TELE-OPERATIVE SYSTEM FOR BIOPRODUCTION - REMOTE LOCAL IMAGE PROCESSING FOR OBJECT IDENTIFICATION -+

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ABSTRACT

This paper introduces a new concept of automation for bio-production with tele-operative system. The proposed system showed practical and feasible way of automation for the volatile bio-production process. Based on the proposition, recognition of the job environment with object identification was performed using computer vision system. A man-machine interactive hybrid decision-making, which utilized a concept of tele-operation was proposed to overcome limitations of the capability of computer in image processing and feature extraction from the complex environment image. Identifying watermelons from the outdoor scene of the cultivation field was selected to realize the proposed concept. Identifying watermelon from the camera image of the outdoor cultivation field is very difficult because of the ambiguity among stems, leaves, shades, and especially fruits covered partly by leaves or stems. The analog signal of the outdoor image was captured and transmitted wireless to the host computer by R.F module. The localized window was formed from the outdoor image by pointing to the touch screen. And then a sequence of algorithms to identify the location and size of the watermelon was performed with the local window image. The effect of the light reflectance of fruits, stems, ground, and leaves were also investigated.

+This research was funded by the MAF-SGRP(Ministry of Agriculture and Forestry-Special Grants Research Program) in Korea. one specialized machine, it resulted into the increase of the total production cost and decrease of the period of machine operation.

In this paper, tele-operative system automation, which is a new concept of automation for bio-production was proposed.

Keywords: Local Image Processing, Tele-operation, Feature Extraction, Bio-production, Real Time Control, Watermelon

INTRODUCTION

Automating agricultural field operation often requires real time information processing such as job environment recognition including object of interest, adaptive decision-making, etc. There have been many research efforts to substitute human's brain and handling functions with various AI technologies for many agricultural applications. (Murase et al., 1998)So far, however, it is still far from the success in object recognition and decision making especially for the complex and time varying environment such as outdoor field operation.

Moreover, producing agricultural products such as fruits, vegetables, and crops requires many diverse processes and requires various kind of specialized machine to automate individual process. There have been also many research and development efforts to develop the robotized automatic system within controlled environment and in open fields.(Kondo et al., 1998a, b).

However, real time and robust processing of job environment recognition with decision making for the task was always problem prior to the manipulator or robot motion especially in open fields. Compared with human's versatility, machines developed focusing on the specialized function to meet the individual process might cause the overall production inefficiency. Though specialized machine used to automate each unit process successfully to some degree, since each individual process required

MATERIALS AND METHODS

Based on the proposition, job environment recognition with object identification was performed using wireless image transmittance and localized computer image processing. Processing an outdoor camera image to extract some useful information is very difficult and requires heavy computing because of the light variation, complexity of the background, and so on. In general, the sensitivity of the image processing results to the environment condition was a key barrier to robotize the field operations in bio-production.

A man-machine interactive hybrid decision-making, which utilized a concept of tele-operation was proposed to overcome limitations in recognizing the environment via computer only. Job environment related to watermelons raised outdoors were selected to realize the conceptual idea. Identifying watermelon from the wireless transmitted camera image of the cultivation area shown in Fig. 1 is very difficult because of the ambiguity among stems, leaves, shades, and especially fruits covered partly by leaves or stems.

2.1 Remote Image Acquisition

First, the image data was transmitted from job environment to the consol for image processing by FM transmitter and receiver. Then the outdoor image of the scene including watermelon was captured remotely and processed via local assignment of the interest area using touch screen. Fig. 2 showed the captured image window of watermelon via pointing watermelons using touch screen. And then the image was clipped to the pre-assigned area.

2.2 Local Image Window

Assigning local image window has an advantage over the conventional processing of entire image area. Specifying local processing area using touch pad screen allowed to extract features of the interest in real time and to utilize the complex algorithm because of the small processing area. Moreover, since the existence of the desired object was guaranteed, some AI or rule based processing techniques could be easily adopted. The pointing the object of the interest by the operator gives basic primary information such as the existence of object and the approximate center point of object.

Usual image processing technology has some problems such as heavy processing time, lack of robustness of processing results, and error of finding objects. However, specification of the localized area of the interest and feature information (shape, color, texture, size, etc.) of the objects(weed, watermelon, stem, etc.) to be extracted could be efficiently used to make a robust decision making. With the specified local window of the interest, a sequence of algorithms to identify the location and size of the watermelon was developed. A local window was specified as a 200 by 200 pixel size rectangular area.

2.3 Local Image Processing Algorithm

The sequence of local image processing was done as following.

1) Assigning local area(200pixels by 200pixels) as shown in Fig. 2 by operator
2) Converting RGB format to HSI format and capturing gray scale data format
3) Noise elimination and simplification of intensity image data by median filtering
4) Image enhancement by histogram equalization
5) Edge detection
6) Restoration of shape of watermelon based on the curvature information.

To restore the shape of the watermelon, search was performed from the approximate center point of the local area along the radial direction. During the search process it eliminated approximate parallel lines (lines which are parallel with radial line) and hard warp lines. And then it selected three points on the longest line of arc. And curve was generated with three selected points to restore the shape of a watermelon.

2.4 Remote Local Image Processing System

Remote local image processing system was built as shown in Fig. 3. Image data of watermelon from the CCD camera was transmitted wireless to IBM PC compatible host computer(Pentium II, 400MHz), by R/F module(RTX-112, RF Korea) with analog types. Received image data by R/F module (RRX-212, RF Korea) was input to the color frame grabber(Meteor 2/4, Metrox Co., USA), and it was displayed through the monitor. The operator touches the point of the interest onto the monitor with finger. Touch-pad screen(IntelliTouch, ELO touch system, USA) was mounted onto the monitor screen.

Fig. 1 Wireless captured image of watermelons being raised outdoor.

Fig. 2 Indicating watermelon after pointing with touch screen.

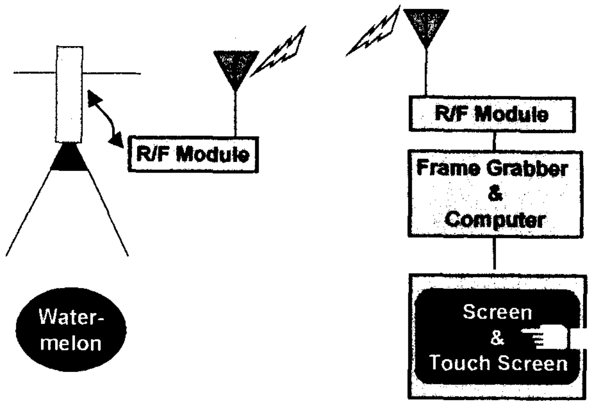

Fig. 3 Remote local image processing system.

RESULTS AND DISCUSSION

Fig. 4 and 5 showed the raw gray scale image and the resulting image after smoothing. And Fig. 6 and 7 showed the resulting image after histogram equalization and boundary extraction respectively. Fig. 8 showed the result of searching watermelon boundary and restored boundary shape of watermelon. From this boundary the size could be computed approximately.

Diameter of watermelon(249.5mm) was measured with the proposed system under various light conditions(5 different lighting environment). And measured results varied from 247.0 to 250.8 mm with appropriate accuracy and total processing time was 0.29 to 0.33 seconds.

Fig. 4 Gray scale image of the local window.

Fig. 5 Image after median filtering.

Fig. 6 Image after histogram equalization.

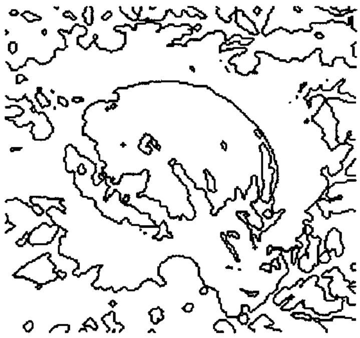

Fig. 7 Image after edge detection.

Fig. 8 Detection of watermelon and shape restoration.

CONCLUSIONS

Since the remote local image processing system worked successfully in identifying object from the remotely captured image, the proposed tele-operative system showed a feasible and practical direction of automation for the volatile bio-production process. A man-machine interactive hybrid decision-making, which utilized a concept of tele-operation worked successfully and overcome limitations of the capability of computer in image processing and feature extraction from the complex environment image. Information of watermelon from the outdoor scene of the cultivation field such as location and size were successfully extracted in real time enough to link with handling tool operations like harvesting and turning.

The proposed algorithm could find out the centering point and shape of watermelon with less requiring processing time. And it could make nearly same results under varying outdoor lighting conditions. Real time and robust decision-making were possible via hybrid tele-operation.

With the proposed concept, development of robust and real time weed detection and removal system is under development and related exchangeable handling tools are being developed.

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