Spider Robot: Kumo

Koralie Porcel

***Abstract*—Multilegged-robots require coordination in order move properly. In this paper, we are taking a look at a tripod movement coordination for a hexapod robot and the behavior in an environment with obstacles.**

***Index Terms*—Arduino, multilegged-robot, object detection, spider-robot**

I. Introduction

In nature, we can find all kinds of terrain: rocky, uneven, flat, with or without obstacles and stairs. The advantage of using a hexapod robot [1] is that it is stable to move in different environments and reach precise points. Properly used, hexapod robots can be pioneers in many fields such as surveillance, collection of samples in distant places, research during disasters, etc.

In this article it is presented the operation of a spider robot made during a school project.

II. The Spider Robot

A. General form

The Spider is a robot that can move in fourth directions autonomously while detecting and avoiding obstacles in its path.

B. Shape

Figure 1: Spider Robot

As we can see with the figure 1, the Spider is a hexapod robot with eighteen servomotors TD-8135MG [2]. At each leg there are three 180° servomotors, and each have three axes of rotation. The overall shape of the robot is a non-regular polygon with six sides. This shape was chosen so that the Spider's legs don't get too bothered during movement.
The robot was completely modeled and simulated in 3D on Fusion 360 [3]

Each leg has five components that connect the servomotors together.

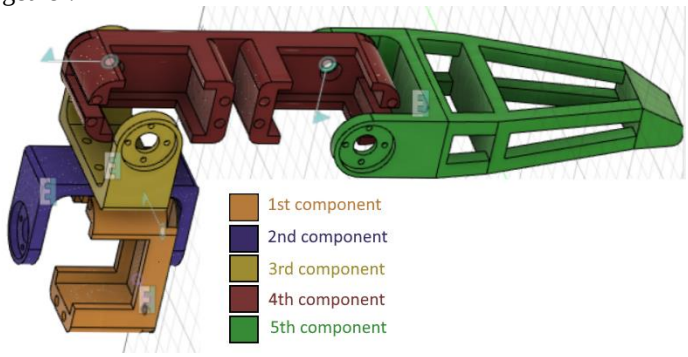

Figure 2: Representation of a leg

On figure 2, the first component is connected to the body of the Spider and allows the fixing of the first servomotor whose axis is horizontal. We add a hole on the other side of the axis of the servomotor to allow a better hold during the rotation. In addition, there are two holes along the entire length to allow the cables of the servomotors to go through.
The second component is connected to the axis of the first servomotor and on the other side of this axis, there is a hole to allow the better hold. The holes in part 1 and 2 are connected by a cylindrical nylon spacer. When this servomotor rotates, this will cause this part to rotate.
The third component is the same as the second one. It is connected to the second piece with screws and to the second servomotor by its axis of rotation and the nylon spacer.
The fourth component is a beam which allows the fixing of the last two servomotors. It has a hole all along to allow the cables of the third servomotor to fit in.
The fifth component allows the rotation of the axis of the third servomotor and contains the end of the leg.

The six legs were printed using a PRUSA 3D printer [4] in PETG [5]. Each leg took 12 hours to be printed.
The body of the Spider is made in aluminium 2mm. There are 4 faces that are holding with metal square and screws. The aluminium was machined using a manual metal shear [6] for exterior cut-outs and a water jet cutter [7] for interior cut-outs. A hacksaw was used to cut the square to size.
There are holes on the top face to allow the robot to be as light as possible.

K. PORCEL student at Université Côte d'Azur Polytech Nice Robotics and autonomous systems 06410 BIOT (koralie.porcel@etu.unice.fr)

At the end of each leg, there is an anti-slip material to allow a better adhesion with the ground and therefore not to slip.

C. *Electronic functioning*

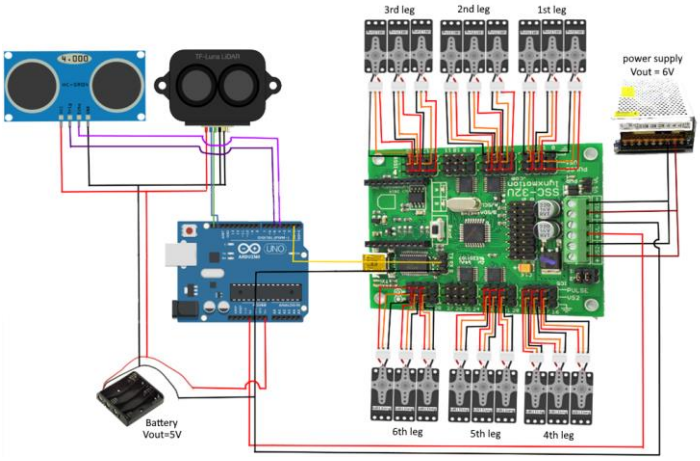

Figure 3 : Electrical diagram of the robot

As we can see on figure 3, a Mega SSC-32U [8] board is used to control the eighteen servo motors.
The Mega board is controlled by an Arduino Uno board [9]. These two cards are connected in series with the RX and TX of the two cards [10].
The Spider has two distance sensors: the HC-SR04 [11] module and the LIDAR TF-Luna [12].
These two sensors are controlled by the Arduino board.
There are 2 power supplies for the robot:
-The servomotors of the robot are powered with a power supply that outputs 6V and 20A.
-The control cards and the sensor are powered with a 5V battery pack.

D. *Spider movement*

The Spider is autonomous, it can move forward, backward, turn left and right [13]. It has a tripod movement. This means that during the movement, the Spider always has 3 points of contact with the ground.
This is not the case with real Spiders which have bipodal movement. However, it is more efficient and more practical for robots to move on a tripod because the legs don't have enough grip for it to be more optimized and the balance is better.
A simulator is used to understand to understand how the move is done [14].
The Spider's code is made on Arduino [15]. The movement is done using a list that contains all the positions of the angles of the eighteen servomotors. Values change to allow to move in the fourth directions using multiple specified conditions. The movement is cut according to what the user wants and at the speed he wants.

E. *Obstacle detection*

The Spider uses two different distance sensors because they have complementary advantages:
-the HC-SR04 module is an ultrasonic sensor that detects transparent obstacles in dark light but can't detect complex shapes.
-the TF-Luna LIDAR is an infrared sensor that can detect complex shapes and is more precise than the first sensor but can't detect transparent obstacles.
The use of two sensors makes it possible to compensate for the negative points of the two technologies and to have a better precision.
Every six seconds, the Spider will turn left then right and come back to the middle. During this movement, it will record the distance to the nearest obstacle using the two sensors. Then using a case disjunction, depending on whether there is an obstacle on the sides and or in front, it will turn more or less to avoid the obstacle.

III. Conclusion

I have made a hexapod Spider robot with eighteen servomotors of 180° of freedom and three axes of rotation that can move in fourth directions and can detect obstacles at an angle of 150° in front of the Spider and avoid them using two distance sensors.
This project is a great introduction to the moving of a hexapod Spider in a 3D complex environment. It can be found on GitHub [13].

References

[1] Hexapod robot : https://en.wikipedia.org/wiki/Hexapod_(robotics)
[2] Servomotor td-8135mg : https://www.racing-power-boat-rc.com/produit/radio-servo/servo/servo-etanche-td-8135mg-35kg/
[3] Fusion360 : https://www.autodesk.fr/products/fusion-360/overview?term=1-YEAR&tab=subscription
[4] Prusa printer : https://www.prusa3d.com/fr/categorie/original-prusa-i3-mk3s/
[5] PETG: https://www.3dnatives.com/plastique-petg-18122019/
[6] Manual metal shear : https://www.optimachines.com/cisailles-manuelles/9534-cisaille-manuelle-metallkraft-ftbs-1050-10.html
[7] Water jet cutter: https://www.techniwaterjet.com/how-it-works/#:~:text=Waterjet%20cutting%20is%20simply%20an,object%20in%20place%20for%20cutting.
[8] SSC-32u : https://www.instructables.com/Controlling-Servos-Using-the-SSC-32-Servo-Controll/
[9] Arduino Uno : https://store.arduino.cc/products/arduino-uno-rev3?gclid=EAIaIQobChMI7OHP-fKS_wIVEsjVCh2ncwSOEAQYASABEgIAy_D_BwE
[10] RX and TX: https://pecquery.wixsite.com/arduino-passion/la-liaison-serie
[11] HC-SR04 : https://www.carnetdumaker.net/articles/mesurer-une-distance-avec-un-capteur-ultrason-hc-sr04-et-une-carte-arduino-genuino/
[12] LIDAR TF-Luna : https://www.lextronic.fr/capteur-de-distance-lidar-tf-luna-59476.html
[13] YouTube video of the spider movement: https://youtube.com/shorts/d3OcA5hZ6ZI
[14] Simulator : https://github.com/mithi/hexapod-robot-simulator
[15] Arduino : https://docs.arduino.cc/learn/starting-guide/whats-arduino
[16] Github : https://github.com/Ilarak/Spider-Robot-KUMO

K. Porcel. Born in Antibes, 2003, enrolled for the CPI at Université Côte d'Azur Polytech Nice and is currently studying robotics at the same school.