A Study on Unmanned Aerial Vehicle Applied to Acquire Terrain Information of Landslide

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ABSTRACT: This research studied the application of UAV on collecting on-site environmental spatial data after the occurrence of disasters. Data of different time frames for a location was collected in this study, and the analysis of environmental change had been conducted. The data collected was used to compare the site environmental before and after a natural hazard. Terrain simulation was also generated to obtain additional understanding. The study results have shown that the application of camera-ready UAV (helicopter-type) and GPS can provide high-resolution images, which can be used to quickly produce 3D spatial image by stereographing. The image post-processing in this study used the site's feature points (obtained from previous site investigation) as control points, saving the time and labor of on-site investigation. This procedure is suitable for post-disaster response when quick response is needed. The images generated by the proposed method have average 5 meter error when targeting a landslide area, which is considerably acceptable and useful for estimating the hazard extent under emergency. The images can also be applied for 3D and flight simulation.

The proposed method of processing 3D images can be done within one day after the disaster, when spatial data is available. The generated images can be used to assist the local government on the hazard impacts, and to provide the emergency response units information of status update and rescue use.

1. INTRODUCTION

Taiwan, since the earthquake 921 in 1999, has frequent natural disasters in recent years due to geology loose and huge changes of the global environment, it impacts people's livelihoods and security heavily. All levels of government in the pre-disaster preparedness, disaster response and post-disaster reconstruction in the emergency response to take various measures and contingency plans, the development of various policy ran really need to diversify information channels to provide assistance, in order to reduce people's lives property damage and to prevent the occurrence of secondary disasters.

The disaster areas are often located in difficult terrain with inconvenient and dangerous traffic, the officers are unable to get into there after the typhoon and earthquake. In emergency situations, the remote sensing technology can be used as real-time information gathering pipelines in order to provide real-time disaster information efficiently.

Therefore, in recent years for the land-use change and disaster detection, mostly aerial photographs or satellite images, and acquired by the interpretation of the information required; but satellite images because of the scope is too large, images of the small scale, in a small area or in the changing differences between small and require more detailed information on the occasion, often limitations and often can obviously see that although the overall changes in the region, but it can not be more precise differences between local area change. Although the aerial photographs of a large scale, but because each line of surveillance photographs, none fixed, doing image comparison, and overlap, the inevitably left beads of regret.
Unmanned aerial vehicles (UAV) can work in dangerous and unreachable areas. While its small size, easy loading, with the better of the mobility, they can be used anytime, anywhere and in a relatively harsh climate of the mission.

2. REFERENCE

As the rapid development of technology-based industries, globalization, climate change, which led to the city, forests, marine ecological environment, the growing changes, gave rise to increasing attention to the problem of the natural environment. In response to a change in this situation, remote sensing technology, data collection, analysis and play an important supporting role in the decision-making. Remote sensing is the use of satellites, aircraft and other vehicles, carrying sensing equipment, from the air to collect on the surface of various spectral data processing and analysis should be sentenced to interpretation in order to understand the characteristics of the ground target technology; another aerial survey can also be carried out in order to access to ground elevation information, such technology has provided human beings in a fixed space, time and spectral resolution, etc., resulting in a broad range of basic information on the land and applied to address the collapse sentenced to natural disasters such as the scope and management issues such as excessive use of sloping fields, to support disaster prevention, slope management and overall governance of the basis for planning.

UAV usually refers to the remote control or automatic control by the flight of unmanned vehicles, collectively referred to as unmanned aircraft. The application of UAV able to perform 3D (Danger, Dirty, Dull) tasks features, as the UAV is currently applicable to a wide spectrum, such as aerial photography, maps, photographs, geological terrain exploration, military uses. Also has great mobility, real-time rapid, timeliness fast, inexpensive compared to the funding, and the more relaxed the advantages of weather conditions can be operated also with the existing of the topographic maps, aerial photographs and satellite images, and other graphics integration and sets of overlapping, not only disaster affected areas in a short time to understand the situation, but also simplify the catchment area of investigation is currently required for the human, and no casualties of the concerns, therefore, can be dangerous or inaccessible areas of human tasks.

In the last years UAV systems are applied in many fields include commercial, industrial, public, scientific and military operations. The tasks include pipeline inspection, dam surveillance, photogrammetric survey, infrastructure maintenance, inspection of flooded areas, fire fighting, terrain monitoring, volcano observations and so on.

In the case of natural hazards the spatial extent of the disaster area is usually large. It is often difficult to conduct search and rescue operations from the ground. Since UAV can fly at a very low altitude, high-resolution images can be acquired which then can be used to detect the victims.
Disaster monitoring and control from the point of view, the disaster occurred (like typhoon or heavy-rain), the affected areas of the climatic conditions are often not very good, the bad weather conditions, the optical satellite sensors and aerial survey equipment is almost useless at this time to play a UAV can be adapted to local conditions of effectiveness. To compensate for satellite images, aerial photos images of the constraints, to provide more immediate, detailed image information, so a high-resolution, high mobility of the UAV technology, build disaster monitoring mechanism.
Disaster, often due to a different space and time, resulting in different levels of disaster, from the disaster prevention, response to the reconstruction, each stage has its connection, it should establish a sound anti-disaster operating procedures and usually ill-prepared to avoid the influence looting of relief operations carried out. The FEMA of United States , for the sake of effective support and integration of government at all levels of disaster management, the process is divided into the disaster mitigation, preparedness, response, recovery four stages.

Satellite Image(SPOT)	Aerial Photo	UAV Image

Figure 1. Multi-scale Remote Sensing Image.

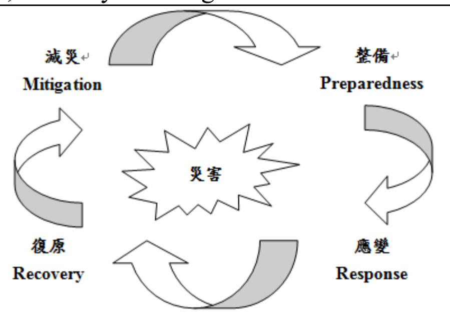


Figure 2. Disaster management steps

The most important of overall anti-disaster management system is providing applicable information and assistance, therefore we need to build a procedure of disaster information collection and build. Base on this we can get effective information at appropriate time and provide the reference for the phases of disaster-preparedness, response and return. This study used the high mobility, high time-resolution and high image resolution and other features of unmanned vehicles to provide government important reference information in planning for disaster response and return.

3. UAV SYSTEM

UAV payloads of equipment, due to the different mission requirements to carry the applicable equipment with high flexibility in use, it can be used in various fields to carry out a variety of different tasks. Hereby will be used in this study the instruments and equipment, their characteristics and functions is set out in Table1.

Table 1. The Specification for UAV system.

Weight	8.5kg
Payload	5.5kg
Engine	15 c.c. oil engine
Main Airfoil	680mm non-symmetry
Empennage	Standard Empennage
Operation Range	3000m / 10000ft
Operation Time	20 minutes
Operation Altitude	3000m / 10000ft

Table 2. The Specification for UAV Photographing System.

Instrument	Model	Specifications
Digital Camera	Canon EOS 5D Mark II	Effective Pixels: 21 million pixels Focal Distance: 1.8mm, Weight: 1.2kg Shutter Speed: 3.9fps
Digital Video Camera	Canon EOS 5D Mark II	Size: 1920 X 1080 pixels Focal Distance: 1.8 mm, Weight: 1.2kg Shutter Speed: 30fps
GPS System	SiRFStarIII Chip	Position Accuracy: ±3-5m Velocity Accuracy: 0.1 m/s RMS steady state Weight: 90g

3.1 Operation Procedure

To effectively improve the accuracy of an empty film operation to be given on an empty film locations to collect environmental baseline information in order to correctly implement the empty shot tasks, related work includes the scope of an empty film confirmed that the mission area, weather factors, survey, Air traffic control confirmed that the operating path and time planning operations.

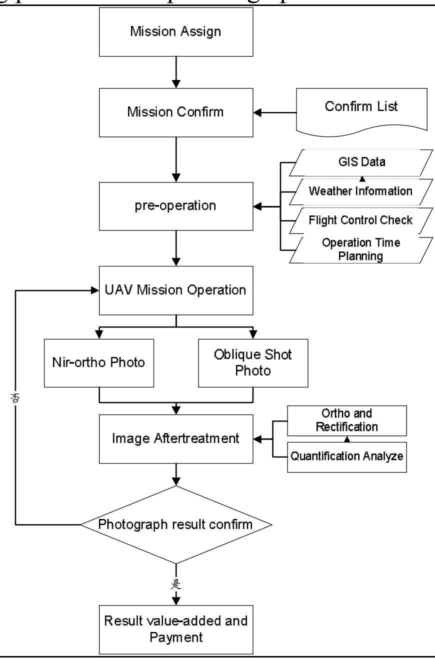


Figure 3. Operation procedure of UAV.

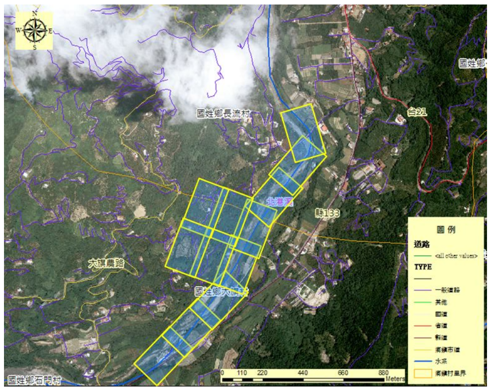


Figure 4. The example of flying planning.

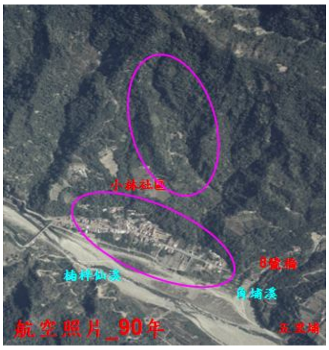
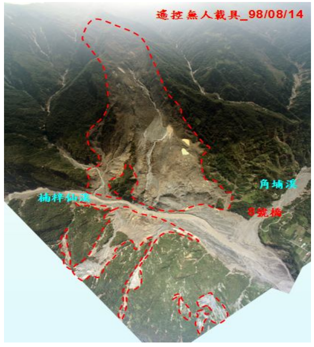
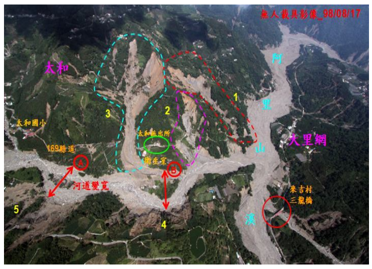
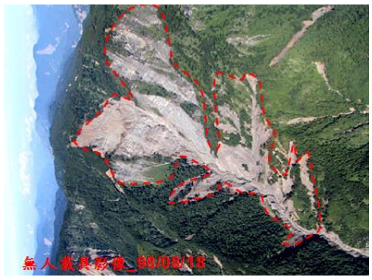
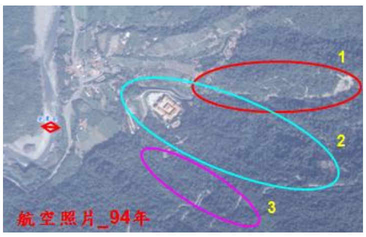
3.2 The Emergency Photographed Result After Typhoon MORAKOT

UAV take high-resolution photos to collect environmental data and offer notable advantages, such as, high flexibility, high resolution, taking off without runway, and momentary adjustment of shooting angle. UAV can satisfy various needs of diverse missions because of their flexible deployment. Moreover, UAV can serve as substitutes for the personnel to carry on the difficult and dangerous duties thus minimizing the risk as well as reducing the associated casualties and losses.

This research studied the application of UAV on collecting on-site environmental spatial data after the occurrence of disasters. Data of different time frames for a location was collected in this study, and the analysis of environmental change had been conducted. The data collected was used to compare the site environmental before and after a natural hazard.

August 2009 Typhoon MORAKOT backdrop of heavy rain hit southern Taiwan. The particularly debris flow disaster Jiasian Township, Liouguei Township and Namasia Township, Kaohsiung County, Alishan Township, Meishan, Chiayi County, and Laiyi Township, Pingtung County, and Sandiman Township the most serious.

Table 3. The Achievement Images of Emergency Photographed After Typhoon MORAKOT .

Before	After
Siaolin Village, Jiaxian Township, Kaohsiung County	
	
Taiho Village, Meishan Township, Chiayi County	
	
Shenmu Village, Xinyi Township, Nantou County	
	
Singlong Village, Liugui Township, Kaohsiung County	
	

3.3 Value-Added Services

UAV is also a part of aerial remote sensing, over the years the collection of information on the environment plays a very successful role. Because of their high mobility and high revisit rate, therefore, the use of remote unmanned vehicles in a similar way the traditional aerial surveys produced digital elevation data can be master of environmental information and analysis, providing important analysis is available.

The use of UAV produced DEM data, remote sensing information can be carried out with related sets of overlapping, and the use of value-added multimedia technology to carry out target areas show environmental change.

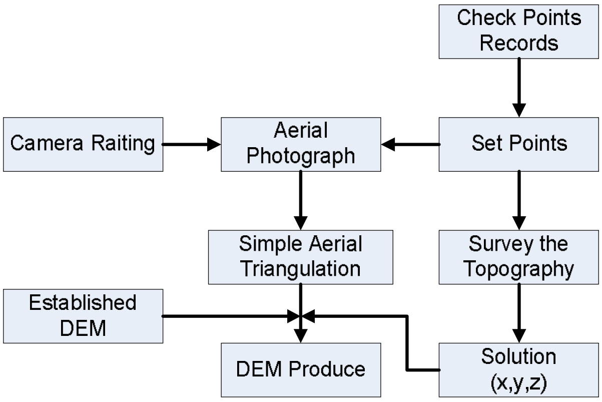
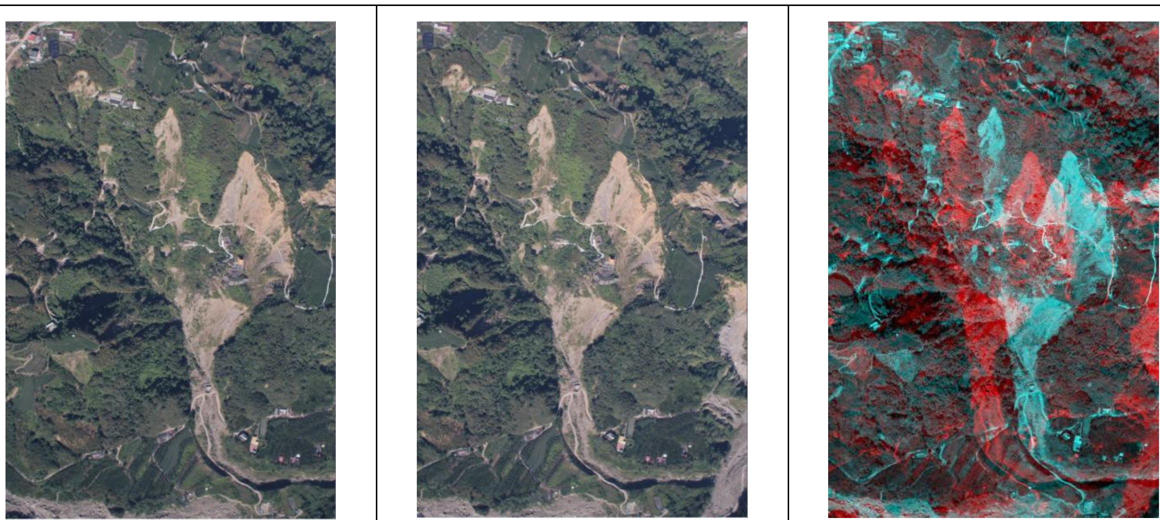


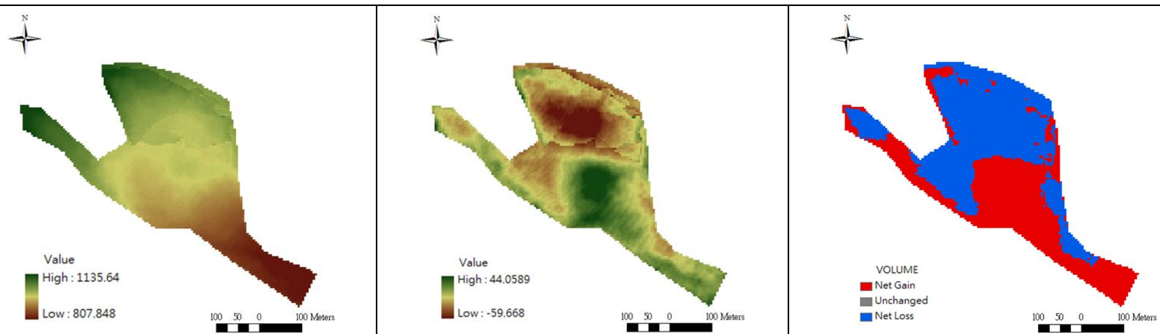
Figure 6. The Procedure of DEM Data Product

Terrain simulation was also generated to obtain additional understanding. The study results have shown that the application of camera-ready UAV (helicopter-type) and GPS can provide high-resolution images, which can be used to quickly produce 3D spatial image by stereographing. The image post-processing in this study used the site's feature points (obtained from previous site investigation) as control points, saving the time and labor of on-site investigation. This procedure is suitable for post-disaster response when quick response is needed. The images generated by the proposed method have average 5 meter error when targeting a landslide area, which is considerably acceptable and useful for estimating the hazard extent under emergency. The images can also be applied for 3D and flight simulation.



(a) left photo of study area | (b) right photo of study area | (c) stereo image

Figure 7. Study area image



(d) original DSM | (e) UAV produced DSM | (f) DSM analyze result

Figure 8. DSM analyze result

4. CONCLUSIONS

The rain of typhoon is a large area, high-intensity, long the pattern, resulting in increasing landslides and debris flow, and the type of disaster is no longer a local area of the flood or sediment disaster hurricane events in the MORAKOT presented for large-scale floods, landslides, debris flow, avalanches, and other barrier lake complex disasters. And a large number of earth and rock entrainment flooding upstream migration, the downstream simultaneously super-heavy rain again, so to make the amount of surge flooding downstream areas, and thus downstream river-crossing bridges, coastal highway facilities, water facilities, causing a major impact, but also in turn affect the resumption of the follow-up disaster relief construction work limitation.
The proposed method of processing 3D images can be done within one day after the disaster, when spatial data is available. The generated images can be used to assist the local government on the hazard impacts, and to provide the emergency response units information of status update and rescue use.

5. REFERENCES

Afzal Ahmed, Dr. Masahiko Nagai, Dr. Chen Tianen, Prof. Ryosuke SHIBASAKI, 2008, UAV Based Monitoring System and Object Detection Technique Development for a Disaster Area, *The International Archives of the Photogrametry*, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B8. Beijing.

U. Coppa, A. Guarnieri , F. Pirotti , A. Vettore, 2008, Accuracy Enhancement of Unmanned Helicopter Positioning With Low Cost System, *The International Archives of the Photogrametry*, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B5. Beijing.