Unmanned Aerial Vehicles and Applications using Image Processing

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***Abstract* —Unmanned Aerial Vehical (UAV) is an aircraft with no pilot onboard.UAV have great potential as a platform for acquiring very high resolution aerial imagery for disaster management. This paper presents the objectives to provide a summary of the current commercial, open source on UAV. It also describes the intelligence, reconnaissance, surveillances and real time applications of UAV in recent times.**

Keywords: Unmanned aircraft systems (UAS), Unmanned Aerial Vehicle(UAV), latitude longitude and height (LLH), universal transverse mercator (UTM), geographical information systems (GIS)

I. INTRODUCTION

An Unmanned aerial vehicle (UAV), is colloquially known as a drone. Its flight is controlled either autonomously by onboard computers or by the remote control of a pilot on the ground or in another vehicle[1]. . They are sustained in flight by aerodynamic lift. They may be expendable or recoverable and can fly autonomously or semi autonomously. These UAVs can weigh as little as a few ounces. UAVs is used to offer the possibility of cheaper, more capable fighting machines that could be used without risk to aircrews. As a tool for search and rescue, UAVs can help find humans lost in the wilderness, trapped in collapsed buildings, or adrift at sea.Small unmanned air vehicles can be deployed at the front lines of combat to provide situational awareness to small units of troops through real-time information about surrounding areas. Small fixed-wing unmanned and micro air vehicles (such as the Dragon Eye, Hornet, and Wasp) have become prevalent and have demonstrated impressive flight abilities and levels of autonomy. They are usually deployed for military and special operation applications, but also used in a small but growing number of civil applications, such as policing and firefighting, and nonmilitary security work, such as surveillance of pipelines. UAVs are often preferred for missions that are too "dull, dirty or dangerous" for manned aircraft.

The earliest attempt at a powered UAV was A.M.Low's "Aerial Target" of 1916. The first UAV created was the Pioneer which helps to identify artillery & boats. A number of remote controlled airplane advances followed during and after World War 1, more were made in the technology rush during World War 2, those were used both to train anti-air craft gunners and to fly attack missions. The greatest use of UAVs has been in the areas of surveillance and reconnaissance. A helicopter is a highly maneuverable and versatile UAV platform for several reasons it can take off and land vertically, hover in place, perform longitudinal and lateral flight, as well as drop and retrieve objects from otherwise inaccessible places. They are indispensable for various applications where human intervention is impossible, risky, or expensive. e.g., hazardous material recovery, traffic monitoring, disaster relief support, military operations, etc. The UAV, in particular, the unmanned helicopter, can serve as an excellent platform for studying plants with maneuverability and versatility.

Recently, there has been a rapidly increasing interest in small UAVs. With the emergence of high power density batteries, long range and low-power micro radio devices, cheap airframes, and powerful micro-processors and motors, small/micro UAVs have become applicable in civilian circumstances like remote sensing, mapping, traffic monitoring, search and rescue, etc.

There is a strong need for near real-time, geo-referenced imagery and geospatial information in the aftermath of natural disasters and humanitarian crises.. A road detection and tracking system will vastly improve the utility of UAV acquired images sets and make a significant step towards the operational deployment of mini and micro- UAV systems for geographical information systems (GIS) purposes.

Fig.1 A group photo of aerial demonstrators at Naval Unmanned Aerial Vehicle Air Demo.

UAVs have many advantages over traditional manned aircrafts or some other remote sensor platforms. For example, UAVs are low cost platforms and can work without consideration of human factors by using an auto-remote control flight mode[2]. They can easily implemented for high-risk and high-tech missions and donot require permission from airspace control for low altitude flights in most countries. UAVs can also provide high resolution images and precise positioning/orientation data from the onboard GPS/GNSS and INS navigation sensors. These characteristics enable the UAV platform to be an effective supplement way to the traditional satellite and manned-plane remote sensing.

The modern UAV originated in the 1970s, motivated by the military's need for a safe way in which to fly over high risk areas without endangering a pilot's life. These flying missions would also benefit from a smaller, covert vehicle compared to a manned aircraft. Engineers in the United States started experimenting with smaller, slower, cheaper UAVs that mimicked large model airplanes

II. BASICS OF UAV

The UAV is used to represent a power driven, reusable airplane operated without a human pilot on board. So the unmanned missile or bomb is not within this category because they are designed for one time use only. UAVs can also be called "unmanned aircraft systems" (UAS). With this definition, remote controlled aircrafts also fall into this category. Actually, most UAVs have remote control abilities to avoid some severe failures that may cause crashes.The first UAV was the Q-2 made by Ryan Aeronautical flown in the 1950's for military reconnaissance. The US military uses many UAVs nowadays to spare human pilots from operating dull, dirty or dangerous jobs. Many UAVs serving in the military weigh hundreds or even thousands of pounds and can fly as high as 6000 feet. The military also uses small or micro UAVs like Dragon Eye, FPASS, Pointer and Raven . These small UAVs use electric batteries for power, weigh less than 10 pounds and fly usually as 1,000 feet or lower. As mentioned above, most early UAVs were developed for military applications. They are expensive to develop and maintain, which makes it hard for civilian uses. Since 1990s, the emergence of high power density batteries (Lithium-Ion and Lithium-Polymer), miniaturized equipments, and wireless network devices makes the small UAVs affordable to researchers and even hobbyists. Based on wing shapes and body structures, UAVs can be categorized into fixed-wing UAVs and rotary-wing UAVs (e.g., helicopters).

III. ARCHITECTURE

Fig2. Architecture of an unmanned aircraft

The imaging subsystem of a UAV relies on a variety of enabling technologies including sensors, computing devices and wireless communications. A typical platform would comprise of multiple digital cameras that interface to a geospatial processor. Georeferenced imaging data is distributed through a data networking switch fabric, making system configuration simple, extensible and flexible[4]. The control computer is used to trigger the camera, store and prepare images for transmission while recording data such as camera settings, altitude and position that are attached to images as metadata. The data is then sent to the UAV ground station via a state-of-the-art wireless network capable of achieving real-time wireless data retrieval of large files. Modern UAVs are capable of capturing and streaming multi-megapixel, large format images and metadata. The imaging control computer is normally decoupled from the flight control computer, with the two computers exchanging information in real time. Flight path and other mission requirements are programmed by ground station engineers into the mission planning software that feeds the autopilot with the data necessary to direct and control the aircraft during the mission. Multiple cameras can be
combined into a unique assembly to increase the sensing capabilities of the UAV system. A modular mounting scheme allows for multiple camera modules to be configured on a single camera frame assembly to suit the need of a specific mission. The multiple camera approach can be used to acquire a mix of colour, false colour and monochrome images covering the same target area. The cameras optical axis must be parallel to one another and their shutter synchronized to operate simultaneously. Image processing is then used to fuse together the various images to generate a single, highly detailed, color image.

IV. CONTROLLING OF UAV

An airplane can rotate around three axes (x y z), from the plane's center of gravity. The position control of UAV is usually converted to the angular control: roll(φ), pitch (θ) and yaw (ψ), as defined later. The axes of motion of airplanes are shown in Fig. 1.

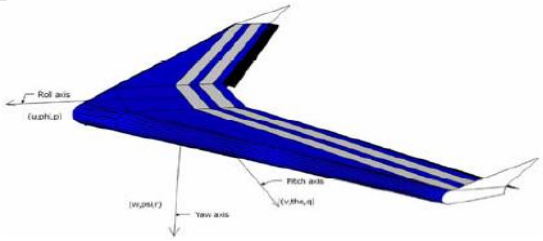

Fig.3 Position control and axis of motion of UAV.

The main control surfaces or control inputs for a fixed wing UAV may include some or all of the following:

- Ailerons: to control the roll angle.
- Elevator: to control the pitch angle (up and down).
- Throttle: to control the motor speed.
- Rudder: to control the yaw angle (left and right).

Small UAVs, however, may not have all these control surfaces. For example, the Unicorn airframe only has one throttle and two control surfaces: left and right ailerons, and the ailerons can be mixed to work as an elevator.
The ailerons of this type of airframe are also called elevons. The state variables of a UAV include

- *n* , *p* pe , and *h :* the inertial (north, east) position and the altitude or the height, e.g., latitude longitude and height (LLH) or universal transverse mercator (UTM) coordinates.
- , n v , e v and vd : the speeds with respect to the ground coordinate frame.

• u, v, and w : the velocities measured along body x, y, and z axes.
• a*x*,*a y* and az : the accelerations measured along body x, y, and z axes.
• φ,*θ* and *ψ* : the roll, pitch, and yaw angles.
• p, q, and r : the angular rates measured along body x,y, and z axes.
• *v* ,*α* and β : the air speed, the angle of attack,
and the sideslip angle.
Actually, small fixed-wing UAVs are highly dynamical and nonlinear systems because of uncertainties caused by speed, altitude, weights, winds and turbulences. Therefore, it is hard to get an accurate and complete nonlinear model. But some linear models
can be used to approximate the UAV dynamics. Small UAVs normally have two control modes: remote control (RC) mode and autopilot control mode. Remote control mode, or radio control mode, requires human pilots to control the UAV through radio signals, while autopilot control mode can automatically keep the airplane at the desired state[3]. There are also mixed control modes in some small UAV applications, such as 3400. Autopilot from UNAV company. A semi-autonomous control mode is provided in where the onboard autopilot controls the altitude and the human operator controls the flight path.

V. REAL TIME UAV

UAVs match the sensor and airframe to the "event", provides autonomous or "remote operation" capabilities to sensor, provide capabilities for data telemetry, examine data compression if required to telemeter large data volumes, capabilities for data handling on ground, Information distribution to community. UAVs Provide Unique Assets, data acquisition capabilities and also UAVs allow extreme altitude flight, Continuous flight for hours to days, No pilot on board, Real-time telemetry capabilities.

Fig.4 Aeryon scout in flight

Beyond the military applications of UAVs with which "drones" became most associated, numerous civil aviation uses have been developed, including aerial surveying of crops, acrobatic aerial footage in filmmaking, search and rescue operations, inspecting power lines and pipelines, and counting wildlife, delivering medical supplies to remote or otherwise inaccessible regions, with some manufacturers rebranding the technology as "unmanned aerial systems" (UASs) in preference over "drones." Drones have also been used by animal-rights advocates to determine if illegal hunting is taking place, even on private property. Drones equipped with video cameras are being used by the League Against Cruel Sports, a British animal-rights group, to spot instances of illegal fox hunting. UAVs are nowadays routinely used in several applications where human interaction is difficult or dangerous. These applications range from military to civilian and include reconnaissance operations, border patrol missions, forest fire detection, surveillance, and search/rescue missions.

A. Remote sensing

UAV remote sensing functions include electromagnetic spectrum sensors, gamma ray sensors, biological sensors, and chemical sensors[6]. A UAV's electromagnetic sensors typically include visual spectrum, infrared, or near infrared cameras as well as radar systems. Biological sensors are sensors capable of detecting the airborne presence of various microorganisms and other biological factors. Chemical sensors use laser spectroscopy to analyze the concentrations of each element in the air.

1) Commercial aerial surveillance

Aerial surveillance of large areas is made possible with low cost UAV systems. Surveillance applications include livestock monitoring, wildfire mapping, pipeline security, home security, road patrol, and anti-piracy. The trend for the use of UAV technology in commercial aerial surveillance is expanding rapidly with increased development of automated object detection approaches.

Fig.6 Fulmar UAV for civilian application

B. Commercial and Motion Picture Filmmaking

Use of UAVs for filmmaking is generally easier on large private lots or in rural and exurban areas with fewer space concerns. In certain localities such as Los Angeles and New York, authorities have actively interceded to shut down drone filmmaking efforts due to concerns driven by safety or terrorism.

C. Sports

Drones are starting to be used in sports photography and cinematography. For example, they were used in the 2014 Winter Olympics in Sochi for filming skiing and snowboarding events. Some advantages of using unmanned aerial vehicles in sports are that they allow video to get closer to the athletes, they are more flexible than cable-suspended camera systems.

D. Domestic policing

UAVs are increasingly used for domestic police work in Canada and the United States.

1). First drone-assisted arrest of an American

On January 28, 2014, a North Dakota cattle rancher was sentenced to three years in prison, with all but six months

suspended, for terrorizing police officers who were trying to arrest him at his property in 2011[5]. The case garnered national attention because it was the first time a law-enforcement agency had used an unmanned aerial vehicle to assist in carrying out an arrest.

E. Oil, gas and mineral exploration and production

Fig .7 A UAV detecting an underground facility

UAVs can be used to perform geophysical surveys, in particular geomagnetic surveys where the processed measurements of the Earth's differential magnetic field strength are used to calculate the nature of the underlying magnetic rock structure. A knowledge of the underlying rock structure helps trained geophysicists to predict the location of mineral deposits[8]. The production side of oil and gas exploration and production entails the monitoring of the integrity of oil and gas pipelines and related installations. For above-ground pipelines, this monitoring activity could be performed using digital cameras mounted on one or more UAVs.The InView UAV is an example of a UAV developed for use in oil, gas, and mineral exploration and production activities.

Fig.5 InView UAV for use in scientific, commercial and state application.

F. Disaster relief

UAVs transport medicines and vaccines, and retrieve medical samples, into and out of remote or otherwise inaccessible regions.Drones can help in disaster relief by gathering information from across an affected area. Drones can also help by building a picture of the situation and giving recommendations for how people should direct their resources to mitigate damage and save lives.

2*). Three UAV Deployed in Uttarkhand rescue operations*

Developed with the idea of surveillance and inducted by the paramilitary forces nearly a year ago, UAVs have been used for the first time in a disaster rescue operation in Uttarakhand and the experiment seems to be success.

An officer of the National Disaster Response Force reported to The Hindu newspaper that they have deployed three such machines for reconnaissance in the flood-ravaged state and this has enabled them to locate and rescue more victims. Not only has it helped them to locate hundreds of trapped victims but with these machines they scan even those areas were the possibility of their presence is little and thus ensure that none of them is left behind. They can also arrange food or water once they received the images sent by the UAVs. These UAVs weighing between 1.5 and 2kg each, these indegenously developed machines called netra can go to isolate and inaccessible areas from where they sent real-time images captured by a high resolution camera[7]. The communication range between the remote and the machine is 1.5km along the sight. The images are sent to laptops which work as the monitoring device and all signals are sent through a local wireless network.

G. Scientific research

Unmanned aircraft are especially useful in penetrating areas that may be too dangerous for manned aircraft. The National Oceanic and Atmospheric Administration (NOAA) began utilizing the Aerosonde unmanned aircraft system in 2006 as a hurricane hunter[9]. Beyond the standard barometric pressure and temperature data typically culled from manned hurricane hunters, the Aerosonde system provides measurements far closer to the water's surface than previously captured. NASA later began using the Northrop Grumman RQ-4 Global Hawk for extended hurricane measurements.

VI. CONCLUSION

In this paper the concepts on UAV are discussed and applications of UAV are highlighted. By improving the technology development and demonstration this prove and extend the use of UAVs to collect critical disaster information in real time to affect decision processes.

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