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Unmanned Aerial Vehicle and Geospatial Technology Pushing the Limits of Development

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ABSTRACT: *Often referred to as unmanned aerial vehicles, or UAVs, drones were most commonly associated with military or police operations but with advancement in information technology in last two decades, cheaper and smaller sensors, better integration and ease-of-use options this tool is start revolutionizing the way geospatial data is collected in many countries, monitoring large, rugged areas, tracking down criminals, observing forest fires and disaster areas. Beyond just viewing the result, with the use of photogrammetry, image processing and ground control points, the captured imagery could provide a base for collecting all the 2D and 3D features that are the last-mile problem in modeling and visualizing the whole world. The research aims to understand various characteristics of this emerging technology that makes it the most promising geospatial and attribute data collection tool in GIS community. Second aim of this paper is to explore the possible applications of UAV in the developing country like India.*

KEYWORDS: *UAV, Drone, Photogrammetry, GIS, 3D Model, Geospatial.*

I. INTRODUCTION

UAVs commonly referred to as drones, are remotely piloted aircraft or systems. They range from simple hand-operated short-range systems to long endurance, high altitude systems that require an airstrip [1]. UAVs have been in use by the military for a long time, mainly as shooting targets, and for surveillance. In the past years, there has been considerable activity in the development of UAVs of all possible kinds, and this is well documented on the UVS-International website [2]. The potential benefits like ease of use, monitoring large rugged areas, tracking down illegal activities, observing forest fires and disaster areas these systems are now extended well beyond defense use to a variety of domestic and personal applications that will improve the safety of our communities, strengthen public services and achieve countless additional benefits to a broad variety of commercial and government organizations. The UAVs not only open up the gateway of new markets but will greatly broaden current markets. In south Mumbai a restaurant 'Francesco Pizza' recently delivered one of their Pizza's using a drone to a location nearby (Worli).

Figure1. Drone to deliver Pizza in Mumbai, India

GIS was developed as a computer system for capturing, storing, querying, analyzing and displaying geographically referenced data [3] but with the advancement in information and computational technology, GIS emerged as a broad term and a complete package, which can refer to a number of modern technologies and advance processes and became mainstream that expands knowledge and connections among people [4]. When working on a GIS project, the very first issue is 'data collection'. The fact that the data collection is one of the

most time consuming step in GIS, turns the decision on how to collect data, one of the most important factor, since the cost of this part of the project may become a great burden for the rest of the future analysis that is going to be performed with this data. GIS users have always craved high-quality, near real-time imagery. Over the years, expectations for resolution and fast delivery have been significantly raised. As the market for UAVs continues to expand from last two decades, they have transformed into data-gathering tools for GIS. Today UAV has become a primary resource to acquire remotely-sensed GIS data.

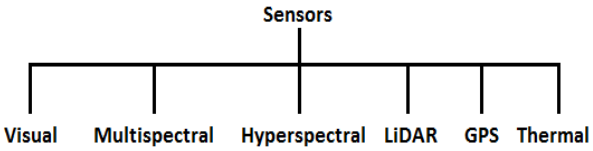

Figure2. Types of Sensors

a. **3D POINT CLOUD**: Traditionally, DEMs have been produced by survey methods or by stereo photogrammetry [5] [6]. Since the introduction of LiDAR in the mapping industry, its applications in GIS and other areas has increased exponentially and diversified innovatively. LiDAR has become the natural choice to provide data for Digital Surface Models (DSM) and Digital Elevation Models (DEM) in different applications. However, instrument cost and point cloud acquisition costs often prohibit LiDAR use solely for various projects in developing countries like India.

Low operation and hardware costs with high quality mapping sensors UAVs have become an attracting choice for aerial photogrammetry [7]. Automatic generation of high-quality, dense point clouds from digital images by image matching is a recent, cutting-edge step forward in digital photogrammetric technology [8].

b. **DIGITAL AERIAL IMAGERY (DAI)**: Recent technological developments in both hardware and software allow UAVs to capture high-resolution, georeferenced still photograph of study area. Acquired images of study area can be successfully processed to produce digital ortho-photo and digital map.

c. **REAL TIME MOTION PICTURE (VIDEO)**: Currently, UAVs are primarily used for capturing and down-linking real-time video. High definition low cost video camera is used to acquire video streams in software friendly format. Aerial video, collected by visible video cameras deployed on small UAV platforms, is rapidly becoming low-cost and up-to-date source to solve many hard real time challenges like natural disaster remediation [9].

d. **OBLIQUE IMAGES**: Oblique imagery is an aerial photography that is captured at specific angle with the ground and allows us to obtain an aerial perspective of the object. For underlying scene/feature oblique imagery helps to extract three major components (i) 3D geometry, (ii) appearance texture/facade, and (iii) properties/attributes. UAV provides cost effective and a quick alternative with an additional feature to capture building texture /façade at all possible angles. This will boost the hope of much awaited 3D GIS system development.

e. **THERMAL IMAGES**: Thermal imaging is a method of improving visibility of objects in a dark environment by detecting the objects' infrared radiation and creating a crisp image based on energy fluxes and temperature variations. Thermal camera is an electro-optical device that can be attached to drones to carry out thermographic surveys. They are used as a perfect solution for defect analysis of solar panels, wind turbines, buildings, and other difficult-to-access structures.

f. **GPS/INS LOCATION**: Many applications like surveillance, surveying and mapping, spatial information acquisition require precise navigation. Currently, the most widely used navigation technologies for the UAVs are GPS receivers and INS devices, alone or in combination. INS is a self-contained device which operates independently of any external signals or inputs, providing a complete set of navigation parameters, including position, velocity and altitude, with a high data rate. In contrast to INS's short-term positioning accuracy, satellite-based GPS navigation techniques can offer relatively consistent accuracy if sufficient GPS signals can be tracked during entire UAV mission [10].

II. APPLICATION OF UAVS IN DEVELOPING COUNTRIES

Developing countries, also known as third and fourth world countries; face economic challenges that first world countries do not, on a large scale. Poverty, Agriculture, low literacy rates, interrupted medicine supply; poor nutrition and lower energy production have become the common constraints on development. These factors must be broken for countries to develop. Technology is the only answer to these challenges. From high definition georeferenced images, oblique photographs, point cloud models to real time motion pictures, UAVs has opened up a world of possibilities for developing countries. Here we are presenting some of the core applications of drone/UAVs to improve the pace of development and level of life in the developing countries like India.

III. DRONES FOR AGRICULTURAL CROP SURVEILLANCE

Slow agricultural growth is major concern in countries like India where agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric. Higher cost and tuff handling of modern technology is the major problem in the use of technology in agriculture and yet farmers are forced to use conventional way of farming. Today 'walking the field' is the only way farmers monitor their crops. But this method often can be incomplete or time consuming, and collected data take long time to process and analyze. As a result, it can be difficult or impossible for the farmer to react to a problem like a disease outbreak before its too late or the costs to treat it have soared. Using drones for crop surveillance can drastically increase farm crop yields while minimizing the cost of walking the fields. Various drone enabled Crop Health Imaging systems at very low cost available that helps to have a composite video showing the health of crops. The Benefits of Drones in Farming are

- **Save Time**: While all farmers know the value of scouting their crops few actually have time to cover the acres on foot.
- **Increase Yield**: The precision application of pesticides, water, and fertilizers only where it is needed for specific crop increase the yield.
- **Crop Health Imaging**: Seeing the true health of your field in a color contrast allows you to see how much sunlight is being absorbed by the crop canopy.
- **Integrated GIS mapping**: Draw field borders for flight pattern

GIS technology has already proved its importance throughout the agricultural industry to manage resources, increase yields, reduce input costs, predict outcomes, improve business practices, and more [11]. GIS has a significant role to play in agriculture at several scales from local to global. The arrival of small and compact UAVs at regional and larger scales provide continuous data and when collected data is processed using thematic mapping system (GIS) at farm scale, produce maps based on themes such as soils or hydrology. Multiple layers of maps can be quickly displayed in a variety of overlap, scales, and combinations to fit the needs of the farmers.

Figure3. Drone over agriculture land.

IV. DRONES FOR DIASTER MANAGEMENT (SEARCH AND RESCUE OPERATIONS)

There is a great need for information gathering from air, at sites of natural disaster and accidents. After disaster strikes it is critical to analyze situation and prepare immediate relief and rescue plans. At the same time it is too expensive, tuff and risky (environmental conditions) for a manned aircraft to acquire information. UAV is attracting a great deal of attention as a safe and efficient means of acquiring information in a region that are difficult for rescue teams to access and get a basic idea about situation such as flooded areas, tsunami, volcano sites or cultural riots. Drones are used to ascertain status of damages and provide information about its impact.

Benefit of UAV in disaster operations are:

- Food and Medical supply: Drones can be used to supply food and medical at disaster site that are not easily accessible.
- Search and rescue operation: After the disaster situation UAVs are used to search for missing people, and rescue people which got stuck.
- Monitoring relief and rehabilitation operations and make them enough to serve persons in trouble.

GIS can be a very useful tool to complement conventional methods involved in Disaster Management Mitigation of natural disaster management can be successful only when detailed knowledge is obtained about the expected frequency, character, and magnitude of hazard events in an area [12] [13]. GIS when integrated with UAV provide layers of information on various themes to enable the managers to take the most appropriate decisions under the given circumstances at run time.

Figure4. Drone over a disaster area.

V. DRONES FOR SUPPLYING MEDICINE AND FOOD IN REMOTE/INACCESSIBLE AREAS

Access to healthy food and full medical support is a basic human right. The policies that affect our food and medical system should be enacted to ensure that everyone has access to these life support services. There have been numerous methods used to identify and analyze food access and medical supplies. Mapping patterns of access to food stores, hospitals, medical centers using GIS is becoming more prevalent and increasingly effective. In India, major percentage of total population is living in rural areas and among them there are many villages that are inaccessible by road for at least part of the year. The only reasonably fast way of getting medicine and other essential goods to these locations is to fly them in by military helicopters. At the same time in India 1.3 million children die every year from malnutrition, it is because of improper diet and interrupted supply of medication. Small UAVs, which would inexpensively deliver payloads to remote communities can bring smile on the face of people who feels disconnected and solve basic problems related to food and medical. Use of drones together with GIS can solve many problems in remote areas like

- Virus affected Areas: In that particular areas which has been affected by virus or infectious diseases and where external man force cannot be entered drone can fulfill the requirement of medicine.
- Tribal and naxalite areas: Areas where life is too hard to survive, where basic need of people is food and where external man force cannot be allowed to enter because of political or security reasons, drone can maintain the supply for basic need of life.

Figure5. Drone for rescue and rehabilitation.

VI. DRONES FOR ENERGY

Setup and maintenance for both the conventional and unconventional energy source is too costly and always a time consuming task. So there is a requirement of continuous monitoring of these systems. In power plants and transmission lines some factor which have to be monitored on periodically/regular basis are cracked insulator string ,frayed power conductor, degraded conductor splices, tower corrosion, tree growth ground clearance, conductor space/damper condition and critical thermal spans along transmission line. Manned helicopter are dangerous to fly along EHV power transmission line during inclement weather. Benefits of Drones in energy sectors are as follows:

- Storm damage inspection: After natural calamities, drones with high resolution imagery and ultra violet sensors used to collect information about status of transmission lines, cracked insulators and connections. This information essential for maintenance operations and in order to restart power transmission.
- Monitor the height of tree around the transmission lines: Drones are main source to monitor status of trees around transmission line and collect information to ascertain need of trimming.

In order to cater the increasing energy requirement another important option is nuclear energy which is rapidly adopted by growing countries all over the world. It is always critical to manage nuclear power plants and nuclear radiations. Because drones are able to fly at low altitudes, they can measure radiation in greater detail than a helicopter or other aircraft. GIS is a potential tool for planning and monitoring both conventional and non-conventional power generation resources. Sophisticated spatial analysis tools when integrated with real time monitoring methods are used for determining optimum generation potential, formulating what-if scenarios, studying environmental impact, and managing facility assets. Geo-database developed with continuous inflow of data is key component for maintaining and managing accurate transmission asset data such as substations, lines, and associated structures.

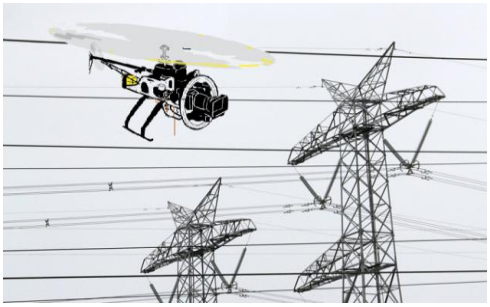

Figure6. Surveillance Drone over power line masts.

VII. DISCUSSION

There is growing interest in unmanned aircraft at the beginning of 21st century in almost all developed countries. There is no way question or doubt regarding technical viability or operational utility of UAVs. Success of UAVs in developed countries represents a historic opportunity to exploit transformational capabilities of this leading technology to support life services. Four major factor which are the symbol of economic growth for any developing country is: Agriculture, Energy, living standard, ability to mitigate natural calamities. UAV can help in many ways to increase and to sustain the development of countries whose economy majorly dependent up on agriculture. Drones fitted with payloads such as cameras, enable farmers to get a bird's eye-view of their crop by flying at low altitudes. Using much advanced sensors like hyper spectral, Infra-red imaging, drones can also detect the health condition of the plants. Spray of pesticides, fertilizers or any other beneficial substance can also be efficiently covered with UAVs. Energy is directly linked with the key global challenges that world faces - poverty alleviation, climate change, global environmental and food security. Ensuring access to sustainable and cleaner energy is a key objective for international community. Many fast-growing developing countries will make their major energy-related investments in next decade [United Nations: Ban Ki-moon Secretary-General of the United Nations]. To ensure supply of electricity, gas and oil, regular inspections of installations are imperative. Because of their size and structure, they are often inspected from the air. Instead of contracting an independent organization/firm, the inspections can be carried out with UAVs.

Natural disasters frequently occur across the world, affecting both developed and developing countries. For people in developing countries where humanitarian impact is often devastating, natural disasters present a larger problem than rest of the world may realize [14] [15]. UAVs equipped with remote sensing instrumentation offer numerous opportunities in disaster related situations. The low flying UAVs can be autonomously redirected to location of interest selected in the high flying UAV images by the user [16]. Video and GPS coordinates can be sent through a network to other responders in the area. The use of UAV imagery for post-disaster assessments has been explored in the capacity of both automatic and manual imagery assessments [17]. In 2012, Food and Agriculture Organization of United Nations (FAO) concluded that, food insecurity is still a major global concern as 1 billion people are suffering from starvation and malnutrition around the world. Rural and remote areas also share common traits such as older population, higher level of health risks and higher rates of diseases, chronic disease and injuries. People living in these areas generally have less access to health services with shortages of almost all health professions and health-related infrastructure. Use of UAVs can speed up the delivery of food, medicines and other supplies to remote areas, and even provides a cheaper alternative to develop a road network rather than other costly alternatives.

VIII. CONCLUSION

As the market for UAVs continues to expand from last two decades, they have transformed into data-gathering tools for GIS. Today UAV has become a primary resource to acquire remotely-sensed GIS data. This study investigated the four basic requirements of developing countries and concluded that there is no doubt regarding the technical viability or operational utility of UAVs in integration to geospatial analysis tools to support life services. This paper finally present UAVs as more reliable, economical, autonomous and easier to use technology with great potential to conduct essential ground operations in a more efficient way.

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