Together, AI and GIS Strengthen Land Administration in Oman

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SUMMARY

The intersection of artificial intelligence (AI) and geographic information systems (GIS), referred to as GeoAI, is creating enormous opportunity in the land administration space. Generally speaking, AI is the ability of computers to perform tasks that typically require some level of human intelligence (Land, 2022). Two areas showing promise are detection of cadastral boundaries from remotely sensed imagery and the mapping of boundary descriptions from scanned documents using techniques like natural language processing (NLP) and machine learning (ML).

The country of Oman, located in the Middle East and situated on the southeastern coast of the Arabian Peninsula, recently turned to GeoAI to improve its land administration and urban planning processes. Specifically, by using it to consolidate land tenure for capturing and registering unlicensed acquisitions and (re)establishing the often-missing linkage between registry and cadastral plans. A task, which by traditional means of field surveying and manual records input, was seemingly insurmountable. By leveraging GeoAI and GIS, officials with Oman's Ministry of Housing and Urban Planning improved efficiency by automating the extraction, classification, and detection of information from aerial imagery, Lidar data, and scanned cadastral plans. With rich, accurate data in-hand, they were able to establish an accurate land tenure system with provisions for urban planning rules, automate the issuance of legal documents such as deeds and krookies, and better communicate with citizens.

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INTRODUCTION

The intersection of artificial intelligence (AI) and geographic information systems (GIS), referred to as GeoAI, is creating enormous opportunity in the land administration space. Generally speaking, AI is the ability of computers to perform tasks that typically require some level of human intelligence (Land, 2022). Two areas showing promise are detection of cadastral boundaries from remotely sensed imagery and the mapping of boundary descriptions from scanned documents using techniques like natural language processing (NLP) and machine learning (ML).

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Starting with a pilot project covering five wilayats [provinces], officials put together a plan to conduct aerial mapping, perform image and data processing on resulting data, train and deploy AI models, analyze resultant data, and build production workflows.

1. AERIAL DATA CAPTURE

With a goal of conducting aerial mapping for 760 sq. km. using both photogrammetry and Lidar technologies, officials first needed to compare techniques of capturing the data. Three different approaches were considered: satellite imagery, aerial mapping with conventional aircraft, and drones. Factors such as weather challenges, time to collect, citizen conflict, positional accuracy, and resolution were considered. After weighing the options, aerial mapping with conventional aircraft was chosen with specifications shown in Table 1.

Table 1. Technical and equipment specifications.

Aircraft:	Diamond DA-42
Flying altitude:	950m AGL
Flight speed:	120 knots
LiDAR system:	Riegl LMS/Leica ALS 80
Camera: Phaseone	150mp with 90mm lens

To prepare for data collection, several steps were necessary including preparing the hardware and software, planning flight missions, and placing ground control points (GCP) (Figure 1). To ensure good positional accuracy was achieved, the GCP's were set and surveyed by coordinating closely with the National Surveying Agency (NSA). It took approximately seven days of flight time to capture the area of interest (AOI). Challenges encountered included cloud cover in the imagery and occasional gaps in the Lidar data.

Figure 1. GCP marked on the ground (left) and GCP as seen in imagery (right).

2. AERIAL DATA PROCESSING

Many thousands of individual images were captured during the flight missions and were photogrammetrically processed and checked against the ground control, resulting in the orthomosaic and digital surface model (DSM) products for the AOI. Software was used to overcome challenges such as color difference, lighting, and cloud cover, resulting in clear final imagery. The resolution of the final mosaic was 5cm (Figure 2).

Figure 2. Example of final 5cm resolution image.

3. GEOAI

The acquisition of high-resolution aerial imagery and Lidar data allowed for the use of GeoAI. The GeoAI tools were trained for specific tasks and used with ArcGIS Pro to extract data and features from the imagery including fences, building footprints, roads, and others (Figure 3). The area of the buildings and vacant land was calculated using the extracted data as well as calculating the heights of buildings and fences.

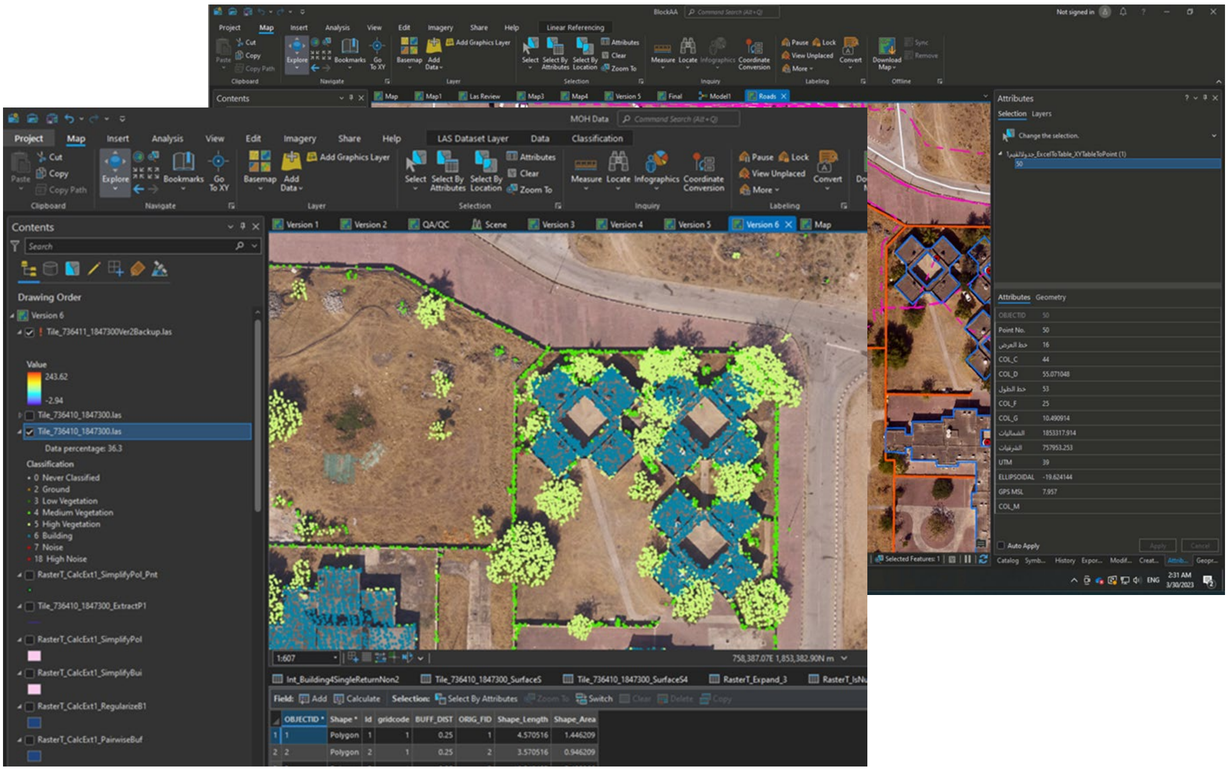

Figure 3. Data extracted from imagery and Lidar using GeoAI.

GeoAI was also used to extract data from scanned text documents (krookies) as the final step in linking landowners to property. By leveraging AI tools, Arabic font was detected in the images, text and coordinates were extracted, and a polygon was drawn on the map. Pertinent attributes were also added to each feature.

4. DATA ANALYSIS AND RESULTS

With all the newly acquired data and information from other governmental and private sources, work could finally be done to identify landowners for each claim so deeds could be issued. Utility data, such as electrical meters and lines were critical in identifying landowners so they could be reached quickly and easily. A deeds generator website was also developed as a part of the project to produce the deeds for the citizens.

In addition to the deed generator website, another product resulting from the project is a dashboard with statistics such as number of vacant parcels, construction status of the parcels, urban growth over time, and footprint area by classification (Figure 4). A very valuable tool for officials in the Ministry of Housing and Urban Planning for future planning and development.

Figure 4. Dashboard of statistics resulting from GeoAI project.

5. SUMMARY

By leveraging GeoAI, officials with Oman's Ministry of Housing and Urban Planning improved efficiency by automating the extraction, classification, and detection of information from aerial imagery, Lidar data, and scanned cadastral plans. With rich, accurate data in-hand, they were able to establish an accurate land tenure system with provisions for urban planning rules, automate the issuance of legal documents such as deeds and krookies, and better communicate with citizens. As a result of the project's success, there are plans to continue replicating this workflow throughout Oman.

REFERENCES

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