Underground drones as a support line for mining companies in Ecuador

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Abstract

We currently live in a world shaped by technology and its constant changes with hardware and software that adapt to specific users that help improve processes, why unmanned aircraft were created, which today is modern technology. applications in the development that for its range of compatibility makes feasible the support with other systems. This is how in the area of work inside information. This article focuses on putting the manifest on the usefulness of drone technology in the mining area. In this same sense, this field includes information on the operation and use of drones in this field.

Keywords

Drones in mining, Technology, Aerial devices

1. Introduction

Currently drones are a modern technology, and there are many companies that offer aerial services by drone, with one of the main features being the audiovisuals that work with video cameras. This technological advance makes its size, availability and low risk for people become an option to reach places of difficult access, at a low cost which gives an advantage to mining companies [1].

Drones have multiple functions in which they are based on diagnosing captures that they collect through coordinates that serve to perform locations, reserve calculations, among other functions [2]. Drones are a kind of technology with very peculiar features, where orthophotographs and topography models are necessary for geological processes and the development of scientific work are obtained [3]. In fact, there are constant changes as technology advances, there is greater precision in this type of aerial devices with sensors with greater information gathering capacity. A particular feature of drones is that they use a very environmentally friendly technology as it does not produce CO2 and provides safety in field work [4].

There are very useful applications that serve us with the help of drones, but also some people do not understand the purpose for which this technology was created. Thus, the first indications

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appear in 1849 when two hundred hot air balloons were placed in an attack of the Austrian troops to the city of Venice [2], after some time it was used during World War I, where the military used it for espionage purposes [5].

This article aims to analyze how aerial devices can help us in everyday life, giving reason to the potential they bring to the field of mining, making feasible the use of this technology, so this article will detail basic concepts that specifically indicate the features and kinds of drones that exist, as well as how these devices help us to solve and optimize processes required in very common areas such as civil engineering derived from mining.

2. Background

The technological advancement of drones benefited the mining industry and positively transformed operations by providing real-time data. Drones allow the identification and mitigation of mining hazards as they emerge, rapid collection of data in risky locations and the ability to share accurate maps and models immediately with stakeholders [6]. Between the main advantages of using drones in mining operations there are: 1) drones can do a quick inspection of an area, either in an emergency situation or hazard identification and 2) the inspection and unblocking of blocked box-holes and ore-passes can be done using drones [7]. Lee and Choi [8] categorized the applications of drones in the mining industry, including surface, underground, and abandoned mines.

A new concept of mining 4.0 has came up and it includes artificial intelligence, internet of things, cloud analytics, and cognitive computing. Usage of drones in the mining industry has peaked at a fast rate in surface and underground mines due to their cheaper and more efficient data collection abilities compared to the traditional techniques [9]. Jackisch et al. [10] demonstrated that unmanned aerial systems (UAS) are very useful to monitor areas affected by acid mine drainage (AMD). They investigated in the Sokolov lignite district of the Czech Republic which was a post-mining landscape. Through four field and flight campaigns that were conducted from April to September 2016, the group identified specific iron absorption bands in the UAS-HSI data. These features were confirmed by ground-truth spectroscopy. The distribution of in situ pH data validates the UAS-based mineral classification results. Evaluation of the applied methods demonstrated that drone surveying is a fast, non-invasive, inexpensive technique for multi-temporal environmental monitoring of post-mining landscapes.

In open-pit mines, optimization of slope angle has an important role in production cost reduction, mine efficiency, and recycling resources (DJI-The World Leader in Camera Drones, 2021). Xiang et al. [11] used integration of terrestrial laser scanning and drone photogrammetry to investigate slope zones by monitoring point displacement and 3D mapping of open-pit slope zones. They also did monitoring for mine inventory and changes in mine area.

3. Drones

Drones or Remotely Piloted Aircraft (RPAs) are unmanned aerial vehicles that allow the collection of a large amount of data with very low cost of money and time [12]. A drone is referred to as an object in terms of aerial aviation capable of being controlled by remote means, where one

of the main features is the operation of image capture, that is performed by means of a GPS system. As technology advances, at the same time their devices evolve, which contain this type of technological functions, this includes drones that came to the world for the public to look from a different perspective the way to control applications that are contained within a device that denotes high autonomy capabilities [2].

Drones focus its work in different areas, such as the educational, industrial and legislative field, and mainly we focus on the specific field of this article that it is the mining area. From all these areas, drones allow to expand its branch of functionality so that it can be useful and be an important device (see Figure 1).

Figure 1: Drones

3.1. Drone types

Depending on the defined mission, drones are generally classified based upon their configurations. Drones can be grouped into nine categories, such as fixed-wing, flapping wing, rotary-wing, tilt-rotor, ducted fan, helicopter, ornithopter, and unconventional types [13].

3.1.1. Rotary Wing

This type of drones have the feature of being less aerodynamic, allowing to reach lower speeds, this includes that it can have restrictions in surfaces of reduced area (see Figure 4).

One of the main features is the autonomy of flight, which is inferior to the previous ones, with the only difference that this type of drone is maneuverability, being much greater in small spaces, as well as spatial, giving it an utility in complex areas where there is vertical work. The camera's controlled through a gimbal support that allows its rotation, facilitating the taking of images, thanks to the combination with the rotation of the aircraft on a fixed point [12].

3.1.2. Mixed wing

Mixed-wing aircraft are larger and present the benefits and limitations of a system that combines fixed wing and rotors.

Drones have multiple capabilities to obtain physical conditions due to their weight and size, and according to this it is possible to implement the types of sensors according to their load (see

Figure 2: Rotary wing drone

Figure 3). With the information collected through various points or coordinates captured with the drone, it is possible to work in a fast and efficient way, thus containing timely information of various types [14, 2].

Figure 3: Mixed wing drone

4. Operations with drones

4.1. Types of permitted flights

4.1.1. Recreational flights

This type of flight allows to have a remote control exclusively destined to these flights, since it allows to perform maneuvers that propel some type of specific skill.

4.1.2. Photographic flights

This type of drone allows to navigate in order to provide images collected through various points captured by the integrated camera.

Figure 4: Uses of Drones. Practical applications for unmanned aerial vehicles. [15]

4.2. Way of piloting

In order to be able to maneuver unmanned vehicles, such as drones, some relevant aspects or points should be considered according to the Colombia web portal:

- Having a course in Civil Aeronautics.
- The pilot cannot operate two simultaneous flights.
- he pilot must not be in a state of drunkenness.

4.3. Factors of drones

The use of drones is common in several countries, since their commercial production is very high, and that is why there are discussions in which the aspects or factors the governments are mainly focused, such as privacy and protection of information and security [16].

Privacy and protection of information. Here the ethics of the professionals involved in the use of these devices, since information is collected according to the interest of the authorities, and these in turn, are at risk of being manipulated [17].

Security. Here intervenes the integration of forms of protection to the RPAS device, so that it avoids having any accident in the airspace while it is in operation [17, 18].

4.4. Aspects of drones in technology

Drones undoubtedly contain advanced technology, which are abstracted by kinds of components needed for the respective operation of the RPAS, such components contain timely information that requires practical aspects such as:

- Detection and control systems. - Drones today contain sensors that detect objects around them to avoid collisions. These devices are according to the technology that has implemented, and according to it, varies the price of trade.
- Communication systems. - It is essential that the RPAS contain a communication system through radiofrequency that scans and broadcasts information through satellites, where they transmit the communication in urban areas.

5. General application of drones

rones as such are versatile in terms of the installations that are made in the predefined attachments in some devices, among which cameras, microphones and sensors stand out [17].

Some of these unmanned vehicles are fundamental for some areas such as:

- **Agriculture:** in this field it is useful to collect information about the crops grown.
- **Audiovisual promotion:** it is characterized by capturing aerial images.
- **Security:** in the field of surveillance in some companies.
- **Education:** it is used for topographic analysis.

On the other hand, there are several investigations that highlight the great usefulness of these devices as evidenced by a work done with drones for photogrammetric and 3D modeling application, in a gray granite mine with which geological and topographic cartographic plans were elaborated [19]. In the same way the drones have been used as a tool for detection and alert of possible illegal mining areas in Colombia, through its cameras and a pattern recognition algorithm [20, 21].

6. Discussion

6.1. Current Legal Regulations for the use of drones in Ecuador

According to the provisions of the Civil Aviation Law in article 6, numeral 3, paragraph (a), the following regulations are mentioned:

"Dictate, reform, repeal technical regulations, orders, internal regulations and complementary provisions of civil aviation, in accordance with this Law, the Aeronautical Code,the Convention on International Civil Aviation and those necessary for flight safety and the protection of air transport safety".

These measures are directed to the Director General of Civil Aviation (DGAC), since it has the function of competent authority, it carries a responsibility to issue regulations according to the safeguarding of the population in general.

6.2. Application of drones in the mining area

The revolution that currently exists within a technological field is completely abysmal, allowing the use of technology for different use of its applications and adaptation to the mining sector, granting greater security and sustainability to workers when making studies of new mining reserves and raw material supply.

Within one of its main applications of unmanned drones in the mining sector, is to replace the man to safeguard his life within the mining activities, allowing in turn to have an automation, to carry out operations quickly without so much human interaction.

In addition, with the implementation of this technology will allow to have more accurate data such as: recognition of the mine, operation planning and terrain stability, giving usability to the features that the drone has due to its sensors that will detect the characteristics of the environment, and mediating algorithms in a systematized way for image processing [22], obtaining information.

Consuming all this resource that they currently provide us, the issue of applications in the mining field would be transformed to a digital mining, through reliable communications, remote control in operations and able to manage different types of services at the same time.

With all this, and once the specific needs of mining have been studied, the potential applications of drones are [2]:

- **Prospecting:** It is performed when cameras integrated internally in a drone intervene in prospecting work in areas with insufficient amount of space, making shots with a formidable resolution [14].

- **Topography:** It is performed when a geological mapping can be captured through an analysis of parameters where the size, grid spacing, pattern density, among other characteristics are captured [14].
- **Technical inspection:** It is performed with the visualization of pathologies or deficits with access to the components of the drone device [23].
- **Remote sensing:** their multispectral sensors allow them to recognize absorption properties of soil, rocks and vegetation. This information is very useful for geologists [2].
- **Aerial magnetometry:** this task the drone can detect magnetic field disturbances thanks to magnetizable materials, such as magnetite, found near iron deposits [2].
- **Airborne gravimetry:** this method measures pressure changes of gravity values and which are caused by the density of earth materials [2].
- **Electromagnetism:**this method generates a primary electromagnetic field that induces the action zone. If the results are positive right away, a good conductivity is produced and will be recognized [2].
- **Airborne radiometer:** use is made of Alpha, Beta and Gamma rays found in the decay of radioactive elements such as Uranium, Thorium and Potassium [2].
- **Photogrammetry:** consists of superimposing aerial images and from the differences of these images the relative X, Y, and Z coordinates between points are determined [2] (See Figure 5).

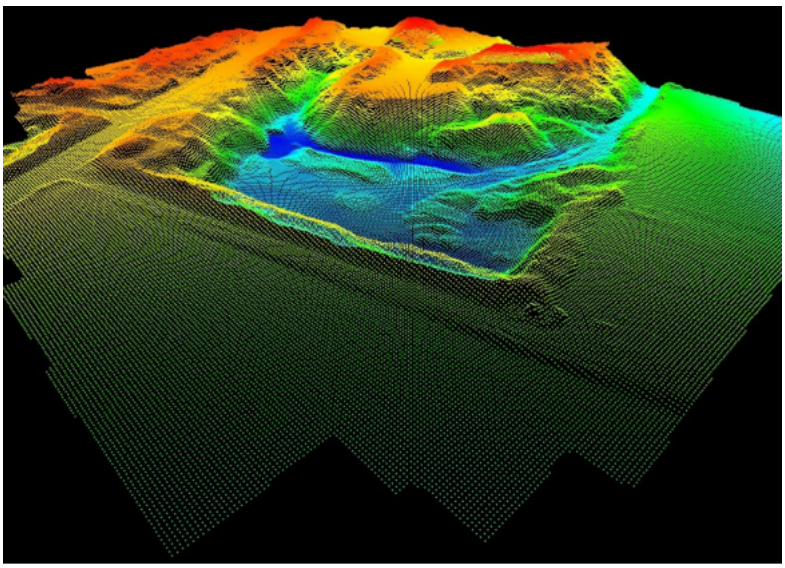

Figure 5: Example of photogrammetric shots

In this way, it can be established that the use of technology is in full development, and it is necessary to acquire these resources for future applications that will come to be made with unmanned vehicles within the mining field, allowing to obtain better accuracy, efficiency and environmental sustainability [2].

7. Conclusions

Through this project, it was detailed and analyzed what a drone is, as well as its features, kinds and how it helps in the field of civil engineering and in the mining area, with its different applications. The help of these devices allows us to perform versatile works where it is obtained to simplify the classic methods of collecting information, be this to capture, analyze and process data that was obtained.

Having said the above, it is concluded that this type of technology is very useful in the fields of all areas that may exist. Its purpose is to obtain and collect accurate, efficient and sustainable information.

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