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Biological Inspired Inspection Underwater Robot (SNAKEY)

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Abstract

This paper presents the designing and development of biological inspired inspection underwater robot. Inspection and monitoring activities have been applied in this project. Two medium involve in this project development. Land has been consider as a normal surface or medium with addition or been specialized in underwater region. Inspection activity is done using a camera at the front of the robot. The monitor display will be the user computer with addition of software and a converter to interface between camera and the computer. The ability to move can be controlled by the user. There are 7 servos been used with 8 segments been design including the head of the robot. The mechanism that been apply is side winding movement and the angle for servo is ±30 degree. The speed of the robot is 0.072 kmh^{-1} in land and 0.18 kmh^{-1} on water. This robot can capture and record using the software that been used to make the inspection activity runs perfectly.

Keywords: Biological inspired, underwater robot, sidewinding movement.

1. Introduction

Nowadays, there are a lot of activities that been done by human that have it own advantages and disadvantages. So due to this matters, there are must be a way to overcome this problem. To be more specified, an underwater activities really causing a lot of problem. Then, user needs a device that can be easily investigating underwater activities.

During long time, human have made a robot that have multi-joint biped robot and mobile robot using wheels. And now, that is developing but it still has some problem that is occurred by condition of the ground and underwater. Wheel structure is more adaptive to make high speed drive on flat ground and more efficiency to control the drive than other robot. But if it is on the non-flat ground or sandy road, wheel-based drive is not efficient way.

Furthermore, an underwater situation also is an important situation. To investigate or do some research needs to deal in every situation. In this case, not only wheel structure been stress out, ability to move underwater freely is one of the matters need to be consider. Moreover, marine livings have million things secret in it.

In this project, the main things that been discussed is the value of underwater material that need to discover and investigate. Nowadays this type of investigate been applied anywhere such as high rated cases such in crime scene investigation that wanted to go underwater to search for any evidence to just having a problem to pick up your car key that been accidently fall on the drain, these are all sometimes been a disturbance or maybe taking such an long period to solve user problem.

A snake-like robot (SNAKEY) has possibilities to be useful in various tasks in spite of its simple and slender structure which is composed of a series of joints. Therefore, using a snake-like robot, this robot can go into the water to search for any material using camera. Once the camera saw anything that related to the user desired, the software that been used will

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capture or record to ensure the right location of the material. Furthermore, this robot wills did not harm material while human will accidently damage the material.

The development of biological inspired inspection snake robot (SNAKEY) is the aim of this project. The development of this project can be applied in investigating and searching for useful material underwater without harm the material itself. To achieve this aim, the objectives of this project are formulated as follows

- To design the controller both in movement and extract information.
- To construct an underwater snake robot that is snake like movement and waterproof.
- To develop inspection mechanism that is camera development which is to transmit the outputs result from the detection activities.

There are several scope had been outlined in order to accomplished the objectives of this project. The scopes of this project are as follows:

- The PIC that been used is PIC16F877A.
- The camera type is small camera with monitoring system on computer.
- Design mechanism of underwater snake robot – hardware.
- Construct circuit and programming – software.
- This robot is being operated by wired remote controlled.
- There is distance that only the snake robot could cover to search the material underwater (1 Meter).
- This robot consists of 8 segments including the head of the robot.

2. Literature review

There are several similar project that been reviewed as a literature to make this project a success. Amphibious Snake-like Robot ACM-R5 [1] is a snake lie robot was called amphibious because this robot is able to work both on the ground and in water. ACM-R5 is an amphibious robot. The requirements that had been discovered were the body should be watertight, the joints must been strong between each segment and the robot. For the propulsive device or in the other words that is engine to make the robot works, each joints will be installed a SANWA ERG-VX servo motor. Furthermore, ACM-R5 also been embedded with wheels to make the robot moved freely and lest friction.

Meanwhile, Autonomous Underwater Robot: Vision and control [2], vision is an important resource that enable autonomous underwater vehicle to do several tasks. The goal of this project in using underwater vision for Autonomous Underwater Vehicle (AUVs) is to enable AUVs to track, follow, and maintain a fixed distance to moving or stationary targets. This kind of visual applications is usually called visual servo.

In addition, Multiple Sensor Fusion and Motion Control of Snake Robot Based on Soft-Computing [3] consist of vertically connection of two servo-motor and 7 modules. The robot also has 12 degree of freedom (DOF) because each module has 2 DOF by using 12 linear connecting of servo motor. A power source is in the tail of robot for freely activity and main module is in the head. Micro controller in head executes sensor fusion algorism by using sensor input data and this can reason proper action by expert system. Consequence of reasoning is sent to servo motor controller, and then servo motor working. As the name of the robot that is multiple sensor fusion, this robot consists of several type of sensor.

3. Methodology

In this project, there are steps that need to be considered in applying all the method. Fig 1 shows the block diagram of the project and Fig 2 shows the block diagram of the project.

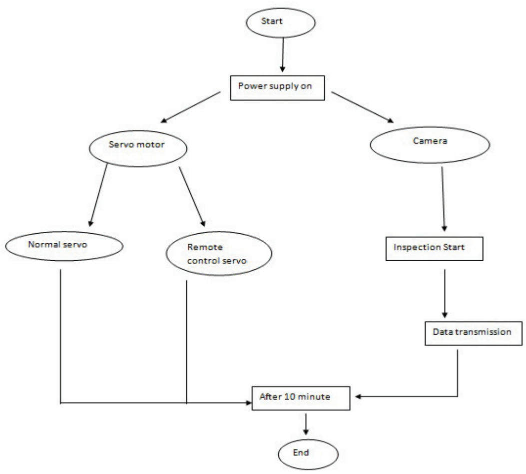

Fig. 1: Diagram is about how the robot works.

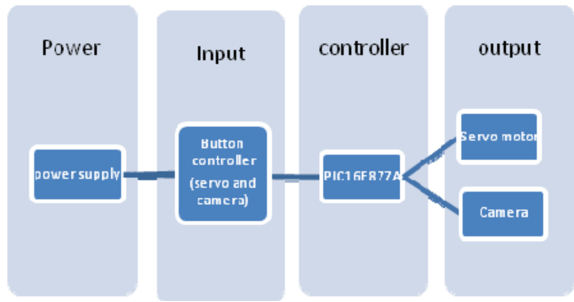

Fig. 2: Block diagram of the project.

3.1. Software Implementation

In this part, the entire software that been used been separated in several categories. Table 1 shows the software been used along with the categories while Fig 3 shows the circuit diagram for servo motor.

Table 1: List of software been used.

No	Categories	Equipment
1	Project simulation	Proteus
2	PIC program	MPlab IDE
3	Hardware simulation	Google sketch , EASYCap , MDLvis, ULead

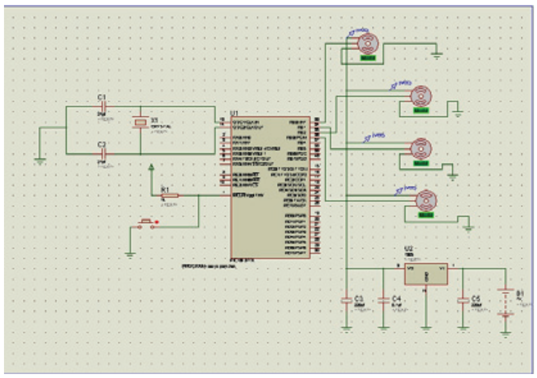

Fig. 3: Circuit diagram for servo motor.

3.2. Structure Diagram

According to the structure, the movement will follow side-winding motion [4]. All the servo motor will operate simultaneously with different type of turn. The entire servo will connect in serial configuration. Fig 4 shows the structure of the robot.

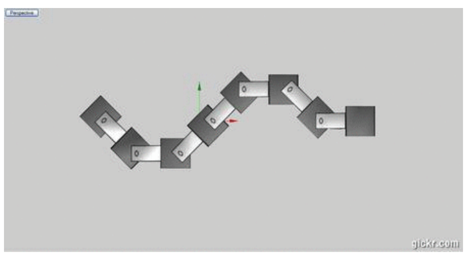

Fig. 4: Structure of the robot [6].

3.3. Hardware Implementation

In this project, PIC16F877A is used to control the movement and all the component of the robot and the language for the programming is c language. In this project, 8 segment are used to connect to the I/O pin. These segments consist of servo motor. Enhanced 40 pins PIC Start-Up Kit (SK40C) been used as a medium to receive an input and the output of the program. PIC16F877A will be embedded through the board to control all the system. The input of the system is button while servo motor will be the output. UART connection been used to interface with 8 Channel Servo Controllers board.

8 Channel Servo Controllers is used to interface between SK40C board with servo motor or in other words, this device will be the medium between the two component or device. This device is connected to UART port on the SK40C board and will connect up to 8 servos that can operate simultaneously. This robot consists of 7 servo motor that will be the drive for the movement of the robot. Servos that are used are 180 degree type of servo motor. 6 servos will operate simultaneously and one servo will be control by the user. The control servo will be at the head of the robot.

The camera (EASYCap) is used to undergo inspection through the underwater region. The camera is connected to the computer or television. There are two methods that the camera will show the output. Television only can display the output but if we connect to the computer, software will be used that is EASYCap to interface the camera with computer using USB. Inside the software, the user will control tone, brightness and so on. Moreover, to investigate more in the underwater region, there are functions that can record and capture the image. This function will help a lot in order to investigate more in some situation.

Metal rollers are used to make this robot move freely with less friction. This is important in order to make the snake move smoothly in every type of surface as friction is the one of matters that need to be stress out. Each segment should at least have one metal roller plugged in each segment of the robot body. External button is used to act as an input with each button has its own function.

4. Result and analysis

The (SNAKEY) robot, successfully swim and move in land and water in side-winding movement as already been proposed before. There are several movements that usually used in biological inspired snake as in Fig 5.

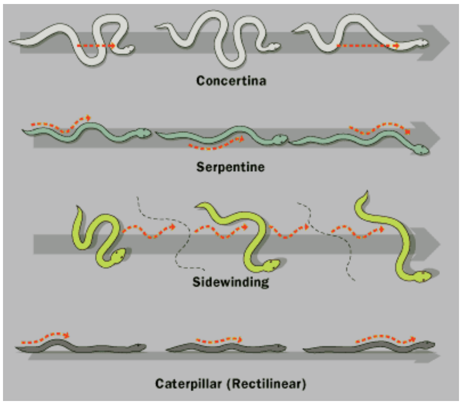

Fig. 5: List of snake movement.[4].

The movement of the robot is using side winding movement. The robot will move in 3 directions with ±30 degree of servo movement. There are 3 buttons or switch involve, the first button will make the head of the robot with the camera looking front, the second button will make the head also with the camera looking right and last but not least the third button will make the head along with the body turns left.

The camera functions as to monitor the marine living and also some valuable things underwater. The camera will be connected with computer using EASYCap connector. The software that been used is ULead software that can capture image and record video.

Two power supplies are used in this robot that is for camera and microcontroller SK40C board. Four units of (AA) battery are used to control the servo in servo controller board.

The robot structure has been designed again to improve the ability to swim underwater [5]. The microcontroller board and USB port for camera are brought out from the body of the robot. In addition, a console been produced to put the other board. The entire button to control the robot is at the console. Fig 6 shows the completed robot along with the console.

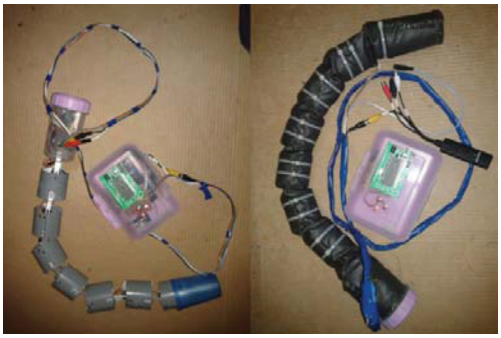

Fig. 6: The complete robot along with the console.

4.1. Structure of the robot

Although the design had been changed and the SK40C board already been brought out from the body of the robot, so it can control manually on the console. Thus, to overcome this problem in controlling the servo 3 new button are developed to to replace the joystick. Thus, the total button involve is 6 including the buttons that already on the SK40C board.

The head of the robot includes the camera and the servo controller board. In addition 4 unit of 1.5V AA rechargeable battery had been included in the head of the robot. The servo bracket as in Fig 7 are designed to make the robot centralized [5]. The bracket or holder are placed at left and right between each segment of the robot to ensure that the robot is always at centre position.

Fig. 7: Servo holder or bracket.

Friction is a force that can affect the biological movement. In order to overcome the problem of slick body in the snake which the robot does not have, 6 units of roller is placed at the body of the robot.

4.2. Mechanism of the snake robot.

Fig 8 is shows the console with the button on top of it. The function for each button in the console is summarized in Table 2. Fig 9 shows the degree of movement to apply the side winding movement. Table 3 until Table 5 summarized the degree of servo motor in the robot with the speed setting of 100. Furthermore, the degree will be declared on 0000(min)-8000(max). In addition, 4000 (centre), 6666 (+30 degree) and 2666 (-30 degree).

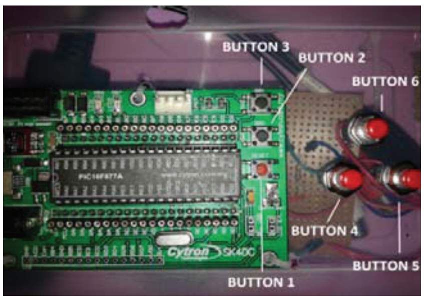

Fig. 8: Console with the button.

Table 2: Fucntion for each button.

No.	Function
Button 1	RESET
Button 2	READY
Button 3	MOVE FORWARD
Button 4	MOVE LEFT
Button 5	MOVE RIGHT
Button 6	REST

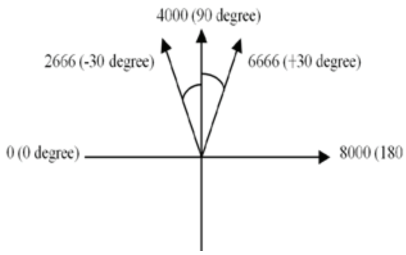

Fig. 9: Degree of movement of the robot.

Table 3: Description for RESET, READY and REST button.

	Servo	1st sequence		Servo	1st sequence		Servo	1st sequence	2nd sequence
RESET	Servo 1	4000	READY	Servo 1	4000	REST	Servo 1	2666	6666
	Servo 2	4000		Servo 2	4000		Servo 2	2666	6666
	Servo 3	4000		Servo 3	4000		Servo 3	2666	6666
	Servo 4	4000		Servo 4	4000		Servo 4	2666	6666
	Servo 5	4000		Servo 5	4000		Servo 5	2666	6666
	Servo 6	4000		Servo 6	4000		Servo 6	2666	6666
	Servo 7	4000		Servo 7	4000		Servo 7	2666	6666

Table 4: Description for MOVE FORWARD and MOVE LEFT button.

	Servo	1st sequence	2nd sequence	3rd sequence	4th sequence		Servo	1st sequence	2nd sequence	3rd sequence	4th sequence
MOVE FORWARD	Servo 1	4000	4000	4000	4000	MOVE LEFT	Servo 1	6666	6666	6666	6666
	Servo 2	6666	4000	6666	2666		Servo 2	6666	4000	6666	2666
	Servo 3	6666	2666	6666	2666		Servo 3	6666	2666	6666	2666
	Servo 4	6666	6666	2666	2666		Servo 4	6666	6666	2666	2666
	Servo 5	4000	6666	4000	2666		Servo 5	4000	6666	4000	2666
	Servo 6	2666	4000	6666	4000		Servo 6	2666	4000	6666	4000
	Servo 7	2666	2666	6666	6666		Servo 7	2666	2666	6666	6666

Table 5: Description for MOVE RIGHT button.

	Servo	1st sequence	2nd sequence	3rd sequence	4th sequence
MOVE RIGHT	Servo 1	2666	2666	2666	2666
	Servo 2	2666	4000	2666	6666
	Servo 3	2666	6666	2666	6666
	Servo 4	2666	2666	6666	6666
	Servo 5	4000	2666	4000	6666
	Servo 6	6666	4000	2666	4000
	Servo 7	6666	6666	2666	2666

The sequence will move as a cycle in which consist of several sequence. The sequence will loop continuously in order to follow the side winding movement [4]. However, delay must be placed in order to enable the microcontroller to read the program correctly. This is because every change of movement from the same servo need a delay with the minimum value of 5ms. The signal that is produced from microcontroller (PWM signal) need a delay because the signal is sent in pulse. Fig 10 shows the movement of the robot on the water. An experiment is done to compare the speed of the real snake that is Crotalus Cerastes type of snake that also perform side winding movement [7] with SNAKEY in land and water. Table 6 shows the different value that been tested between SNAKEY and real snake.

Fig. 10: SNAKEY on water.

Table 6 : Different value that been test between SNAKEY and real snake.

	Distance (km)	Time (min)	Speed (kmh^{-1})	Length of the snake (cm)
Crotalus cerastes snake	11.1	180	3.7	41.9
SNAKEY (land)	11.1	9250	0.072	79.5
SNAKEY (water)	11.1	3700	0.18	79.5

In addition, the experiment was held by calculating the time taken for SNAKEY to move in both condition. SNAKEY can move for 20 cm in 10 sec in land and 4 sec in water. The speed a little bit slower than the real snake because the factor and limitations of the robot snake. The time delay of the servo, the strength for each joint and also the length of the snake also are considered to make the robot move faster.

4.3. Inspection system.

For the monitoring system of the robot, small camera is used. The camera will directly connect to the computer using EASYCap converter. EASYCap converter is actually a converter form normal audio and video cable to USB 2.0 connector. The EASYCap converter comes with Ulead software that can capture photo and record video.

The camera needs a 12V power adapter to supply the power to the camera. All the images and videos will be stored in computer storage. The camera can be used on land and underwater as the camera is waterproof [2]. Fig 11 shows the view of inspection activities.

Fig. 11: View of inspection activities.

5. Conclusion

The biological inspired inspection underwater robot (SNAKEY) have been successfully developed. The robot (SNAKEY) ability to swim has also been considered since the servo can be controlled to enable the robot to swim with desired direction. The speed of SNAKEY is 0.072 kmh^{-1} on land and 0.18 kmh^{-1} in water. The inspection activities can be very useful in investigating the material underwater or land that in the difficult and extreme situation. Plus with the ability to capture and record is very important to the user in order to re-check and revise the situation.

The movement of the robot had some limitations but the side winding movement has been applied correctly. For future development, a wireless system is a very practical in order to make the robot move and swim freely. Plus, a variable degree of freedom [6] is very useful in order to make the robot swim and dive better. A submarine system ballast tank can also be implement in order to control the buoyancy of the robot[6]. Finally, sensor implementation can also be very useful to avoid any obstacle and blind angle of the camera.

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