Development of Fish Separator Conveyor based on Fish Identification System

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Abstract. Indonesia as the largest archipelago and maritime country in the world has a very large marine resources. Fish is one of the marine wealthies (marine biota), which have large numbers in Indonesia. Fishermen is an important role in the process of fishing, however fish caught by fishermen are often mixed with other types of fish. Currently, the process of fish separation is done manually, which takes longer time and many error occur due to fatigue. In this work the conveyer separator based on the fish identification system is developed. The fish conveyer separator is designed and developed. The fish identification system is based on Fast Fourier Transform (FTT) technique and Artificial Neural Network (ANN). The system is working properly, since it resulting the training and testing accuracy of 80% and 66%, respectively.

Keywords: Automated Conveyor; Fast Fourier Transform; Artificial Neural Network

1. Introduction

Indonesia as the largest archipelago and maritime country in the world. It has a very large marine resources and is an important and strategic economic aspect, one of which is the marine wealth (marine biota), namely fish [1]. This fisherman is an important role in the process of fishing, when fishing in the sea the fishermen catch fish in large quantities, so that not only one type of fish is caught. Fish caught by fishermen are often mixed with other types of fish. At this time the process of separation of fish species is still done manually which requires 3-4 people and takes three hours or more and often an error occurs due to fatigue.

Machine sorting can reduce production costs by increasing the yield in sorting, and the overall efficiency of the rest of the line. It also adds quality to the end product but in turn increases investment and process complexity. When the process involves raw material and is labour cost intensive, small increases in yield and productivity lead to significant cost reductions [2].

This automatic sorting system that uses image processing and identification system techniques has been used in several studies such as machine vision for fruit sorting [3], monocular vision for sorting teeth [4], fish identification based on Support Vector Machine [4], dan sorting mangoes using fuzzy logic.

Moreover, various image processing techniques are also used in the field of fisheries such as tuna classification using image processing [5] which applied edge detection technique. The colour detection technique is applied for fish classification [6].
In this paper, the conveyer fish separator based on the fish identification system. The conveyer designed and developed. The fish identification system is based on intelligent system neural network. The artificial neural network (ANN), which is a relatively popular artificial intelligent, are introduced and proposed for fish identification system. ANN is a simple and very powerful method. ANN work based on human brain principle [7]. The proposed ANN-based fish identification system used Fast Fourier Transform (FFT) as input. The effectiveness of the proposed system is evaluated experimentally. The results show that the proposed technique has produced the better training and testing accuracy.

2. Proposed System
This paper considers two main works, which consist of conveyer development and fish identification system. The Converyor fish separator in this study is based on mechanical and electrical design. On the other hand, a fish Identification system based on image processing and artificial intelligence. Figure 1 shows a flow chart of Fish Separator Conveyor based on the fish identification system. The infrared sensor detects the existence of fish. The servo gate and conveyer motor are active, if the fish is detected. The servo gate will automatically open (fish input), so the fish will come out, automatically in order. Otherwise, the conveyer motor is inactive and the gate servo will not open, it aims for power saving. After the fish are on the conveyer will be continued in the process of identifying fish species by the camera. The camera will capture the fist and then processed in the Identification fish detector system. This system identifies the type of the fish, servo (fish separator) will be active to change its position in order to locate the fish based on their type.

![Figure 1. Flow Chart Fish Separator Conveyor based on the Fish Identification System](image)

2.1 Development of conveyer
Conveyer separator development involved two main parts, mechanical and electrical designs. Mechanical design consists four main parts, mechanical design, determine the power of the motor, pulley and v belt, and diameter of the roller. Figure 2 is the design of fish separator conveyer, fish input that is used to place the fish from the catch before the fish proceed with the sorting process. In the fish input there is an infrared sensor and a gate servo as in shown in Figure 2. This fish input is used to make the fish come out one by one automatically before the fish is detected by the camera. This fish input has an angle of 25° obtained from the trial results by considering the composition of the fish output, with a surface the fish will go down to the gate servo, then the infrared sensor will detect the presence of fish so the servo will open automatically. The slope angle of the fish input is sufficient to launch the fish one by one.
Conveyor system design involves determining the correct dimensions of the conveyor belt components and other parameter values to ensure optimal tool performance. The design of a belt conveyor system involves three important parts, power of the motor conveyer, V belt and pulley and Roller konveyor. The consideration of the choices the power of the motor is depend on the capacity of the fish going to cover, the choice of the type of material being transported, the belt width and motor power used will affect the belt transport speed and transfer distance [8]. The rotation of the roller conveyor formulated as below:

\[ n = \frac{v}{\pi D} \]  

(1)

where \( n \) is the number of the rotation of the roller, \( v \) is the belt speed and \( D \) is diameter of the roll. The rotation of the torque in the conveyor roller, in order to determine the rotation of torque based on the load that has been adjusted, as formulated:

\[ T = W d \]  

(2)

where \( T \) is the Torque, \( W \) is the load of tangensial, and \( d \) is the diameters of the roller. The power of the motor cab be defined as:

\[ kW = \frac{n T}{974} \]  

(3)

where \( kW \) is the Motor power, \( n \) is the number of roll rotation, \( T \) is the torque.

2.1.1 Pulley and V belt determination

Pulleys are manufactured in a wide range of sizes. The pulley diameters is obtained from standart value from catalogue. Once the pulley diameters is determined, the size coupling can also be decided from the catalogue. The correct way for measuring the V- belt length is by mean of pulley. The belt is put on 2 pulleys, specific for the family and size of the belt and having the same pitch diameter[9]. The power plan on the conveyer can be determine with formula below;

\[ P_{d} = P \cdot f_{c} \]  

(4)

where \( P_{d} \) is Power plan, \( P \) is Power and \( f_{c} \) is the correction factor

The diameter pulley machineand diameter of drivepulley can be formulated as:

\[ \frac{n_1}{n_2} = \frac{D_2}{d_1} \]  

(5)

where \( n_1 \) is a rotation of drive pulley, \( n_2 \) is rotation of the machine pulley, \( I \) is the reduction, \( D_2 \) is diameter of the machine pulley, \( d_1 \) is diameter of the drive pulley. The distance between the axis of the shaft between the motor pulley and roller pulley, as formulated below

\[ C = \frac{b + \sqrt{b^2 - 8(D_p - d_p)^2}}{8} \]  

(6)
where \( C \) is distance axis shaft, \( D_p \) is diameter pulley machine, \( d_p \) is diameter drive pulley, length of the pulley, \( V \) belt, \( L \) (mm), is formulated as

\[
L = 2C + \frac{\pi}{2}(d_p + D_p) + \frac{1}{4C}(D_p - d_p)^2
\]

(7)

where \( L \) is around the belt, \( C \) is the distance of the axis, \( d_p \) is the pulley pitch diameter of drive, \( D_p \) is pulley pitch diameter of the machine.

### 2.1.2 Diameter of Roller

The roller support belt and facilitates ease as well as free rotation of the belt conveyor in all direction. The correct choice of roller diameter must take into consideration with the belt width [10]. The minimum diameter of the conveyor roller can be determined based on this formula:

\[
D_a = \frac{F_u C_3 180}{b_0 \beta}
\]

(8)

Where \( D_a \) is minimum diameter of drum drive, \( F_u \) is the effective tensile force, \( C_3 \) is correction factor, \( b_0 \) is the belt width, and \( \beta \) is the contact roller drive arc. The conveyor roller drive shaft diameter, given as follows [11]:

\[
d_s = \frac{5.1 K_t C_b T}{\tau_a}^{1/3}
\]

(9)

Where \( d_s \) is drive shaft diameter, \( K_t \) is correction factor of 1.5 to 2.3, \( C_b \) is correction factor of 1.2 to 2.3, \( T \) is twisting moment, \( \tau_a \) is shear stress permits material.

### 2.1.3 Electrical Circuit Design of the Conveyer

Figure 3 shows an electrical circuit design on this system. This system uses Arduino UNO as a microcontroller. The infrared sensor used to detect the fish in the input fish detector. The infrared sensor then sends the signal to the Arduino Uno, which will activate the motor and servo.

![Figure 3. Circuit Design Conveyor System](image)

### 2.2 Fish Identification System

Figure 4 shows the proposed fish identification, description the system basically consists of three main components, namely image processing, data selection, and identification system. Image processing is used to obtain images using the camera, data transferred to the computer and processed to select features. The feature data is then selected based on important feature data using the data selection method. The selected data are used as input to the identification system which applied artificial neural network, in order to identify the species of the fish. The system is trained to identify the fish based on its picture. The fish image is digitized and some of them are carried out to create a template for the fish pattern and stored in the memory.
2.1.4 Image processing

In the image processing step, the image is converted into the feature vector which will be used as input to the identification system. In this stage, there are three important image processing steps, namely image pre-processing, edge detection and FFT technique. The fish image is converted to grayscale, color and blurred using a Gaussian filter. The pre-processing image is detected by the edge using canny edge detection and then the edge detection, image is the extract based on FFT technique, as shown in Figure 5.

2.1.5 Gaussian Filter

Gaussian Filter is applied to reduce noise taken by the camera while capturing the pictures. This step is applied in order to reduce the noise at the edge of the image. The Gaussian Filter technique can be formulated below

\[ G(x, y) = \frac{1}{2\pi \sigma^2} e^{-\frac{x^2 + y^2}{2\sigma^2}} \]  

(10)

Where \( x \) is the distance in the horizontal axis, \( y \) is the distance in the vertical axis, and \( \sigma \) is the standard deviation of Gaussian distribution.
Figure 6a. Fish captured by the camera

Figure 6b. Gaussian filter and grayscale image of a fish

Figure 6. The process of Grayscale and Gaussian filter of the fish

Figure 6 shows the fish images, with the grayscale and Gaussian filter are applied. The leftside in the image after the grayscale image. The image on the right is blurred slightly to reduce the existing noise.

2.1.6 Application of Canny edge detection
The canny edge detection is used to take the edge of the shape of the fish, so that the fish's features are more clearly visible [12]. The Canny edge method has three key criteria [13]:

- **A low error rate.** It is important that edges occurring in images should not be missed and that there should be no response where edges do not exist.
- **The detected edge points should be well localized.** The distance between the edge pixels as found by the detector and the actual edge should be a minimum.
- **There should be only one response to a single edge.**

Figure 7 shows the result of canny edge detection. The background image turns black, all that remains is the line from the fish.

Figure 7. The result of canny edge detection

2.1.7 Fourier Transform of an image
Feature extraction process using a Fast Fourier Transform (FFT) technique. FFT helps to convert an input 2D image into real and imaginary components which are a representation of the image in the frequency domain. Each point in the domain is represented as frequencies in Fourier or frequency domain. FFT calculates as see in equation below:

\[
F(a, b) = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x, y) e^{-j2\pi(ax + by)/N}
\]

(11)
Where \(F(a,b)\) is the frequency.
Figure 8 shows the result from the Fourier transform, where it is shown that the maximum frequency and amplitudes are 640Hz and 9000V, respectively.

![Fourier Transform of a fish image](image)

**Figure 8.** Fourier Transform of a fish image

### 2.2 Identification system using Artificial Neural Network (ANN)

Artificial Neural Network (ANN) is a system that mimics the workings of the brain and can also be trained like the brain in humans. There are two important phases in the ANN, training and testing phases, respectively. The training phase or called neural network training, ANN can provide the model of the feature data which applied to identify the data. In the testing phase, the extracted data is applied as input to the ANN in order to identification the results. The advantage of ANN is its ability to adapt only from looking at input and output data relations [15]. ANN consists of three main layers, namely, Input layer, Hidden layer, and Output layer as shown in Figure 9.

![Layers of ANN](image)

**Figure 9.** Layers of ANN

Figure 9 shows an example of an ANN multilayer where the input layer is in the input, hidden layer and output in the first, second and third rows, respectively. In this work applies 12 inputs of ANN, two hidden layers, and one output are used. There are two hidden layers are involved, which first hidden layer containing ten nodes and the second hidden layer containing eight nodes. The output consists of two nodes, which will identify the two types of fish.
3. Experimental Result

The fish is placed in the fish input before the fish proceed to the sorting process. Fish input is useful for fish coming out one by one regularly so that the fish are not close together when the fish are on the conveyor. After the fish come out one by one the fish will be brought by conveyors to enter the fish species identification process by the camera. After the fish have been identified by the camera, the servo as a fish separator will be active to separate the fish according to their species.

![Figure 10. Conveyer fish separator](image)

The experiment result shows that the system of conveyer fish separator is working properly as illustrated in Table 1. Fish used in this work are Chub Mackerel and Yellowstripe Scad. Each kind of fish involves three fish. Each of the fish capture by camera twice, so there are six pictures of every kind of fish as total there are 12 picture applied as training data of the fish identification system. The fish image is then extracted based on FFT techniques which resulting 640 and 360 each fish. The extracted fish data are the reduced and selected using Principle Component Analysis (PCA) into $640 \times 4$ data. Therefore, the total data for training is $7680 \times 4$. The training accuracy is 80%. In the testing phased, there are three fish each of every specie of fished. Therefore, with the length of the same data, the total of the testing data is $2560 \times 4$. The testing result is shown in Table 1.

| Fish                  | Output Detection | Accuracy |
|-----------------------|------------------|----------|
| Chub Mackerel 1       | Yes              |          |
| Chub Mackerel 2       | Yes              |          |
| Chub Mackerel 3       | No               |          |
| Yellowstripe Scad 1   | Yes              |          |
| Yellowstripe Scad 2   | No               |          |
| Yellowstripe Scad 3   | Yes              |          |

Table 1. Testing results of Fish Classification

In Table 1, there are two fish that are missclassified, with an accuracy of 66%. The other four fish can already be classified. The testing is done in a well-lit room, so that it can facilitate the camera to take pictures and also facilitate the image processing system and identification system in processing images and classifying fish.

4. Conclusions

The process of separate the fish species after catching is discussed in this work. This separation process is carried out to classify fish according to their type before the fish are sold. At this time, the process of separation of fish species is still done manually, which requires a long time and requires 3-4 people to do the task and errors can occur due to fatigue. With the conveyor system for separating fish based on the fish identification system, it can reduce the occurrence of errors when separating fish species, making it easier to separate fish based on their species and speeding up the time in the process of grouping fish species.
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