GIS and Drone Photogrammetry: Transforming Spatial Analysis and Mapping into Digital Reality

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SUMMARY

Drone photogrammetry, together with Geographic Information Systems (GIS), is transforming the geospatial industry by providing precise, cost-effective, and efficient data collection. Using the drone aerial images, they can be stitched together into high-resolution orthomosaics, Digital Elevation Models (DEMs), and 3D models. The smooth integration of photogrammetric outputs into GIS platforms allows insightful spatial analysis and decision-making, especially when urban planners make decisions on new green spaces on unutilised slopes, identifying cracks in buildings, or quality assurance.

Keywords: Photogrammetry, Real Estate Development, Spatial Planning, Urban Renewal

1. INTRODUCTION

In these days, there are modern techniques which are used to provide real time monitoring and precision mapping. We can utilise drones with advanced cameras and sensors which can capture high-resolution aerial imagery and 3D modelling. This can provide more effective and accurate outcomes especially for construction, engineering and urban planning when it comes to as-built conditions. There is also advanced data processing from other sources such as satellite data, open GIS data from the government which can be integrated together in the GIS software, which will allow more detailed analysis of phenomena.

The challenges of urban planning in fast growing cities is to ensure cities remain sustainable, efficient and flexible whilst addressing issues such as optimisation of resources, population growth and environmental effects (Fulcrum, 2024). Whilst Hong Kong is a developed, high density city, it only has 25.6% of developed land area and less than 60 kilometres square for "community facilities" and "open space". Therefore urban planners in Hong Kong should plan and develop open spaces with less steep slopes that have a gradient that is less than ⅕ and has more than 200 metres square of vacant land (Planning Department, 2023). This can be done with the open data that is available such as remote sensing data, drone photogrammetry, and vector data to create slope analysis maps which will determine areas which need to be developed for open green spaces (at present it is 3000 hectares of land).

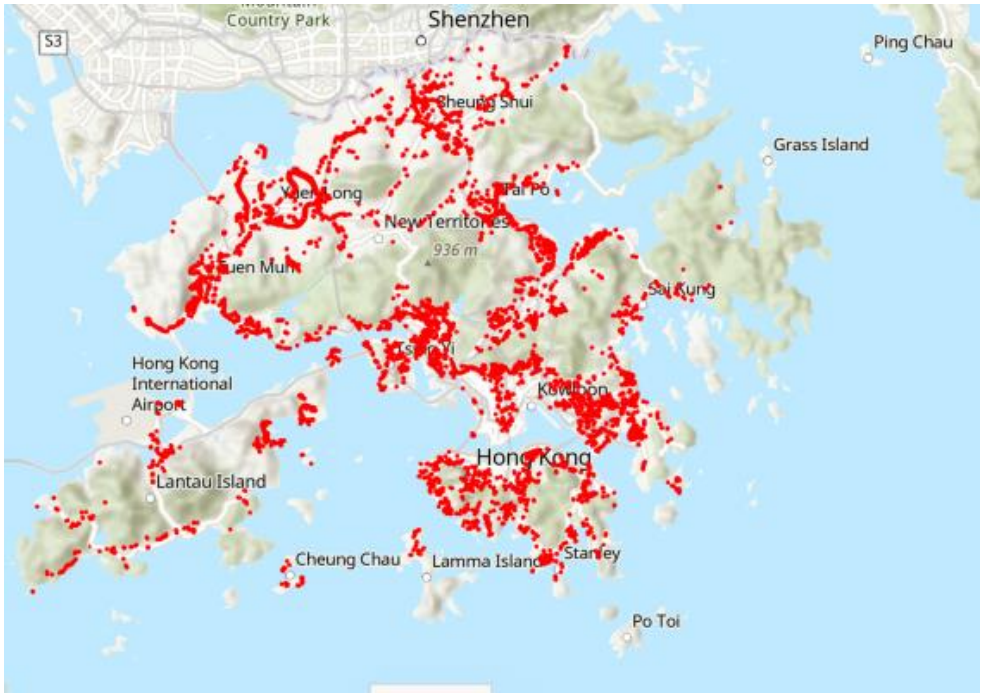

Figure 1: Distribution of less steep slope areas which can potentialy be used for open space areas

Drones are able to provide a high spatial and temporal resolution with their high operability for different circumstances (Colomina and Molina, 2014). GIS acquires, manages and analyses spatial data. When they are combined together, this can significantly enhance efficiency and accuracy of data acquisition and analysis . Drones can substantially minimise time required to collect data over large extents, whilst at the same time collecting high resolution images which are stitched together to create high quality map with precise georeferencing (Asteria Aerospace, 2025). Integration of GIS and drone photogrammetry is needed today because they can provide comprehensive details on the conditions of assets in aerial maps and 3D models especially in agriculture, urban planning and other industries (Quamar *et al.*, 2023).

There are now advances in technology when it comes to creating dynamic mapping and analysis. Active SLAM integrated with drones and GIS allows autonomous, adaptive mapping in GPS limited areas by capturing large swathes of data when on the go. This is considered to be 10 times more efficient as compared to traditional methods (Willoughby, 2022). In addition SLAM algorithms would integrate the sensor data such as LiDAR scans, camera images to create a fusion to complement the strengths and weaknesses of each technology, creating a decent map and 3D model (Gupta and Fernando, 2022).

Finally drones should be integrated with **both** GIS and BIM to generate digital twins specifically for construction projects. When drone images are stitched up to create 3D models, these 3D models can be used in pre-construction where pre-construction issues are identified to minimise design errors (Hammer Missions, 2023). Furthermore, in a construction site at Dubai, drones were utilised to acquire live data of the project so as to

update the 3D digital twin model. This can create comprehensive information in such a short amount of time so that an informed decision can be made to improve construction performance (Global Drone Conference, 2023).

Therefore, this paper has several objectives. It will primarily explore how integration of GIS and drone photogrammetry improves spatial data accuracy, especially for real time mapping applications. In addition, it will delve into case studies on how the integration is used in terrain analysis and urban planning. Lastly, this study will discuss about the wider implications of adopting this approach to a wide variety of industries.

2. METHODOLOGY

The case study was completed in South East Victoria which is aimed to showcase the difference in the landslide extent and severity through the integration of drone photogrammetry and GIS. In this case the DJI Phantom 4 was used to capture this extent and a flight grid plan was used to ensure there is more redundant captures to create a detailed 3D model. An overlap of 70% was used in this case.

Here are the steps utilised to accomplish this study:

1. Use a flight grid plan with an overlap of 70% or more using a flight planning software such as DroneDeploy or Pix4D

2. Use Pix4D/DroneDeploy to process the photos, stitch them together to create an aerial map and 3D model, as well as the Digital Terrain Model (DTM) and Digital Surface Model (DSM) of the area

3. Create contours from the DTM and DSM, as well as creating the slope map of the region in ArcGIS

4. Use the subtraction function of both rasters in ArcGIS to identify the difference in elevation between both 2019 and 2020.

3. RESULTS AND DISCUSSION

When the photos are stitched together to create an aerial map and a 3D model, it appears as follows:

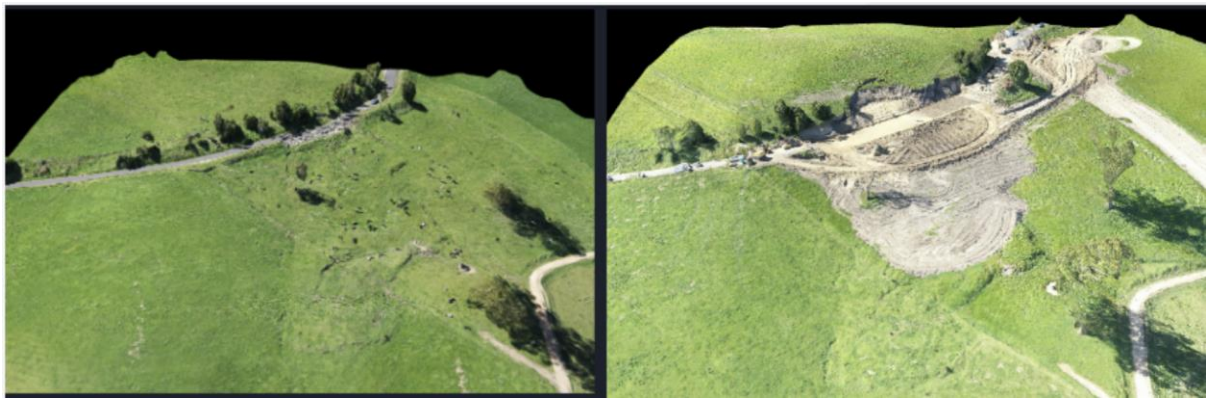

Figure 2: 2019 landslide only shows ridges (left), whilst 2020 showcases a larger extent of the landslide, resulting in more works that were done (right)

In 2020, there is a larger extent of the landslide which resulted in more works to be rectified, whilst in 2019, there were ridges that were starting to show which could deteriorate over time.

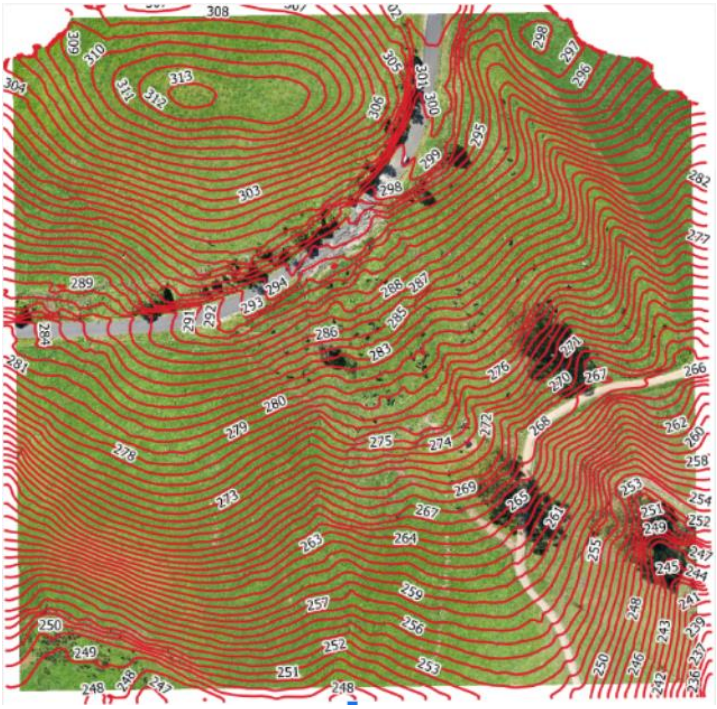

Figure 3: 2019 contours

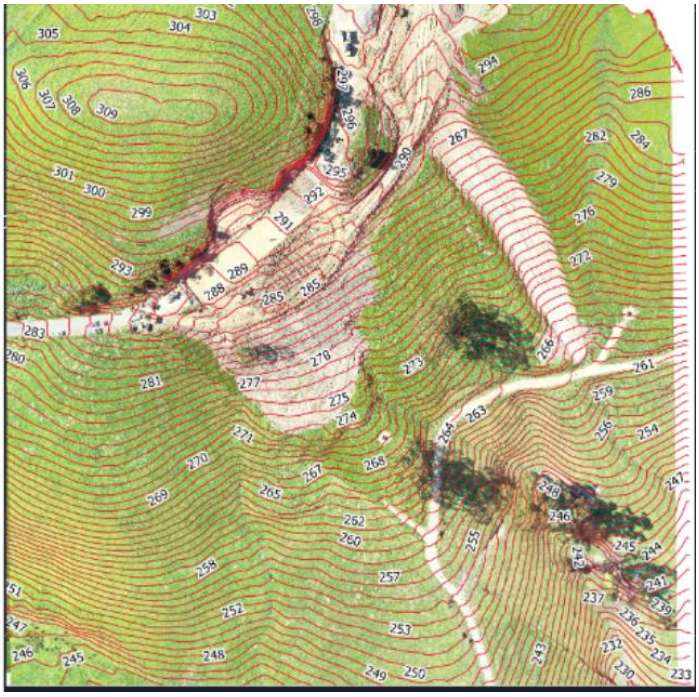

Figure 4: 2020 contours

In 2019, the land terrain is described to be extremely steep when it comes to contour levels shown in Figure 3. However in 2020, there were modulations in slope levels especially when it came to the road work rectification and the landslide rectification.

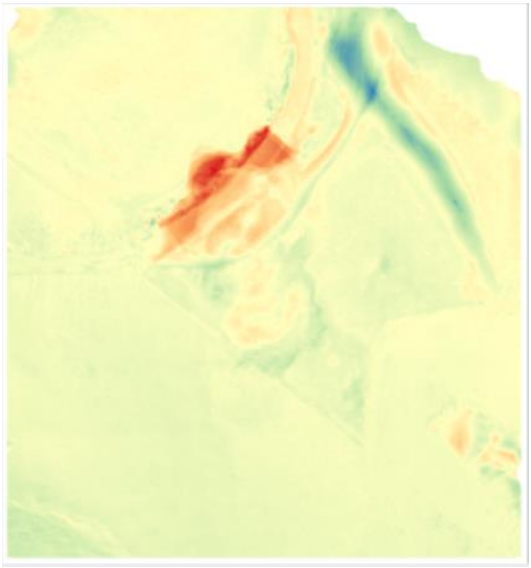

Figure 5: The subtraction function was used to identify areas which were more severe

After creating an elevation map in ArcGIS, the red areas showcase the difference in elevation between 1 to 3 metres.

Finally the subtraction function was used to visualise the severity of landslides between 2019 and 2020. It was found that the road had the most severity when it comes to the difference in elevation. The grider areas had indicated little or no significant change.

4. OTHER CASE STUDIES

4.1 Earthworks

Figure 6: Transformation from quarry to residential estate

Drones can be utilised to assess the changes that have happened between one time frame to another. This is an area which is converted from a quarry into a residential estate. There are changes especially when it came to the soil type and the increased residential area. The cut fill can also be measured as 3D photogrammetry can measure the volume of stockpiles being dug up.

4.2 Asset Management

Figure 8: 3D model of a sports building, with detailed conditions of pipes and roof

Drones and GIS can also be integrated together to form a 3D model which can showcase the conditions of the assets. This is especially useful when it comes to the maintenance and construction projects. The building model has shown some rusting which could mean that maintenance of the roof should be rectified. There is also potential for identifying the condition of the pipes and vents in the building.
There should be more advancements where GIS and drones can be utilised in digital twin and BIM projects so as to allow more informed decisions on how issues can be addressed on site through stakeholder collaboration in a unified platform. This is because by using drone photogrammetry in construction projects, we can see where the asset is in which location visually and stakeholders can tag the condition of these assets, notifying other stakeholders if the asset needs attention.

5. CONCLUSION

Therefore, GIS and drones should be combined to create effective solutions in different industries. This has been proven to be effective in the construction site and urban development. Further work should still be made in construction projects where drones can be integrated together with IoT to ensure more information can be captured in a timely manner.

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7. BIOGRAPHICAL NOTES

Ian has worked in the water and civil engineering industry combined over the past 6 years. He developed a solution which assesses the susceptibility of landslides with drones using GIS software. In addition, he has also attended business competitions where he developed spatial solutions on waste management in a local council in Sydney, as well as identifying vacant slopes which will be useful for recreational spaces in Hong Kong. Ian believes in a world where digital transformation creates comprehensive information in a short space of time, such as digital twins. He hopes to make an impact on the geospatial, construction, urban planning and engineering industries.

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