Long Range Aerial Photo Survey Experiments for Disaster Monitoring using Electric Foam Plane

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[Introduction]
We are conducting experiments of small UAV for applications to disaster risk assessment, monitoring and response. We first used multi-rotor UAV for our survey, which is easy to operate and can take-off and land at any topographic conditions. We now use fixed wing Styrofoam planes, which can fly faster and longer, and safer when it crashes. Our foam plane is a flying wing (tailless) type with 118cm wingspan, 750g weight without battery and camera, and with APM autopilot system. We use a light-weight GoPro camera for long-range flights. The cruise air speed is about 60km/h. It flies 60km in 60minutes to fully consume the 3-cell 5200mAh Lipo battery in circuit experiments at flatland under the no-wind condition.
[Experiment for application to disaster response]
We are carrying out experiments of utilization of UAVs as a part of a disaster information management systems. We demonstrated a long-range aerial photo flight at Kamaishi bay, Iwate prefecture on August 8, 2015, in the presence of Kamaishi city officers, fire fighters and police officers. The plane took off from a fishery port and flew over the Kamaishi-bay in clockwise for 15km at 140m ground altitude to take photographs along the coast.
[Experiments for application to river monitoring]
Fixed-wing UAVs are useful for monitoring river in both ordinary time and during and after disasters to watch the conditions of river dikes and other facilities along the stream. We demonstrated long-range aerial photo flights at Chikugo-gawa river in Fukuoka prefecture on November 20, 2015 and at Naka-gawa river in Tochigi Prefecture on December 9, under permissions of river management offices of Ministry of Land, Infrastructure and Transportation. The plane made 20km round trip (10km one-way) along the Chikugo-gawa river, and 24km round trip (12km one-way) along the Nakagawa-river at 140m ground altitudes.
[Experiments for application to volcano monitoring]
It is desirable to be able to monitor topography and temperature distributions of a crater and chemical components of gases and ashes to predict the activities of underground magma. Fixed wing UAVs can fly from outside the off-limit area few kilometers away from the crater when the volcano becomes active. We tested our UAV at Taal volcano of the Philippines on October 8, 2015, launched at 8km north from the crater with 200m elevation difference. We also tested it at Kirishima Shin-Moedake volcano of Kyushu on November 21, from 3km west of the crater with 400m elevation difference. An Asama volcano mission was made on December 8, from 5km north-east of the summit with 1300m elevation difference. The plane however accidentally hit the ground near the top. We found out that the baro-altitude meter on the flight controller had an +8% of systematic altitude error, which caused a wrong flight altitudes. We will climb the mountain to retrieve the craft when the snow melts. The crash point was recorded by the telemetry. We successfully made a crater mission for the Nasudake volcano in Tochigi prefecture on December 9, from 3.6km southeast of the summit, with 12km total flight distance and 1000m climbing up and down.
[Discussion]
Our experiments above were done all under weak wind conditions. The battery consumptions were only about a half or less. Calculations show a flight time to return to the launching point increases to 111%, 125%, 200% and 500% if the wind speed is 10%, 20% 50%, and 80% of the cruise air speed of the

craft, respectively. You have to make a short enough flight plan for the safe return, depending on airspeeds expected over the survey area. We plan to quantitatively evaluate the effects of battery capacity, payload, wind speed, elevation difference, cold temperature and rains. We also plan to make experiments for bigger planes for longer range, and smaller planes for easier and safer operations to find practical limitations of electric foam planes.

Keywords: UAV, Disaster, Fixed wing plane