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A Research on State Recognition in Wide Area by Aerial Images Analysis

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Abstract: This paper proposes an autonomous monitoring system to track the subject in real time by using aerial images, novel image processing method, and helicopter control technique. In this study, flying robot named AR.Drone is used for solving the problem of insufficient tracking capability in previous studies. In order to track the subject correctly and control the flying robot in right direction, it is important to understand the information of the subject's moving direction. For calculating the moving direction correctly from aerial images, new method by integrating various kinds of modules is proposed. With experiments, the stability of human tracking capability and the effectiveness of the direction estimation by aerial images analysis is verified.

Keywords: State recognition, Aerial images, Autonomous monitoring system, Moving direction, Automatic human tracking, AR.Drone autonomous control.

1 INTRODUCTION

Recently, the study on state recognition has developed rapidly [1]. For recording the state and behavior of the subject, automatic monitoring system is necessary. In previous studies, multiple fixed cameras are used to analyze the subject state [2]. However, when it is difficult to ensure field of view due to shielding, setting of cameras is restricted. Also, when the subject leaves out of the camera view, the subject would be lost. In other words, insufficient tracking capability and limited field of vision as the main problems exist in conventional technique.

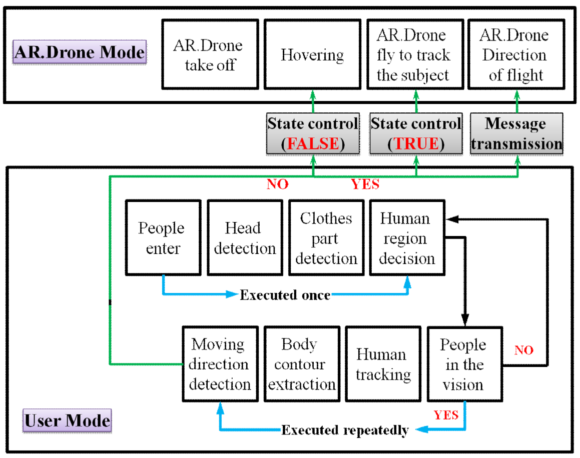


Fig. 1. Functional diagram of study

To ensure effective field of view, and appropriately recognize indoors and outdoors, the aerial images have been our attention in this research. By using flying robot named AR.Drone, the aerial photography system is built. According to aerial photography and motion analysis, the system on state recognition in wide area is developed.

Fig.1 shows the functional diagram of the study. Firstly, flying robot takes off, and hovers in air waiting human entry. When subjects enter, it is to carry out head detection, clothes detection, and human area determination. Then, judges whether human is in the vision. If human is in view, track the subject and calculate the moving direction. If human is out of the viewing range, it will move back to search the subject again by features of head and clothes color learned. If the data of moving direction is received, the flag of state control will become true, and transmit the data to AR.Drone mode to control flying robot tracking the subject. Otherwise, flying robot is hovering continuously. The purpose of this study is to monitor the subject in real time by utilizing flying robot.

The novelties of this study are as follows.

(1) To improve the effective range of vision and tracking capabilities, the aerial images taken by flying robot is utilized.

(2) Comparing to conventional tracking method, new method by integrating various kinds of modules is devised.

(3) Control flying robot accurately with the propeller control and predictive control.

2 PREVIOUS STUDIES

Formerly, there are many studies on human behavior, action, and state recognition. In the present study, it is a new idea to monitor human action and behavior by using flying robot and novel image processing method.

In the study of FUKUDA et al. [2], human detection by characteristics of hair color, head shape, clothes color, and position have been done by multiple fixed cameras. When the subject is out of camera view, the subject would be lost. Also, when hair color is not black or clothes color is black, misdetection usually occurs. In the present study, for ensuring effective field of view, flying robot is utilized. From aerial images, the subject can be monitored in any time.

Also, there are many tracking methods such as Mean Shift, Particle Filter, and Active Contour Model (ACM) previously, but there are some problems in each method, so it will affect the tracking result. For example, in studies of YUSUKE et al. [3], NAKAGAWA et al. [4], and AOKI et al. [5], when the number of particle is too much, processing time will increase. On the other hand, if the number of particle is few, accuracy will degrade. On Mean Shift [6], the HSV or BGR information is used to track the subject. However, if the subject is not in the search area at the beginning, the average vector cannot be calculated, so the subject cannot be tracked. About ACM method [7], it is difficult to set the position of initial closed curve exactly. This problem will affect the contour extraction result. In addition, if there are some image noises, it is difficult to extract the subject contour correctly.

From the above, it is necessary to build a novel system to track the subject accurately, and then control flying robot by moving direction of the subject.

3 AERIAL PHOTOGRAPHY SYSTEM

Generally, there are two ways of active flying robot and passive balloon robot.

The advantages of using balloon robot are small power consumption, and high stability, while the disadvantages are poor tracking performance, low degree of freedom, and susceptible to outside influence. On the other hand, the advantages of flying robot are high tracking performance, possible to automatic control, and high stability, but it also has disadvantages of high power consumption.

Depending on the purpose of this research, the high tracking performance is essential, so flying robot is chosen.

In this study, AR.Drone manufactured by the Parrot Company is utilized. About AR.Drone, there are two cameras attached on the front and bottom. Also, there are sensors installed on it, such as the Gyro Sensor, the Ultrasonic Sensor, and the Acceleration Sensor.

4 PROPOSED SYSTEM and METHOD

4.1 Proposed system

Fig.2 shows the proposed system of the study. The proposed system is composed of two threads. One is image processing thread, and another is flying robot control thread. In image processing thread, by carrying out human detection, area determination, and tracking, the human moving direction vector can be obtained by time series analysis. At the same time, flying robot control thread start, and moving direction data is fed back to control thread. After that, flying robot is controlled to track the subject by human direction vector.

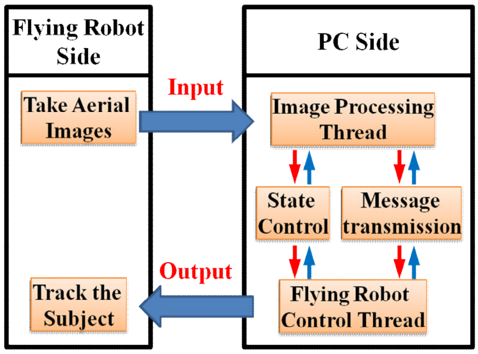


Fig. 2. Proposed system

4.2 Proposed method

In image processing part, this paper proposes the new method by integrating various kinds of modules to detect human moving direction.

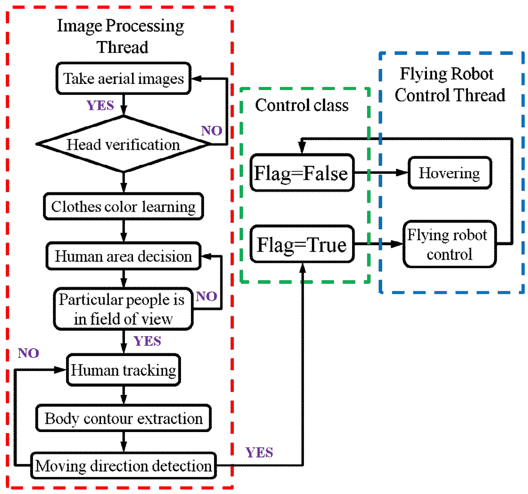


Fig. 3. Flowchart of research

From the top view, characteristics of human are few, such as head shape, head and clothes color, body contour, and moving direction. In order to control flying robot exactly, it is important to detect moving direction accurately. Fig.3 shows the flowchart of our research. From aerial images, head is important feature of people, so head detection is carried out firstly. To calculate moving direction exactly, precise body contour is essential. Thence, through calculating the human area and human tracking, accurate initial contour can be determined for ACM algorithm. Therefore, accurate body contour can be got by initial contour extracting. It is the different from the conventional ACM method.

In flying robot control part, through controlling the propellers speed and rotation direction, flight direction of AR.Drone can be controlled. In addition, by predictive control, AR.Drone will be controlled to track the subject correctly.

4.2.1 Head detection

Beforehand, the standard HSV histogram (Hist1) is calculated by analyzing standard head image. Then, head candidates are detected from aerial images of each frame by the Hough Transform method. The edge image processed by the Sobel Operator is used for detecting head candidates. In addition, HSV histogram (Hist2) of each head candidate is calculated. Furthermore, head can be determined by comparing Hist1 to Hist2.

4.2.2 Human area decision

From aerial images, clothes part is in the surrounding of head. Therefore, by the algorithm of repeatedly outward diffusing based the head, the rough outline around head can be obtained.

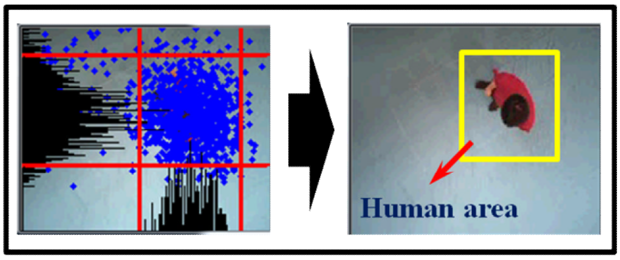


Fig. 4. Human area determination

Within this range, clothes color can be detected. After that, the color of clothes and head are learned. Then, many particles are distributed randomly on the image. Furthermore, the maximum likelihood of particles can be calculated due to BGR or HSV of head and clothes. Then, particles distribution could be calculated shown in Fig .4. In addition, human area will be determined according to particles distribution. Because color of clothes and head are learned, when particular people is out of view, subject can be detected again by Particle Filter algorithm. Otherwise, system must return to head detection again. Therefore, this process not only improves the accuracy of detection, but also reduces the processing time of whole system.

4.2.3 Human tracking

Human area has been determined in previous paragraph. In human area, according to the BGR or HSV histogram of clothes, human motion vector can be decided by Mean Shift algorithm. However, when multiple people are wearing the same color clothes, it is difficult to judge who the particular people is. Therefore, stability of moving direction with time series analysis is used to decide who the particular person is (as shown in Fig.5). It is important to achieve multiple people tracking with aerial images.

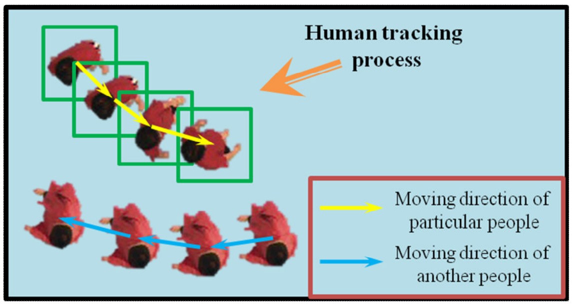


Fig. 5. Human tracking

4.2.4 Body contour extraction

In order to get human body contour, the Active Contour Model (ACM) is utilized [8]. In conventional ACM method, if image background is complex or object contour is irregular, it is difficult to set the initial contour and parameters. In this study, since human area has been determined accurately, the inscribed circle of human area can be as the initial contour. Then, body contour can be extracted exactly by initial converging.

4.2.5 Moving direction detection

From aerial images, moving direction is perpendicular to the shoulder. Therefore, it is necessary to know the direction of shoulder. The connecting line between the farthest points of body contour is as the direction of shoulder in this study. However, wrong results are received sometimes. Therefore, the time series analysis is utilized to except wrong results and predict moving direction next time.

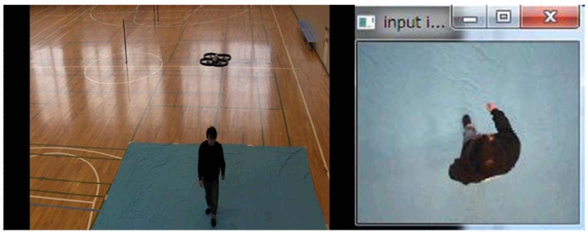
4.2.6 Flying robot control part

The movement of AR.Drone is controlled by controlling speed and turning direction of four propellers. When moving direction is obtained in image processing thread, it is fed back to AR.Drone. At the same time, flying robot control thread starts, and then AR.Drone flies along the moving direction of human. However, when the moving direction of human changes, AR.Drone cannot automatically put on the brake rapidly in air, so predictive control is also important. By using time series analysis, the probability of moving direction in next time can be predicted. By chance, if a particular person is out of view, AR.Drone will go up to detect particular people again.

5 EVALUATION EXPERIMENT

5.1 Experiment environment

The experiment is carried out in gymnasium. The third person view image and AR.Drone camera image are shown in Fig.6. This experiment is carried out when AR.Drone is hovering in air.



Third person view image Camera image

Fig. 6. Experiment environment

5.2 Experimental result

There are three cases in the evaluation experiment. First case is only one person is in the scene. Second case is there are two persons wearing clothes with different color. Third case is there are two persons wearing clothes with the same color. Sample images of each case are shown in Fig.7.

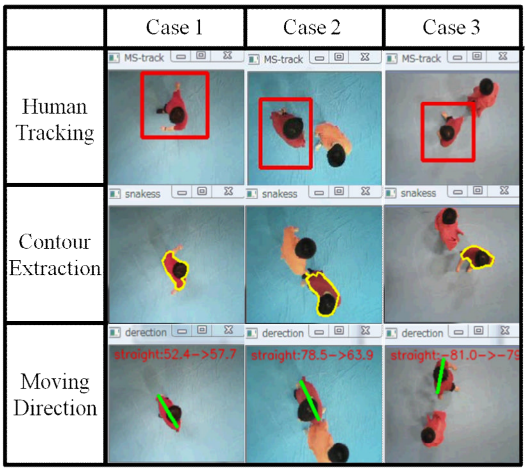


Fig. 7. Sample images of experiment results

With experiment, the success rate of human tracking is over 99%. When other people wearing the same color clothes enter into scene, the particular people also can be tracked exactly by using stability of moving direction. Compare to conventional ACM algorithm, success rate of contour extraction can be dramatically improved from 66% to 98% by setting initial contour accurately. In addition, success rate of moving direction is 95% by utilizing time series analysis. In future, the study on particular people is tracked automatically by AR.Drone will be carried out.

6 DISCUSSION

Due to evaluation experiment, the effectiveness of proposed system is proved. However, there are inadequacies also. To control AR.Drone accurately, the success rate of moving direction detection will be improved as much as possible. Currently, the time series analysis is limited in 10 frames. In future, it will be carried out in smaller interval. In addition, because there are many influences such as airflow, inertia, and the accuracy of sensors, it is difficult to control AR.Drone accurately. In future, this matter will be considered in detail.

7 CONCLUSION

In this study, aerial images system is utilized to solve the problems of insufficient tracking capability and limited field of view. With evaluation experiment, the high tracking performance, the high stability, and the effectiveness of proposed system are verified. Also, the moving direction of human can be detected in high accuracy. From now on, flying robot control part will be carried out. High efficiency aerial images system will be expected.

REFERENCES

[1] Takahiro KOIZUMI, Yuichi NAKAMURA, and Shin'chi SATOH, "Video Processing and Retrieval for Finding Lost Item from Personal Eye-View Video", Technical report of IEICE. PRMU 109 (470), 395-399 (2010).

[2] Toshio FUKUDA, Tatsuya SUZUKI, Yasuhisa HASEGAWA, Fumihito ARAI and Masaru NEGI, "Visual Surveillance System with Multiple Cameras in Wide Area Environment", Transactions of the Japan Society of Mechanical Engineers. C, Vol.69, No.680,
pp.1011-1018 (2003).

[3] Yoshizawa YUSUKE, Koichi SHINODA and Sadaoki FURUI, "Surveillance Event Detection Using Local and Global Features", the Technical Report of IEICE, PRMU, 110 (27), pp.163-168 (2010).

[4] Hidehito NAKAGAWA, Hitoshi HABE and Masatsugu KIDODE, "Efficient prior acquisition of human existence by using past human trajectories and color of image", the Technical Report of IEICE, PRMU, 108 (484), pp.305-312 (2009).

[5] Yasuhiro AOKI, Yoshio IWAI and Masahiko YACHIDA, Detecting Suspicious Actions Using Particle Filtering", the Technical Report of IEICE, IE, 107 (538), pp.95-102 (2008).

[6] R. T. Collins, "Mean-shift blob tracking through scale space", Proc. IEEE Computer Society Conference on Computer Vision and Pattern Recognition, pp.234-240 (2003).

[7] Masahiro HORIE, Masayuki KASHIMA, Kiminori SATO, Mutsumi WATANABE, Kouzi KUMA and Koichi TOYONAGA, "Automatic Endocardium Contour Tracing Method Using Standard Left Ventricles Shape Model", the Technical Report of IEICE, PRMU, 108 (94), pp.35-40 (2008).

[8] Ryohei TANAKA, Hitoshi YAMAUCHI and Akihiro KANAGAWA, "Object Tracking Using Color Distribution Based on Active Contour Model", Forum on Information Technology, 7 (3), pp.293-294 (2008).