# Infrastructure (Transmission line) Check Autonomous Flight Drone (1)

Hironobu Kinjo*, Michinari Morita, Shido Sato
Tansuriyavong Suriyon, Takashi Anezaki

GPS data can become faulty under bridges, inside tunnels, or near high-voltage power lines, which could lead to drone flight errors. To address this issue, we are developing a system for conducting infrastructure inspections using drones that basically use GPS for autonomous flight control, but can also estimate self-position through image processing when GPS cannot be used under situations such as those mentioned above. This paper describes a method for estimation of self-position using ground images, with the aim of developing an autonomous drone flight system for use in infrastructure inspection.

**Keywords:** drone, infrastructure inspection, autonomous, non-GPS

## I. BACKGROUND

Drones are currently being used for a wide range of applications, such as for the public surveys conducted by the Ministry of Land, Infrastructure, Transport and Tourism, and for surveillance and for crop-dusting operations. For these purposes, drones are controlled either by a pilot through a smartphone or mobile device, or drones fly autonomously by estimating self-position using GPS. GPS data, however, can become faulty under bridges, inside tunnels, or near high-voltage power lines [1], which could lead to drone flight errors. To address this issue, we are developing a system for conducting infrastructure inspections using drones that basically use GPS for autonomous flight control, but can also estimate self-position through image processing when GPS cannot be used under situations such as those mentioned above.

In particular, we developed a drone system aimed at performing automatic inspections of transmission lines. According to the National Tax Agency of Japan, transmission lines have a lifespan of 40 years [2], and the transmission lines built during the postwar rapid economic growth period require regular inspections. These highlight the importance of using drones for inspection of transmission lines.

## III. OBJECTIVES

In cases when GPS data cannot be used, autonomous flight similar to GPS navigation is still possible as long as the absolute position coordinates and the relative moving distance of the drone are known. Therefore, in this study, we used ground images directly underneath the drone to estimate self-position. In particular, the method involves detecting feature points from a ground image sequence, estimating camera position and attitude, as well as mapping. In this study, we refer to this system as "ground-image gyro."

## II. GROUND-IMAGE GYRO

### 3-1 Feature point detection

One of the problems in implementing the ground-image gyro system is the detection of feature points. Since ground images taken aerially do not show texture clearly, the SURF algorithm, which enables detecting multiple features, was used.

The following figures show a comparison of the FAST and SURF algorithms.


Figure 1 FAST algorithm

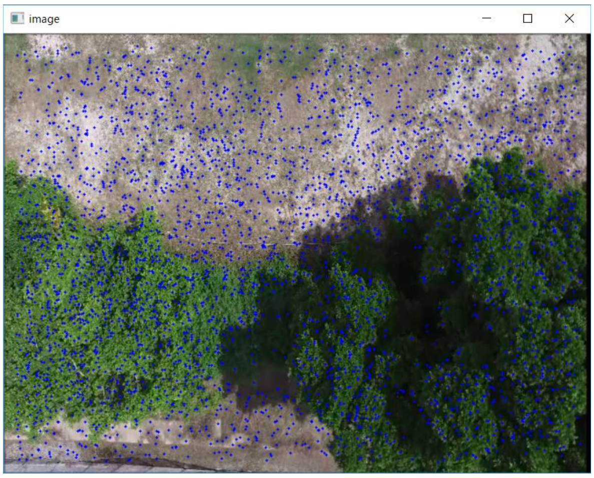

Fig. 2 SURF algorithm

3-2 **Matching**

The Lucas-Kanade method [3], an algorithm for tracking particular objects in an image, is used for the matching of feature points between consecutive image frames. It is characterized by its ability to carry out rapid processing by performing a hierarchical search beginning from the vicinity of the search object. RANSAC is then used to remove mismatches from the matching results.

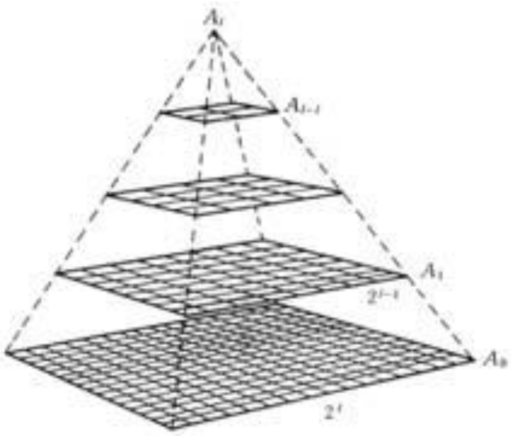

Fig. 3 Lucas-Kanade method

〈3・3〉 Estimation of 3D position of points in the image

The five-point algorithm is used to estimate the camera's relative position and attitude based on two images. The five-point algorithm is an algorithm for estimating the essential matrix from at least five matched points. On the basis of the estimated relative position and attitude of the camera, 3D coordinates of feature points in the image are inferred from matches between two images, in accordance with the principle of triangulation.

3-4 **Solving the PnP problem**

The PnP problem is resolved based on the inferred 3D coordinate points and their corresponding points in the image. Solving the PnP problem enables finding the camera position and attitude from the multiple matches between point "P" with a known 3D position and its observed coordinate "p" on the image. The camera's motion vector and rotation vector are determined by solving the PnP problem.

3-5 **Mapping**

The coordinates calculated trigonometrically are reprojected, the validity of the calculation is determined based on the errors, and the key frames are selected.

## IV. EXPERIMENTS AND RESULTS

In this study, we determined the usefulness of the motion accumulated using the motion vector between two images calculated by obtaining the mean of all optical flows detected through the Lucas-Kanade method. The following figure shows the flowchart of the program.

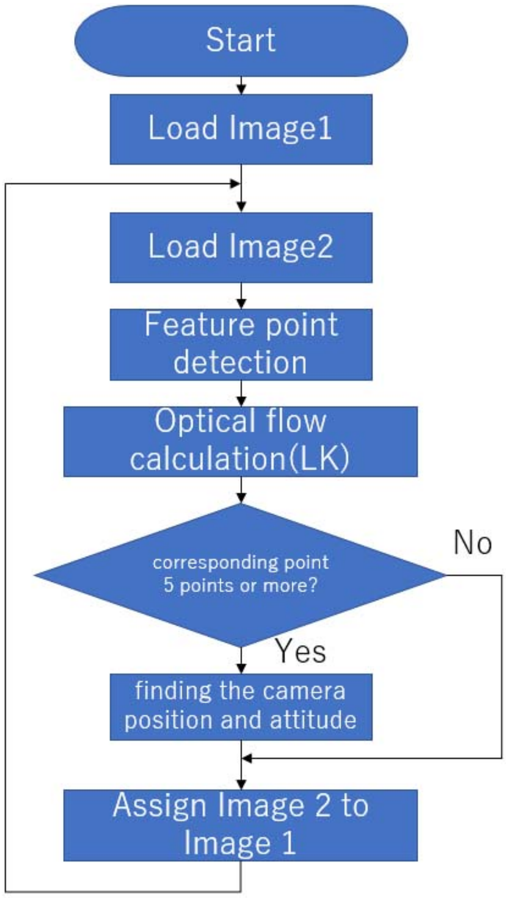


Fig. 4 Program Flowchart

Figures 5, 6, 7, and 8 show the results of executing the program for calculating motion based on the mean of the optical flows.

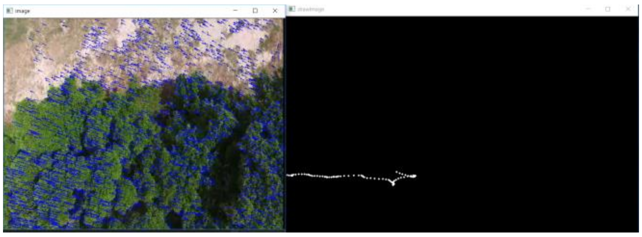

Fig. 5 Execution result

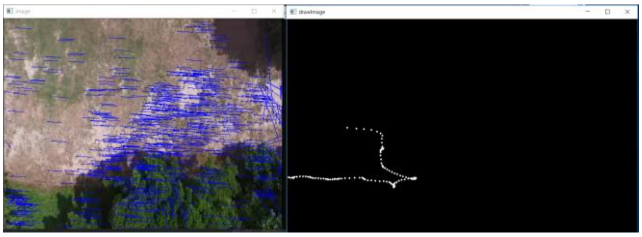

Fig. 6 Execution result

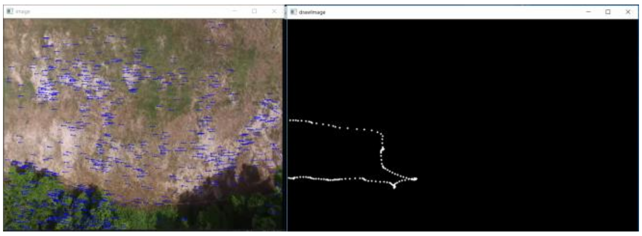

Fig.7 Execution result


Fig. 8 Execution result

The motion vector between two images calculated by obtaining the mean of the optical flows rendered a trajectory that was almost identical to the path of the drone's movement. This result shows that using the mean of the optical flows is useful for calculating the motion vector if motion of the z-coordinate is not taken into consideration.

Further, matching was carried out using the Lucas-Kanade method, and mismatches were removed using RANSAC.


Fig. 9 Without Ransac

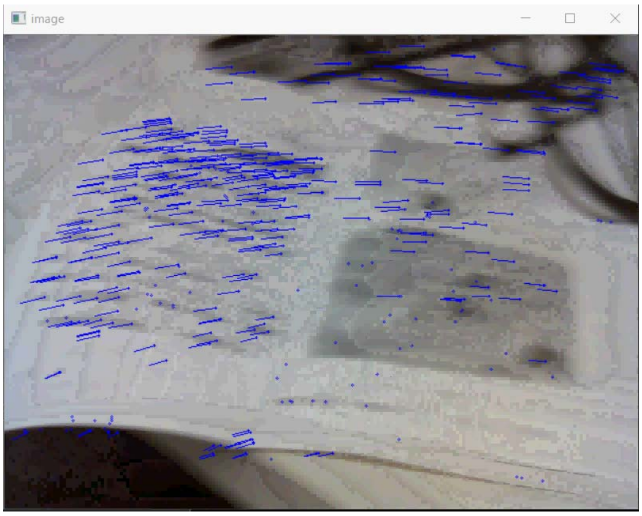


Fig. 10 With Ransac

Compared to results without using RANSAC in Figure 7, the image after applying RANSAC in Figure 8 shows fewer mismatches.

## V. SUMMARY

This paper describes a method for estimation of self-position using ground images, with the aim of developing an autonomous drone flight system for use in infrastructure inspection. Since the motion vector between two images calculated from the mean of optical flows rendered a trajectory that was almost identical to the drone's flight path, it is useful in calculating motion vector when movement of the z-coordinate is not taken into consideration. Also, RANSAC was used to successfully remove mismatches from the matching results. Going forward, we will implement the mapping function and complete the implementation of the ground-image gyro system.


## ACKNOWLEDGEMENT

Part of this research was funded through the Ministry of Internal Affairs and Communication SCOPE budget (No.152311004)


## References


(1) Atsushi Tsuchiya, Hiromichi Tsuji: "New and Easy GPS Surveying" Japan Association of Surveyors (2017) [in Japanese]

(2) National Tax Agency: "Appendix on handling notifications regarding the applications of service life" (https://www.nta.go.jp/shiraberu/zeiho-kaishaku/tsutatsu/kobetsu/sonota/700525/fuhyou/04.htm) [in Japanese]

(3) Naoyuki Hara: "Automatic parking system based on image data: Object tracking using OpenCV" (2012) [in Japanese]