VISUAL SERVOING FOR MONITORING AND DIAGNOSING IN FARMING

GIÁM SÁT VÀ CHẨN ĐOÁN BỆNH TRONG NÔNG TRẠI BẰNG CÁCH ỨNG DỤNG ĐIỀU KHIỂN HỒI TIẾP ẢNH

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ABSTRACT

This paper presents a visual feedback control algorithm for a system using in the green house to monitor and diagnose health of vegetable in a garden. Firstly by using image processing, the position of a vegetable will be positioned. Secondly by using PD controller and continuously updating the position of vegetable, the PD image based visual serving (PDIBVS) algorithm is applied to move the camera to that vegetable location helping the system to track and diagnose their health. The disease need for recognizing in this paper are yellow leaf and red dot. A webcam will be attached on the 2D mechanism, if in the webcam the center of the camera coincide with the center of the vegetable the control algorithm are effective affected. The effectiveness of the proposed method is proved by doing the experiment. In the future, the algorithm can also be applied to the garden where the size is expanded.

Keywords: *feedback control; PD control; image processing; visual servoing; position cotrol.*

TÓM TẮT

Bài báo trình bày phương pháp điều khiển sử dụng hồi tiếp ảnh phục vụ cho việc giám sát và chẩn đoán bênh trên cây trồng trong nhà kính. Đầu tiên vị trí của cây trồng sẽ được nhận biết thông qua một camera gắn trên hệ cơ khí và phương pháp xử lý ảnh. Sau đó bằng giải thuật điều khiển sử dụng hồi tiếp ảnh, cơ cấu sẽ di chuyển hệ thống đến chính xác vị trí của cây trồng để chẩn đoán bệnh và theo dõi. Bênh cần chẩn đoán trong bài báo là bệnh thông dụng hiện nay trên cây: vàng lá và mắt đỏ. Giải thuật kết hợp việc cập nhật dữ liệu liên tục hình ảnh từ camera trong quá trình chạy và bộ điều khiển PD (PDIBVS). Nếu vị trí của camera trùng với tâm của hình vùng cây, giải thuật điều khiển hồi tiếp ảnh có tác dụng. Sự tác dụng của giải thuật được chứng minh thông qua thực nghiệm. Trong tương lai, giải thuật và cơ cấu cơ khí cũng có thể áp dụng cho những khu vườn có diện tích lớn hơn.

Từ khóa: *điều khiển hồi tiếp; điều khiển PD; xử lý ảnh; hồi tiếp ảnh; điều khiển vị trí.*

1. INTRODUCTION

Nowadays, clean and fresh vegetable is one of the most significant issues in Vietnam. They are often grown in a green house where they have special treatment from famers, receiving perfect condition to grow up. This condition helps them to grow up without having any chemical addition.

However, to take care of clean and fresh vegetable, it needs a lot of investment and man power that monitor and track them all day. That leads to the high price of product. To reduce the price, there are many researches to develop an autonomous system that can help farmer to monitor the status of vegetable as shown in Fig. 1

Fig. 1. *Robot using in farm*

Among those solutions, using vision to monitor the status of vegetable is one of the promising topics in Vietnam.

Various authors have studied the issues related to use the vision for monitoring. Tarca R et al [1] use the camera installed at the remote side to transmit the movie to the server site, and from watching on the screen, the operator will manually control a system to move the camera to the suspected area of vegetable. In order not to put the large load on the human like in [1] and the needing in automatically monitoring and diagnosing vegetable disease in the industrial application, there are several previous researches focused on using vision information for tracking and monitoring.

One effective approach is position based tracking [2], the paper presents the design methodology for Cartesian position based visual servo for robots with a single camera mounted at the end effecter or in [3], the paper use the linear approximations in modeling of an image based visual servoing system with the purpose of devising control strategies. P. Prem Kumar et al [4], using the stereo vision to track the current position and orientation of the arm's end-effecter and the grasped object, then using the self-organizing map to control robot to reduce the error between the arm's end-effecter and the object. The intelligent control also applied in tracking problem [5], in the paper after finding the relationship between the word coordinate and image coordinate of the ball the sliding mode control is applied to control the trajectory of the ball on the flate. In the position based tracking [1-5] when the scenes are generally complex, difficult to model and partially occluded depending on the view point, more over depending on the calibrated camera, translating the geometric feature into mechanical device movement are often burdensome, computationally intensive and prone to errors.

To overcome the difficulty of position based visual servoing, Shirai et al. [6] and Peter et al. [7] have proved that by using the visual feedback loop, the precision of robot positioning will be increased. Hence from that time, many researches focus on using eye-in-hand visual servoing system or image based visual servoing. Luo et al. [8] presented an algorithm to track the moving object on the conveyor by combining visual and acoustic sensing. The algorithm accomplished 1D visual tracking in real time. In [9] the author proposed an adaptive control scheme for robotic visual servoing with the goal of reducing the error between the desired and currented image, but the verification of the proposed algorithm has been limited in simulation. D.I. Kosmopoulos [10] uses the camera attached at the end-effecter to calculate the image Jacobean matrix without the need of depth estimation. Then he uses this matrix as the feedback to control the robot to reduce the error between the camera and object orientation.

The advantages of those eye-in-hand visual servoing [9], [10] are more precise and less sensitive to the noise. More over the area of monitoring and diagnosing is very large and unfixed, so image based visual servoing method can significantly reduce the time of installing system especially the calibration process. To implement the tracking system for the monitoring and diagnosing system in the future, the image based method was chosen because of the complex real scenes environment changing and the error in calibrated camera. The remaining parts of this paper are organized as follows: section 2 will present the image processing methodology for this research. Sections 3 discusses about the PD controller. The experiment is presented in section 4, followed by the conclusion in section 5.

2. IMAGE PROCESSING FOR DISEASE RECOGNITION

When occurring disease, vegetable will have symptoms: yellow leaf, red dot on leaf, blights etc..This research will focus on two common symptoms yellow leaf, red dot as shown in following Fig. 2.

Fig. 2. *Yellow leaf and red dot disease*

To recognize these diseases color filter is applied. As we known that, the color of one object is the combination of 3 basic colors: red, green, blue forming RGB color model. By changing the R, G, or B component value, it will form the new color. Filter is one of the most useful techniques to recognize or localize an object in scene. Filter by using its color feature is to find the location of the object by using the object's color. After filter, only the color of the object will appear in the camera frame, from that information the position or coordinate of center of the object is calculated. Firstly system will recorded the feature color of the vegetable and then the yellow leaf feature color and red dot color are recorded. System will based on those three recorded color to diagnose the disease. The result of diagnosing of vegetable is illustrated in Fig. 3.

Fig. 3. *Result of using image processing to recognize disease*

More over based on the vegetable color, system also can monitor the growing-up process of vegetable by calculating the area of its pixel. The coordinate of the vegetable is also calculated then this coordinate will be transmitted to the mechanical system to move the camera to that vegetable.

3. PD IMAGE BASED VISUAL SERVOING

PD controller has been widely used in the industry because of its simple structure and it assures acceptable performance for the majority of industrial projects. It is a kind of linear controller, which forms a control variable by linearly combining the proportional, integral, and derivative of the error e. The discrete-time equivalent expression of PD controller is given as follows

$$u(k) = u(k-1) + K_p e(k) + K_d \frac{d}{dt} e\ t(\quad (1)$$

where u(k) and e(k) are control input to the plant model and the error between the reference and the output signal, respectively; K_p, K_d are the positive parameters created by the trial and error process

To move the camera, a mechanical system is designed as shown in the following Fig. 4. System has two degree of freedom and it is driven by two independent motors. Two motors will move the mechanism in X direction and Y direction. Camera will be attached at the end-effector. This structure have an advantage that Camera can travel to any 2D position in range space.

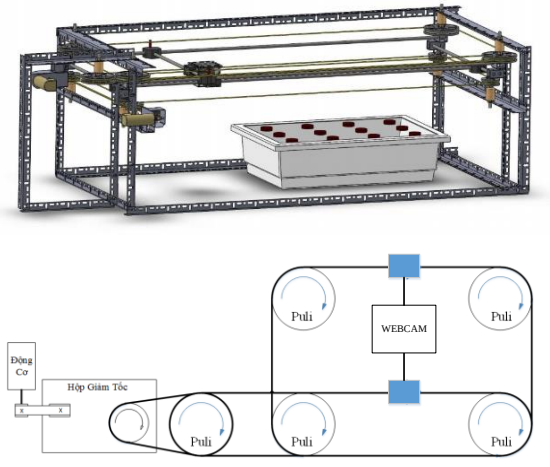

Fig. 4. *The mechanism using to track and diagnose disease*

This Mechanism will move the camera to the center of the vegetable, however due to the image processing noise and the error reading from the camera. This mechanism will use the information feedback from the camera to correct its position. After roughly approaching vegetable, the position of object viewed in the camera attached at the end effecter is presented as shown in Fig. 5. This is the image showing in 2D space. The maximum of the x coordinate and y coordinate in the frame coordinate is 640 pixels and 380 pixels respectively. The intersection of two dot lines is the center of the camera.

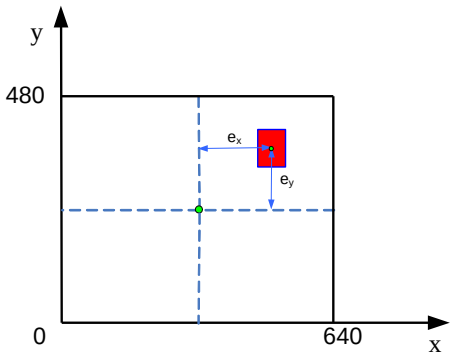

Fig. 5. *Orientation of a vegetable in 2D*

PD controller has been widely use in the industry because of its simple structure and it assures acceptable performance for the majority of industrial project. It is a kind of linear controller, which form a control variable by linearly combining the proportional, integral, and derivative of the error e(t).

Referring to Fig. 5, to command for the system to move to the center of object there is a simple control strategy: reducing the error of the center of the vegetable in the x direction, y direction with the center of the camera.

We will have the strategy to control as: the link 1, link2 will take the role to reduce the error of the center of the camera in the x direction, y direction respectively.

The error e(t) is defined as

$$e(t) = s^* - s \qquad (2)$$

where $s = \begin{bmatrix} x_f \\ y_f \end{bmatrix}$ and $s^* = \begin{bmatrix} 320 \\ 240 \end{bmatrix}$ are vector of measurements and desired value of visual features respectively.

The overall structure of the system is shown as following Fig. 6

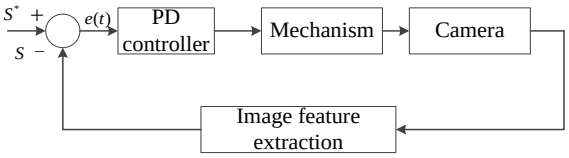

Fig. 6. *The PD image based visual servoing*

4. EXPERIMENT

The experimental setup is shown as Fig. 7. The area that system can monitor and diagnose is 65cm x 42cm. System consists of the moving mechanism and the tray containing 3x3 vegetable. The pre-known direction of moving camera is chosen as shown in Fig. 8. so that camera can travel to all the vegetable position in the tray. The algorithm applied to approach and diagnose the vegetable is described in the Fig. 9. Firstly the mechanism will approach the vegetable based on the pre-known direction of moving. Then to move exactly to needed position, the PD image based visual servoing is applied. When It stops above the vegetable, it will take the picture and then using image processing to diagnose the symptons and the growing up process. To monitor the growing up process the data is taken in three different days. And the time of experiment is also setup similarly every day.

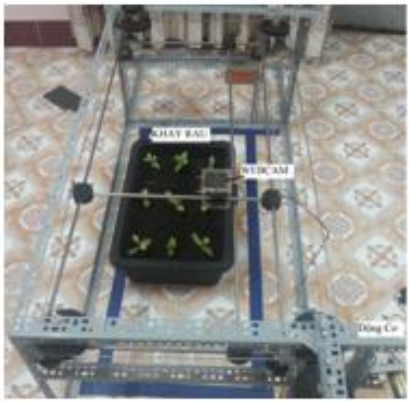

Fig. 7. *Experimental setup*

Fig. 8. *Moving direction of the mechanism*

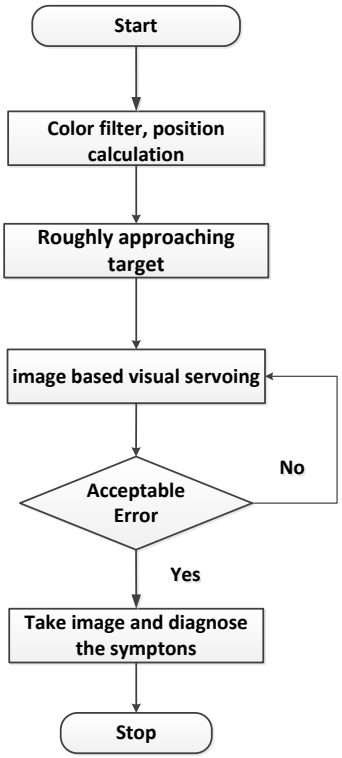

Fig. 9. *The algorithm to control the mechanism moving*

The performance of the PD image based visual servoing and the result of monitoring and diagnosing the disease are shonw in the following Fig. 10 and Table 1

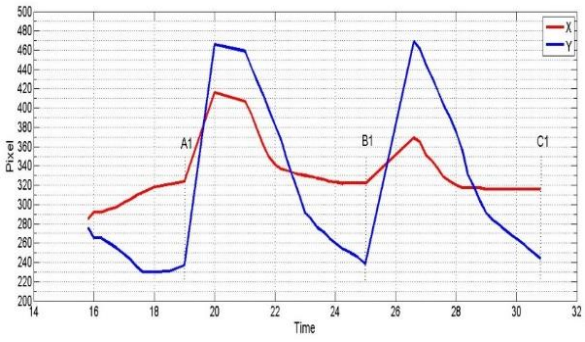

Fig. 10. *The performance of PDIBVS controller*

From Fig. 9 It can be realized that by using PD image based visual algorithm, system has the fast response to the different positions of the vegetable, the error between the center of camera and position of the vegetable is acceptable. The system can effectively perform monitoring large area with small error. The result of monitoring and diagnosing the disease are also shown in Table 1

Table 1. *Disease and growing up tracking*

Day 1	1			2			3		
	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf
C	9894		0%	8752	x	11.09%	22837	x	14.25%
B	22772	x	2.56%	18221	x	8.11%	12459		3.26%
A	17451	x	2.46%	9808		1.93%	22117	x	12.24%
Day 2	1			2			3		
	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf
C	23016	x	13.09%	9597	x	1.6%	17201	x	5.47%
B	14041	x	3.67%	18321	x	10.63%	24170	x	2.01%
A	23002	x	13%	9161	x	12.3%	10425		0%
Day 3	1			2			3		
	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf	Area	Red dot	Yellow leaf
C	10222		0%	7707		7.86%	22748	x	10.15%
B	28510	x	3.21%	19160	x	14.71%	13499	x	0%
A	18582	x	0.63%	9740	x	1.04%	21314	x	8.18%

From Table 1 it also can be realized that system can diagnose the disease symptoms of the vegetable and monitor the growing up process by using image processing. In column 2, data showed that the growing up of vegetable is not good. The yellow leaf disease at B3 is reduced and the red dot problem happened at C1 after the 3rd day

5. CONCLUSION

In the paper, the autonomous monitor system for a green house is proposed based on vision and PD controller. The performance of the system shows that it is applicable to the real green house. The system show that it is easily to implement in the real complex environment with the structure eye-in-hand system. This system helps farmer effectively save time in monitoring the status of vegetable. By using other image processing algorithm, other diseases are also can be recognized

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