Designing Fish-Like Swimming Boat Robot with Two Speed Modes Based On Proximity Sensor

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Abstract

Submarine robot were being interested topics but rarely observed because it was too sophisticated and expensive. However, the fish robot floating on the water was the simplifying form without loosing the state of research. In this research, energy transfer from motor to flipper by yoke system. Flipper functionally acting as moving mechanism, it followed the tail fin of fish behavior. It making undulation with frequency controlled by speed relay. IR sensor working as proximity sensor, microcontroller used information from IR sensor to make the decision of speed switching. The speed-switching algorithm bases on proximity ranges. The proximity detected by IR sensor processing by microcontroller and determined the switching command to relay. The ability not to hit the obstacle becomes the main goal of this research, not like mobile robot which transport on the land, controlling obstacle avoidance became more difficult because there was not brake system in fish robot. The thrust speed became optimized parameter. The result were the fish-like swimming boat could avoid the obstacle with two braking distance 15 cm and 40 cm according to slow speed and normal speed respectively. The thrust speed showed the accelerated phenomenon when robot floating on the water.

Keyword: fish robot, control, IR sensor, microcontroller.

1. INTRODUCTION

There were many researches about fish robot done by Hirata and his student at *National Maritime Research Institute Institute* on 2003 [1, 3, 4]. The research was readable on the internet. These all research becomes the inspiration to more observed and developed the fish robot which rarely done. In Indonesia there was some experiment about sub merged Fish Robot done by Handoko at Insitiut Teknologi Bandung [2]. Actually, Fish robot has two types: floating robot and diving robot. Sometimes diving robot called as submarine robot. The forces from water, specific mass, resistance from water were become the main problem in controlling moving and stabilizing. Although submarine robot was the most expensive type but this tape becomes more observe than the floating robot.

2. THEORY

Fish swimming mainly with fin and as general the swimming gait could be classified into two class [5] : Body and/or Caudal Fin (BCF) and Median and/or Paired Fin (MPF). Fish in BCF class using the body and tail (caudal) fin to accelerated and swimming forward. The examples of this type were eel, tuna, and shark. Fish in this class moving his tail fin and/or the body simultaneously. However, in MPF class the fish only used pectoral fin to moving or hovering. Fin system of fish shown on Figure 1.

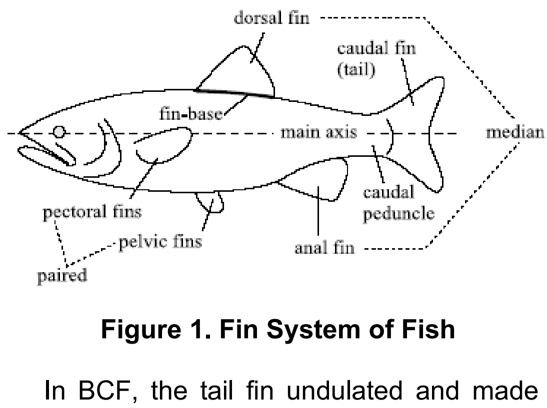

Figure 1. Fin System of Fish

In BCF, the tail fin undulated and made the momentum of water to push the body forward. The dexterity of fish determined by the body angle and tail fin which moving simultaneously as done by shark and tuna.

Diving Fish had some force involving when swimming like showed in Figure 2 The forced involving in diving swimming were thrust, air resistance, buoyancy and hydrodynamic lift, weight [6]. The action of fish could be yaw, pitch, and rolling. The normal fish rarely used rolling action when its body stabilized. The deeper it dived the more pressure it can get. When fish floating or not diving so deep, the significantly forces only resistance and drag force from water. Drag force produced form water attached to its skin or from the water resonance at the back of tail. However, in floating fish and fish-like swimming boat the problem to be dealt only the rolling as stabilized factors. The thrust speed become parameter to be maximized and influences by dexterity behavior of fish itself

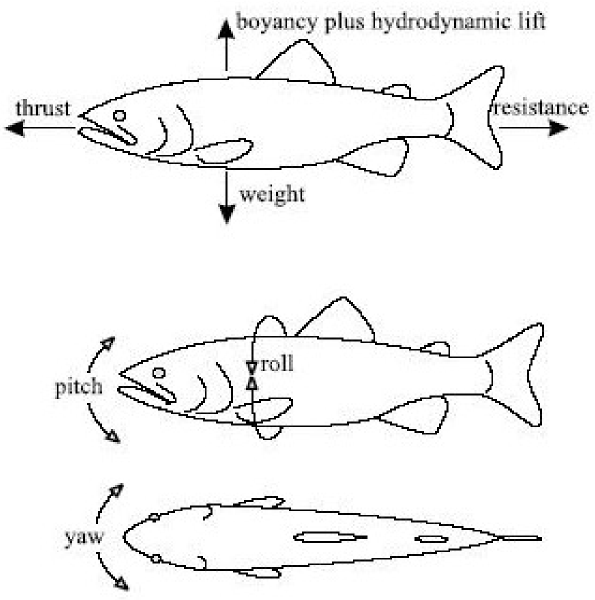

Figure 2 Force acting on fish body

3. DESIGN OF FISH-LIKE SWIMMING BOAT ROBOT

The fish-like swimming boat constructed from kid swimming boat. The microcontroller and tail fin added later. Figure 3 shows mechanical body of fish-like swimming boat robot. There was IR-sensor in front of the boat, stabilizer made from plastic tube were placed in right and left side of the boat. Microcontroller and dc motor were placed at the center of the mass. The tail fin was made from plastic plat polystyrene.

To make the tail fin oscillated and form undulation wave to water, DC motor gear was connected to yoke system. Yoke system has a function to produce sinusoidal pattern from circular rotation.

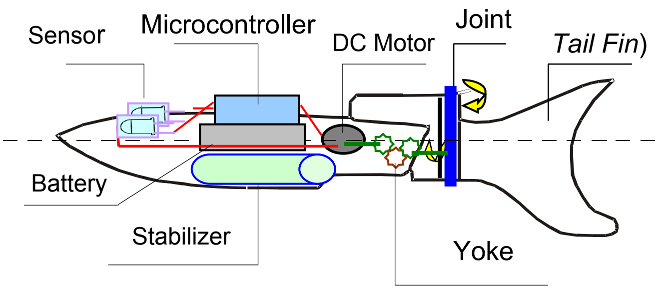

Figure 3. Mechanical Design of Fish-like Swimming Boat Robot

This sinusoidal pattern was transferred to tail fin. So, the tail fin although had ability to oscillated but it could not be direct and encompassed the boat to desired direction. As general the fish-like swimming boat was not designed to have turning action itself. It had only stop (thrust condition) and straight swimming ability. The turning action only caused by the final position of the tail fin and the remaining energy kinetic when the speed stopped.

The schematic of signal transfer and power was showed in Figure 4.

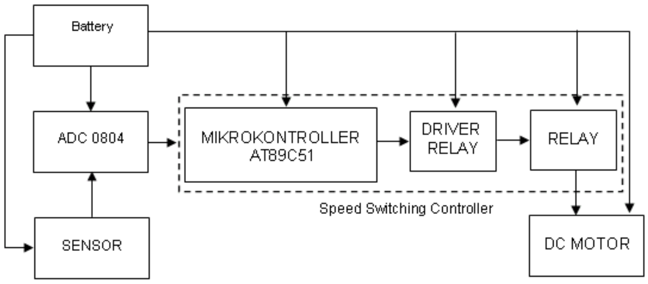

Figure 4. Schematic of signal transfer and power

IR Sensor and IR Phototransistor acted as transmitter and receiver device [2, 6]. Signal reflected by the wall was capture by phototransistor.

Adjustment of phototransistor placement and gaining the signal become initial calibration procedure.

Analog sensor was converted to digital signal input to microcontroller. The microcontroller made decision of choosing speed modes which conducted by relay to DC motor. DC motor rolling the disk of yoke and by paddle mounted on elliptic house, the rotating direction convert to sinusoidal undulation of tail fin (Figure 5)

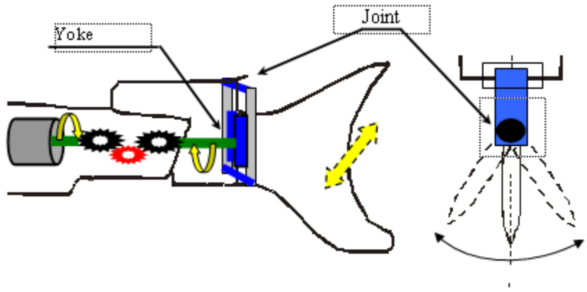

Figure 5. Yoke system and tail fin undulation

4. EXPERIMENTAL

4.1. Experimental Procedure

Experimental procedures were choose based on the hypothesis that first there was some optimized frequency of the tail fin which can made maximum thrust speed. The secondly, there was some stop point and minimum braking distance of boat to avoid obstacle that influenced by its speed and environment condition (drag force from water, resonance wave at the back of boot). From these hypotheses, the experimental procedures were determines as followed:

a. Finding two speed mode of tail fin which can give the most fastest thrust speed
b. Calibrated the proximity sensor
c. Finding braking distance from the obstacle related to speed and environmental condition.

The obstacle in this research was the wall of tank itself. The fish-like swimming boat robot was place in arbitrary position the capability possessed only to switch two speed mode. Robot could not choose the direction to turn, the turning condition are caused only by the final position of tail fin. This condition were normally occurred when yoke was used as rotating mechanism

4.2. Experimental Result

4.2.1. Determining of Braking Distance

Table 1 shows some braking distance with two speed mode and hit condition (Yes/No)

Table 1. Determination of Braking Distance

Braking Distance	Hit condition	
	Normal Speed	Slow Speed
15	Y	N
20	Y	N
30	Y	N
40	Y	N
50	N	N
60	N	N
70	N	N

From the experiment, it was found there were two braking distances which suitable for each two speed modes. There was 40 cm and 15 cm, mathematically could be derived into algorithm as follows

Pseudocode of speed control

If $x \geq 40$ cm then normal speed
Else
If 15cm $\leq x < 40$ cm then slow speed
Else zero speed
Endif

And form these algorithm could be developed flowchart diagram of decision system as showed in Figure 6.

4.2.2. Consistency of tail-fin frequency

The tail fin frequency, which determined the speed of tail, was vulnerably and performed inconsistency. This behavior caused by its joint construction and energy loss happened in the yoke system and tail fin itself caused by environment

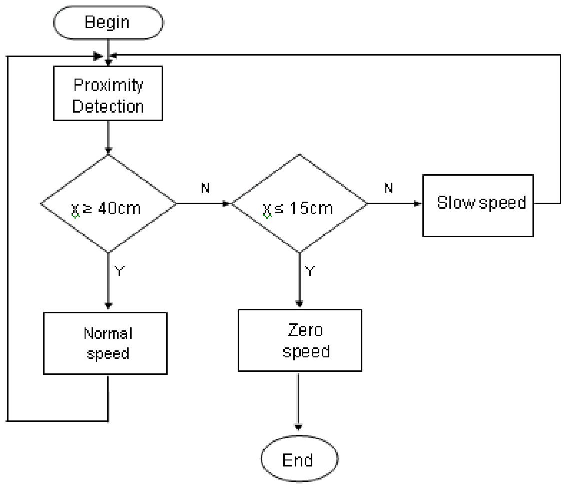

Figure 6. Flowchart Diagram of Decision System

Table 2. shows the data measurement of tail frequency in the water. The consistency phenomenon in this table was detect by doing some measurement of oscillation number of tail according to time its achieved.

Table 2. Consistency measurement of tail fin frequency

No	Oscilation Number	Time (second)	frequency (Hz)
1	10	9.05	1.104
2	20	12.86	1.261
3	30	22.64	1.326
4	40	30.15	1.326
5	50	35.21	1.420
6	60	48.27	1.243
7	70	61.43	1.395
8	80	68.26	1.171
9	90	75.65	1.189
10	100	83.94	1.191

Consistency measurement was done when the fish-like swimming boat robot swimming. Frequency of tail measure by observing the time showed in stopwatch. The inconsistency was quit significant; the frequency of tail in the water had a range in1.104 to 1.420. Although the number was looked like small it could cause difference thrust speed as showed in Table 3.

Table 3. Thrust speed related to traveling distance with no obstacle

No	Distance (cm)	Thrust speed (cm/detik)
1	15	4.82
2	20	7.74
3	30	12.63
4	40	15.46
5	50	18.11
6	60	20.49
7	70	23.06

From table 3. with no obstacle the thrust speed become variably along the traveling distance. This might be happened by the thrust force added from kinetic energy which made the boat accelerated.

5. DISCUSSION

This was only the simplest method to avoid the obstacle (wall), many technique can be developed later by used more complex decision system and derivative input and output. Fuzzy logic and expert system could be handled using error and error rate as input to fuzzy membership function. Nevertheless, this preliminary research has good step to observe the phenomenon of fish robot which rarely made in Indonesia.

The interaction between environment force and the force generated in robot could become subsequently research in finding efficiency and loss-less energy transfer. Yoke itself has a greet deal in making losing energy.

Many influence than occurred when fish-like swimming boat robot traveling that made variably thrust speed. The drag force at the bottom of boat, the friction between plastic tail fin with the water and the paddle from yoke to tail fin has contributed inconsistent thrust speed.

6. CONCLUSION

From the experiment some conclusion are made

a. There was found two optimized braking distance that assure the boat not hit the wall (obstacle). There were 15 cm and 40 cm according to slow speed and normal speed respectively.

b. With two speed modes and no obstacle there was found an accelerated phenomenon along the traveling distance.

7. REFERENCES

[1] Aoki. (2003). Fish-Like Model Boat. *National Maritime Research Institute Institute,* Japan: Tokyo Denki University. 8 Januari

[2] Handoko, Y., Nazuddin, Y.Y., Riyanto, B., Leksono, B., (2006), Study on Turning and Straight Motion of a Fish Robot Using Catching Prey and Escape Behaviors Mode, Proceeding of The 2nd Indonesia Japan Joint Scientifice, Symposium, Indonesia: Indonesia University, page 413-416

[3] Hirata, K., Takimoto, T., & Tamura, K. (2001). *Study on Turning Performance of A Fish Robot*, Power and Energy Division, Ship Research Institute Shinkawa, *6-38-1,* Japan: Mitaka Tokyo,181-0004.

[4] Kawai, S., & Hirata, K. (2000). *Model Fish Robot PPF-06i,* National Maritime Research Institute, Japan: *Tokyo Denki University,* September.

[5] Lane, M, D., Stakiotkis, M., Bruce, C, Davies. (1998). Review of Fish Swimming Modes for Aquatic Locomotion. *IEEE Journal of Oceanic Engineering,* Scotland, Desember.

[6] Liu , J., & Hu, H. (2005). Mimicry Of Sharp Turning Behaviours in a Robotic Fish. *IEEE International Conference on Robotic and Automation,* 0-7803-8914-X/05. Spain: Barcelona.

[7] McComb, G. (2001). The Robot Builder's Bonanza, 99 Inexpensive Robotics Projects, Second Edition*, A Division Of The McGraw-Hill Companies,* TAB Electronics, United States Of America,1987.

[8] Sakurai. (2003). *Model Underwater Vehicle*, National Maritime Research Institute. Japan: Hosei University, Januari.

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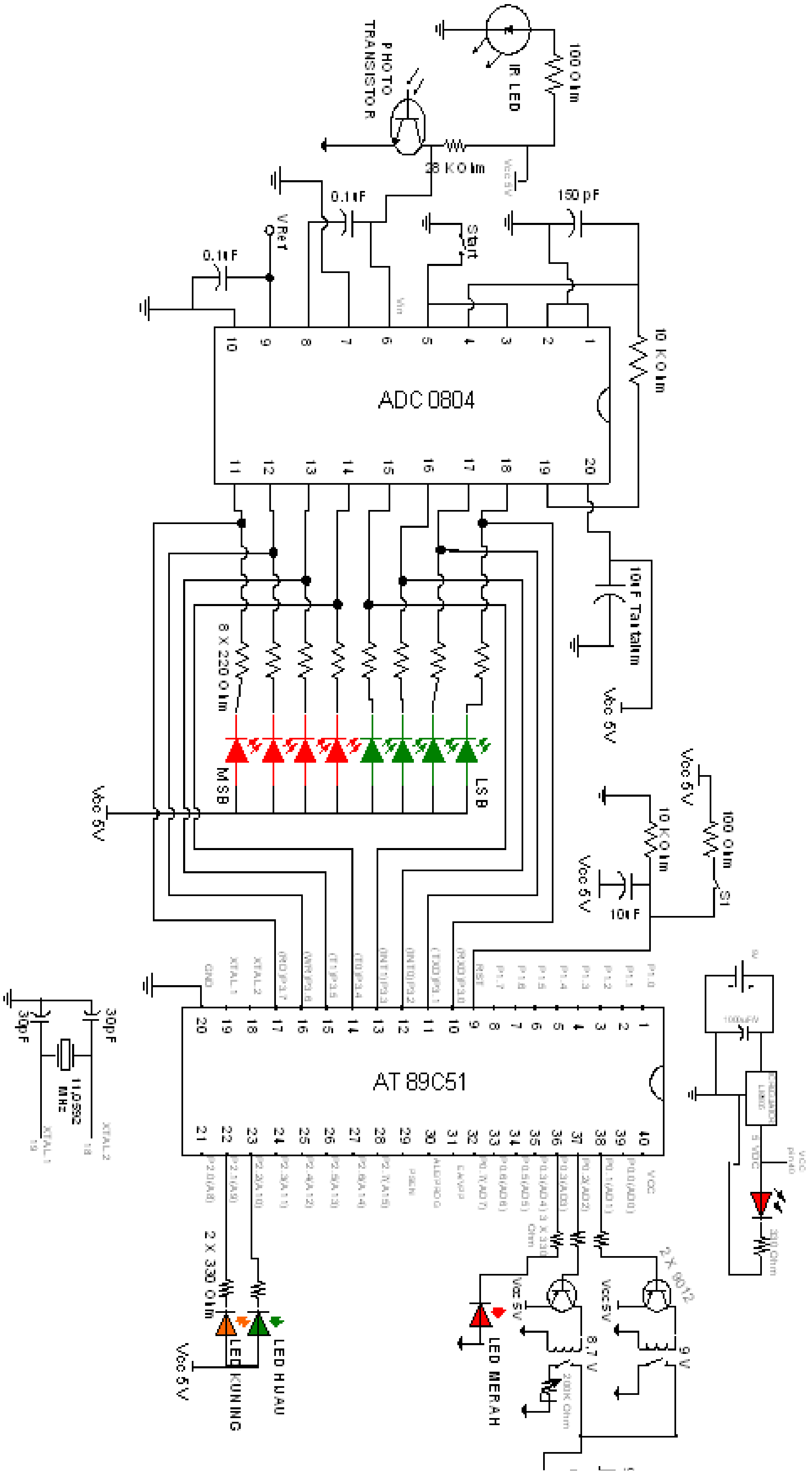
Listing Program

```
ORG 00H                 ;  initial address
START:
SJMP KON40CM            ;  jump to KON40CM
KON40CM:
CJNE A,#0F8H,KON30CM    ;  if A =  0F8H then jump
MOV P0,#0FEH            ; relay activated at port0.1
SJMP KON40CM            ;  jump to KON40CM
KON30CM:
CJNE A,#0F9,KON15CM     ;  if A = 0F9H then jump
MOV P0,#0FDH            ; relay activated at port0.2
SJMP KON40CM
KON15CM:
CJNE A,#0FAH,OUT        ; if A = then jump
MOV P0,#0FBH            ; relay activated at port0.3
SJMP OUT                ;  jump to OUT
OUT:
SJMP START
```


ADC 0804
AT 89C51
PHOTO TRANSISTOR
IR LED
100 Ohm
0.1uF
150 pF
Start
VRef
10 K Ohm
10uF Tantalum
Vcc 5V
8 X 220 Ohm
MSB
LSB
S1
30pF
11.0592 MHz
2 X 330 Ohm
LED KUNING
LED HIJAU
LED MERAH
2 X 9012
8.7 V
9 V