Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

HTT30-01 Room:101A Time:May 25 16:30-16:45

Performance evaluation of UAV to use for disaster prevention

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Especially in the past several years, other disasters caused by extreme weather because of our changing climate, such as heavy typhoons, rain cataracts, flurries, and tornadoes, also cause widespread destruction. When these disasters or earthquakes occur, rapid situational assessment is crucially important, but it is difficult because transportation systems including roads and railways often shut down under those circumstances. Therefore, a monitoring system that provides information immediately when a disaster occurs is required. When a disaster occurs, monitoring from an airplane or satellite is effective but such systems are not easy to use. This study examines the performance of disaster monitoring systems using ready-made uncrewed aerial vehicles (UAV).

Keywords: UAV, sensor network, disaster prevention

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

HTT30-02 Room:101A Time:May 25 16:45-17:00

Small fixed wing UAV for natural disaster survey: Its needs and challenges

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Recently multicopters are used for disaster survey, environment and agriculture survey, civil and construction engineering survey and new reports and will become more popular in coming few years. They could, however, always have a chance to crash by an improper mission plan or judgment of situation, GPS signal loss, battery or equipment failure and other causes. According to our experiences, it is difficult to reduce the chance less than once a hundred flights at least for new users. If the number of uses increases, many of the equipment will crash, some of them hit humans, vehicles and houses, and some of them cause severe injury and damages. The chance of such accident may be small at rural areas, but should not be neglected in urban areas. One of the purposes of our usage of UAV is for disaster risk assessment, monitoring and response, and the target areas are inhabited. It is therefore at the first priority to reduce the chance of accident.

Possible safety counter measures are, more strict regulations of the usage, improvement of flight controller and safety gears by manufacturers, proper operation of the equipment by the users. Another way we propose in this paper is use of fixed wing drones instead of multicopters. Fixed wing drones here are electric-motor planes made of Styrofoam with one to two meters wingspan. We purchased and are testing several types of foam planes with APM flight controller including 3DR Aero. We also used eBee of sensFly in outside Japan. Fixed wing planes can also crash as similar to multicopters by equipment failure and human erros. They, however, are made of soft material, heavy parts such as battery and camera can be within the fuselage, motors and props are facing rear side, thus they will not cause heavy damages to someone or objects when they hit. This simple safety mechanism is the biggest advantage of fixed wing drones. Fixed wing planes can also fly faster and float in the air by wing with less energy, they can fly longer time and go longer distances with the same size of batteries as compared with multicopters. This is the biggest merit in case the danger caused by crash is not significant such as flights in mountain areas.

Fixed wing drones, on the other hand, also have demerits. The biggest difficulty is landing. Take off is not difficult by hand launching and no wide space is not necessary. Switching to autopilot immediately after the take-off makes the following flight with no difficulty. A pin-point landing by a slow speed is not easy either by manual or by autopilot and a wide area is needed. Manual cruise is also more difficult than multicopters which can hover without any stick control. This is a fate of fixed wing planes which always have to move forward not to stall and crash. The auto-landing function of fixed wing drones is, however, improving. The limitation of the choice of landing point is reduces by using large net to catch the aircraft. Manual controllability is also improved by the flight controllers, such as straight and constant altitude cruise or circling around a point in the sky even without touching the controller. The difficulties of fixed wing planes are going to be reduced. The advantages of the safety and the ability of 10km over flight outweigh the weaknesses. The safety is of paramount importance in flights above urban areas. As long as a multicopter which never crashes or never injures people on the ground even when it crashes is not available, we must use a foam plane.

Keywords: natural disaster, UAV, fixed wing, safety

Japan Geoscience Union Meeting 2015
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HTT30-03 Room:101A Time:May 25 17:00-17:15

Position measurement of ground control points and its accuracy with UAV photogrammetry

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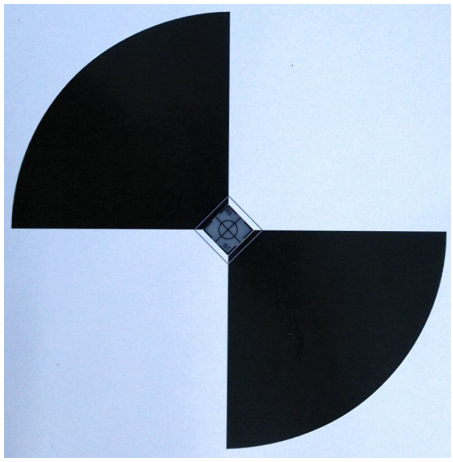
It is sometimes possible to measure surface position in the spatial density of a few cm by SfM (Structure from Motion) - MVS (Multi-view Stereo) techniques using photographs taken by UAV (Unmanned Aerial Vehicle) at low altitude. The higher the accuracy is, the more diverse the field will be in the fields of geoscience, geospace, and disaster prevention.

The accuracy of the estimated positions highly depends on the camera, camera model, quality of photos, flight altitude, overlap, position accuracy of the drone, analysis software, and conditions of the analysis.

We installed ground markers in the site of Geospatial Information Authority, Tsukuba and took nadir and oblique images with a multicopter. Comparisons of estimated positions varying some of the parameters will be reported.

Keywords: UAV, Ground Control Point, SfM, MVS, Drone



Japan Geoscience Union Meeting 2015
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HTT30-04 Room:101A Time:May 25 17:15-17:30

Monitoring the sediment movement in deep-seated landslides in Nara Prefecture utilizing UAV

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By the great floods in Kii Peninsula in September, 2011 large-scale of slope failure occurred frequently in the wide area of the southern part of Nara Prefecture, and gave serious damage to many houses as well as human lives. In the area of deep-seated landslides in 2011, the heavy rain subsequent to the typhoons caused a secondary sediment movement. It is, therefore, very important to perform continuous monitoring in this area. In this presentation, we examined the possibility of monitoring sediment transport using UAV. Among 60 locations of large-scale collapse by the great floods in Kii Peninsula, 11 places were selected and survey using UAV was conducted in order to investigate sediment transportation around the landslide.

The field survey was carried out on the 11th and 12th of November, 2014. Flight speed was set between 20 and 45km/h. The longest flight with automatic navigation was about 14km (one way 7km). The flight of UAV with rotary wings in steep terrain may be the first trial in the world. We have investigated both of the photographs taken by the UAV and the ones by airplanes or helicopters in the previous research, and detected the change of terrain and vegetation. We also calculated with deference analysis the amount of the sediment movement on the slope where measurement data of laser survey were obtained immediately after the landslide. As the result we could detect the change of the followings,

-Topographic change of terrain such as erosion of cliff, flow channel of small rivers, development of gully.
-Change of vegetation such as outflow of fallen trees and elimination of woods.
-Amount of sediment erosion at the lower part of the landslide within one or two year.

Keywords: UAV, Monitoring, Measurement, Deep landslinde, Sediment disaster

Japan Geoscience Union Meeting 2015
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HTT30-05 Room:101A Time:May 25 17:30-17:45

Rice growth condition estimation using small UAV

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The advances of GPS, gyro and acceleration sensor has made possible low-cost and miniaturization. Thereby, multi-copter mounted with these sensors have appeared. That it requires a high level of technology and knowledge in the handling of RC traditional helicopter, beginner to steer is difficult.However, it has become possible to get easily geospatial information of high-resolution for beginners.

In this study, we examined method of rice growth monitoring by using small UAV.

Keywords: small UAV, NDVI, orthophoto, DSM, rice growth monitoring

Japan Geoscience Union Meeting 2015
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HTT30-06 Room:101A Time:May 25 17:45-18:00

Rice growth monitoring by radio control electric-powered Multicopter

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[1]Chiba Univ. Graduate school of Sience, [2]Japan Map Center, [3]Chiva Univ. CEReS

1. Introduction

Currently,radio control electric-powered Multicopter became miniaturization and cost reduction also the attitude control technology improves. And it became to do the proximity remote sensing at a low cost by mounting a camera or sensor as UAV (Unmanned Aerial Vehicle).

Crop production management is one of the important issues of remote sensing,the number of case studies have been accumulated.In particular,in the paddy rice is Japan's key crops,such as yield and harvest optimum time forecasting and eating quality decision is challenged, observation and prediction that target a vast field that utilizes the aircraft and satellite remote sensing has been carried out.

In this study,by using the UAV for growth monitoring of rice,it was attempted a detailed growth situation monitoring based on the image of high time-spatial resolution.In addition,we used SfM (Structure from Motion) technic to the analysis of a plurality of images taken,which can create ortho mosaic image,DSM,were utilized for growth monitoring of rice. Observation by the UAV,less limitations by clouds,such as a satellite,in addition UAV is possible to observe at any time. So if the observation costs are inexpensive and the data is the high accuracy,the advantage of using UAV is increase especially the wet area like Japan.

2. Methods

In rice Proving Ground in Chiba Prefectural Agriculture and Forestry Research Center, we observed in June 2014 from May to September.In this field is subdivided two of paddy in 48 compartments, seeding, transplanting time in each compartment,varieties and changing the amount of fertilizer,can be grown in different conditions.

To observation,electric-powered Multicopter and digital camera were subjected to aerial using.

Creation of ortho photographs and paddy fields of DSM(Digital Surface Model)was created using the SfM software PhotoScan.DSM in order to change due to the growth of rice,is subtracted the initial ground surface altitude (ground surface before planting) from DSM of each shot time,determine the average plant length of rice in each compartment.

3. Results,Discussion

1) NDVI

NDVI of rice for each partition in common,rises from transplanting time,it was lowered toward maturity around heading to the peak.

Transplant period 4 phase(4/10,4/23,5/14,6/3),appear peak earlier about what time that was transplanted early,began then descent. Due to differences in the varieties, the difference of the growth process also observed,NDVI of the same period of the previous heading slow-growth Koshihikari became lowest. In addition, even those of the same day of transplantation-breed,a higher fertilization amount became high NDVI.

Differences in growth conditions in field by growth conditions were observed in detail. (Using the NDVI)

2) DSM (the Plant length)

Results of the comparison the plant length measured from the DSM and actual measured plant length previous heading,we could observe in the error number cm level. Plant length is one of the important indicator rice to growth conditions and we could observe it from the Aerial photos.

The cause of the error, as well as DSM accuracy problems,strictly to seeking high state fallen state and wind hanging the DSM is measured "plant height". On the other hand, Actual measured values is measured by stretched straight(plant length).

3) Growth estimation using NDVI (plant length, LAI)

Based on the correlation between the measured data and NDVI of rice, I was led to the regression model for plant length ? LAI estimation in before heading using the NDVI. Each of RMSE of these models, 0.047m (plant height) 0.478m2 / m2(LAI), estimation accuracy is high, the possibility that can be applied to the growth state measurement of critical time to adjust, such as top-dressing amount has been suggested.

Keywords: UAV, SfM, NDVI, DSM, Plant length

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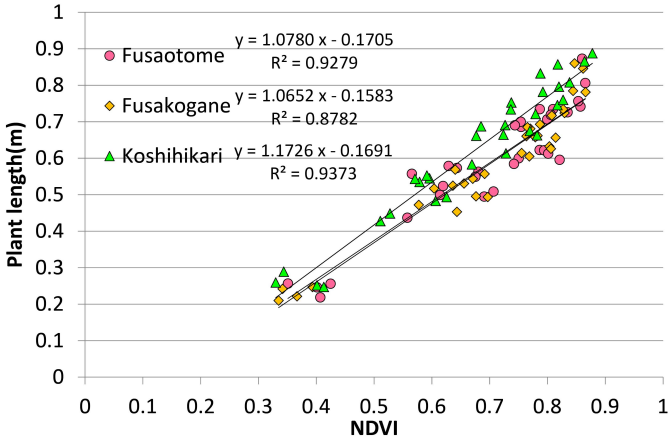

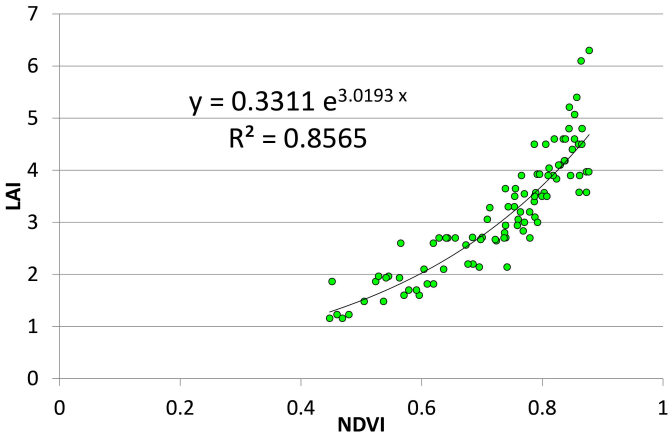

Japan Geoscience Union Meeting 2015
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HTT30-P01 Room:Convention Hall Time:May 25 18:15-19:30

Dose rate mapping by UAV and application to radioactive contamination area

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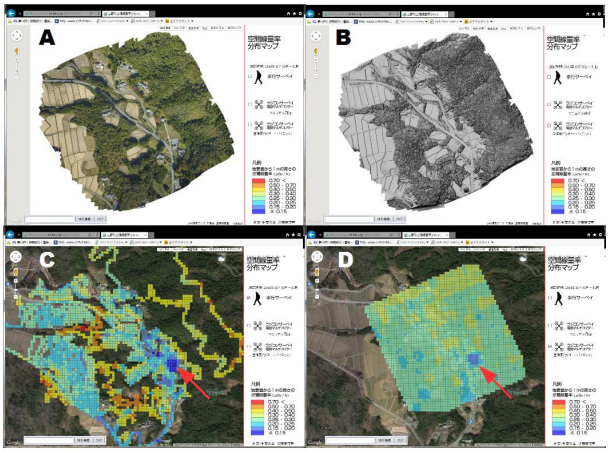
Dose rate mapping in radioactively contaminated area is inevitable to make acknowledgement to live in the land, and to monitor external dose continuously. As convenient tool to measure dose rate especially in mountain area, we develop the system to measure dose rate by UAV (Unmanned Aerial Vehicle). The system is applied to two regions in Fukushima Prefecture. At the JpGU meeting, examples of practical use of UAV system will be presented.

Keywords: dose rate, unmanned aerial vehicle, nuclear disaster, Fukushima, Structure from Motion, Digital Surface Model



Japan Geoscience Union Meeting 2015
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HTT30-P02 Room:Convention Hall Time:May 25 18:15-19:30

A method for measuring surface rupture displacement by using UAV - Application to the 2014 Kamishiro fault earthquake

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[1]NIES, [2]Hiroshima University, [3]Toyo University, [4]Chiba University, [5]Yamaguchi University, [6]Hosei University, [7]Okayama University, [8]Shinshu University

The surface ruptures associated with the 2014 Kamishiro fault earthquake (Mj 6.7), central Japan was photographed by digital cameras mounted on an unmanned aerial vehicle (UAV) and a high pole. The resulting Digital Surface Model (DSM) generated using the Structure from Motion (SfM) -Multi-View Stereo (MVS) software enabled accurate measurement of the terrain section, as well as variations in directions and amounts of three-dimensional surface displacements. Imaging technology mounted on a UAV is used to obtain widespread surface measurements, while the pole camera is used for the detailed photography of important locations. The accuracy of the DSM will be confirmed by the comparison of our findings with the measurements by other methods, such as auto-level, Total Station, and terrestrial LiDAR.

As a result, we were able to create a DSM of a resolution of a few centimeters. The shaded diagram of the DSM indicates the following: 1) Surface rupture has propagated in an intricately bent and branched manner. 2) Small-scale deformation and deformation along several meters of width have taken place. Subsequently, this DSM was compared with the cross-sectional survey and measurements carried out by the auto-level and LiDAR, and it was confirmed that the DSM is characterized by fine topographic changes. However, an error of about 10 cm could have been present depending on the location.

Keywords: The 2014 Kamishiro fault earthquake, surface rupture, UAV, SfM-MVS, Ultra-high-resolution DSM

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HTT30-P03 Room:Convention Hall Time:May 25 18:15-19:30

Accuracy validation of DSM that has been generated by UAV and SfM-MVS, Part3

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Preface

Nowadays, more and more people are drawing attention to a measuring technique using UAV and SfM-MVS(Structure from Motion). Using this technique enable us to obtain the topographical information of the spatio-temporal resolution. This technique has applied to information acquisition of the initial stage of the disaster, measurement of the amount of displayment of landslide configuratio and active fault terrain, and utilizes to generate ultra high quality resolution DSM which only has a few cm resolution images. On the other hand, any of the research has tried to take a shot of a micro object, such as gravel of the riverbed, from sky and then turn it to DSM. Verification of accuracy has not yet done sufficiently as well.

This essay is going to write about the best way to take picture from sky and analyzing method on SfM-MVS, in order to turn a few cm micro objects into DSM, through various experimental set-up.

Experiment technique

Set acrylic plate as a criteria surface, and place three bricks (height respectively 6, 12, 18cm), then photographed them from the air by UAV. These bricks intrinsic merit is fixed. After, process captured images with SfM-MVS software, and produced the DSM. Display DSM on GIS, extracts their DSM of each center of the brick and the criteria plane and tried to calculate individual value. Average, maximum, minimum, and standard deviation of the extracted individual values were compared with other experimental data and intrinsic merit. I used DJI Phantom2 Vision+ as UAV, Agisoft PhotoScan Professional 1.1.2 as SfM-MVS, and ArcGIS 10.2 as GIS.

There are 6 experimental set-ups, for taking pictures from sky.

Exp.1 Take pictures from different height; 5m, 10m and 20m.

Exp.2 Change the number of photo to analyze; 10, 20, 50, 100 and 150.

Exp.3 Change the position of GCP in 4 ways, on the criteria plane and on the bricks, only on the criteria plane, only on the bricks, only on top of the bricks and the criteria plane.

Exp.4. Manually compensate the GCP which is automatically granted by SfM-MVS.

Exp.5. Change the setting of the Camera calibration on SfM-MVS, using the new faculty of PhotoScan1.1.1.

Exp.6 Change the tile angle of the camera.

Setting for Exp.5 and Exp.6 are provided on the day of experiment.

Result

The result of Exp.1 shows that DSM resolution differed by the heights; 0.6cm in ground advanced 5m, 1cm in ground altitude 10m, 2cm in ground elevation 20m. As the flight altitude got higher, the advance height of DSM on bricks and standard deviation became smaller. Also, higher the flight altitude

Keywords: UAV, SfM-MVS, Super high-resolution DSM, Accuracy validation

Japan Geoscience Union Meeting 2015
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HTT30-P04 Room:Convention Hall Time:May 25 18:15-19:30

The development of ultra-high resolution 3D measurement system by a multicopter using the latest laser scanner

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[1]Tokyo Metropolitan University, Graduate School of Urban Environmental Sciences, [2]Nakanihon Air Service CO.,LTD, [3]RIEGL JAPAN LTD

In recent years, unmanned helicopters, especially multicopters which have multiple rotors, have been developed rapidly and the compact laser scanner which can load on them have been also developed. RIEGL VUX-1, ultra-lightweight compact laser scanner, was released in 2014. This scanner is assumed to load on unmanned aerial vehicles. The specifications of the scanner are as follows: weight 3.6kg, size 227∗180∗125mm, a large field of view (330 degrees) and a high measurement rate of 500,000 points / seconds. The scanner also corresponds to multiple targets processing by the waveform analysis.

In this study, at first a multicopter that can be loaded with this latest laser scanner was newly developed. In the second, attempts to ultra-high-definition 3D measurement will be done by the new multicopter with the scanner.

The accuracy verification test was done by the unmanned helicopter YAMAHA RMAX L18 with a gasoline engine. This test was done by Nakanihon Air Service CO.,LTD, RIEGL JAPAN LTD and KoHaTa Inc. in Oct. 2014. As a result of horizontal direction verification, vertical direction verification and small object identification verification, it was revealed that the system can grasp the small step of the relative height 1cm unit as Fig.1.

The influence of the vibration of the engine was concerned, but the effect of vibration was relatively small comparing with the actual aircraft. This may be because the high frequency vibration was dominant. The newly developed multicopter moved by the motors for reducing the vibration, it is considered to be able to ensure the accuracy with the smaller and lighter IMU.

The new multicopter is designed to be able to exert maximum performance of the sensor. Considering the VUX-1 transmission and reception of the laser, the shape of the multicopter around the sensor was specially designed so that be able to acquire the 330 degree wide viewing angle data from low altitude flight. This makes it possible to create a wide area and high speed ultra-high-resolution 3D model of terrain and structures from the sky to the same extent of the accuracy by ground-based laser scanner measurement.

This new measurement system is considered as effective where measurements from the ground level are difficult, such as the landslide disaster. Various applications, such as early condition ascertainment, prevention of secondary disaster and recovery and reconstruction planning are expected by this system.

It is planned to upgrade the system to retrieve data in various weather conditions and to view and print the measurement results in real time in disaster area. After upgrading, the system will be used in the activities of ”Tokyo Metropolitan University Disaster Investigation & Assistance Special Team by Unmanned Aerial Vehicles” in a real disaster field.

Acknowledgments

We would like to give a special thanks to Mr. Mitsunori KOHATA, the president of KoHaTa Inc. This research was partially supported by RISTEX, JST.

Keywords: Unmanned Arial Vehicle, Laser scanner, 3D measurement, Mmulticopter, Drone

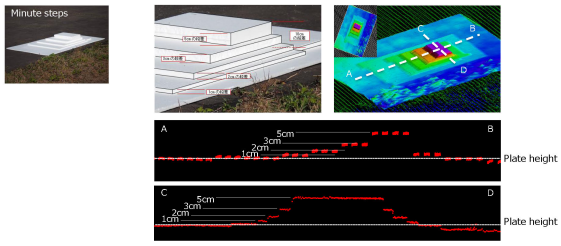

Fig.1 Result of the accuracy verification test

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Glacier change analysis in Tien Shan using digital camera images

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In mountainous regions of Central Asia, benchmark glaciers which mass balance has been observed for a long time period are Abramov, Golubin, Karabatkak, Tuyuksu, and Urumqi No.1 Glaciers (UNEP, 2007). Because of collapse of the former Soviet Union, some glaciers had been stopped to observe in the late 1990s. Observation of glacier mass balance has some problems such as optimal glacier to the survey, approach, greater burden budget and effort for observation. Although there are reports of mass balance changes using digital elevation model (DEM) generated from satellite data, it is difficult to calculate the annual variation of glacier surface in arid or semi arid region using DEM for small scale glaciers. In this study, we researched glacier mass change of small glaciers in Tien Shan, using SfM (Structure from Motion) and digital camera images from aerial. Average annual mass balance of small scale glacier (0.129km^2) was -1042mm/a^{-1} between ALOS/PRISM DEM (2006) and Camera DEM (2014). We found that it is effective to use digital images taken from the aerial for glacier research.

Keywords: mall-scale glacier, mass balance, Tien Shan, digital camera image, DEM

Japan Geoscience Union Meeting 2015
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HTT30-P06 Room:Convention Hall Time:May 25 18:15-19:30

Research method development by using UAV over restricted areas of volcanoes

FUJIWARA, Shinya[1*] ; TEZUKA, Munehiro[1] ; MORIYAMA, Yuji[1] ; SHIMADA, Toru[1] ; SAKAGAMI, Masayuki[1] ; KANAI, Hiromichi[1] ; NAGATANI, Keiji[2] ; IZU, Tomoyuki[3]

[1]Kokusai Kogyo Co., Ltd., [2]Tohoku Univ., [3]Enroute Co., Ltd.

It is known that deformation and tephra fallout by volcanic eruptions could cause severe geographical changes around the crater. If some volcanic ash emitted from the crater can be collected, we have a greater chance of getting information on its magma reservoir and its eruption type, and by examining the contents of volcanic ash, we may be able to assess the possibility of an occurrence of a secondary disaster such as debris flows.

We have been conducting a series of field test for collecting ash or gravels from volcanic area, obtaining images at crater and creating DSM by using UAV and other devices. In this study, we present methods and results based on a field test conducted in Sakurajima volcano, in December, 2014.

The UAV used in this project is ZionQC730 by Enroute Co., Ltd., equipped with four pieces of propellers. At Sakurajima, we send this device from lower Kurokami River to over Showa crater. Translational distance from take-off point to the crater was about 3,700 m, at altitude 1,200 m, flying distance of 8,000 m with speed of 10 m/s, and flight duration was approximately 20 minutes per flight. 56 % of the battery remains after a flight under the wind speed 5 m/s. A total of three flight experiment was conducted to the crater and at each flight, 4K resolution images were successfully obtained. Though lower in resolution, the UAV also provided real-time images during these flights. As stated above, it is possible to obtain high-resolution images at restricted area by these UAVs.

We used 300 images obtained at upstream area of Kurokami River to create DSM by using several utilizing structure from motion (SfM) softwares, and compare them in terms of their accuracies, point densities, and model creation times.

We then assess the difference between existing laser profilers (LP) and our models. As a result, we found that these softwares had a little difference for data accuracies while point densities differed significantly. We also found a few meter differences in vertical direction when not employing GCPs. Usually erupting volcanoes do not allow little time to set them up, therefore we have to resolve the problem as to fix this inaccuracy.

In this project, we attached a special device to UAV to collect samples of volcanic ash from the surface. This device equips a motor to rotate double rollers inwards to collect soils. It has been used successfully in some test fields.

We collected soil from Kurokami River sediment using above device. The rainfall from the previous day might cause harder soil and collecting insufficient amount of sample. In the future, it may be necessary to be able to make changes to the physical structure of the device according to soil conditions.

Keywords: UAV, Sakurajima, Volcano