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Design Modeling and Characterization of Robotic Fish for Aquatic Monitoring

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Abstract— **The project is concerned with the design and motion control of a radio- controlled, multi-link and free swimming biometric robot fish based on an improved kinetic propulsive model. The performance of the robot fish is determined by the fish's both morphological parameters and kinematic parameters. By ichthyologic theories of propulsion, a framework taking into consideration of both mechatronic constraints in physical realization and feasibility of control methods is presented, where multiple linked robot fish propelled by a flexible posterior body and an oscillating tail fin can be easily developed. The motion control of robot fish is divided into speed control and orientation control. The speed of swimming fish can be adjusted by changing oscillating frequency, oscillating amplitude and the length of oscillatory part, respectively, and its orientation is tuned by different joint's deflections. By using the sensors obstacle avoidance is done. Sensors will sense the object and give the signal to the motor and the robot will eventually move away. The working model of it has been fabricated and tested.**

Keywords—arduino controller, servo motor, gain IR sensor, polystrene, camera, execution time, scheduling policy.

I. Introduction

Introducing a robot fish that is able to swim and recognize tank edges and obstacles. Find out how it can easily create it with common insulating material and a few servo motor controlled by Arduino. Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins which allow the user to attach various extension boards.

Using wireless camera is interface with fish robot use to surveillance purpose and monitoring purpose. In this wireless cam are connect to PC or TV.

The size of the robotic fish is designed as 35cm length, 18cm height,10cm width and 1.500 grams weight respectively. In the prototype servo motor 3 could act as the motorized tail. For the fish body it used common polystyrene as the one used as insulating material for walls. Inexpensive, very robust and lightweight: it floats easily and is easily moldable. Great deal to make fish's swimming more realistic, it need three joints between the trunk and the caudal fin. As actuators it have chosen of common modeling servos small, powerful enough and easily controlled by a microcontroller.

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The servos are ideal because with them it can manage the movement of a small shaft connecting all segments of the fish, varying at will the position, even a few degrees.

The fish body is divided into a central part and three parts, each of which moved by a servo. The caudal fin is made with plastic recycled from supermarket goods packages. The flexibility of the fin allows it to give more realism to movement. To obtain harmonic motion, each part is attached to the next by a servo: the body of the servo should be glued on a body segment while the servo arm (connected to the shaft) shall be glued on the next.

II. Hardware Description

Arduino microcontroller

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.x) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. The Nano was designed and is being produced by Gravitech.

The ATmega168 has 16 KB of flash memory for storing code (of which 2 KB is used for the boot loader); the ATmega328has 32 KB, (also with 2 KB used for the boot loader). The ATmega168 has 1 KB of SRAM and 512 bytes of EEPROM (which can be read and written with the EEPROM library); the ATmega328 has 2 KB of SRAM and 1 KB of EEPROM.

The Arduino Nano can be programmed with the Arduino software (download). Select "Arduino Diecimila, Duemilanove, or Nano w/ ATmega168" or "Arduino Duemilanove or Nano w/ ATmega328" from the Tools > Board menu (according to the microcontroller on board).

The ATmega168 or ATmega328 on the Arduino Nano comes preburned with a boot loader that allows it to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol.

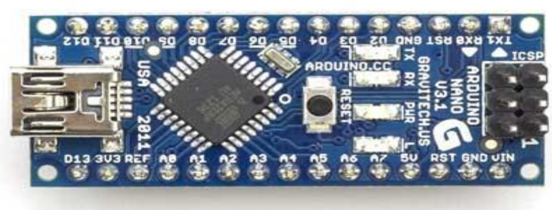

Fig. 1. Arduino Microcontroller

A. IR sensor

The IR Sensor-Single is a general purpose proximity sensor. Here it uses it for collision detection. The module consists of an IR emitter and IR receiver pair. The high precision IR receiver always detects a IR signal. The module consists of 358 comparator IC. The output of sensor is high whenever it IR frequency and low otherwise. The on-board LED indicator helps user to check status of the sensor without using any additional hardware. The power consumption of this module is low. It gives a digital output.

A black absorbing layer on the hot junctions transforms the incoming radiation into heat. A voltage proportional to the radiation is generated by the thermoelectric effect. The used thermopiles are processed on 400 mm silicon substrates using BiSb and NiCr for the thermo junctions. For different radiation spectra various filters are available to get the optimal solution. Easy and accurate measuring of the sensor temperature can be done with a built-in temperature sensor (only for type SMTIR9902).

The important features of IR sensor are High accuracy, High sensitivity (110 V/W), Low resistance (50 kohm).Very good signal-to-noise-ratio, and Good response time (40 ms) Low cost thin film technology, Easy and accurate measuring of the sensor temperature by means of a built-in temperature sensor (SMTIR9902).

B. Battery

Fig. 2. 7.4 V Li-Ion rechargeable battery

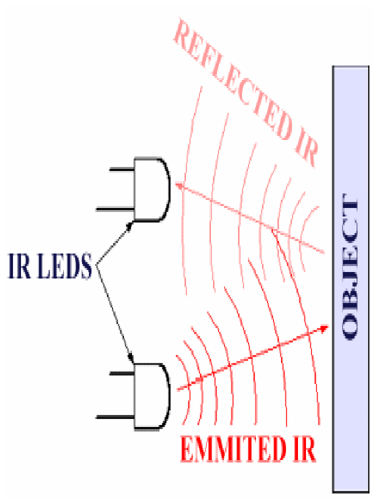

Fig. 3. IR Sensor

The important features of rechargeable battery High quality 7.4 V Li-Ion rechargeable battery pack, Made of 6 2200mAh cylindrical 18650 cells PCB and poly switch for full protection Light weight and higher energy density than any rechargeable battery, No memory effect and rechargeable, Longer storage life than NiMH battery, It can build 14.8V/6.6 ready battery module in parallel, Built-in IC chip will prevent battery pack from over charge and over discharge and prolongs battery life, Perfect for building 7.2V battery pack for bike lighting, RC toy (cars and airplanes), robots, cameras, DVD external battery.

C. Servo motor

The servo motor use PWM signal for controlling the DC motor; unlike normal PWM usually used in ordinary DC motor; this PWM signal is not use for controlling the rotation speed, instead it is use for controlling the motor direction or position. Most servo motor will work well on 50 Hz of PWM frequency; this mean the PWM signal should have a period of 20ms. The electronic circuit inside the servo motor will response to the PWM signal width; the 0.7ms to 1ms PWM width will make the servo motor to turn clockwise (CW), the 1.7ms to 2ms PWM width will make the servo motor to turn counterclockwise (CCW). For the standard servo the 1.5ms PWM width will turn the servo motor to its center.

Fig. 4. Servo Motor

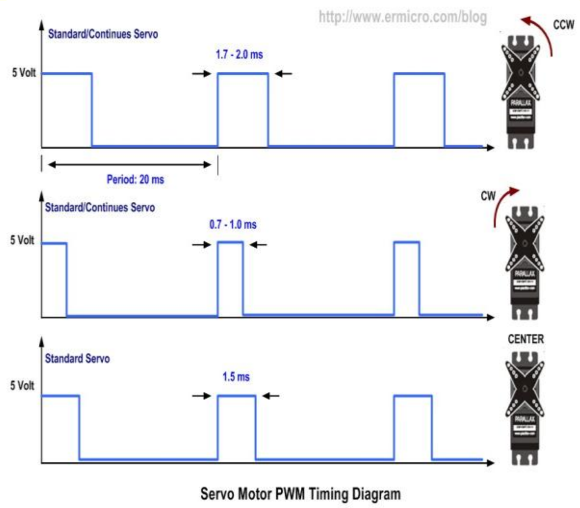

Fig. 5 PWM Timing Diagram

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The exact PWM width is depend on the servo motor types and brands; on this tutorial it will use the Parallax Continues Servo which using 1ms and 2ms respectively. The Parallax servo motor consists of three wires colored with White, Red and Black. The Red and Black wires go to the Vcc and Gnd, while the White wire is use to feed the PWM signal from the PIC 16F690 microcontroller I/O port.

Driving the servo motor using PIC 16F690 microcontroller might be simple as it thing at the first time; it just use the PIC PWM peripheral to do the job (it could learn of how to use the PIC PWM peripheral on the article H-Bridge Microchip PIC Microcontroller PWM Motor Controller posted on this blog), but looking at the PIC 16F690 datasheet with the 8 Mhz of internal frequency clock (use in this tutorial) and using maximum prescalar of 16 (TIMER2) the minimum PWM frequency it could achieve can be calculated using this formula:

PWM period = [(PR2 + 1)] x 4 x Tosc x (TMR2 prescalar value) second

Using maximum PR2 register value of 0xFF (255 decimal), it will get this result:

PWM period = (255 + 1)x4 x(1/ 8000000) x16= 0.002048s
PWM frequency =1/PWM period =1 / 0.002048 =488.28 Hz

D. *Camera*

Wireless Small size spy camera for Surveillance and robotics. The very small size and low power operation makes it useful for mounting on wireless robots to transmit the video to receiver.

Wireless Small size spy camera for Surveillance and robotics. The very small size and low power operation makes it useful for mounting on wireless robots to transmit the video to receiver. The received signal can then be directly seen in to tv or in pc through TV Tuner or Video Capture Card. For Laptops USB TV Tuners can be used.

The important features of camera are very small size, low power consumption, inbuilt microphone, also transmits audio along with video, RF receiver included in package, range upto 25 feet in open space, auto gain and white balance control, camera working voltage from 5v to 12v, all cables and connectors required are included, video can be taken to PC through video capture/TV tuner for image processing.

Fig. 6 Spy Camera

III. TESTING

The first, Servo Write Microseconds, allows it to set the position of the servo command by specifying the length in microseconds. The value in this case should be between 1,000 and 2,000 µs. The midpoint of 1500 corresponds to the neutral position respect the shaft line. The second statement, Write, allows positioning by specifying the angle in degrees: the value of the angle must be between 0 and 180°, 90° intermediate value corresponding to the neutral position of the servo.

The value of the i variable together with that of phase, determines the position of the servo motors. This value is referred to a full 360° loop and then must be offset, keeping in mind the neutral position of the servo, of the potential shift and that of the maximum deflection it want to give to the movement.

The latter is defined by the variable max Defluxion (decimal degrees) and defines the maximum deflection of each stroke: the higher this value, the wider will be the movement of the three trunks of the fish.

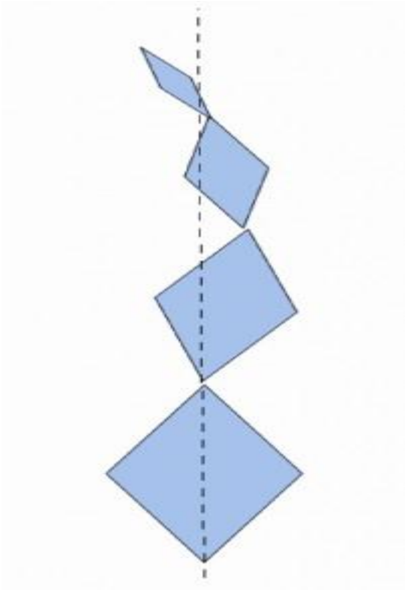

Fig. 7 left movement

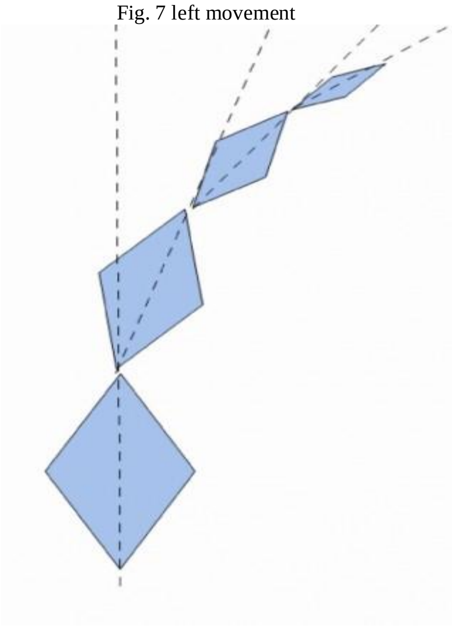

Fig. 8 right movement

With phase set to 0 mail all the servo will move along; increasing this value introduces a phase shift between the servo positions. As a result it will get a movement that is similar to the letter S, the more pronounced the greater the value of phase is.

Before testing the robot into water it must carefully check every mechanical and electrical connection. Turn the fish on and control the movements and ensure that both sensors provide signal to the Arduino. Use a multimeter to measure the voltage on their output: At this point we're ready to waterproof the robot: there are many solutions, it have introduced the robot in a plastic bag (breathe inside to see if it has holes and seal it with duct tape). Use rubber bands to keep the bag lying close to the body of the robot and make sure the servo are free to move. The swim will take place in surface water: it'll probably have to weigh down the robot with sufficient weight to keep it at the correct height. As mentioned above, in our prototype, it added like 460 grams. Once the robot floats in the right way it can turn it on by placing the small magnet and let him sinuously swim in digital freedom.

IV. Design

For the fish body it used common polystyrene as the one used as insulating material for walls. Inexpensive, very robust and lightweight: it floats easily and is easily moldable.

To make fish's swimming more realistic, it need two joints between the trunk and the caudal fin. As actuators it have chosen of common modeling servos: small, powerful enough and easily controlled by a microcontroller. The servos are ideal because with them it can manage the movement of a small shaft connecting all segments of the fish, varying at will the position, even a few degrees. The fish body is divided into a central part and tail parts, each of which moved by a servo. The caudal fin is made with plastic recycled from supermarket goods packages.

The flexibility of the fin allows it to give more realism to movement. To obtain harmonic motion, each part is attached to the next by a servo: the body of the servo should be glued on a body segment while the servo arm (connected to the shaft) shall be glued on the next. Robot fish able to view record by using wireless camera.

V. Conclusion

Thus the autonomous fish robot is a radio-controlled, multi-link and free-swimming biomimetic robot fish based on an improved kinematic propulsive model. Within a systematic framework taking account of both mechatronic constraints and hydrodynamic characteristics, the detailed design method was proposed. The basic motion control laws for speed control and orientation control were then presented. Several kinds of robot fish prototypes with different functions were designed and built to validate the presented method

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