and also the geological properties at this point of interests.

3.3.1(a) Felda Teloi, Sik, Kedah

Figure 3.2 : Felda Teloi Rock Slope Outcrop

Felda Teloi Timur is located in Kuala Ketil, Kedah (5°44'38.3"N 100°40'46.5"E) which is a state in the north of Semenanjung Malaysia that is in between Perak, Penang and Perlis borders. The position of the rock slope outcrop is along the federal road that was built by Federal Land Development Authority(FELDA). This outcrop location is selected as one of the

site to be modelled into VR environment due to its geological characteristics and its unique appearance where the bedding of the rocks could be clearly distinguish along the rock slope outcrop with its interesting discontinuities properties.

3.3.1(b) Kg. Wai, Kuala Perlis, Perlis

Figure 3.3 : Kampung Wai Rock Slope Outcrop

Kampung Wai, Kuala Perlis (6°25'43.6"N 100°08'41.0"E) is a local village which is located near Malaysia-Thailand border and only 3 kilometres away from Kuala Perlis. There is also a canal which is connected to Timah Tasoh lake, a man-made reservoir that was built in 1992. The rock slope outcrop spot here is chosen as one of the outcrop to be modelled into virtual reality environment due to its distinctive geological rock properties and its aesthetic features. There are a total of two simulated 3D model to be constructed at this site due to the huge size of the slope.

3.3.2 Geological Background of The Study Area

Before going in details about the rock slope outcrop analysis in these locations, the geological conditons of these area were first studied and observed. These studies were done by

referring to the geological map of the peninsular Malaysia. The geological conditions of both the study areas will be further discussed in the next subtopic.

3.3.2(a) Felda Teloi, Sik, Kedah

Figure shows the geological lithology assessed in Felda Teloi area. From the geological map, Felda Teloi study area is located on Schist, phyllite, slate and limestone with minor intercallations of sandstone and volcanics. Schist is a metamorphic rock which is formed from the mudstone or shale or some other types of igneous rock. Schist is generally a hard rock foliation with smoothish to touch. To summarize, this study area consists of various metamorphic rocks which formed under high heat and high pressure.

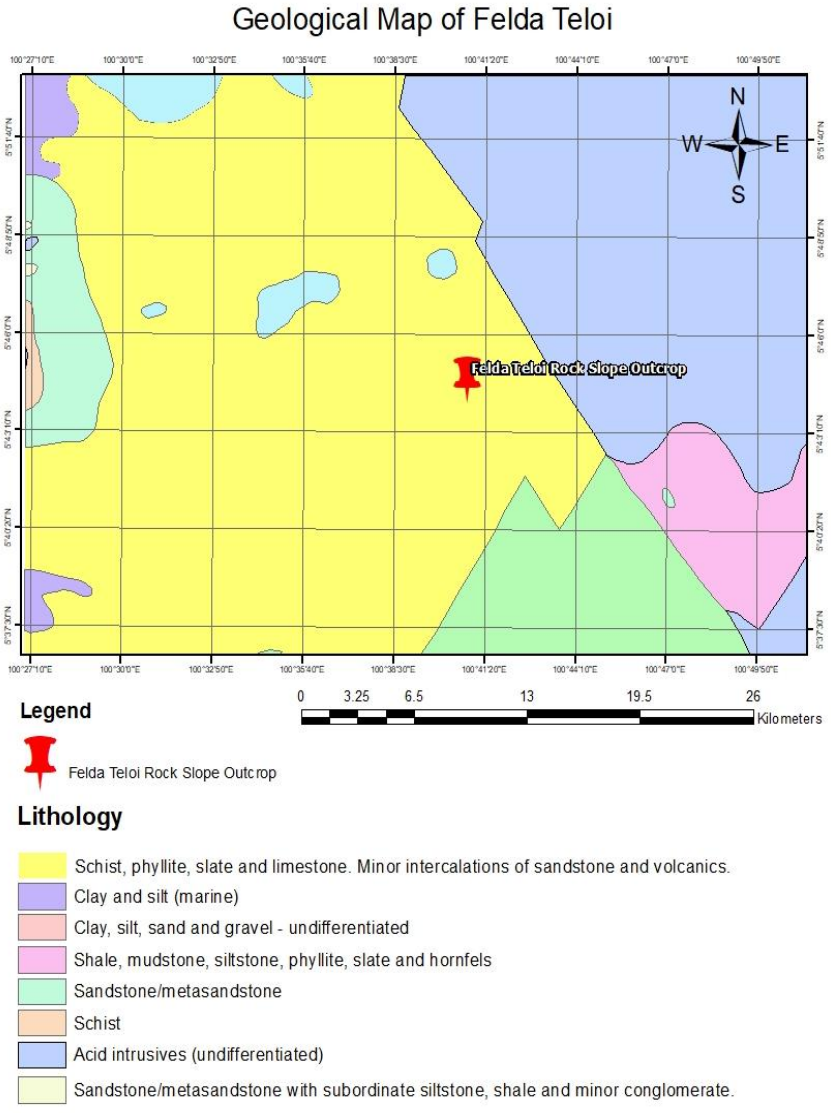

Figure 3.4 : Felda Teloi Geological Map (Source: ArcMap 10.8 Software)

3.3.2(b) Kg. Wai, Kuala Perlis, Perlis

Figure describes the geological lithology of Kampung Wai study area. Based on the geological map, it is shown that the study area is situated on marine clay and silt area. Marine clay is normally situated near the coastal areas which can be considered as one of the problematic soil mainly because its high moisture content and often linked with high settlement and also instability.

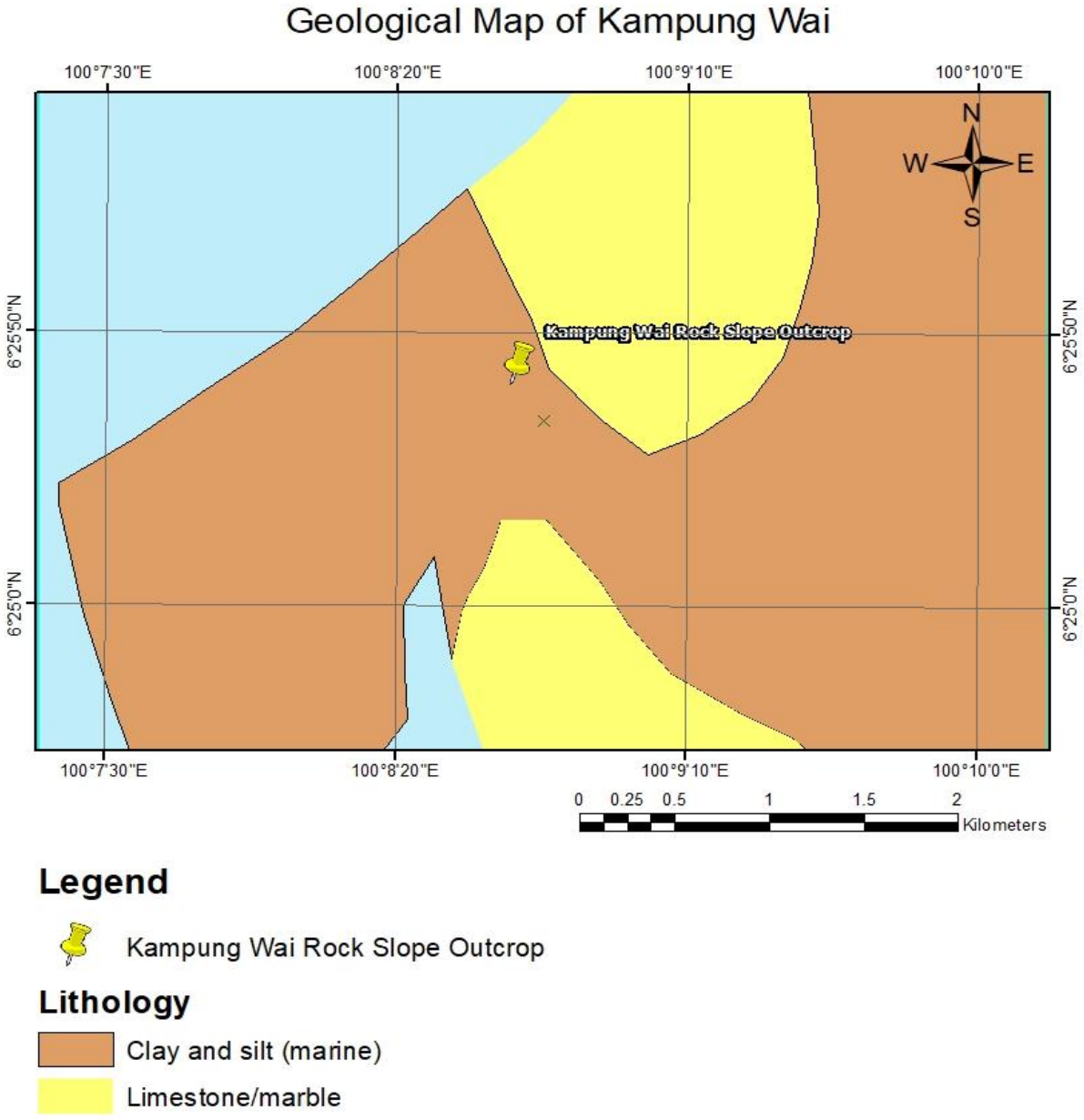

Figure 3.5 : Kg. Wai Geological Map (Source: ArcMap 10.8 Software)

3.4 In-Situ Data Acquisition

In-situ data is data that were gathered from the physical location such as the exact measurements of the actual site and other data that was recorded and observed during the physical site observations. Some specific tools and equipments are needed in order to collect the data and sample from the site that will be explained in the next subtopic.

3.4.1 UAV Images Acquisition

Unmanned Aerial Vehicles (UAV) are remotely controlled vehicles, semi-autonomous, or even have fully autonomous capabilities. Although the pilot is not physically needed to be in this vehicle to maneuver the aircraft, this does not simply imply that UAV flies by their own autonomously. In most cases they are controlled by the crew on the ground station via remote control. The vehicle is equipped with photogrammetric system such as high definition camera with active gimbal stabilizer. UAVs nowdays also included the registration with postion and orientation tracking ability in a local or global coordinate system. In this study, collection methods are mainly using aerial-based technology like UAV to capture the overlapping images of the rock outcrop from multiple angles and would undergoes images analysis procedures until final output of two-dimensional (2D) or three-dimensional (3D) model are produced. This process is formally known as photogrammetry.

During autonomous flight, the UAV mounted camera receives and captures images. Software such as Map for Pilot (MAP) or Drone Deploy mission planner which are installed on smartphones are used. The Google Earth feature is used to denote a waypoint and a flight path. This feature enables self-sufficient images as well as autonomous take-off and landing. Mission Planer highlights waypoint passage with a point-and-click and modifies the coveted flight parameter before transferring the mission, allowing the UAV to take off to complete the mission. Image resolution and clarity are critical components of the nature of information

checking. The captured images are examined immediately following the consummation, and if necessary, a flight is rescheduled. All data collection and analysis is done in real time.

Figure 3.6 : DJI Phantom 4 Pro (Source: DJI website at dji.com)

For this research study, DJI GO application is used to connect the controller and drone to mobile device via an iPad. First of all, drone firmware is checked for any potential firmware updates. Once there are no pending updates, drone is activated and the aircraft status is in 'Normal – Ready (GPS)' mode. Next, on the drone itself, memory card is inserted before turning on the drone. Compass recalibration is checked on DJI Go and the drone will be flown manually to estimate the potential obstacles in case the avoidance features failed to respond. After the flight readiness is prepared at the point of take-off, an appropriate taking off with small interferences is used.

DJI Waypoints features in DJI Go will allows a flight based on two points or more which can be configured in the apps itself. The flight plan which covered all the study area and its altitude with camera overlapping are set prior to the actual flight. Drone will first flown automatically using the autopilot features according to planned path while the camera angle and its orientation are controlled manually using the controller.

Drone will then be manually piloted using the controller to capture in details all sides of the rock slope outcrop at various altitudes. Multiple images will be captured during this modes to cover all sides of the outcrop and once the images are collected, the drone will be brought to land at the take-off point and the memory card is removed to transfer all the images taken to a computer.

3.4.1(a) UAV Specifications

DJI Phantom 4 Pro drone is used to capture aerial photos of all the rock slope outcrop in order to produce a high definition 3D models and dense point cloud models. This drone is fully equipped with highly intellignet features such as autonomous flight modes, long range transmission ability, and omnidirectional obstacle avoidance. The full specs of the drone is shown in the table 3.1 and table 3.2.

Table 3.1 : UAV Official Specifications

DJI Phantom 4 Pro Aircraft	**Specifications**
Weight (Including battery & Propellers)	1388 g
Maximum Ascent Speed	S-mode : 6 m/s P-mode : 5 m/s
Maximum Descent Speed	S-mode : 4 m/s P-mode : 3 m/s
Maximum Speed	S-mode : 45 mph P-mode : 31 mph A-mode : 36 mph
Maximum Service Ceiling Above Sea Level	19685 feet (6000 m)
Maximum Flight Time	Approximately 30 minutes
Satellite Positioning Systems	GPS / GLONASS

Table 3.2 : UAV Camera Specifications

DJI Phantom 4 Pro Camera	**Specifications**
Sensor	1” CMOS Effective Pixels: 20M
Lens	FOV 84° 8.8 mm/24 mm (35 mm format equivalent) f/2.8 - f/11 auto focus at 1 m
ISO Range	Video : 100 – 3200 (Auto) 100 – 6400 (Manual) Photo : 100 – 3200 (Auto) 100 – 12800 (Manual)
Image Size	3:2 Aspect Ratio: 5472 × 3648 4:3 Aspect Ratio: 4864 × 3648 16:9 Aspect Ratio: 5472 × 3078
Still Photography Modes	Single Shot Burst Shooting: 3/5/7/10/14 frames Auto Exposure Bracketing (AEB): 3/5 bracketed frames at 0.7 EV Bias Interval: 2/3/5/7/10/15/20/30/60 s