

An overview of workflows for developing Geological Virtual Field Trips, limitations, and future implications: A case study from Peninsular Malaysia

*Grisel Jiménez Soto, Rohil Suryavarma Kunasegar, Saw Bing Bing, Siti Sarah Rahman, Choong Chee Meng*

*South East Asia Carbonate Clastic Research Laboratory, Department of Geosciences, Universiti Teknologi PETRONAS*

Received March 5, 2021; Accepted July 13, 2021

---

## Abstract

Recent literature has demonstrated the importance of fieldwork in geology. However, as the pandemic of COVID 19 emerged since 2019, several issues have arisen to develop fieldwork experiences in several educational centers around the world, at the same time resources have become scarce, and field experiences are often targeted for cuts. In courses throughout, field trips and other excursions were postponed, making it so students do not have the opportunity to participate in geology field trips. In response, we have developed a virtual field experience (VFEs) from one of our nearby outcrops, Kinta Valley limestone to create a virtual reality (VR) model and 3D rock model based on available rock samples in our Laboratory at Universiti Teknologi Petronas..

**Keywords:** *Virtual field trip; Workflow; Digital geology; Digital outcrops.*

---

## 1. Introduction

The importance of fieldwork in geoscience had widely been discussed in multiple publications throughout the years. However, due to the recent pandemic COVID -19, fieldwork resources have become increasingly scarce, and they have become one of the most often targets for cuts in several teaching institutions [1]. Logistics about time and generating an experience that checks the course learning outcomes of a specific course are the main challenges that exist when planning a traditional field trip. Routine issues such as an increase in student enrolments will cause the peak in learning opportunities to be out of reach meaning that the effectiveness and quality of the field trip will be potentially reduced. With the collection, curating, compilation, and processing of visual data from locations of geologic interest and the integration of augmented and virtual reality, virtual field trips (VFT) were developed as a viable method to help solve these issues [1].

"These virtual field trips can be described in a narrow sense as an electronic exhibition of diverse natural and cultural phenomena that also provide digital simulations of the three-dimensional processes of surveying, observing, exploring and adventuring in some actual field sites" [2]. Observing, gathering data, and solving problems by generating existing field sites using computers best summarizes virtual field trips [3]. According to Qiu & Hubble [2], instructions, images and accompanying descriptions, media, glossary, illustrations, and quizzes are some of the important elements that should exist in a typical virtual field trip (VFT) where each of these elements is connected logically and intellectually.

With the development of these new teaching tools, students are allowed to explore real-life geological areas and develop useful skills such as observation and interpretation [1]. This newly developed pedagogical tool allows instructors to bring the field to the classroom when the conditions to take students into the field are not possible. Virtual field trips exist as an electronic version of a traditional field trip where the field trips are designed in a linear structure with a single predetermined path through a field site [3].

In this study, we explore a preliminary study in a fieldwork site in Peninsular Malaysia, which potentially can become an interesting site to have a better understanding of carbonate geology.

## 2. Geology of study area

The Kledang Range and the Main Range-Bound the Main Range bound the triangular-shaped Kinta Valley, located in the Western Stratigraphic Belt at approximately latitude  $4.60^{\circ}\text{N}$  and  $101.07^{\circ}\text{N}$ , at the west and east respectively [4-5]. The valley tilts towards the south where the Kinta River drains the topography towards the south [6]. Prominent remnant tropical karstic hills composed of massive heavily jointed and fractured limestone protrude from the thick Quaternary sediments that overlie most of the subsurface continuation of these limestones (about 77%) characterize the flat valley floor of the Kinta Valley [4-6]. The limestones of Kinta Valley were interpreted to be deposited in a shallow marine setting during the Devonian to Permian [5].

These numerous steep-sided massive limestone hills formed by the dissolution of carbonate rocks reach a maximum height of 546 m and have an average size of  $1.08\text{ km}^2$  [5]. These limestones in the Kinta Valley were labeled as the Kinta Limestone Formation in 1983 [5]. Tsegab [6] stated the thickness of the Quaternary overburden sedimentary varies from north to south and reaches 30 m. Other than the dominant limestone lithologies such as schist and granite flank the eastern and western sides of the Kinta Valley [5]. Besides, this Late Triassic to Early Jurassic granitic intrusions that underlie the Kinta Valley is represented in the elevated areas in the east and west by the Main Range and Kledang Range [6]. An erosional unconformity bounds the top of the Kinta Limestone while the lower boundary is unknown, except for the speculative older basement complex [6]. In structural terms, the presence of a major fault is postulated by the existence of a straight scarp that extends up to 26 km [5]. Towards the eastern side of Kinta Valley, several smaller faults have been identified [5].

## 3. Materials and methods

### 3.1. Proposed workflows to develop a model of hand specimen to Blender/Sketchfab

Structure-from-motion is an image-based modeling technique, which calculates the 3D structure of an object from the overlapping 2D images [7]. Smartphone cameras or any other digital cameras are used to take images of the sample from different angles and later generates a point cloud of the sample [8]. For demonstration purposes, 60 images were taken of the sample from various angles using a 12-megapixel digital camera in a Samsung Note 10+ [9]. These images were later processed using the structure-from-algorithm, which is available in VisualSFM [7,9]. VisualSFM is open-source software with a simple, user-friendly interface with enhanced structure-from-motion editing capabilities [10]. A 'dense' point cloud containing >103 times more points than the initial sparse point cloud is generated using multiview stereo (MVS) algorithms in VisualSFM [7]. A 3D mesh is later generated by the interpolation of the dense point cloud using the surface interpolation algorithms available in Meshlab [7]. This mesh output is later uploaded to a web-based interface such as Sketchfab where rendering options (e.g., lighting, material properties) are defined [9].

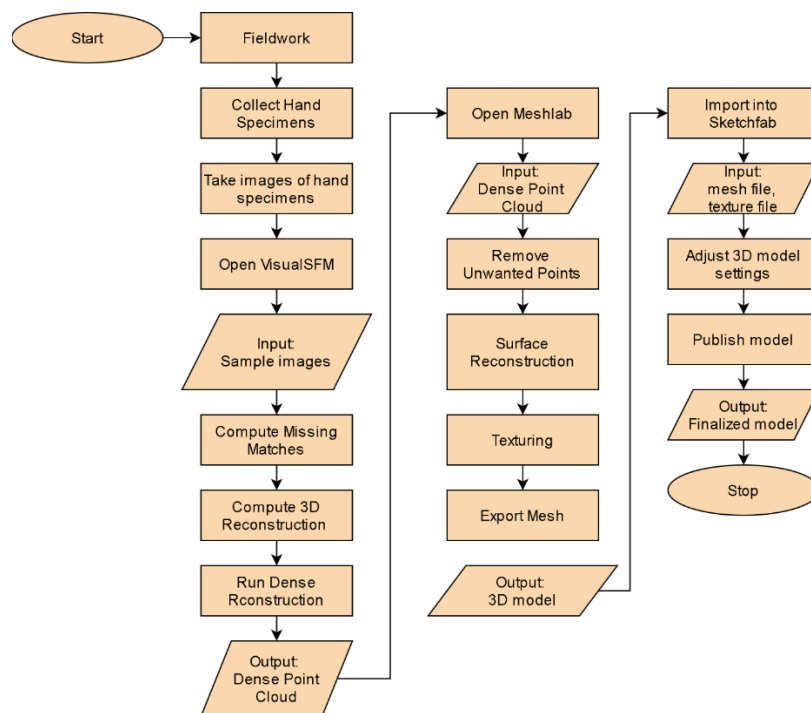


Figure 1. Workflow for the viewing of 3D outcrop models



Figure 2. The final 3D view in Sketchfab of the carbonate sample rock in Kinta Valley by using Blender

### 3.2. Proposed workflows to develop a digital elevation model

The set of high-resolution regional outcrop terrain satellite images were downloaded from USGS (United States Geological Survey). These satellite images were imported into ArcGIS (ArcMap) with the georeferenced added, exported as georeferenced imagery and digital elevation model. ArcScene was used to display the digital elevation model and overlaid with the georeferenced imagery, and then exported it.

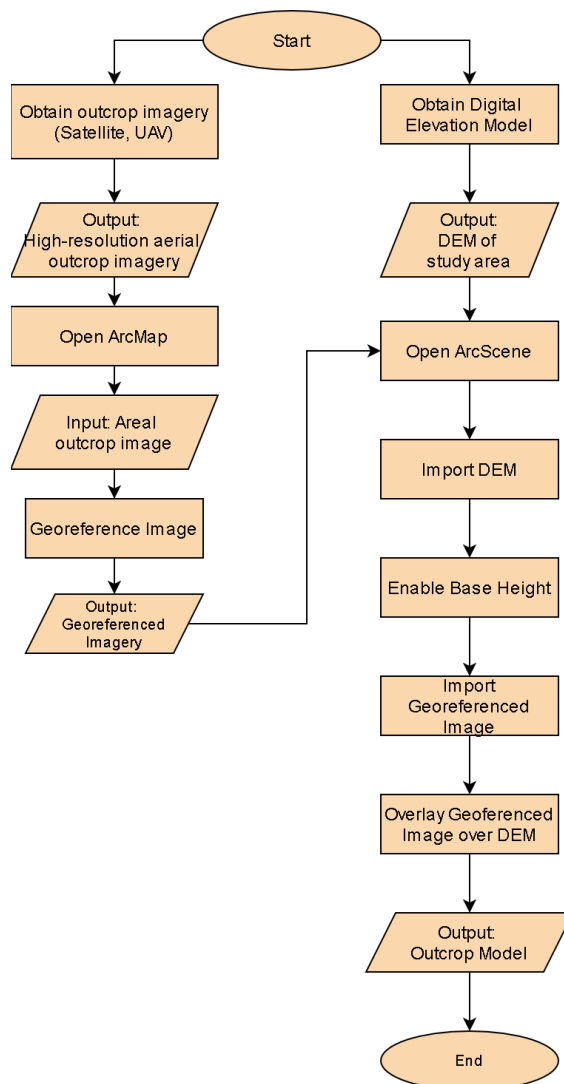


Figure 3. Workflow for the viewing of 3D outcrop models

### 3.3. 3D Terrain modelling

With the advancement in technology, many companies from different disciplines are moving from visualizing information or data from two-dimensional to three-dimensional (3D). In geology, 3D terrain modeling is an example of this transition from 2D to 3D and it is a unique way of representing the topography of a specific area of interest. The technique allows the user to rotate and view the model from various viewpoints.

Furthermore, this allows an individual to get a composite view of the selected study area at a time instead of visualizing the zone using a series of images that would take a while for a geologist to piece all the images together.

Although Google Earth has the option to view 3D terrain imagery of the study area, it cannot remove the surrounding terrain to help focus on the terrain within the study area. The presence of the surrounding terrain may take the attention away from the terrain within the study area. This is the reason why the Blender software was chosen for this study.

Firstly, an external plugin called 'Blender GIS' is required to be downloaded from GitHub and imported into Blender. This plugin allows access to data regarding global elevation obtained through Nasa's Shuttle Radar Topography Mission (SRTM) and the ability to import common GIS data formats such as shapefiles and GeoTiff files. Using the data obtained, the software can generate topography similar to the real world as in the example generated in the 3D terrain model of Kinta Valley, Perak (Figure 4).

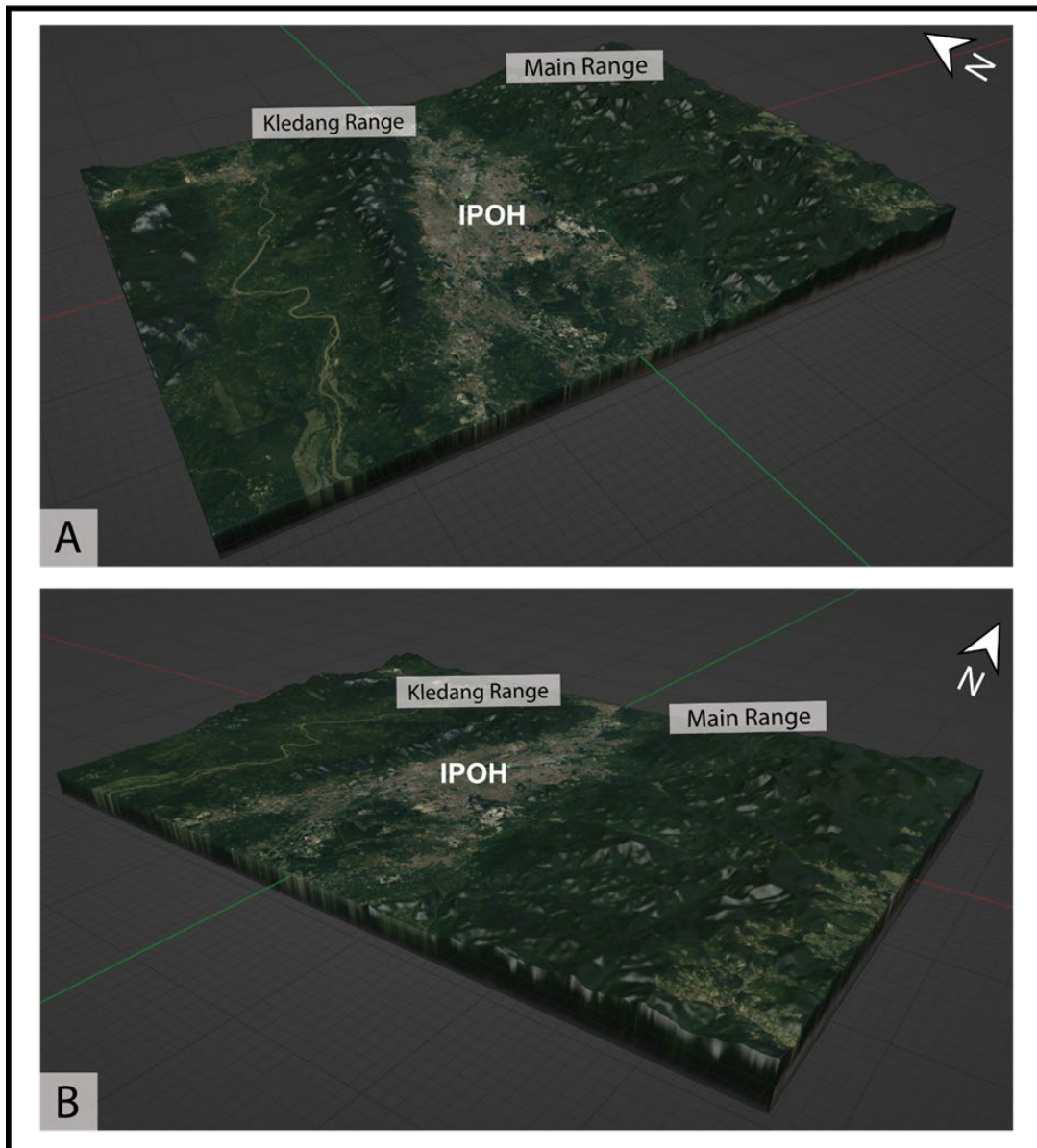


Figure 4. View of 3D Terrain Model of Kinta Valley, Perak from the (A) southwest and (B) southeast generated in Blender using elevation data from NASA's Shuttle Radar Topography Mission (SRTM)

## 4. Current overview of fieldwork

### 4.1. Before the pandemic: COVID-19

Before the pandemic, a large number of students from different levels of education such as degrees and masters were able to travel far distances for traditional field trips. This resulted in a high variety of geological studies being done. The class would be divided into smaller groups if the number of students was too large. Virtual field trips were not popular and not often used at the time as they were treated as alternatives if the conditions for the field trip were not practical.

### 4.2. After the pandemic: COVID-19

Due to the pandemic, no traditional fieldwork for classes could be conducted for health reasons. Many students were not able to travel far distances, which reduces the scope and variety of geological studies that were being done. Currently, virtual field trips are increasingly becoming popular, as they serve as a viable solution due to the travel restrictions even if it may be not as effective as traditional fieldwork.

## 5. Most common software to develop Virtual Trips

There is few common free software were used to build the virtual outcrop model (Table 1).

Table 1. The most common software used to conduct Virtual Field Trips (VFT's)

Software	Platform
Virtual Reality Geological Studio (VRGS)	PC
LIME	PC
Google Earth Pro	PC, Mobile
Tour Creator	PC
Pano2VR	PC

## 6. Discussion

### 6.1. Benefits

The ability of these state-of-the-art field trips to display data at various scales and the ability to simultaneously view an image or area from various angles [2]. The 3D modeling of the study area proposes visualizing commonly inaccessible areas or places where hazardous processes could take place. The multiple viewpoints help enhance the virtual field trip through interaction. The support for highly diverse data types that have been obtained from the field, laboratory, or library allows it to be integrated to form instantly available material [2]. From the student's perspective, virtual field trips allow the student to learn at their own pace. This means that students can practice and acquire skills by repeating the virtual field trip. Both previewing and reviewing of field trips that have been conducted or that will be conducted can be done using virtual field trips. This allows the instructor to visualize the field trip to determine if it achieves the course learning outcomes and enhances it to ensure maximum usefulness.

### 6.2. Limitations

Qiu & Hubble [2] stated that the main limitation of virtual field trips is that the effectiveness of imparting field-based skills is lower compared to traditional field trips. This is because the material presented on a computer is only an abstraction of the real thing. The non-visual and aural senses such as smell and touch that are crucial in a real fieldwork setting are not conveyed in virtual field trips. According to Hurst in Qiu & Hubble [2], he stated that the subtle clues that aid in geological interpretation could not be done due to the technologies' lack of ability to generate the true geometric nature of the geological location.

Although virtual field trips are designed to be interactive, the interaction that the participants have with the field trip instructor is something that the technology cannot simulate. This poses a major problem for the student as this takes the social aspect of the field trip. A lack of emphasis on working as a team is observed in previous field trips [1]. The size of the display screen serves as one of the contributors to more solitary work instead of a larger group. It is



also observed these virtual field trips lack one of the main objectives of field trips, which is the nature of discovery.

### 6.3. Future implications

It is irrefutable fact that virtual field trips are playing an important role in geoscience education in the future but the experience with this learning tool needs to be enhanced. There are a few ways to help enhance the experience of this technology with one of them being early preparation. As stated by McKenzie 2001 in Qiu & Hubble [2], teachers should prepare carefully and ahead of classes and use the field trips as complementary tools. Geological areas of interest must be reviewed and ensure that they can be related to the content presented in class. Teachers play an important role to develop the student's ability to evaluate the quality of these virtual field trips and making proper choices about when to use these field trips.

It is recommended that teachers with the students should hold sessions after completing a virtual field trip to obtain feedback. Students will be able to learn effectively from virtual field trips if they have a proper foundation to build upon. Three questions have to be answered in developing high-quality and effective virtual field trips which are (1) What do the students need to learn? (2) How do these students best learn the material? (3) What is an appropriate design for this virtual field trip? To answer these questions, a virtual field trip must be designed based on good educational practice with appropriate theories and the course requirements.

In terms of the material used, quality plays an important role in the effectiveness of the virtual field trip. The available technology, resources, and time are directly related to the quality of a virtual field trip. A high-quality virtual field trip should allow the users to have a detailed investigation on the location or area of interest, which can be done by using quality input such as high-resolution images. This can be enhanced even further by organizing information along a virtual route as this will improve the ability to properly simulate a traditional field trip. A large amount of information and collection of images is a necessity required to increase the possibility of a proper simulation of real activity.

### References

- [1] Dolphin G, Dutchak A, Karchewski B, and Cooper J. Virtual field experiences in introductory geology: Addressing a capacity problem, but finding a pedagogical one. *J. Geosci. Educ.*, 2019; 67(2): 114–130.
- [2] Qiu W and Hubble T. The advantages and disadvantages of virtual field trips in geoscience education. *China Pap.*, 2002; 1: 75–79.
- [3] Granshaw FD, and Duggan-Haas D. Virtual fieldwork in geoscience teacher education: Issues, techniques, and models. *Spec. Pap. Geol. Soc. Am.*, 2012; 492(20): 285–303.
- [4] Al-Kouri O, Al-Fugara A, Al-Rawashdeh S, Sadoun B, and Pradhan B. Geospatial Modeling for Sinkholes Hazard Map Based on GIS & RS Data. 2016; 5(6): 584–592.
- [5] Simon N. Assessment of rockfall potential of limestone hills in the Kinta Valley. *J. of Sus. Science and Management*, 2015; 10(2): 24–34.
- [6] Tsegab H, Sum CW, Yuriy GA, Hunter AW., J TalibAB, and Kassa S. Higher-resolution biostratigraphy for the kinta limestone and an implication for continuous sedimentation in the paleo-tethys, western belt of peninsular Malaysia. *Turkish J. Earth Sci.*, 2017; 26(5): 377–394.
- [7] Nesbit PR, Durkin PR, Hugenholtz CH, Hubbard SM, and Kucharczyk M. 3-D stratigraphic mapping using a digital outcrop model derived from UAV images and structure-from-motion photogrammetry. *Geosphere*, 2018; 14(6): 2469–2486.
- [8] Martinez-Rubi O, de Kleijn M, Verhoeven S, Drost N, Attema J, van Meersbergen M, van Nieuwpoort R, de Hond R, Dias E, Svetachov P. Using modular 3D digital earth applications based on point clouds for the study of complex sites. *Int. J. Digit. Earth*, 2016; 9(12): 1135–1152.
- [9] Nesbit PR, Boulding AD, Hugenholtz CH, Durkin PR, and Hubbard SM. Visualization and sharing of 3D digital outcrop models to promote open science. *GSA Today*, 2020; 30(6):4–10.
- [10] de Paor DG. Virtual Rocks. *GSA Today*, 2016; 26(8): 4–11.

*To whom correspondence should be addressed: Grisel Jiménez S., South East Asia Carbonate Clastic Research Laboratory, Department of Geosciences, Universiti Teknologi PETRONAS, E-mail: [jimenezso-togrisel@gmail.com](mailto:jimenezso-togrisel@gmail.com)*