Articulated snake with servomotors, Bluetooth control and obstacle sensor

Universidad Ricardo Palma
Professional School of
Mechatronics Engineering

Electronic Circuits
Semester: 2023-I

Authors' Names : Chong Maza, Edson; Curioso Huaita, José; Macetas Mondragón, Leonardo; Mendoza Mantilla, Piero; Rojas Mallqui, Bruce
Professor : Ing. Javier Rivas León

.

***Resumen* — Este documento presenta un robot de serpiente basado en Arduino controlado mediante Bluetooth y reconocimiento de voz. Se tiene como objetivo brindar una solución para el rescate de vidas humanas, ante un desastre natural, ya que este robot serpiente será capaz de movilizarse entre los escombros y zonas de difícil acceso. Este robot consta de 16 servomotores, 2 motores de alto torque, PLA para estructura 3D, Arduino Nano, Módulo Bluetooth. La serpiente contiene 7 segmentos unidos por servomotores y soportes metálicos. Los servos son controlados por Arduino Nano y alimentados por una fuente de alimentación conmutada de 5V/10A. La serpiente también podrá moverse de manera autónoma.**

Palabras Clave - robot, serpiente, servomotores, Bluetooth.

***Abstract* — This paper presents an Arduino-based snake robot controlled via Bluetooth and voice recognition. The objective is to provide a solution for the rescue of human lives, in the face of a natural disaster, since this snake robot will be able to move among the rubble and areas of difficult access. This robot consists of 16 servo motors, 2 high torque motors, PLA for 3D structure, Arduino Nano, Bluetooth Module. The snake contains 7 segments joined by servomotors and metal supports. The servos are controlled by Arduino Nano and powered by a 5V/10A switching power supply. The snake will also be able to move autonomously.**

Keywords - robot, snake, servo motors, Bluetooth.

I. INTRODUCTION

Autonomous mobile wheeled robots constitute the major part of ground transportation vehicles. For inspection and rescue work in dangerous places, there is now a common need: mobile robots that are able to move through the collapsed debris and that can pass through small crawl spaces.

Snakes are animals that have unique capabilities to move in a wide variety of terrains, where humans are not capable of, therefore, they can monitor and capture those terrains that humans are not capable of. Unlike robots with moving mechanisms with wheels or legs, this one is designed with sensors and servomotor controller for better locomotion.

In order for this robot to function as a real snake, it is built by gear motors and several servomotors that will make the "S" movement. Therefore, the robot has a degree of curvature of 90° on one side and 90° on the other side, in addition to allowing the robot the ability to be flexible.

On the other hand, the snake's movement is determined by Bluetooth control and the use of the voice sensor. This gives the robot the ability to move forward, backward, left, right, up and sideways.

The robot can be used in various applications, such as search, rescue responsibilities, fire detector and with the help of a camera, know which areas are limited to inspect (either by a collapsed structure or a dangerous environment where people or some conventional machines cannot access or operate).

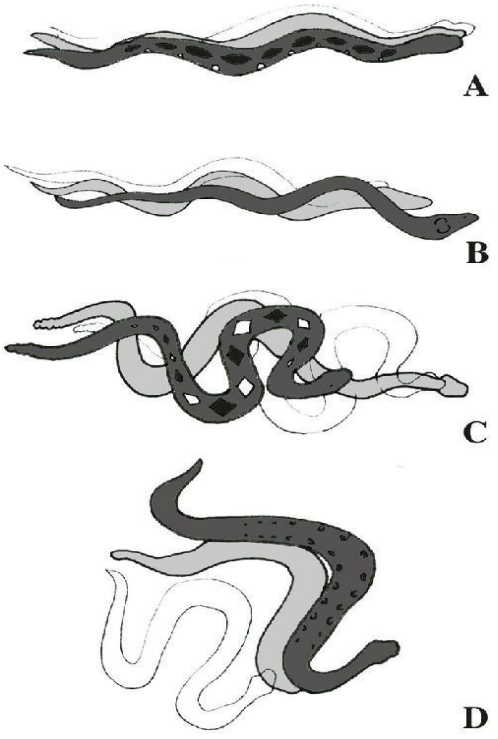


Figure 1 Movement of snakes A) Rectilinear of caterpillar e.g. rainbow boa, B) Serpentine e.g. king cobra, C) Accordion e.g. rattlesnake, D)Sideways strike e.g. desert viper [1].

II. MATERIALS AND METHODS

A. Mechanical design

The snake robot has been designed in Autodesk Inventor and Fusion 360 software. It has a 3D structure. In addition, the design allows servo motors to be attached to each of the 7 segments and operate separately. Each part is attached with bolts and nuts. At the end of the prototype, there is a camera module that would be connected via the ESP-32 Wi-Fi to be able to inspect the environment.

Figura 2. Módulo de cámara OV2640

B. Electronic design

For the electronic part, we will use the Arduino Nano microcontroller that connects to the 5V switch source, 10 dual-axis geared motors for the movement of the robot, an OV2640 camera module for the robot to visualize in real time and not collide with any obstacle that is presented, a Bluetooth module, an L298N driver to control the yellow geared motors, 10 medium-power servomotors for the oscillatory movement and the I2C protocol to control the servos.

TABLE I. SELECTED COMPONENTS

N°	Tabla		
	Componentes	***Modelo***	***Alimentación***
1	Módulo Bluetooth	HC-06	5V
2	Arduino	Nano	5V
3	Driver Motor DC	L298N	9V
4	Controlador de Servos I2C	PCA9685	3.3 - 6V

Figure 3. Robot circuit

C. Mechatronic system

Figure 4. The sequence of the snake's movement is shown in Figure 4.

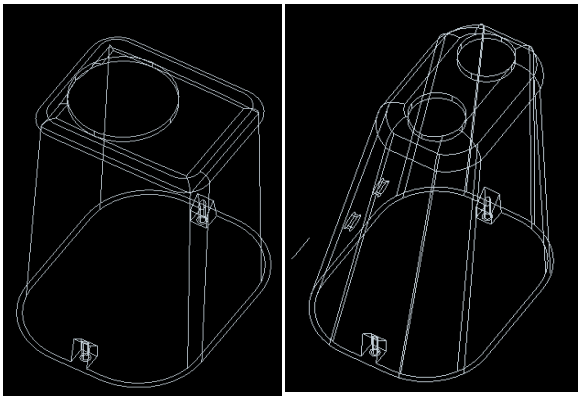
Figure 4. Final implementation of the robot locomotion based on serpentine motion.

D. The implemented prototype is shown in the following image:

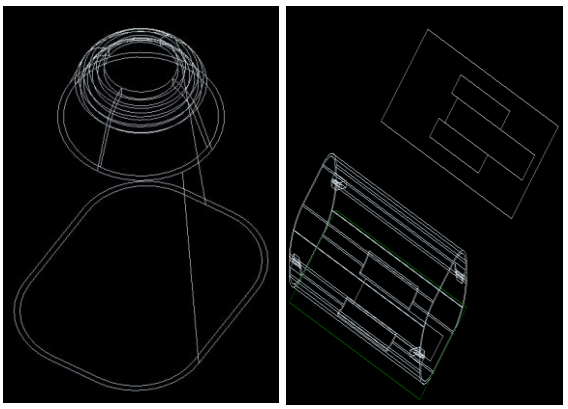
III. CHARACTERISTICS

A. *Mechanical structure*

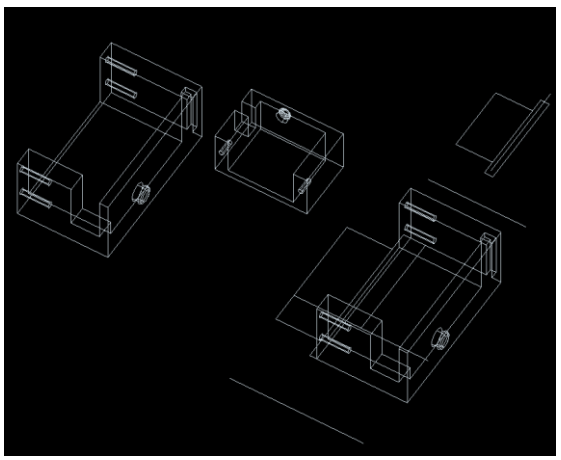
The mechanical design of the robot was made on Inventor with the purpose of being implemented using PLA filament and it will be manufactured with the help of a 3D printer. It is also composed of 7 segments, the head, the tail and 8 joints.



a) b)



c) d)



e)

Figure 5. Mechanical design in Autodesk Inventor

B. *Control y Hardware*

Figure 6 shows the functions of the control knob where the buttons are located. These allow us to change the direction and control the joints in X-space and Y-space.

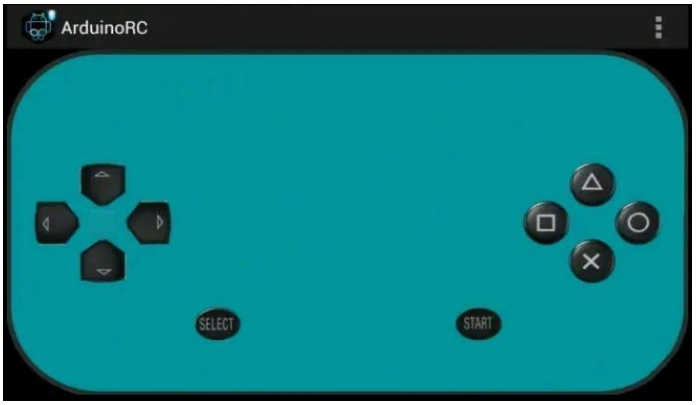


Figure 6. Function control knob

IV. DEVELOPMENT AND ANALYSIS

A. *Robot description*

We propose the design of a snake robot capable of getting into the debris of a natural disaster and thus detect human presence.

Figure 7. OV2640 camera

B: Programming in Arduino IDE

For the servo motors programming that can make turns as articulations in the trajectory of the snake and avoid any collision with objects, the following code was used in Arduino.

```
unsigned int pos0=172; // ancho de pulso en cuentas para pocicion 0°
unsigned int pos180=565; // ancho de pulso en cuentas para la pocicion 180°

void setup() {

 Serial.begin(9600);
 bt.begin(9600);
 pinMode(5, OUTPUT);
 pinMode(6, OUTPUT);
  servos.begin();
  servos.setPWMFreq(60);


}
void setServo(uint8_t n_servo, int angulo) {
  int duty;
  duty=map(angulo,0,180,pos0, pos180);
  servos.setPWM(n_servo, 0, duty);
}
```

Figure 8. Program in Arduino IDE

```
unsigned int pos0=172; // ancho de pulso en cuentas para pocicion 0°
unsigned int pos180=565; // ancho de pulso en cuentas para la pocicion 180°

void setup() {

 Serial.begin(9600);
 bt.begin(9600);
 pinMode(5, OUTPUT);
 pinMode(6, OUTPUT);
  servos.begin();
  servos.setPWMFreq(60);


}
void setServo(uint8_t n_servo, int angulo) {
  int duty;
  duty=map(angulo,0,180,pos0, pos180);
  servos.setPWM(n_servo, 0, duty);
}
```

Figure 9. Arduino program for the turning control for the snake robot.

V. FINAL ROBOT

Figure 10. Snake body

Figure 11. Control unit (Arduino, controller and modules).)

VI. OBSERVATIONS AND CONCLUSIONS

This paper describes the design and features of the prototype snake robot. The most important features are the joint mechanism with servo motors, the Bluetooth module to receive the motion commands and provide them to the microcontroller, and the Arduino Nano that powers all sections of the robot.

The snake prototype has 2 types of motors in general to obtain the movement of the snake and move in a straight line.

By modifying the design and adding more components, the implementation of this robot can be used in other areas of research..

REFERENCES

[1] Jiménez, Juan & Montes-Correa, Andrés & Vergara-Ríos, Danny & Arévalo-Páez, Miguel. (2019). Serpientes, del mito a la realidad. 11. 1-20.

[2] Transeth, Aksel & Leine, Remco & Glocker, Christoph & Pettersen, K.Y.. (2008). 3-D Snake Robot Motion: Nonsmooth Modeling, Simulations, and Experiments. Robotics, IEEE Transactions on. 24. 361 - 376. 10.1109/TRO.2008.917003.

[3] Bastías, A. (2017). *Sistema de asistencia en rescate mediante robot movil.*

[4] Kristin Y. Pettersen, ØyvindStavdahl and Jan Tommy Gravdahl, "Snake Robot Locomotion in Environments with Obstacles", IEEE/ASME Transactions on Mechatronics, vol. 17, no. 6, pp. 1158-69, December 2012.

[5] Pal Liljeback, Kristin Y. Pettersen, Oyvind Stavdahl,Jan Tommy Gravdahl, "Snake Robot Locomotion in Environments with Obstacles",IEEE/ASME Trans.On Mechatronics, December 2012, Vol. 17, No. 6,Pg. 1158-1169

[6] Renjifo, J. M. & M. Lundberg. 1999. Guía de campo anfibios y reptiles de Urrá. SKANSKA. 96 p.

[7] Borenstein, Johann, Hansen, Malik y Nguyen, Hung. (2006) The OmniTread OT-4 Serpentine Robot for Emergencies and Hazardous Environments. International Joint Topical Meeting: Sharing Solutions for Emergencies and Hazardous Environments, Febrero

[8]] S. A. Fjerdingen, J. R. Mathiassen, H. Schumann-Olsen, and E. Kyrkjebø, ''Adaptive snake robot locomotion: A benchmarking facility for experiments,'' in European Robotics Symposium 2008, vol. 44, 2008, pp. 13 -- 22.

[9] T.Kamegawa, T.Yamasaki, H.Igarashi and F.Matsuno. Development of the snake-like rescue robot "KOHGA". IEEE International Conference on Robotics and Automation, pp.5081-5086, 2004.