Chrysanthemum Cutting Sticking Robot System

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Abstract

Cutting sticking operation is essential on a chrysanthemum production to enhance its productivity, since many cuttings can be obtained from one mother plant. Usually, human being manually sticks the cuttings to plug tray, however, it takes a lot of time and much labor, since the number of cuttings is said to be about 200 million in a district where yields the highest number of chrysanthemums in Japan, so automation of this operation is desired.

The robotic cutting sticking system mainly consisted of three sections; a cutting providing system, a leaf removing device and a planting device. First, a bundle of cuttings was put into a water tank. The cuttings were spread out on the water by vibration of the water tank. The cuttings were picked by a manipulator based on information of cutting position from TV camera. Secondly, another TV camera detected the position and direction of cutting transferred from the water tank by the manipulator and indicated the grasp position of the cutting for the other 5 DOF manipulator moving. Thirdly, the manipulator moved the cutting to a planting device through the leaf removing device and then the cuttings were stuck into a tray by the planting device. In this paper, outline of the robotic components is described.

Key Words: chrysanthemum, cutting, bio-production, robot system

1. Introduction

Chrysanthemum is the most typical cut flower in Japan, which has been associated with Japanese people as the national flower. It is said that several hundred million chrysanthemum seedlings are produced every year and that chrysanthemum has occupied about 30% of the total production value of cut flowers in recent years in Japan. The procedure to produce the seedling is as follows; 1. pick cuttings from mother plants of chrysanthemum. 2. preserve the cuttings in refrigerator to get an appropriate amount of cuttings for sticking at a time. 3. stick them into plug tray after refreshment with water for a night. Fig. 1 shows the procedure. A commercialized transplanter was already developed and can be used for transplanting them in the field. In the procedure 3, the cuttings should be singulated from a cutting bundle and a few lower leaves of the cutting should be removed before sticking the cutting into plug tray. Procedure 1 and 3 are still done by manual, so earlier developments of machine systems for the procedures are desired.

The procedure 3 includes three sections; 1. a cutting providing section to singulate the cutting from a bundle of cuttings which was stored in a refrigerator and to transport the cutting to the next stage, 2. a leaf removing section for the lower leaves preventing another cutting from being stuck to a plug tray and for their being obstacles for transplanting the cuttings to the field by a transplanter, and 3. a sticking section to plant ten cuttings at a time.

To automate the three sections, the following operations were considered; First, a bundle of cutting is put into a water tank. The cuttings are spread out on the water by one shot vibration of the water tank. The cuttings are picked by a manipulator based on information of its position from a machine vision system. Secondly, another machine vision system recognizes shape, size and direction of the cutting transported from the water tank. Another manipulator grasps a position of the cutting main stem indicated through the machine vision system to transport to a leaf removing device, and the lower leaves are cut. Finally, the manipulator transports the cutting from the leaf removing device to the sticking device and then the cuttings are stuck into a plug tray. In this paper, the outline of the robotic cutting sticking system is described.

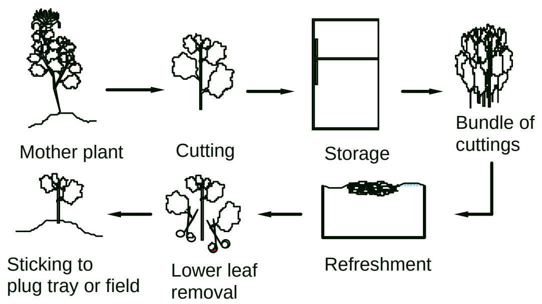

Fig. 1 Chrysanthemum seedling production procedure.

2. Materials and methods

2.1 Chrysanthemum cutting

Before designing a robotic sticking system, physical properties of chrysanthemum cutting were investigated such as cutting length, number of spreading leaf, diameter of cutting stem, leaf length, leaf width, petiole length, petiole removing force, and etc. From the results, it was observed that the cutting was 57 mm to 87 mm in length and that the average length was about 70 mm. The number of spreading leaves was from 3 to 6. When the cutting has 5 leaves, 2 or 3 lower leaves should be removed before sticking, since they may prevent another cutting from being stuck to the tray. Besides, they can be obstacles for planting the next cutting to the field by a transplanter. The tray developed for a special chrysanthemum transplanter was used for this system and it had 220 cells (10X22). The cell depth is 35 mm and the cutting is manually stuck at a depth of 25 mm.

2.2 Cutting providing system

Cuttings are usually preserved in a refrigerator for a few weeks to stick a certain amount at a time. It is, therefore, necessary to refresh the cuttings by soaking them in a water for several hours before sticking. In addition, the cuttings are sometimes soaked in a chemical water to hasten root of cutting. In human being's sticking, it is not difficult to separate a cutting one by one, however it is hard for a machine to do that with similar method, because a mechanical hand is not so flexible and the cutting shape is very complicate. In this system, it was adopted to use a manipulator and a water tank as shown in Fig. 2. The total link length of manipulator was 635 mm and the size of water tank was 715 mm in length, 650 mm in width and 240 mm in depth. Putting a bundle of cuttings into the water tank, the cuttings were spread out on the water in 5 to 7 seconds by vibration using a solenoid actuator.

An image of the cuttings acquired by a monochrome TV camera whose sensitivity included not only visible region but also infrared region could effectively tell the cutting positions to the manipulator with 5 degrees of freedom, since the chrysanthemum cutting had much higher reflectance in the infrared region. In this experiment, an 850 nm interference optical filter was used to enhance the contrast of cutting in the image. 10 to 50 cuttings were put into the water tank for image acquisition and were picked up by the manipulator using long fingers of its end-effector like a pair of chopsticks.

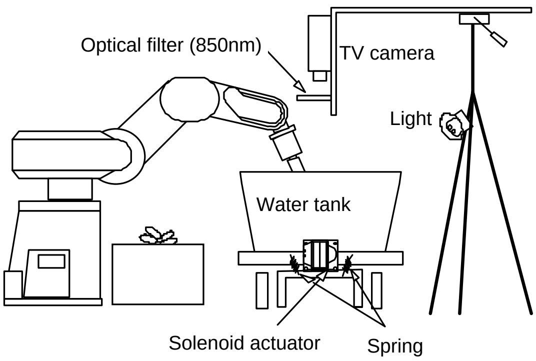

Fig. 2 Cutting providing system.

2.3 Machine vision system

To transfer the cutting and to remove lower leaves properly, detection of grasping point of cutting for the manipulator is required. A monochrome TV camera whose sensitivity included not only visible region but also infrared region was used with a 850 nm interference optical filter to enhance the contrast of cutting.

Fig.3 shows the algorithm to detect the grasping point; After thresholding an acquired image, complexity of boundary line of cutting on a binary image is investigated using thresholding value T1 and candidate points of stem tip are found. If only one candidate point is found in the image, the point is assumed as a stem tip. When there are more than two points, the complexity of boundary line around the candidate points is detailed and points which are not adapted to condition of main stem are removed using thresholding value T2. The condition is that boundary lines around the stem tip have much linearity. Further, if only one candidate point remains at that time, the point is assumed as the stem tip. In case of plural points remaining, the whole boundary line is detailed and region of leaves is detected. A candidate point which has a certain distance from the region of leaves is determined as the stem tip using thresholding angle θ. When the points which are not corresponded to this condition and when plural points remain even after the procedure, the cutting is supposed to be transferred back, because it is not able to obtain a point to be assumed as the stem tip. The grasping point was defined as the position of 10mm above the stem tip [1].

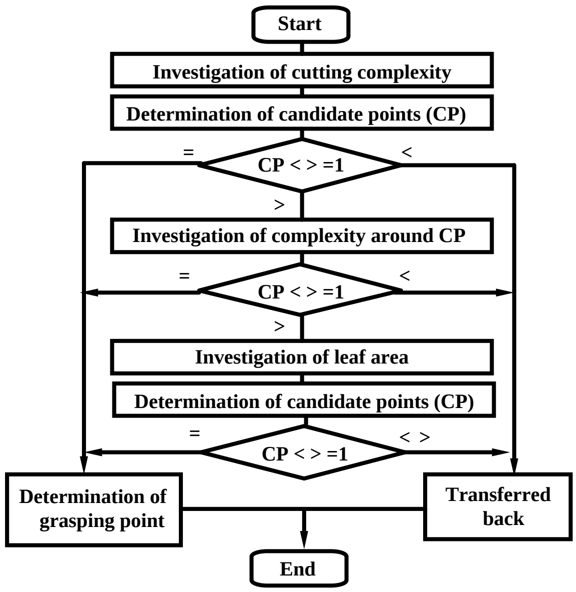

Fig. 3 Flowchart of machine vision algorithm to detect grasping point.

2.4 Leaf removing device

Fig.4 shows a schematic diagram of procedures of cutting sticking operation. A manipulator was necessary to transport the cutting from the leaf removing device to the sticking device. An articulated 5 DOF manipulator was used in this system.

The manipulator had 2 aluminum plates as fingers whose length and width were 60 mm and 10 mm respectively to grasp the cutting at the end of the stem.

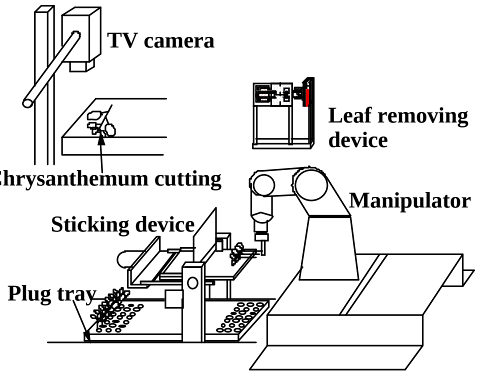

Fig. 4. Robotic cutting sticking system.

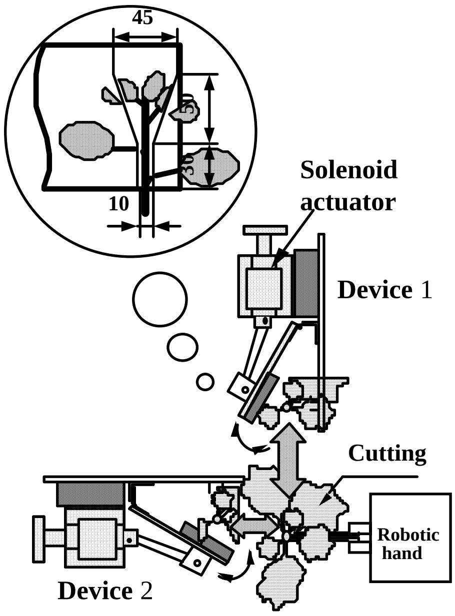

Fig. 5 Leaf removing device.

The leaf removing device consisted of a frame with a cutter and a movable plate with a rubber board. The movable plate was opened and closed by a solenoid actuator to cut the lower leaves and to arrange the shape of the upper large leaves by Y-shape cutter. Two sets of the removing devices were manufactured, and were placed at an angle of 90 degrees to remove the lower leaves completely, since each leaf of chrysanthemum basically emerges making an angle of every 144 degrees (Fig.5). The cutting are transferred to the sticking device by the manipulator after this operation [2].

2.5 Sticking device

The sticking device mainly consisted of a table for cuttings and a holding plate. (Fig.6) The manipulator transported cuttings to the table, while the holding plate waited until ten cuttings were put on the table. The holding plate was closed as soon as the ten cuttings were put on the table and stuck them to the plug tray at a time (Fig.7) [2].

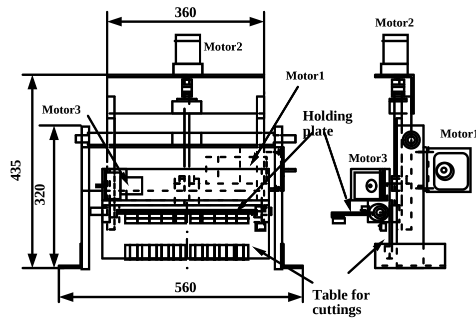

Fig. 6. Sticking device.

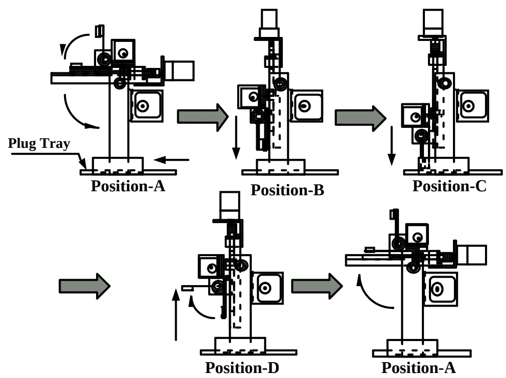

Fig. 7. Action of sticking device.

3. Results and discussions

3.1 Cutting providing system

Fig. 8 shows an example of binary images when 30 cuttings were acquired by the TV camera. Based on this image, approximate positions of cuttings were detected and the manipulator picked them.

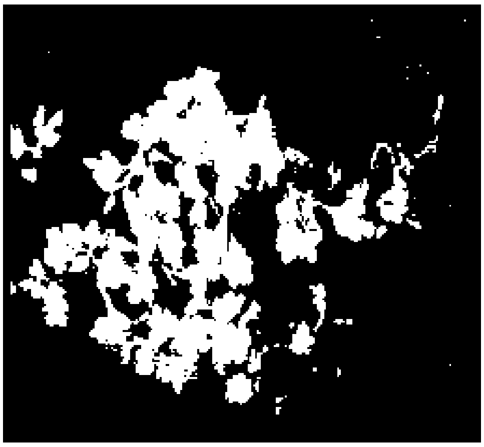

Fig. 8. Binary image.

Table 1 Picking result of cutting providing system

Cutting number	Success	Failure
10	41	9
20	41(5)	9
30	41(6)	9
40	42(4)	8
50	42(8)	8

Numbers in parentheses express plural cutting picking.

Table 1 shows a result of 50 time picking attempts for each condition. From the result, more than 80 % of attempts were succeeded to pick the cutting from the water tank, however it is unknown which part of the cutting was grasped. It was observed that several cuttings were picked with another cutting when the number of cuttings floating on the water surface was more than 20. The other many cuttings were singulated, even when they were overlapped. To improve the success rate, it was considered that visual feedback algorithm would be necessary to follow slight moving of cuttings.

3.2 Machine vision system

Fig.9 shows an example of complexity of cutting and its cutting image. From the experimental results using this vision algorithm when 51 cuttings were used, it was obtained that the stem tips of 23 cuttings were determined by the thresholding value T1 and that those of 14 cuttings were by the thresholding value T2. The thresholding angle θ could determine the single candidate points of 12 cuttings and it totally made 96 % success rate. The rest of two cuttings were transferred back, since this algorithm did not determine the candidate points as the grasping points. It took about 1.5 seconds to determine the grasping point in this machine vision algorithm. To improve the result, it was considered that more detail investigation would be necessary such as measurement of stem width.

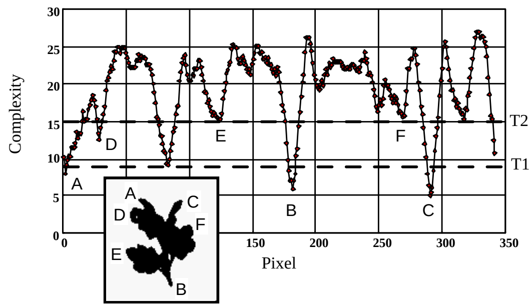

Fig.9 Result of cutting complexity.

3.3 Leaf removing device

On the leaf removing device, lower leaves of 99% (207/209) cuttings were successfully removed at the first removing procedure, while 91.4% (191/209) cuttings were removed at the second removing procedure. The failures of 8% implied that their main stems were cut, since the main stems were originally bent. It took about 10 seconds to do this operation, but it was considered that the operating time could be shorter, if the manipulator was controlled with higher speed.

3.4 Sticking device

In the sticking device, 94.2% (180/191) cuttings were successfully stuck into the plug tray. The failures happened when cuttings whose lower leaves were not completely removed at the leaf removing device. It took about 14 seconds to stick the 10 cuttings, however it was considered that the operating time could be also shorter, if speed of each motor which was used in the device was made higher.

Fig.10 shows result of sticking depth. From this, it was observed that most of the cuttings were ideally planted. To obtain stable sticking result, it was also considered that no-bent cuttings were provided.

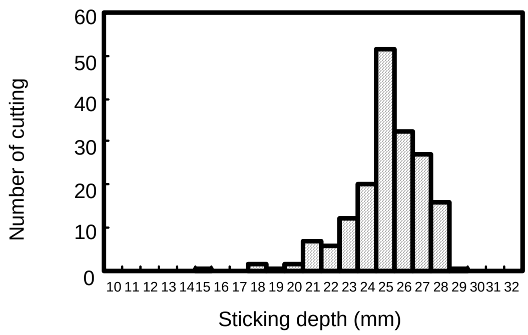

Fig. 10 Result of sticking depth.

4. Conclusions

It was found not only that the performance of each robotic components should be improved but also that no-bent cuttings should be provided to improve the performance of the whole robotic sticking system. As the near future research, an experiment to clarify the total performance of the sticking system should be conducted.

5. References

[1] Kondo, N., Y. Ogawa, M. Monta, and Y. Shibano: Visual sensing algorithm for chrysanthemum cutting sticking robot system, acta horticulturae 440, pp.383-388, 1996.

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