UAVs are proving to be disruptive technology for disaster planning, response and relief operations

Over the past two decades, the impact of disasters has been devastating, affecting 4.4 billion people, resulted in 1.3 million causalities and $2 trillion in economic losses. The first 24 hours following an earthquake, hurricane or tornado are critical in terms of damage assessment, and search and rescue.

UAVs have emerged new disruptive technology for disaster management, Portable micro-UAVs can be launched quickly in dangerous situations, locate survivors and send data about their whereabouts to responders on the ground. In preliminary research conducted in Europe last year, drones found isolated people much faster than did traditional ground-based rescue teams. Drones can also deliver rescue ropes and life jackets in areas that are too dangerous for ground-based rescuers to venture into. Drones are also providing help in the aftermath of disasters – for example, to assess damage to buildings, roads and bridges, and power lines.

UAS is becoming increasingly popular for civilian use due to their relatively low cost, ease of operation and the emergence of low cost navigation and imaging sensors, with performances comparable to higher priced sensors. Prices for commercial UAVs range from $15,000 to $50,000 – a fraction of what a helicopter costs. They can fit in the trunk of a car and be up in the air in no time. The global commercial UAV market is expected to reach $2.07 billion by 2022, according to a new study by Grand View Research Inc. In recent years, several humanitarian organizations and governments have used UAVs in disaster management, most notably for assessing vulnerabilities before an emergency and damage after the disaster.

Increase of Employment of UAVs

The Texas A&M Engineering Experiment Station Center for Robot-Assisted Search and Rescue (CRASAR) coordinated the largest known deployment of unmanned aerial systems (UAS) by public officials for a federally declared disaster- both serving as Air Operations for manned and unmanned aircraft and deploying small UAS ranging in size from DJI Mavics to the Insitu ScanEagle.

The deployment was for the Fort Bend County Office of Emergency Management with whom CRASAR had provided assets for previous floods. CRASAR flew 119 mission flights from August 25 (preparing for landfall) to September 4 (when the emergency life-saving response and restoration of services phases of the disaster were largely over), with a record 61 flights on one day. The deployment was led by Justin Adams, who served as Air Operations branch director for Fort Bend County manned unmanned ops and CRASAR Roboticists Without Borders coordinator.

The UAS flights were for

- rapid spot checks of situation awareness of people in distress
- the extent of flood and tornado damage
- how many people had not evacuated, access routes to

neighborhoods

- projecting how long the neighborhoods would be cut off, throughout the county (which is very large and hard to get a handle on)- based on information coming to EOC, the county's projections and knowledge from 2016 floods- not just easiest or most compelling for media to fly or waiting for complete coverage by manned assets
- inform the public and dispel rumors- allowed County Judge Hebert to immediately and directly address Citizens' concerns and dispel rumors, e.g., postings to social media about a particular neighborhood, then tasked to fly that neighborhood to get eyes on to inform the EOC as to the situation and to show the community; water is coming over the Richmond railroad bridge
- systematically document damage for federal disaster relief and future planning
- project river flooding by monitoring the river and confirming river flood inundation models
- monitor the river and condition of over 100 miles of levees through out the county

They have already been deployed by humanitarian actors in Haiti and the Philippines after Typhoon Yolanda for mapping, improved situational awareness and needs assessment. During magnitude-7. 0 earthquake, which jolted southwest china's Sichuan province People Liberation Army (PLA) employed UAV's for capturing high resolution pictures that provided valuable information about the location of landslides, damaged roads etc.

Dozens of unmanned aerial vehicles were deployed in Houston in response to Hurricane Harvey, and UAVs are expected to be out in full force across Florida in coming days. Experts say UAVs will likely play an even bigger role in relief efforts when future storms or earthquakes hit.

When Super Typhoon Haiyan devastated the city of Tacloban in the Philippines in November 2013, UAV of the size of a backpack with a range of up to five kilometers and a high-resolution video camera was used to assist humanitarian responders. It was first used to identify where to set up a base of operations, and then to check if roads were passable, a task that could take days when done on foot or by helicopter. The UAV was also flown up the coast to evaluate damage from storm surge and flooding and to see which villages had been affected. The aerial assessments “really helped to speed up …efforts, cut down on wasted time and work, and make them more accurate in their targeting of assistance.” It was also suggested that the UAV might have located survivors in the rubble using infrared cameras if it had arrived within 72 hours.

Disasters and Disaster Management

In 2014, 324 triggered natural disasters were registered killing 7,823, and 140.8 million people become victims worldwide. The cost of disasters worldwide has reached an average of $250 billion to $300 billion every year, according to the Global Assessment Report on Disaster Risk Reduction released by the United Nations.

Over the last decade, China, the United States, the Philippines, Indonesia and India constitute together the top 5 countries that are most frequently hit by natural disasters. These are expected to further exacerbate in the future as there is further increase in extreme climate events. Nuclear power plants, chemical plants, microbiological research labs and military warehouses are other High risk areas. There is tremendous risks to countries and communities that are unprepared for such risks

Van Wassenhove (2006) proposed a classification of natural and man-made disasters according to the speed with which the disaster strikes: slow-onset or sudden-onset. Famine, drought, political, and refugee crises are examples of the former category, whereas the latter includes, for example, earthquakes, hurricanes, technological failures, and terrorist attacks.

There are four primary stages of a disaster management: mitigation, preparedness, response, and recovery. Mitigation is assessing possible sources of crisis and identifying sets of activities to reduce and/or eliminate those sources so that crisis never happens or its impact is reduced. Preparedness is developing a crisis response plan and training all the involved parties so that in the case of a crisis people know their roles and will effectively be able to deal with it. Response constitutes the set of immediate actions taken after a crisis occurs, and it aims to reduce the impact by utilizing the plans created during the preparedness stage. Recovery is the final set of activities in which the objective is to support all involved parties until they resume their normal operations. The UAVS can be of tremendous utility in all of these phases of operations.

UAVs for disaster management

Unmanned Aerial Vehicles (UAVs), also known as remotely piloted aircraft or “drones” are small aircraft that fly by remote control or autonomously. Although previously associated with the military, UAVs are increasingly performing civilian tasks as the technology becomes more common – 57 countries and 270 companies were producing UAVs in 2013. In the U.S., the Federal Aviation Administration (FAA) forecast that some 7,500 commercial small UAVs could be flying in the U.S. within five years.

UAVs vary greatly in size, flying capability, capacity and methods of control. At the larger end, are systems of the size of a manned plane like Predator that can fly up to 25,000 feet for 40 hours, guided via satellites by a pilot up to 7,500 miles away. At the other end are mini and micro UAVs systems, that are small enough to be carried by one or two people, with some easily fitting in a backpack or weighing less than a kilogram. They can include both fix-wing aircraft, better at distance flying, and rotor aircraft that can hover. These systems are generally limited in range to anything from line of sight to a few kilometres, and to flight times under an hour. Operating these systems is much simpler, with little training required.

Due to their affordability, ease of transport, and regulatory concerns UAVs used in humanitarian response are likely to be small or micro-UAVs of up to a few kilograms, while larger systems will remain the province of military and civil defense actors.

Key Issues to consider UAV’s while employing them for Disaster Management are the deciding the airframe and sensor suitability to the “event,” requirement of autonomous or “remote operation”, capabilities for data telemetry, examine data compression if required to telemeter large data volumes, and capabilities for data handling on ground.

of Queensland this week and was followed by severe flooding in NSW. Follow updates on the flooding in NSW and the Queensland clean-up in our live blog “I think during the recovery and reconstruction, rebuilding process … providing this high resolution, high frequency imagery, it’s going to make all the difference,” Dr Meier said.

UAVs now preferred means for Effective emergency response

Effective emergency response and sustainable post-disaster reconstruction are crucial and lie at the heart of disaster management activities.

Data collection and observation

The most common use of UAVs in humanitarian response today is data-collection and observation. UAVs Provide Unique capabilities for Data Acquisition, they can fly at extreme altitudes continuously for from hours to days, without need of any pilot on board and provide real-time telemetry capabilities. UAVs can collect critical disaster information in real time to affect decision processes.

Satellite imagery has also played a pivotal role in relief operations for almost two decades now. But satellites do present a number of limitations including cost, data sharing restrictions, cloud cover, and the time needed to acquire images.

In contrast, UAVs can capture aerial imagery at a far higher resolution, more quickly and at much lower cost. And unlike satellites, members of the public can actually own UAVs. This means that disaster affected communities can launch their own UAVs in response to a crisis.

Real time information and situation monitoring

The most common use of UAVs is the provision of high-altitude video feed or photos, allowing a rapid overview of conditions. More sophisticated systems can broadcast a live feed directly or over the internet. These images can assist in tasks that include:

- Rapid assessment of damage, such collapsed buildings or blocked roads
- Monitoring distribution of goods, such as tarpaulins or tents
- Identifying and analysing temporary settlements or tracking displacement or movement of people even the least expensive UAV systems can aid in these tasks, often using standard cameras

UAVs can be equipped with a wide range of monitoring equipment, from a strapped-on smartphone to infrared systems or Synthetic Aperture Radar (SAR) that can see through cloud cover, forest canopy or even buildings.

The success of the reconstruction phases, i.e., rescue, relief, and rehabilitation, is mainly dependent on the accessibility to the site, availability of efficient project teams and timely information to make informed decision.

Search for survivors and rescue

Interest is building in the use of UAVs to assist in search and rescue, particularly when equipped with infrared, or other specialty cameras. For example, the European Union is funding ICARUS, a research project to develop unmanned search and rescue tools to assist human teams.

Artemenko et al. (2014) develop an UAV that moves around buildings and localizes "survived" devices inside a building. This can help to detect victims and to accelerate the rescue process – in which fast and accurate localization is essential. A LMAT (Localization algorithm with a Mobile Anchor node based on Trilateration) path planning algorithm is being validated using simulations and evaluated in experiments using a real UAV.

3D mapping, mapping of affected areas and image analysis

The main objective of early impact analysis after a disaster is to define the damages of infrastructure and/or to facilities, and that requires suitable data, such as high resolution satellite images. The 3D mapping and the image analysis provide more clear views of the affected areas as input data for early impact analysis in medium and large-scale map.

UAVs can rapidly produce geo-references (GPS accurate) or 3D maps that are often more detailed and faster than satellite imagery. This mapping enables improved logistics, awareness of informal communities, damage assessments, disaster risk reduction or early warning activities, agricultural monitoring to promote food security, flood monitoring, etc. This type of mapping requires specialized equipment, software and training.

Patterson et al. (2014) present novel work on autonomously identifying Safe Landing Zones (SLZs) through image analysis which can be utilized upon occurrence of a safety critical event.

Logistics and package-delivery

Information collection may be just the first step, as the humanitarian community explores the use of UAVs for delivery of in-kind goods. The US military uses unmanned Kaman K-Max helicopters that can deliver over 2,700 kg in Afghanistan, a few delivery projects have been tested in China, and pilot projects have been announced in Australia and New Zealand, by the US retailer Amazon, and others. Jack C. Chow, former Assistant Director-General of the World Health Organization, has suggested that UAVs “can supplement existing supply chains or provide emergency drops

They can act as quick delivery agents for high-value supplies, such as medicines, through sky which might be only route possible during early response activities, as UAVs could traverse terrain that might be impassable otherwise. They also appreciated their potential to supply lighting, power and connectively from the air until more permanent solutions on the ground can be restored post-disaster.

Google has already built and tested autonomous aerial vehicles, and believes they could be used for goods deliveries. They could be used after earthquakes, floods, or extreme weather events, the company suggested, to take small items such as medicines or batteries to people in areas that conventional vehicles cannot reach (STEWART, 2014).

Challenges

This rapid growth has resulted in a low level of awareness for safe and compliant operation of UAV’s This low level of awareness will create challenges for industries on how to best utilize UAV applications

However, at present, UAVs cannot autonomously detect or avoid other UAVs, aircraft or obstacles such as buildings, and therefore present a severe concern for mid-air collisions. As a consequence, they cannot be flown out of line of sight or within close proximity to large gatherings of people, thus restricting their uses within the commercial sector. In order for a UAS to safely navigate in the already crowded aerial environment of the modern world, the U.S. Federal Aviation Administration (FAA) and other international organizations have mandated that unmanned aircraft must have an on-board Sense and Avoid (SAA).

The aims of Sense and Avoid technology, also referred to as ‘detect and avoid’, sense and avoid’ or ‘collision avoidance’ technology are the same; to detect aircraft & obstacles within the vicinity of the UAV and to execute manoeuvres to restore a safe situation if needed.

UAVs must be reliable and have the ability to take appropriate action when some functionality is lost due to failure. Brazenaite et al. (2010) present a reconfiguration process, which is based on optimizing the mission reliability under its current conditions and environment. This is demonstrated using a UAV carrying out a search and rescue operation.

Harnett et al. (2008) demonstrate an experimental surgical robot using an UAV as a network topology. For the first time, a mobile surgical robotic system was deployed to an austere environment and surgeons were able to remotely operate the systems wirelessly using a UAV.

Future Directions

UAVs can be employed for Volcanic Event Monitoring, Tsunami Monitoring, Hurricane Tracking, Flooding and Major Storm Events and Earthquake-triggered events.

University of Bristol has developed the drone, called the ARM system for Incidents like Fukishima Disaster, through project funded by the Engineering and Physical Sciences Research Council and Sellafield. The drone has visual, thermal and radiation monitoring payloads for radiation mapping of radioactively contaminated sites like those of Fukishima disaster. The team is also working on UAV mapping and exploration algorithms for detecting buried explosives and depleted uranium ordinance.

Disaster assessment

Researchers of University of New Mexico, along with partners at San Diego State University and BAE Systems, under Commercial Remote Sensing and Spatial Information Technologies

Program (CRS&SI), are exploring the ability of UAV to layer a pictorial history of an area prior to a disaster with post-disaster images, and immediately deliver any deviations to engineers and support staff on the ground for timely decisions on how to mitigate such things as road washouts, bridge damage, or other critical infrastructure abnormalities.

UAV formations

The future trend is to use Multi-RPAS use during disasters. These are either flown one at a time (depending on the needs of the mission and the general location/weather conditions) or then multiple RPAS are airborne at the same time (for search and rescue tasks, for example).

This “Swarm RPAS” approach may lead to several RPAS being used to scan certain areas for a missing person simultaneously and cover more ground quicker. Or a “Lead RPAS” could, through computer vision and algorithms, send potential findings to a “Follow RPAS” that will then fly directly to that location for a closer look, while “Lead RPAS” will continue its search pattern.

Currently flying multiple RPAS systems can introduce additional challenges, from potential flight-path interference to video signal interference. As with any team-work tasks, proper communication is needed between the drone operators and support teams.

Quaritsch et al. (2010) deploy an aerial sensor network with small-scale, battery-powered and wirelessly connected UAVs carrying cameras for disaster management applications. The UAVs fly in formations and cooperate to achieve a certain mission. This paper focus on the optimal placement of sensors formulating the coverage problem as integer linear program (ILP).

As the number of disaster is still increasing, it indicates that there is a need for research on UAV applications on the pre disaster phases. The Sendai Framework for disaster risk reduction 2015 – 2030 therefore emphasis on disaster risk management as opposed to disaster management, a goal focused on preventing new risk and reducing existing risk (UNISDR, 2015, cited by Niederer, 2015).

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