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Case Study: UAV Implementation in Mapping and Site Layout Design

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Abstract

Maps are graphical tools that show the features of a specific area, be it a city, country, or continent. The distribution of objects on Earth, including the precise locations of homes and streets in a metropolitan town, can also be seen on maps. Typically, GPS is used for mapping purposes. One of the drawbacks is that it is time-consuming and fails to produce current and actual results. So, using the UAV photogrammetry approach provides an alternative solution to this issue. In order to support development planning work the UAV will produce orthophoto images, orthophoto maps, and site layout designs using UAV photogrammetry technique, Global Mapper and Adobe Photoshop software. Unmanned Aerial Systems (UASs) can be useful in pre-construction applications such as site planning and surveying. The suggested UAV system was designed to carry out surveying tasks in civil engineering applications with success.

1. Introduction

Maps are illustrations that represent the characteristics of a particular region, such as a city, nation, or continent. They are usually displayed on a level surface and can display pertinent topographical, geological, or other data. Maps are used to show how various features, such as highways, rivers, mountains, and more, relate to one another spatially. Mapping from UAV can produce a site layout design and an orthophoto map. Utilizing UAV imagery, can create detailed site layout designs and accurate orthophoto maps. Site layout design is a crucial aspect of construction planning, significantly impacting construction duration, cost, and productivity. A well-designed site layout maximizes efficiency by strategically placing structures and features [7]. Effective site planning helps project managers optimize these factors, making it an essential task in the construction process [4]. Orthophoto maps are beneficial for many applications because they combine the geometric accuracy of maps with the visual detail of images. For instance, orthophoto maps help in the design and construction of new infrastructure in urban planning by enabling planners to see the current landscape and smoothly incorporate future developments [7].

There are several methods and strategies for mapping an area, and the tachymetry method is one of them. The tachymetry method, a conventional surveying technique that uses angular measurements to calculate distances,

has notable disadvantages such as the need for light-reflecting markers, which can increase costs and may not be feasible for aesthetic or technical reasons. This method also lacks the ability to create realistic visuals and synthesize recent information. In contrast, the recommended UAV system is designed to execute surveying activities efficiently in civil engineering applications, offering benefits in terms of speed, precision, safety, and cost [2]. UAVs are particularly advantageous for pre-construction site planning and surveying, providing high-quality spatial data and serving as a cost-effective alternative to traditional methods [6]. Unmanned aerial vehicles, ranging from small to medium in size, are emerging as a superior solution for site mapping and volumetric analysis, delivering enhanced spatial sensory data [2]. UAVs equipped with LiDAR sensors and high-resolution cameras can capture accurate topographical data and aerial visuals, creating precise and up-to-date maps. Despite limitations like weather sensitivity and limited battery life, UAVs expedite mapping processes, making them invaluable for surveying large or hard-to-reach areas [3].

The objective of this study is to produce an orthophoto image using UAV photogrammetry techniques, create an orthophoto map using Global Mapper and Adobe Photoshop, and design a layout plan for future planning. The study focuses on Sekolah Islam Hidayah Pasirris, located in Jalan Olak Batu, 86400 Ayer Hitam, Batu Pahat, Johor, Malaysia. The school's plan map was captured using Unmanned Aerial Vehicles (UAV) to develop a comprehensive school development mapping and layout plan. Software and techniques, including AutoCAD, Pix4D, and Global Mapper, was employed for UAV data processing to generate accurate and actionable maps and layout plans. AutoCAD is essential for optimizing site layout design in building projects. When designing items and site properties, AutoCAD's drawing skills enable the generation of varied shapes with the required precision [7]. Because building sites are various, AutoCAD's adaptability also extends to designing site layouts. Besides, Pix4Dmapper is photogrammetric software that can convert images into highly accurate and georeferenced digital models by using multi-view stereo (MVS) and structure from motion (SfM) methods results in digital surface models, digital terrain modes, and highly accurate orthophoto maps [4] . Global Mapper can show the most used raster, elevation, or vector data sets. The program manages vectors and raster elevation data and offers standard GIS functions like viewing and conversion. It is an extremely user-friendly software package that lets you convert, edit, print, create GPS tracks, and utilize the capabilities of GIS data sets . The software is known for its ease of use and affordability, making GIS capabilities accessible to a broader audience [1].

2. Methodology

This comprehensive methodology for UAV implementation in mapping and site layout design extends beyond data processing to include the production of an orthophoto map and subsequent site layout design. The study's methodology begins with data acquisition, which includes Planning and Preparation of a DJI Mavic 2 Pro for a UAV mapping mission at Sekolah Rendah Islam Hidayah Pasirris and using Pix4DCapture to capture images.

2.1 Data acquisition

The area of flight must be planned to ensure that the battery capacity is adequate to complete the grid mission of the study area which is Sekolah Rendah Islam Hidayah Pasiris using Pix4D Capture. Safety aspects must be emphasized before flying to ensure that all systems are working as planned. Before flying it is crucial to locate the site's boundary points and cover it using GCP so the merging process between orthophoto image and site layout plan can be precise since it will connect the boundary markers in site layout plan as well as in real life. The flying was executed on 22 March 2024 at 10.00 a.m. DJI Phantom 2 Pro is used to capture the image from the atmosphere region and the UAV controller and UAV were connected to the phone with IOS application control which is Pix4dcapture before the flight began. Pix4dcapture is opened and connected to the UAV and the Global Positioning Systemic (GPS). The flight was conducted only in the morning to avoid any shadow of the building that would affect the image quality. The flight mission was controlled by the Pix4D Capture application using polygon type for grid mission and the camera angle was set at 90 degrees. In order to produce good images for producing an orthophoto image in a shorter time, the images were taken at a height of 50m with 70-80% picture overlapping for the front and the back. The total time to capture 463 images to complete the entire study area was about 21 minutes 41 seconds.

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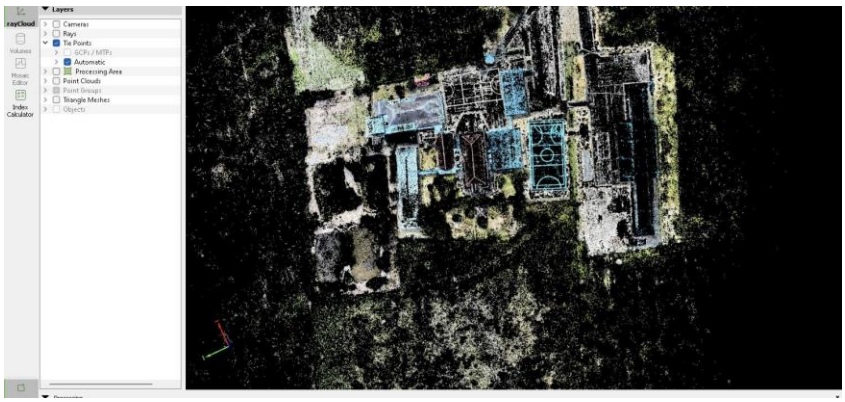
2.2 Image processing

In order to process orthophoto images on Pix4DMapper, there are three main steps that were needed : the initial processing, the point cloud and mesh, and DSM, Orthomosaic and Index process. The first step to process an orthophoto, which is initial processing, as shown is the process of generating Point Cloud and Mesh (refer Fig. 1 (a)), and the complete process of an orthophoto image, which is orthomosaic (refer Fig. 1 (b)). The time taken to process all 463 images was approximately 20 hours.



(a)

(b)

Fig. 1 *Process orthophoto images*

3. Result and Discussion

The pix4d mapper program was used to process all of the UAV-captured images and create orthophoto images. Following processing using the apps global mapper and pix4d mapper, Sekolah Rendah Islam Hidayah Pasirris specific data and measurements was obtained. To create a comprehensive and realistic orthophoto map and site layout design, this study was additionally made use of programs including AutoCAD and Adobe Photoshop.

3.1 Produce Orthophoto Map

Two programs were utilized to finish the development of the orthophoto map: Adobe Photoshop and Global Mapper. Using the map layout editor, Global Mapper was used to determine the scale, add the north arrow and scale bar, and create the latitude/longitude grid frame. For the orthophoto map, the A0 paper size measuring 841mm x 1189mm was selected, and the orientation was set to landscape. Finally, a mosaic version of the map was exported into a PDF. The whole set of elements that Global Mapper added to the orthophoto map is displayed in Fig. 2.

Fig.2 *Complete map element add*

The building label, the title, the Sekolah Rendah Islam Hidayah Pasirris's logo, and the map legend were all created using Adobe Photoshop. Prior to editing, there are two primary steps in this software. To maintain the map scale, the initial stage involved selecting the canvas size in pixels, which was determined to be 9610 × 9442 px, the size of an A0 piece of paper. The second stage was importing a PDF file into Adobe Photoshop from Global Mapper. The orthophoto images were labeled using adobe photoshop. An export of the entire orthophoto map in JPG and PDF formats was made. The entire orthophoto map is displayed in Fig. 3(a).

3.2 Quality Analysis of Orthophoto Map

This section's goal is to perform a thorough analysis of the enlarged pictures taken from the orthophoto map of Sekolah Islam Hidayah Pasirris Batu Pahat. The main objective of this comparison is to evaluate the photographs' sharpness and amount of detail at various zoom levels. Fig. 3(a) display an image of entire orthophoto map, Fig. 3(b) display the orthophoto map at an altitude of 6 meters above ground level (mdpl) before becoming blurry and Fig. 3(c) shows the image from the orthophoto map at an altitude of 3 meter above ground level (mdpl) after becoming blurry.

(a)

(b) (c)

Fig. 3 *Analysis of Orthophoto Map*

3.3 Comparison Quality Google Earth view and orthophoto image

In this section, the quality of orthophoto photos of Sekolah Islam Hidayah Pasirris Batu Pahat, Johor, and images from Google Earth are compared. The map was enlarged to a similar location that is clearly visible in both photos in order to provide a comparable comparison. This comparison focuses on the quality of the photos at the height where they become blurry. In order to obtain a clearer image, the image obtained from the orthophoto images at a height of 6 m (refer Fig. 5 (a)), and the second image shows view from Google Earth at a height of 84 m (refer Fig. 5 (b)), which is 14 times higher than the image obtained from the orthophoto map. The image from the same place is seen in Fig. 5. The clarity and color integrity of the high-quality images generated by orthophotography are maintained, providing clear and accurate visual information that is essential for precise analysis and decision-making.

3.4 New infrastructure development

Comparing the satellite imagery from Google Earth with orthophoto generated in Global Mapper. This comparison is essential because newly built facilities and infrastructure often do not appear in Google Earth's imagery but can be captured by UAVs. Utilizing UAV captured orthophotos allows us to identify and document recent development with high precision and accuracy, providing a more up-to-date and detailed representation of the current landscape. Fig. 4 illustrates the difference between the orthophoto map in Global Mapper (refer to Fig. 4(d)) and the image from Google Earth (refer to Fig. 4(c)).

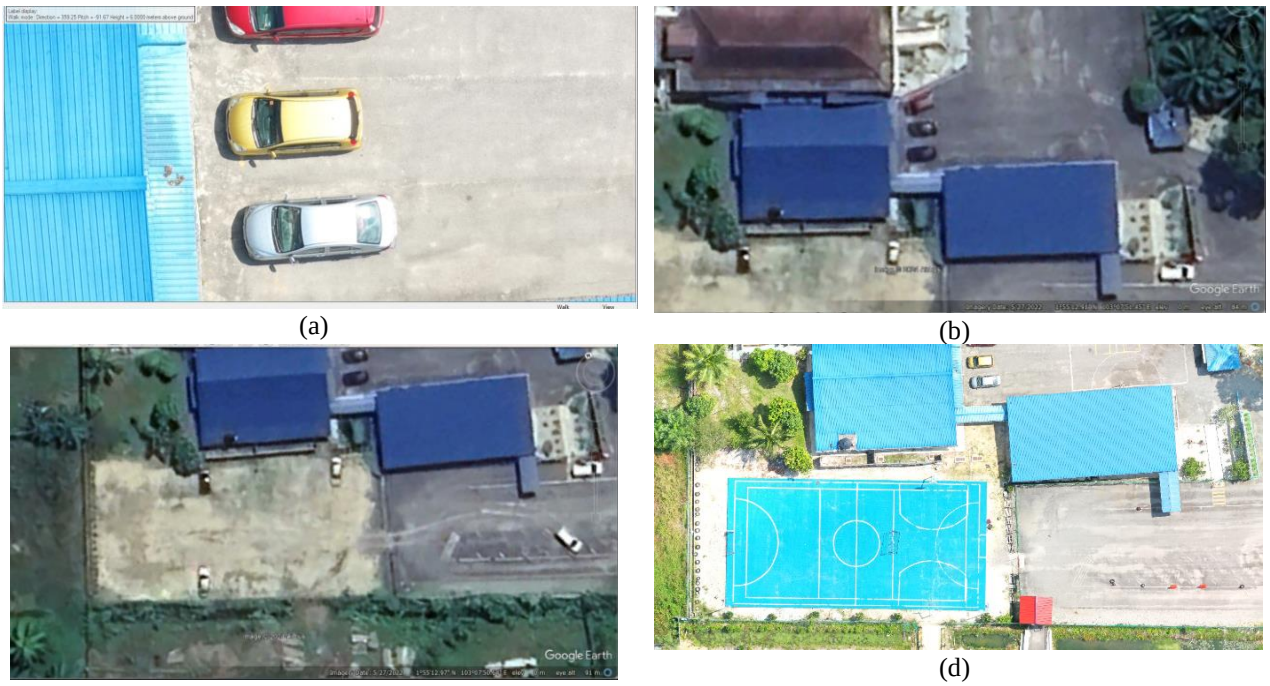


Fig.4 *Comparison between Google Earth view and orthophoto image*

3.5 Merging between orthophoto image and layout plan

From the result of an orthophoto image that has been processed using Global Mapper, use AutoCAD to align the layout plan with the image using the overlaying method. Import photos into AutoCAD and select the orthophoto image file to import. The orthophoto image will not be aligned with the layout plan (Refer Fig. 5(a)). Aligning the orthophoto image with layout plan by using align command guided using the Ground Control Points (GCPs) found that have been marked in orthophotos image. This enables exact alignment of the picture and the plan based on distinguishable elements (refer Fig. 5(b)).

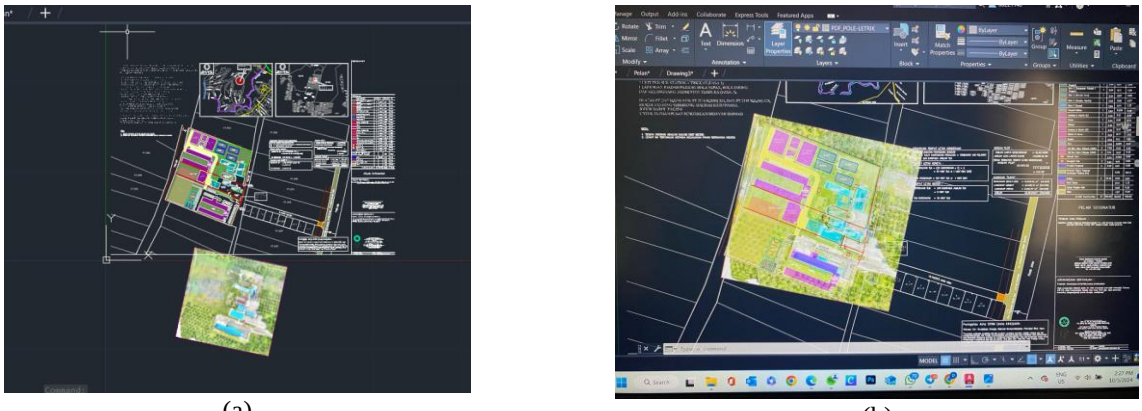


Fig.5 *Before and after alignment*

3.6 Redraw Layout using Adobe Photoshop

Adobe Photoshop is used to draw and label the building that needs to be built. As a result, creating the plan will be more engaging and practical. The AutoCAD processes begin with opening the original plan and the output PDF file from AutoCAD. Next, use Photoshop's tool to overlay a picture of the layout plan and the plan from AutoCAD for reference, then adjust the opacity to 37%. Create a new layer after the reference layer is ready. Start redrawing

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the planned building to be constructed using the layout plan as a guide. Add layers to each component of the structure, such as the field and building, to give it depth and complexity. The orthophoto images and layout plan will be useful for upcoming construction. The outcomes obtained by employing the overlay method are demonstrated in Fig. 6.

Fig.6 *Site Layout Using Orthophoto Image*

3.7 Comparison Site Layout Plan Using Orthophoto Image, Not Using Orthophoto Image and Google Earth

Consequently, it was found that the layout design that was created would allow the school to succeed in the projects that are planned for development. As it stands, the development project will move forward according to the established plan without any issues. Incorporating orthophotos into layout plans offers various advantages, such as enhancing the layout plan's aesthetic value and realism while maintaining a clear image of the region and the most recent details regarding a building's location. Orthophoto pictures can be used to locate the real position on Earth. The site layout design that was produced utilizing the orthophoto picture in Fig. 6 was found to be far more successful than the layout plan (Refer Fig. 7(a)). When The layout plan using orthophoto image (Refer Fig. 6) and the Google Earth photo (Refer Fig. 7(b)) are compared, it is discovered that the picture data in Google Earth has errors and missing data. A blurry image is another disadvantage that can be evaluated.

(a)

(b)

Fig.7 *Layout Plan and Google Earth Photo*

4. Conclusion

Throughout this study, it was found that employing a Unmanned Aerial Vehicle (UAV) could produce an orthophoto map and site layout design far more quickly and affordably. It took roughly 23 hours to generate this map in its entirety. This demonstrates that the UAV photogrammetry method beats traditional methods in terms

of work, expenses, and time consumption. It may be said that the goal of this study has been accomplished because the orthophoto map and site layout design of Sekolah Rendah Islam Hidayah Pasirris was created. The goal of the project is to map the Sekolah Rendah Islam Hidayah Pasirris because Google Earth was unable to provide the most recent image and produce a site layout design for the school due to the future planning and development. One of the needs and demands of the research is the production of an orthophoto map, which may be accomplished with the help of the UAV photography image outcomes. This study also emphasizes how UAV photogrammetry is superior to satellite photography for obtaining more precise and useful local landscape data. A high-resolution orthophoto map created with a time- and money-efficient UAV is the research's end result. Viewers can obtain a higher-up view of Sekolah Rendah Islam Hidayah Pasirris by utilizing this orthophoto map. The product can have a number of advantages for planning and development in the future in addition to appearance.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception, design, data collection, analysis, interpretation of results, draft manuscript preparation:*** *Muhammad Fadhillah Al Hafiz, Dafinah Insyirah, Nurul Aimi, Masiri Kaamin. All authors reviewed the results and approved the final version of the manuscript.*

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