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Real-Time Measurement of Fry in the Cultivation Field Using a Line-Image Sensor

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Abstract

In this paper, we present a system which enables a real-time measurement of the number and also the body length of the fry (baby fish) using a line image sensor. Here, we consider a situation that fry are transported from a pond to another pond through a pipe . At one position of the pipe a transparent rectanglar channel is mounted. The images of the fry, which run through this rectanglar channel, are detected by a line image sensor. The image signals are digitized to binary ones and the contour of the fry are detected. After that, a real-time image analysis is executed with a digital signal processor. Labeling program analyses the connection of every pixel. The results are transfered to a personal computer and displayed on the on-line monitor graphically.

1. Introduction

Recently, in the field of the fishery the improvement of the efficiency and reduction of the manual work are desired.[1)]

In this paper, we present a system which enables a real-time measurement of the number and also the body length of the fry(baby fish), using a line image sensor. This system is developed mainly in order to reduce the manual work in the cultivation center.

The basic procedures to breed the fry at the cultivation center are as follows.

First eggs of fish are bred to the fry.

Secondly in the small pond the fry are bred until they have 10 mm or 20 mm body length.

Thirdly the fry are distributed to the larger breeding pond. When the fry grow to have 30 mm or 40 mm body length, they are shipped to the cutivation trader. In the above precedures, one important manual task is to count and distribute the appropriate number of the fry to the breeding pond in order to obtain efficient growth of the fry. Another important manual task is to count the fry without any mistake when the fry are shiped to the cultivation trader , since the fry are very expensive.

At present, since these tasks are performed manually, they spend long time and need a great skill. Using our system developed, these two tasks can be free from troublesome manual work.

Here, we consider a situation that fry are transported from one pond to another pond through a pipe with water, whose flow velocity is less than 10 m/s.

Our system detects the images of fry, which are transported through a pipe with a transparent rectanglar channel. Image signals of the fry are digitaized to binary ones and the contour of the fry are detected. After that, a real-time image analysis is executed with DSP (Digital Signal Processor: TMS 320C25). Labeling program[2)] which runs on DSP analyses the connection of the countor of the fry. Overlapping of two fry images is also judged. The results of the measurement are transfered to a personal computer and displayed on the on-line monitor graphically. Experimental results show that our system enables a real-time measurement of fry with accuracy.

2. Measuring System

Consider the situation that fry are transported with water from a pond to another pond. The configuration of our system is shown in Fig.1. On one part of the pipe, which transports the fry, a transparent rectanglar channel which is made of the glass or acryl is mounted. The image of the fry that passes this channel is detected by a line-image sensor, which is composed of 512 optical sensors. High accuracy count becomes possible by using the technique of the image precessing. The cross-sectional view of the transparent rectanglar channel is also shown in Fig.2. The light source project the shadow of the fry on a line-image sensor. The image signals are detected by the line-image sensor with a scanning rate 5 kHz. The image signals are digitaized to binary ones and after that they are sent to boun dary detector and a digital signal precessor (DSP). Whenever the fry passes the rectanglar channel, prejected area and surrounding length of the fry are sent to a personal computer. This computer stores and displays the result on the on-line monitor graphically.

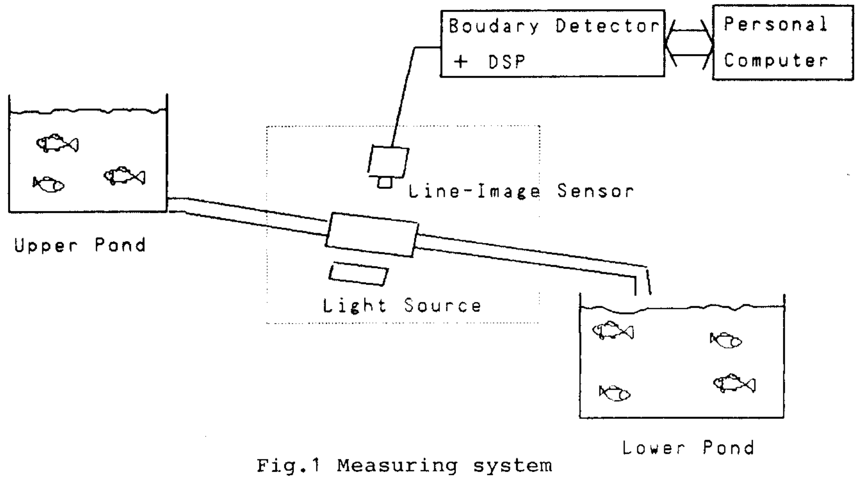


Fig.1 Measuring system

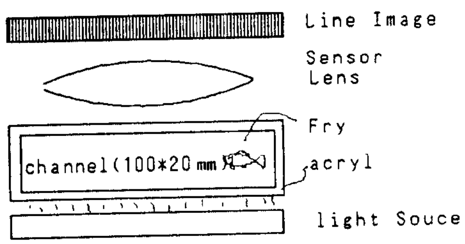


Fig.2 Cross sectional view of rectanglar channel

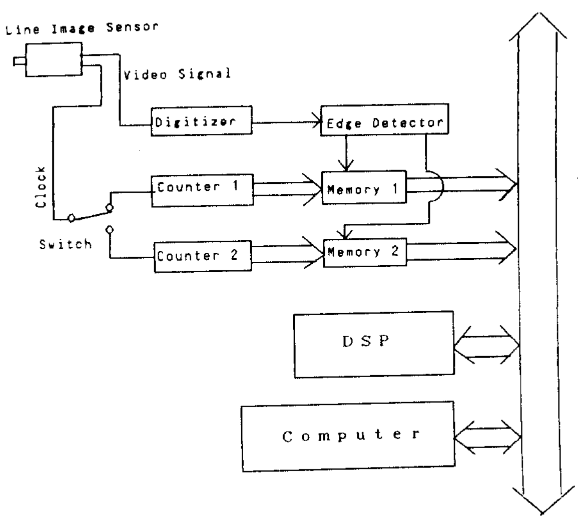


Fig.3 Block diagram of measuring system

Boundary Detector

In order to enable a real-time image-data processing, our system employed a boundary dectector to give the number of the boundary point of the fry image. The block diagram of the boundary detector is depicted in Fig.3. In Fig.3, when a rise or fall of binary image signal is detected, Edge Signal 1 is activated and the data in Counter 1 is stored in Memory 1. Since Counter 1 is counting steady clock pulses coming from the line-image sensor, the data stored in Memory 1 corresponds the pixel number of the boundary point. In the next scanning cycle boundary data are stored in Memory 2 and the data in Memory 1 are loaded by DSP simultaneously. Similarly in the subsequent cycles Memory 1 and Memory 2 are switched alternatively. Fig.4 shows a timing chart of this boudary detector, where pixel numbers n1-n4 of boundary points are stored in the memory. The above switching of the memory increases the efficiency of our system and enables the real-time operation.

After loading the boundary data from the memory, the digital signal precessor analyses the connection of the fry images and obtains the projected area and surrounding length of the fry image. To every image of the fry a label is allocated like Fig.5. Moreover, the overlapping of images of two fry are judged. The judgement is executed as follows. Let L be the surrouding length of the fry image and A be the projected area of the fry. Then value of L/A can be employed to judge the overlapping of the images, because the value L/A of the overlapping image becomes nearly twice of the normal value without overlapping like in Fig.5. Therefore,excess value of L/A means that the image is overlapping one. However, it is important to note that the normal value of L/A does not necessarily mean the image is not overlapping. If almost all part of the fry image is overlapping, we can't judge with the value L/A if the image is overlapping or not.

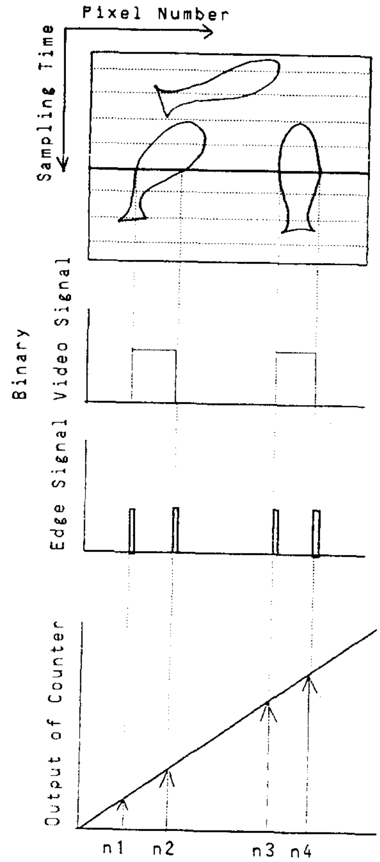
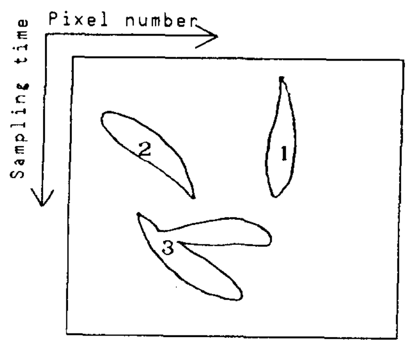


Fig.4 Timing Chart



No.	A Area	L Length	L^2/A Ratio
1	1019	166	27.0
2	912	160	28.1
3	1925	310	49.9

Fig.5 One example of image

3. Experimental Results

In order to show the applicability of our system, we built a test loop in our laboratory. The flow velocity of water was adjusted to 5 m/sec. The scanning rate of line-image sensor was 5kHz.

Test fish were Tetra-penguin, whose body length were from 20 mm to 30 mm. At the experiment, fifty test-fish were transported from the upper pond to the lower pond. Fig.6 shows one regenerated image of the fry, where five contours of the fry are shown. Our system ran fast enough to obtain these results with 5kHz sampling rate. Table 1 shows experimental results of ten trials.

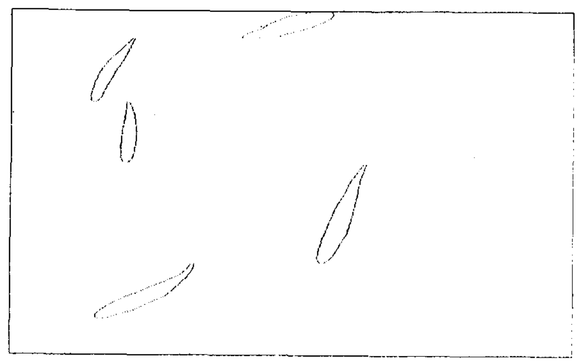


Fig.6 Regenerated image

Table1 The results of the measurement

Trial No.	Actual Count	Output of the system	Error
1	50	50	0
2	50	50	0
3	50	49	-1
4	50	50	0
5	50	50	0
6	50	50	0
7	50	50	0
8	50	49	-1
9	50	50	0
10	50	50	0

4. Discussion

While we have two failed results, the experimental results were satisfactory. Counting error caused by unexpected bubbles or some trash were not observed. Therefore, the error of counting by the proposed system might be caused by overlapping of the fry images. In order to overcome this overlapping problem, one more line-image sensor might be needed or completely different technique might be employed. Considering the counting task, our system is satisfactory. However, mesurement of the body length of the fry was unsatisfactory. The reason is that flow velocity of fish were not constant because of the arrangement of our test loop.

5. Concluding remarks

The authors developed a system which enables a real-time measurement of the fry in the cultivation center. Experimental rasults show that the function of our system is satisfactory. The superior features of our system are summarized as follows;

(1) Boundary detector and DSP enable a real-time measurement of the fry.
(2) Line-image sensor enables a non-contact measuring of the fry.
(3) Technique of image processing enables a accurate measurement and also compensation the effect of the overlapping of the images.

References

1) Annual Report of Japanese Association of Cultivation Fishery(1985)
2) M. Takeshi et al., Labeling Algorithm Using Content Addressable Look up Table, IE., ICE. Pru87-79(Japanese) (1987)