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A study on situation recognition in wide area by aerial image analysis

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Abstract: Recently, social security and natural disasters are worrying. In order to solve these problems and to reduce the damage, wide-area monitoring by computer vision is needed. Traditional monitoring systems have many problems that are caused by limited visual field in conventional technique. In this research, the air vehicle system which is to track a particular person indoors and outdoors where there are multiple people exist is proposed. Besides that, the four blades helicopter as a flying robot named AR.Drone is used. On experimental method, Hough transform method, Histogram method, Snakes method and Particle filter method are used in the research. Experimental results indoors and outdoors have shown the effectiveness of the proposed methods. The purpose of the study is to perform a wide area situation recognition and autonomous control of flying robot indoors and outdoors.

Keywords: Hough Transform, Histogram, Snakes, Particle Filter, Computer Vision, Wide Area Monitoring.

1 BACKGROUND

Recently, the number of crime incident at university, bank, convenience stores and so on occurs frequently because of the increase of invasion by intruders. In addition, natural disasters such as volcanic activities and earthquakes occur frequently, which makes damage become worse. For example, 400,000 people were affected by earthquake in Sichuan, China on May 12, 2008 while more than 200,000 people were affected by earthquake in Japan on March 11, 2011 because rescue was not done promptly after disasters (Fig.1.).

Fig.1. Northeast earthquake in Japan

In agricultural sector, it is a subject about how to understand the production status in vast farmland and how to prevent vermin damage. Therefore, the pesticide usage and residue status monitoring is also important.

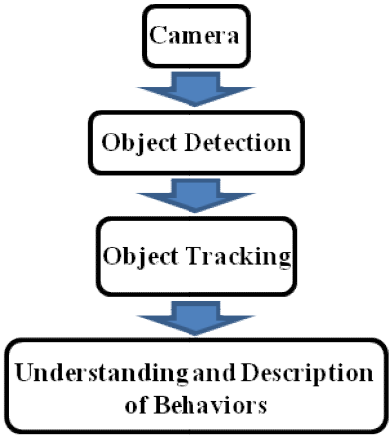
In order to solve these problems and to reduce the damages, it is important to carry out the wide area monitoring.

2 RELATED RESEARCHES

2.1 The Traditional Monitoring System

As for traditional monitoring system, firstly, it is to detect dynamic objects from image, and to track it. Secondly, it is to understand what is the object classified, and then to understand the structure of the object. The problem of background fluctuation and illumination change the effect of the recognition results. Flowchart of traditional monitoring system is as follows (Table 1.).

Table 1. Flowchart of traditional monitoring system [1]



2.2 The problem of conventional method

Typical approaches of automatic monitoring are the background difference method and model method. The background difference method is explained as follows. Beforehand, the background image is taken where dynamic objects do not exist. After that, dynamic object is detected depending on differential results of input image and background image. The robust of technique is influenced by complex environment. Detection accuracy of model method

is reduced when part of the body is shielded (Fig.2.).

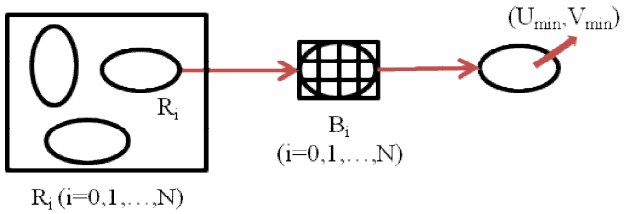


Fig.2. Conventional method [1]

There are many problems that are caused by limited visual field in the traditional monitoring system, such as difficulties to decide the border situation, shielding due to buildings and trees and difficulties to track target object.

On the other hand, in aerial images there are scarcely vision problems and obstacles problems that make it possible to track single or multiple target objects. Besides, it is easy to carry out wide area monitoring. The matter of aerial image is that it has less characteristics of target object and flying robot is likely to be susceptible to wind and weather.

3 AERIAL IMAGE

There are two ways to take aerial image. The first way is to use the retention type robot (balloon robot) and the second way is to use the flying type robot (flying robot). The merits and demerits of both are as follows (Table 2.).

Table 2. merits and demerits of Balloon Robot and Flying Robot

	Merits	Demerits
Balloon Robot	battery is not required	can not track target object
	safety is high	Low degrees of freedom
		susceptible to wind and weather
Flying Robot	can track target object	battery is required
	autonomous co-ntrol is possible	vibration effects image quality

Because the purpose of study is to track target object and the flying robot can be controlled automatically, the flying robot is chosen for this study.

4 PROPOSALS OF STUDY

The air vehicle system which is to track a particular person indoors and outdoors where there are multiple people exist is proposed. The purpose of the study is to perform a wide area situation recognition and autonomous control of flying robot indoors and outdoors. It is to detect a particular person by head of the person as a feature, because the characteristics is few from aerial image, and to track the person detected by head, clothing color and so on as features. As for autonomous control of flying robot, flying robot is controlled by landmark recognition.

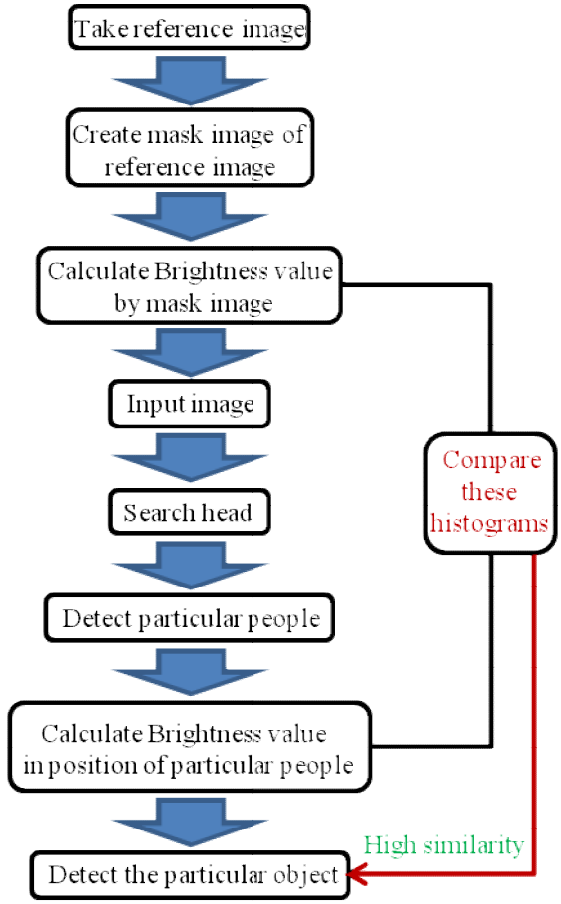
There are many types of flying robots such as helicopter type , flying robot with wings and flying robot with blades. In this research, four blades helicopter as a flying robot named AR.Drone shown in left of Figure 3 is used. AR.Drone can be controlled by ipod touch and iphone, because of the Wireless communication function (Fig.3).

Fig.3. Types of the Flying Robot

5 EXPERIMENTAL METHODS

5.1 Experiment for detecting a particular person

Table 3. Flowchart of detecting target object



Firstly, the reference image is taken in the same scene and the mask image is created from reference image by the

Photoshop. The size of mask image is the same as the reference image. Secondly, it is to perform the edge extraction on AVI video taken by AR.Drone in the scene. Thirdly, the video processed is done by expansion and smoothing processing. Then, it is to detect the head of person exist by the Hough Transform method (Equation (1)) [2].

$$r^2 = (x_i - centreX)^2 + (Y_i - centreY)^2 \quad (1)$$

After that, the brightness histogram of the circles detected and mask image above-mentioned are calculated. Additionally, to compare two histograms to decide who is the particular person (Table 3.).

5.2 Experiment for tracking a particular person

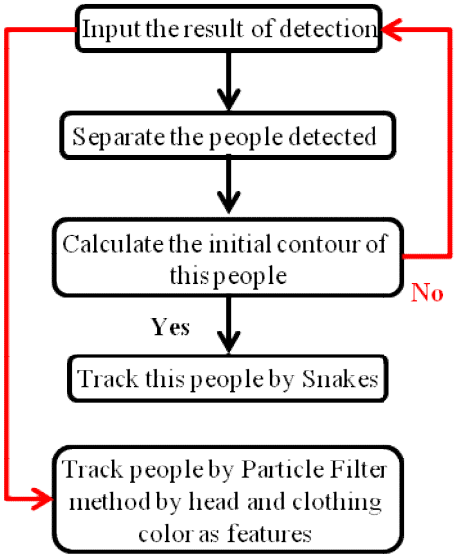
Firstly, input the image processed above. Secondly, it is to separate the people detected above and calculate the initial contour of this people. Thirdly, it is to track these people by Snakes method (Equation (2)).

$$E^*_{snake} = \int_0^1 E_{snake}(v(s))ds$$
$$= \int_0^1 E_{\text{int}}(v(s)) + E_{image}(v(s)) + E_{con}(v(s))ds \quad (2)$$

Where E_{int} represent the internal energy of the spline due to bending, E_{image} gives rise to the image forces, and E_{con} gives rise to the external constraint forces [3].

When snakes failed, it returns to the beginning image, and tracks this people by Particle filter method (Table 4.).

Table 4. Track the particular target object

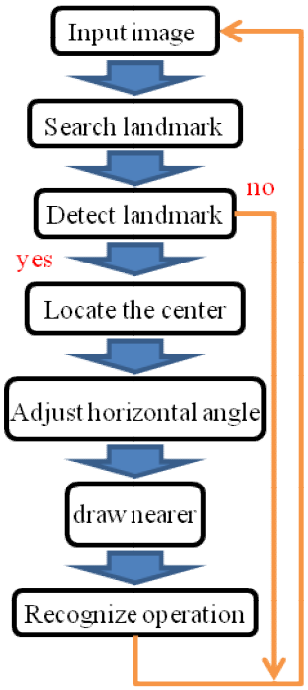


Particle Filters are usually used to estimate Bayesian models. The particle filter aims to estimate the sequence of hidden parameters, xk for k = 0,1,2,3,…, based only on the observed data yk for k = 0,1,2,3,…. All Bayesian estimates of xk follow from the posterior distribution p (xk | y0, y1… yk). In contrast, the MCMC or importance sampling approach would model the full posterior p(x0, x1… xk | y0, y1… yk) [4] [5].

5.3 Autonomous Control of Flying Robot

This part is to recognize landmark and be controlled by landmark. At first, the image is inputted. Secondly, it is to search the landmark, and then to detect the landmark. If landmark is detected successfully, the center is located, and horizontal angle is adjusted. Finally, flying robot draw nearer to object and to recognize it (Table 5.).

Table 5. The method of autonomous control



6 EXPERIMENTAL RESULTS

At first, the problem of height restriction is solved. There is a three meters height restriction on AR.Drone. In order to ensure the range of vision and be able to track the objects, this problem has to be noted. In addition, there are two cameras with AR.Drone. They are located at the bottom of AR.Drone and the front of AR.drone. In order to take the front image and bottom image, the problem with switching the camera has been solved (Fig.6.).

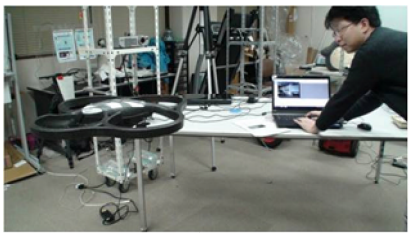


Fig.6. AR.Drone is controlled

6.1 Detect People by Flying Robot

Figure.7 shows the four blades helicopter as flying robot named AR.Drone is controlled by PC. In addition, automatic setting of the thresholds used in Hough Transform method has been achieved (Fig.7).

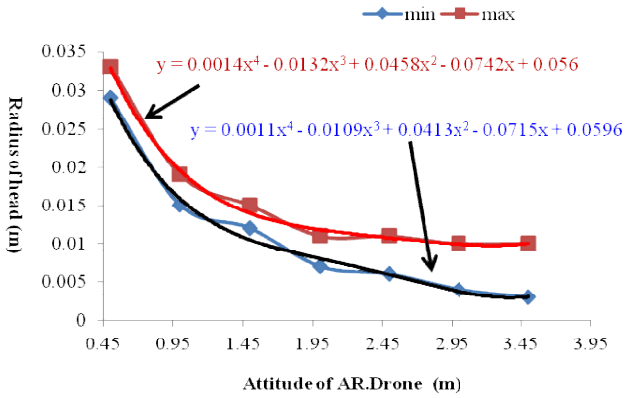


Fig.7. The Relation Between Attitude of AR.Drone and Radius of Head

It shows that particular person is detected by AR.Drone by Hough Transform method and Brightness Histogram method in Figure.8.

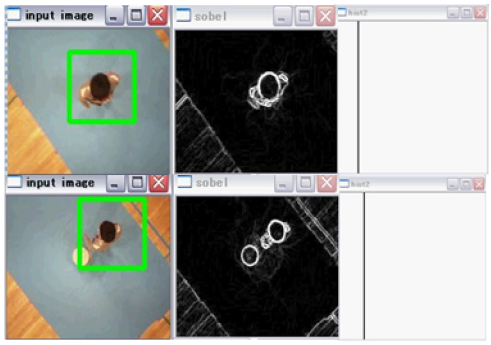


Fig.8. Detect person by Hough Transform and Brightness Histogram

The images on the top are without obstacle and the images on the bottom are with obstacle in the scene. Images on the left show people were detected and results are drawn by green rectangles. Images on the middle show results of edge extraction by the Sobel Operator. Images on the right show results of brightness histograms of head.

6.2 Track a Particular Person

The process of tracking person by Snakes method is shown in Figure.9. At first, the initial contour is decided and then parameters of Snakes are fixed by Equation (2) above-mentioned.

6.3 Results of Autonomous Control

Fig.10 is the result of autonomous control. Left image shows AR.Drone is controlled by red object, and right image shows it has detected red object successfully.

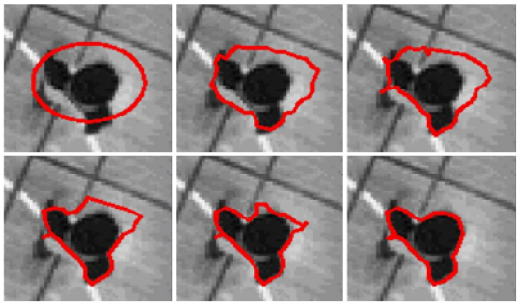


Fig.9. Tracking Process by Snakes Method

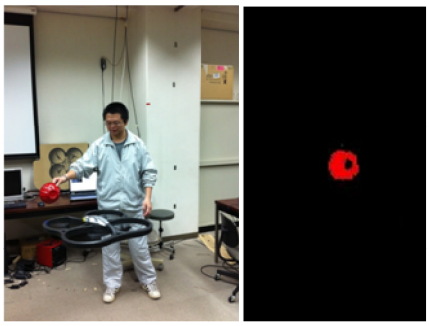


Fig.10. Red Object Recognition

7 CONCLUSION

The study is to detect and track the specific people. We hope that the flying robot is able to track the person by itself. Therefore, it is important to carry out autonomous control on flying robot. We also hope to achieve the aim that flying robot is able to detect and track target object automatically and help the people who wants to be helped.

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