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# Image-Guided Searching for Landmark

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***Abstract:*** A novel image-guided structure is proposed in this paper for searching any apron. The key feature of the presented structure is the introduction of a stationary camera placed beneath the helicopter so that it can arrive at the right top of any apron by image-guided searching. The validity of the proposed image-guided structure is verified by means of a practical testing on an experimental Ball & Plate apparatus. The experimental results validate the superiority and practicality of the image-guided searching for landmarks.

***Keywords***: Image-Guided Searching, Landmark, Ball & Plate Platform.

## I. INTRODUCTION

Over the past twenty years, the machine vision has been successfully used for robotic development and servo-position control. For example, pneumatic robotic arm controlled by on-off valves for automatic harvesting based on vision localization [1], automatic micro-indentation and inspection system by piezo driven micro robot with multiple inner sensors [2], and localization and error correction for mobile robot with an image sensor [3] etc., deal with positioning problems via machine vision. However, as regards image-guided control, few researchers delve into flying robots. In 2007, Kei Watanabe et al. presented an image-based visual servo control for a micro helicopter [4]. A stationary camera is placed on the ground, and it obtains image features of the helicopter. This visual servo system enables the helicopter to enter a stationary hover procedure, but it still does not apply to anyplace.

In this paper, we place a stationary camera beneath the helicopter so that it can arrive at the right top of any apron by image-guided searching. To illustrate the effectiveness of the design, the proposed method will be verified through practical testing on an experimental setup, called Ball and Plate system. The experimental results validate the superiority and practicality of the image-guided searching for landmarks.

## II. IMAGE-GUIDE ALGORITHM

To obtain a relative location of the landmark to the helicopter, an image-guided searching algorithm will be used to evaluate the center of the landmark and the moving vector. These procedures for the image processing are shown in Fig. 1.

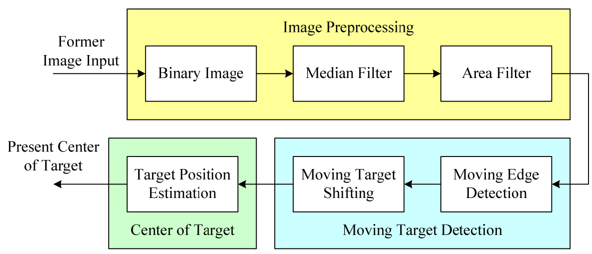


Fig. 1. Procedures for image processing

### 2.1 Image Preprocessing

The image preprocessing contains binarization and filtering with the aim of distinguishing the object from the background. To reduce the data, the three-dimensional RGB-image information is transformed into a one-dimensional colour axis in this paper. Unfortunately, the regulation of the threshold value usually produces noises. To improve image quality, the median and area filter will be used to reduce these noises.

### 2.2 Moving Target Detection

*A. Sobel Filter*

To detect the edge of a binarized picture, Sobel filter is the most common and very useful tool. The following two matrices are used as the filtering operators:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{1}$$

$$G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & 1 \end{bmatrix}, \tag{2}$$

where $G_x$ and $G_y$ are used for edge detection along x-direction and y-direction, respectively. These two 3x3 convolution masks are applied to each pixel. The result of each convolution is treated as a vector representing the edge through the current pixel. If the magnitude of the sum of these two orthogonal vectors is greater than any user-specified threshold, the pixel is marked in black as an edge. Otherwise, the pixel is set to white.

*B. Moving Edge Detection*

To extract the background automatically, enough number of successive structures must be available for processing. The procedures for moving edge detection are shown in Fig. 2. First, three successive structures ( $I_t$ , $I_{t+1}$ , $I_{t+2}$ ) will be taken from CCD and the differences $D[I_{t+2}-I_{t+1}]$ and $D[I_{t+1}-I_t]$ can be calculated. Logical AND operation can be used to evaluate the difference product. Hence the moving vector of $I_{t+1}$ can be obtained.

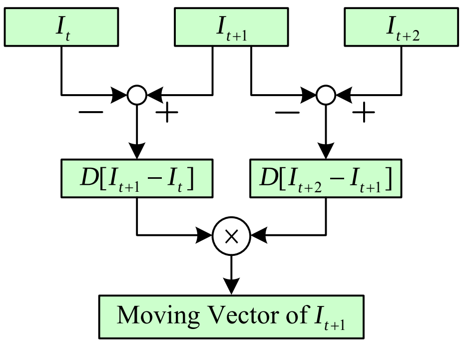



Fig. 2. Moving edge detection

*C. Moving Target Shifting*

As shown in Fig. 3, to overcome image-delay, the moving target shifting method will be used to get the new landmark *M2*. Compare $D[I_{t+2}-I_{t+1}]$ with *M1*, the shift values $X_d$ and $Y_d$ can be estimated as follows.

$$\begin{cases} X_d = (C1-C2)+(A1-A2) \\ Y_d = (B1-B2)+(D1-D2) \end{cases} \tag{3}$$

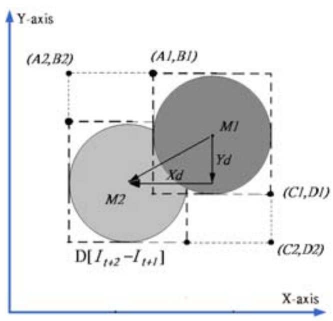



Fig. 3. Moving target shifting

**2.3 The Central Point of Landmark**

In this paper, 0 and 1 gray-level images are regarded as the background and the landmark, respectively. If the maximum and minimum values of projection are found in x-axis and y-axis, respectively, then the center point will be obtained (see Fig. 4).

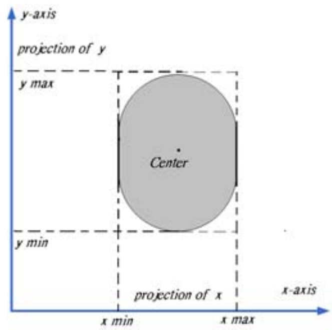
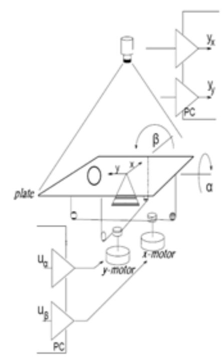



Fig. 4. Central point of the landmark

## III. BALL & PLATE APPARATUS [5]

To experimentally justify the validity of the proposed algorithms described above, a test device, called Ball & Plate apparatus (see Fig. 5-a), is constructed. It is a dynamic system with two inputs and two outputs. Its system configuration is shown on from the Fig. 5-b. Moreover, the system consists of a plate pivoted at its center such that the slope of the plate can be manipulated in two perpendicular directions. A servo system consisting of motor controller card and two stepper motors is used for tilting the plate. Ball position and target location are measured by a vision system which is composed mainly of a CCD camera and an FG 201 Structure Grabber PC add-on card. Afterwards, the PWM signal will be transmitted by MF614 multifunction card. The time period for updating the ball position measurement is set to 40ms. The basic control task is to control the position of a ball freely rolling on the plate.

5-a Actual picture




5-b Schematic diagram

Fig. 5. The Ball & Plate Apparatus

## IV. EXPERIMENTAL DESIGN

To completely show the effectiveness of the design, a situation flowchart has to be planned, shown in Fig. 6. Once we find the coordinates of the landmark via image-guided algorithm, the flying direction of the helicopter will be changed by tuning the swashplate.

**Step 1.** As shown in Fig. 7, let A and B be regarded as the landmark and the location of the projection of the helicopter, respectively. Once A and B are laid overlapping each other, the helicopter will be steered to arrive at the right top of landmark.

**Step 2.** Calculate the moving vector and the central coordinates of the landmark.

**Step 3.** To further control the servo motors of swashplate, the central coordinates and the moving vector will be transferred to the control signals. Fig. 8 shows the relationship between the motion of the swashplate and the flying direction of the helicopter.

The swashplate can be regarded as the X-Y plane and the ball, freely rolling on the plate, an apron. In addition, the arbitrary set-point can be viewed as the projection of the helicopter. The experimental goal is to control the servo motors of the swashplate such that the ball can arrive at the assigned point as rapidly as possible.

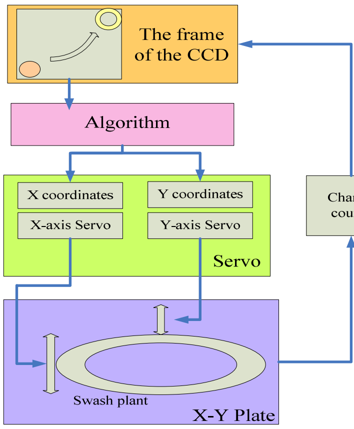



Fig. 6. Flow chart of image-guided searching for landmark

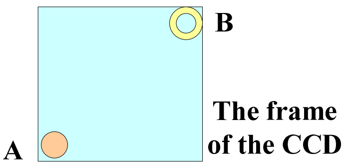



Fig. 7. Schematic diagram of the structure of the CCD

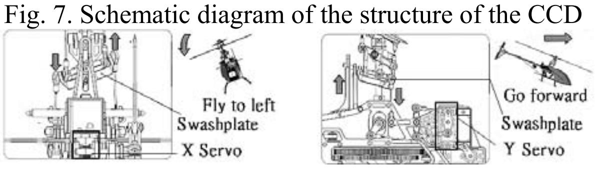



Fig. 8. The relationship between the motion of the swashplate and the flying direction of the helicopter

## V. EXPERIMENTAL RESULTS

The location picture, taken from CCD, is shown in Fig. 9. The range of X-Y coordinates is between -1 and +1. To simulate the different tracking situation, 5 set-points are dispersedly over the plate. The initial point of the ball is set to be (.79,.91) due to the restriction of the physical size of the ball and the edge-wall of the plate.

Fig. 10-14 shows the tracking responses, where the targets are arbitrary with the same initial point. The corresponding actual responses are shown in Fig. 15-19, respectively, where the point in each structure is the default target.

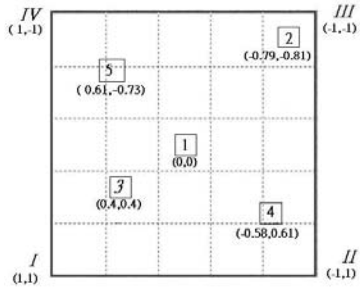



Fig. 9. Locations of the set-points

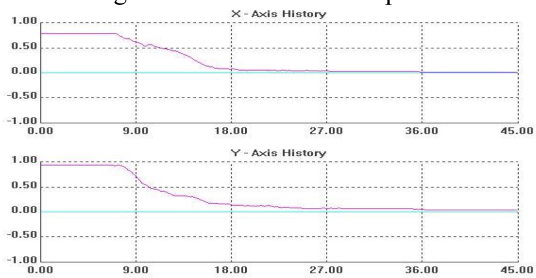



Fig. 10. Tracking responses from (.79,.91) to (0,0)

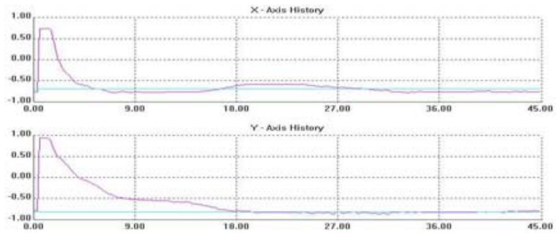



Fig. 11. Tracking responses from (.79,.91) to (−.79,−.81)

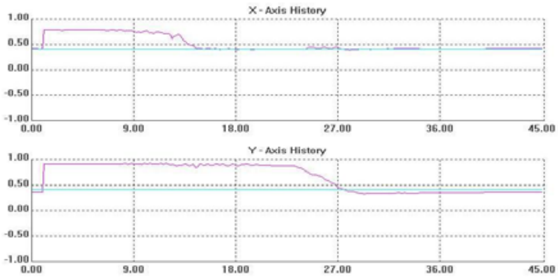



Fig. 12. Tracking responses from (.79,.91) to (.4,.4)

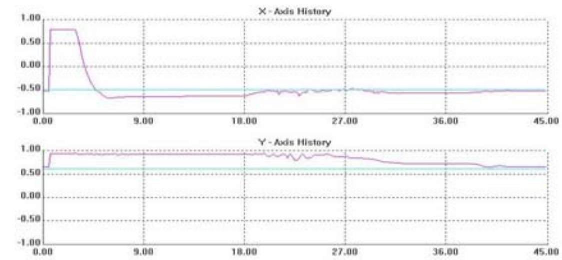



Fig. 13. Tracking responses from (.79,.91) to (.58,.61)

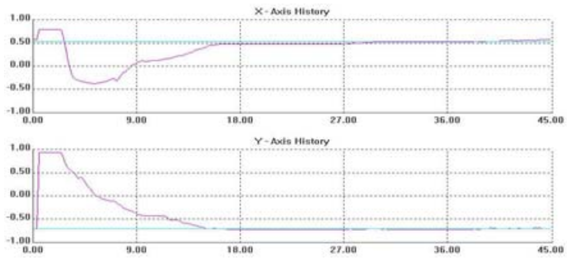


Fig. 14. Tracking responses from (.79,.91) to (.61,−.73)


15-a 15-b


15-c 15-d

Fig. 15. Actual responses from (.79,.91) to (0,0)


16-a 16-b


16-c 16-d

Fig. 16. Actual responses from (.79,.91) to (−.79,−.81)


17-a 17-b


17-c 17-d

Fig. 17. Actual responses from (.79,.91) to (.58,.61)


18-a 18-b


18-c 18-d

Fig. 18. Actual responses from (.79,.91) to (.61,−.73)


19-a 19-b


19-c 19-d

Fig. 19. Actual responses from (.79,.91) to (.4,.4)

## VI. CONCLUSION

In this paper, a novel image-guided structure is proposed for searching any apron. The key feature of the presented structure is the introduction of a stationary camera placed on the helicopter so that it can arrive at the straight top of any apron by image-guided searching. To verify the effectiveness of the design, the proposed method will be verified through practical testing on an experimental setup, called Ball and Plate system. The experimental results validate the superiority and practicality of the image-guided searching for landmarks.

## REFERENCES

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