ASSESSING THE USE OF UNMANNED AERIAL VEHICLES (UAV)/DRONES IN MINING INDUSTRY

Faisal Sheikh[1], Dr. Anupam Bhatnagar[2]

[1]M.Tech. Scholar, Dept of Mining Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India
[2] Professor and Head, Dept of Mining Engineering, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

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Abstract - *An unmanned aerial vehicle (UAV), often known as a drone, unmanned aerial system (UAS), or by a variety of other names, is an air plane that does not have a human pilot on board. UAVs can fly with varying levels of autonomy: under remote control by a human operator, or totally autonomously by onboard computers. UAVs are frequently selected over manned aircraft for operations that are "too dull, unclean, or dangerous" for people. The goal of this study was to see if using UAV for topographic mapping and surveying may reduce the cost and time required to do the same task using conventional methods while still reaching acceptable accuracy. This study analyses and contrasts the deployment of unmanned aerial vehicle (UAV) in the surveying and mapping sector with traditional and recognised methods.*

***Key Words*: Drone, GNSS, GPS, Survey, 3D Mapping, Monitoring etc**

1. INTRODUCTION

Drones have been employed for a number of civilian and military applications and tasks, including unmanned air vehicles (UAVs) and micro air vehicles (MAVs). Depending on the sort of mission, these unmanned aircraft systems can carry a variety of sensors, including acoustic, optical, chemical, and biological sensors. Researchers have concentrated on the design optimization of drones to improve the performance and efficiency of drones, which has resulted in the invention and manufacture of many types of aerial vehicles with diverse capacities. Drones have recently piqued the mining industry's interest for everyday operations in surface and underground mines. The goal of this research is to look at how drone technology is being used in the mining business. Previous research and information from companies that provide drones to the mining industry are also used for this aim.

1.1 Applications of drones in surface mining

Mines are typically found in huge, inaccessible mountainous environments. As a result, monitoring mines and associated infrastructures is a difficult operation that necessitates a large amount of people. As a result, traditional techniques of monitoring mines are time and money expensive. Drones can be useful in monitoring, surveying, and mapping the area around mines if used correctly. Drones can be used to track mine activities and topography changes in the mining area, resulting in better mine planning and safety rules. A drone equipped with a hyper spectral frame camera, for example, was utilised to monitor the safety of the production pit in. In open-pit mines, slope angle optimization is critical for lowering cost of production, increasing mine performance, and recycling resources.

1.2 Application of drones in underground mines

Drone use in deep mines has been limited despite advances in drone technology. This is due to the complexity of using drones in below surface mines. Drones flying in harsh subsurface conditions have numerous challenges. Flying a drone in underground working locations is difficult due to confined space, poor sight, air velocity, dust concentration, and the lack of a wireless connection system. Also, a drone operator's access to inaccessible and dangerous regions in deep mines is almost impossible. Drones in underground mines could be used for a variety of health and safety purposes. Surface roughness mapping, rock mass stability analysis, ventilation modelling, hazardous gas detection, and leakage monitoring are some of these uses.

i. Geotechnical characterization of underground mine.
ii. Rock size distribution analysis in underground mines.
iii. Gas detection in underground coal mines.
iv. Mine rescue mission in underground mines.
v. Common sensing methods for drones in underground mining.

1.2 Conventional Surveying Techniques in Mining

Surveying plays an important role in the mining sector since it provides vital information to all other mining disciplines. Surveying allows for precise measurement of mined areas and volumes, as well as accurate portrayal of surface and subterranean conditions on mining plans. The following are the conventional techniques of Surveying in Mining.

i. Theodolite.
ii. Total Station.
iii. Photogrametry.
iv. Differential global positioning system (DGPS)

Surface mines	Underground mines	Abandoned mines
Mines Operation 3D Mapping Slope stability Mine safety Construction monitoring Facility management	Geotechnical characterization Rock size distribution Gas detection Mine rescue mission	Subsidence monitoring Re-cultivation Landscape mapping Gas storage detection Acid drainage monitoring

This study was conducted in a Soapstone mine. The study area is situated in the Dingri – Nathara ki pal region of Udaipur, Rajasthan. The area lies about 40 km South-East of Udaipur. The area of the study site is 22 Hectare. The method of extraction in the mine is Shovel – Dumper combination, blasting is done to remove the overburden. Here the soapstone is found alongside talcose schist and dolomitic limestone from the Aravalli period. Soapstone is found as lenses and veins with lengths ranging from 18 to 90 meters and thicknesses ranging from 2 to 15 metres. Soapstone is a large, foliated stone that ranges in colour from white to pale green in appearance. The above study was carried out in order to assess the applications UAVs in mining industry. This assessment was done by carrying out UAV survey of the chosen mines.

2. Working Procedure

Step 1: Assembling of the drone and the communication box

The first and foremost step is to assemble the drone properly. For this, the following procedure was adopted:

i. First the propeller was assembled with the drone. There are two type propeller provided with the package, one is silver color marked and another is black color marked. The black color marked propeller was mounted on black color marked motor and silver color marked propeller mounted on silver color marked motor.

ii. Then the lithium battery was assembled with the drone using Velcro straps on the drone. It was ensured that the battery was tightening the battery properly.

iii. The battery's cable was tightened with landing gear using the help of Velcro attached with the landing gear.

iv. Antenna was assembled into the drone at designated port and snapped it on drone's body.

v. Camera was mounted on the drone at designated slot and the rubber was pushed back.

vi. The communication box was mounted on tripod with the help of the tripod connector. The tripod's height was adjusted as per the requirement.

vii. The battery power port was connected with designated port on the drone. Make sure the port is tight. The screw driver supplied with maintenance kit was used to increase the diameter of contacts of the drone's port.

viii. The button on the communication box was long pressed to switch it on.

ix. After 90 seconds, the standard boot time for the drone two green lights in front and two red lights in back started blinking at 1 Hz rate. 1 Hz means, it would on for one second and then off for one second.

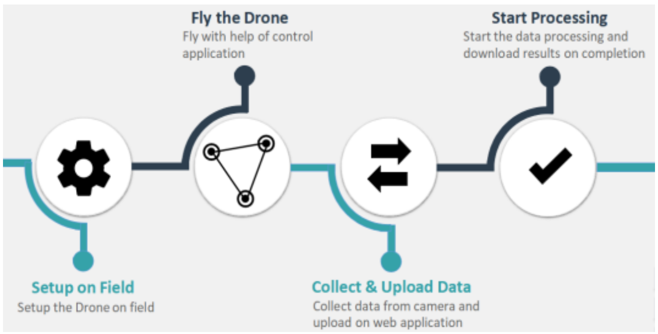

Fig-1 Drone's Working Flow chart

Fig-2 Drone at Study Site

Step 2: Flying the drone

a) The Application was opened in an Android mobile phone.

b) First logged in.

c) Once the drone has booted up, a camera and connection selections were made.

d) The camera model was chosen. Camera details were entered for GoPro 10 black or GoPro 9 Black as payload and clicked on "Quick App" button to make camera Bluetooth visible.

e) Clicked on confirm button on App. It took few seconds for camera to connect with the drone wirelessly. On successful connection, it was notified on the App saying "Camera Wi-Fi Connected" and also a beep sound was heard on camera.

f) Although most of the settings are done automatically on the camera by drone, few things must be checked to have a successful survey. They are:

g) Checking of zoom level of camera. For which "photo linear" button on camera was used, then clicked on edit icon, and scrolled down to see how much the zoom level is? If it wasn't 1x, it was changed to 1x.

h) Checked whether the camera GPS is locked or not. To check it, scrolled down the setting screen from home screen. Saw that if the GPS icon is of white color or not. If it is not of white colour, waited for some time for GPS to lock. If it didn't lock for long time, the camera was restarted.

i) The camera icon of the App was clicked to see if camera is clicking images or not. If it is not clicking the images, everything was reconnected again from the start.

j) Clicked on "Plus icon" on right side bottom of the camera to plan the mission. After giving desired altitude, angle and overlap.

k) Clicked on "Arm" button on top of the screen to check whether the motors are working fine or not.

l) After checking everything successfully, swiped the "swipe to fly" button. The mission got uploaded on to the drone and drone took off to complete the mission.

m) Once the flight was completed and drone had landed on to the ground, clicked on photo icon on App and checked whether the camera is clicking photo or not.

2.1 Data Acquisition and Processing

To satisfy the data goals of work or mission, drone flight planning entails setting the flying schedule, pattern, altitude, and image or image capturing parameters, as well as any weather-related needs (e.g. temperature, light, or irradiance constraints). Failure to design the proper flight plan can result in not only a waste of time and resources, but also serious implications such as damage to the drone or endangering the safety of others. For this study purpose the following flight plan was adopted.

i. Height of Flight was set to 100 m.

ii. The chosen overlapping was 70%.

iii. Flight speed 35 km/h.

iv. Camera set to linear photo mode.

The flight is planned after the KML import. Figure shows the flight plan for this study.

i. The broad yellow line polygon represents the imported KML boundary.

ii. The green drop pin represents the start position of the drone, the red drop pin represents the end point of the flight.

iii. The green arrow represents the drone and its direction.

iv. The thin yellow lines (inside the polygon) represents the path on which the drone will fly.

Fig-3 Flight Plan of the Study

After the completion of the Flight according to the Flight plan, the obtained data was sent for processing. For this study the Drone data processing was done through H.K. & Associates, Udaipur.

The following resultant images were obtained:

i. The image of the whole pit showing all the benches, pit area and lease area (if required).

Fig-4 Orthomosaic image of area

ii. Elevation profile of the pit, where blue region represents deeper location and reddish shades represent higher pit area. Deepest point of the point is at 578 m, while highest is at 691 m.

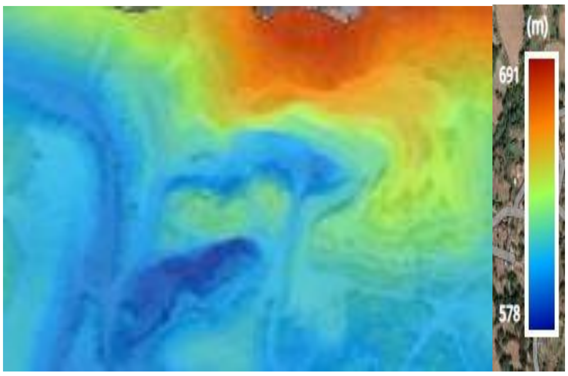

Fig-5 Elevation Profile

iii. The Contour profile depicting the points of same elevation in the pit.

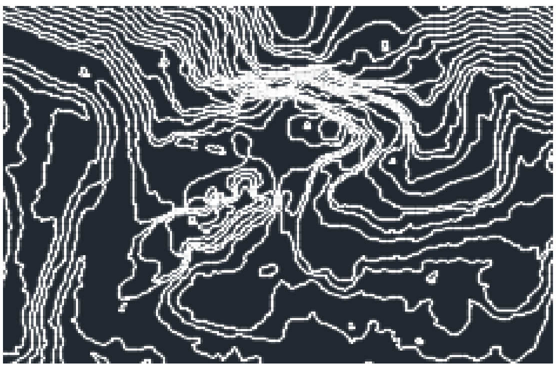

Fig-6 Contour File of the Pit

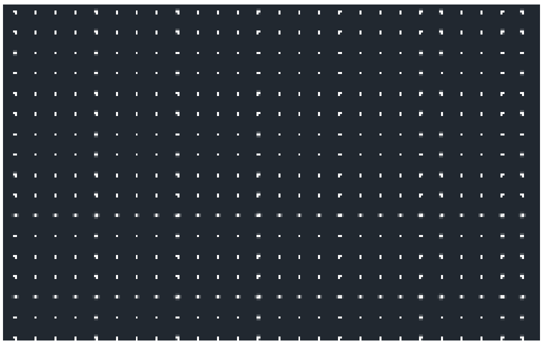

Fig-7 Point File of the Pit

The following images were obtained by drone surveying, which can be used to calculate:

i. Mine (pit) area.

ii. Bench height

iii. Bench Slope

iv. Volumetric analysis.

v. Lease Area and Demarcation

All this data was obtained by a single drone, performing only one flight. The duration to carry out this survey of 22 hectare mine pit was about 30 minutes & an additional time of 24 hours is spent in processing the data. Comparing this with the conventional surveying method of DGPS, it would have taken approximately 4 days to survey the same area size.

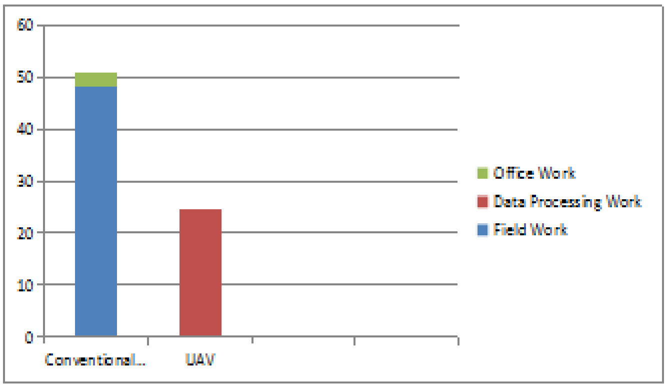

Fig-8 Comparison between Conventional and Drone Survey

Also, the man power required to perform Drone survey is 2 persons, while it requires 4 persons to carry out a survey through DGPS. The drone was able to capture hard to reach areas, while the DGPS would was not able to acquire data from those regions.

Finance being an important part of mining industry, thus the cost of carrying out these surveys also need to be evaluated.

During this study, industry sources were reviewed. It was found that:

i. The Drone surveying costs about INR 10000/hectare.

ii. The Surveying through DGPS cost about INR 800/pillar. The number of pillars depend on the size of mine.

According to business to cost ratio, the UAVs are cheaper than the conventional methods.

3. CONCLUSIONS

The primary purpose of this research was to assess the application of UAVs in mining. The secondary purpose was to make recommendation regarding the utilizing the maximum potential of UAVs in mining industry. In this regard a survey was carried out in a Soapstone mine. The obtained and processed data was then compared with the conventional survey methods. The major focus of this study is to highlight the ease of data acquisition by UAVs in hard terrains of mining industry. With high risk factor in mining industry and mining being primarily a safety oriented sector requires the safety of its work force. This safety factor can be achieved if all the working areas are observed, monitored and surveyed efficiently. This can be done using efficient tools like UAVs in various sectors of mining. In this regard the current study was conducted with focus on UAV survey and following conclusions were made:

i. It was observed that the Drone survey was efficient in saving time taken to acquire images. Drone survey took about half the time to present the result as compared to the conventional methods.

ii. The overall cost to carry out the Drone survey is cheaper compared to conventional methods with respect to the size of area.

iii. The manpower required in Drone survey is about half the manpower required in conventional method.

iv. The resulting data and images can be used to calculate area, stockpile analysis, stope stability.

With these aforementioned merits UAVs showed great scope in mining industry with further development in UAV technology, UAVs can be more efficient in the mining field

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BIOGRAPHIES

Faisal Sheikh, completed the B.Tech. degree from RTU Kota in 2018. He is currently a final year M.Tech. student of College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Dr. Anupam Bhatnagar, Associate Professor & HEAD, College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India, Ph.D. (Marble Waste Minimization), M.Tech. (Mining) IIT Kharagpur, B. E. (Mining).