UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

Colegio de Ciencias e Ingenierías

Diseño y construcción de una mano robótica inalámbrica con sensores flex

.

Proyecto de investigación

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Ingeniería eléctrica y electrónica

Trabajo de titulación presentado como requisito
para la obtención del título de
Ingeniero Electrónico

Quito, 23 de mayo de 2017

UNIVERSIDAD SAN FRANCISCO DE QUITO USFQ

COLEGIO DE CIENCIAS E INGENIERÍAS

HOJA DE CALIFICACIÓN
DE TRABAJO DE TITULACIÓN

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Quito, 23 de mayo de 2017

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RESUMEN

En este trabajo, se diseña una mano robótica con 5 dedos. Ésta es controlada por un guante usado por una persona. El guante tiene sensores flex que obtienen datos mediante la flexión de cada dedo de la mano humana. Estos datos son procesados por un arduino nano. El movimiento de la mano está controlado por servomotores que funcionan como actuadores. La rotación de cada servomotor es controlada por un Arduino uno. La comunicación entre el guante y la mano robótica se realiza a través de la comunicación serial inalámbrica utilizando los módulos de radio Xbee S1. El prototipo de esta mano robótica está destinado para ser utilizado no sólo para la industria y la automatización, sino también para entornos que pueden ser peligrosos para las personas.
Palabras clave: sensor flex, Arduino, servomotor, robotic hand, Xbee

ABSTRACT

In this work, a robotic hand with 5 fingers is designed. It is controlled by a glove that a person wears. The glove has flex sensors that capture data by the bending of each finger of the human hand. This data is processed by an arduino nano. The hand´s motion is controlled by servomotors which work as actuators. The rotation of each servomotor is controlled by an Arduino uno. The communication between the glove and the robotic hand is made through wireless serial communication using Xbee S1 radio modules. The prototype of this robotic hand is intended to be used not only for in industry and automation but also for environments that can be dangerous for people.
Key words: flex sensor, Arduino, servomotor, robotic hand, Xbee.

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I. INTRODUCTION

A robotic hand is an electromechanical system consisting of many parts. In this system, the movement is generated by electrical components that provide mechanical drive and control. The way human hand works has been object of research in the medical and engineering field. The system is developed by using the same structure of a human hand, which is the inspiration for robotic hand researches. The human hand has 27 degrees of freedom which allow different grip and posture positions. The tendons, muscles, and stimulus nerves attached to the joints allow gripping to occur. In order to cover a large part of our daily activities, 5-6 different movements are sufficient.

Most of industrial holders usually have two or three fingers. These can perform a single type of clutch, controlled by a single drive. The control and design of such systems can be easy to develop, but their flexibility is not enough. The goal of our project is to improve the hardware environment that will perform the control of five autonomous fingers of a robotic hand, which can be remotely manipulated by glove-wearing people. For the wireless connection between the glove and the hand, Xbee S1 modules will be used. In our project it will be shown that it is possible to mimic human movements simultaneously by using flex sensors. The signal from the sensors are processed in an Arduino nano placed in the glove, and the servo motors are driven by an Arduino uno. In our prototype, 5 degrees of freedom are provided for our system.

II. MECHANICAL DESIGN OF THE HAND

The design of the hand consists of thumb, index finger, middle finger, ring finger, little finger, palm and base structure. The tendons of the robotic hand are made of nylon thread. Each finger is controlled by a single servo motor. All fingers have 3 individual parts except for the thumb which only has 2. The joints are made of a flexy plate. A schematic of the hand is shown in figure 1.

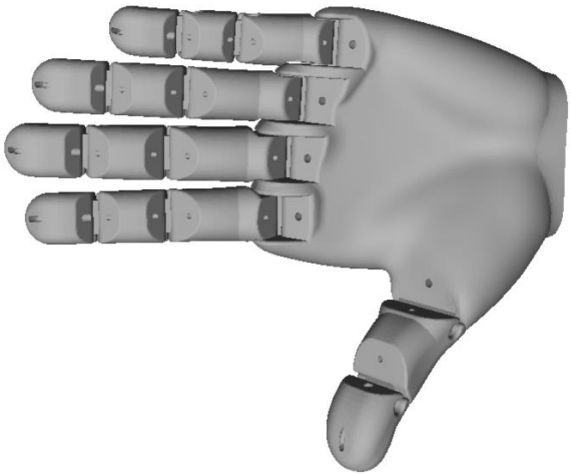

Figure 1: Schematic of robotic hand

The different parts of each finger are show in figure 2.

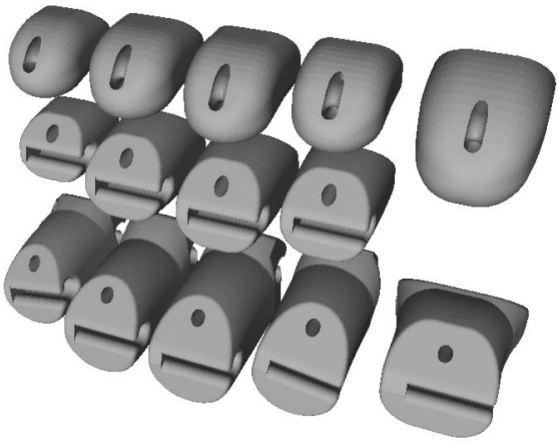

Figure 2: Schematic of fingers

The base structure of the hand is mainly made as a support for the hand and for holding the servo motors. The robotic hand printed and completely assembled is shown in figure 3.

Figure 3: Robotic Hand assembled

III. DESIGN OF THE CONTROL GLOVE

The main components of the control glove are the flex sensors. A flex sensor is a structure that changes it´s resistance with the pressure or bending applied on it. Flex sensors are found in many applications, some of them are the following: robotic design, game consoles, medical devices, etc. Since human fingers can be bent in only one direction, the type of sensor selected is unidirectional. This sensor has a nominal resistance of approximately 10Kohm and 135 Kohm when it is fully bended.

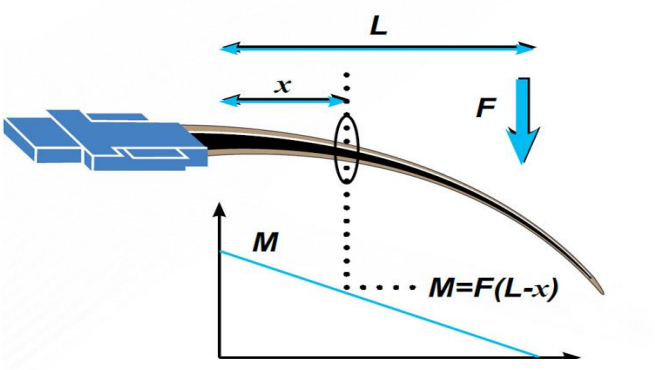

Figure 4: Flex Sensor

It will be seen that it is possible to control the servo motor from 0° to 180°. The sensors are placed in each finger of the glove and soldered to a 15kohm resistance in order to create a voltage divider, which will be then read in the analog pins of the Arduino nano. The pins 2 and 3 of one Xbee module are soldered to the reception and transmission pins of the Arduino nano respectively. Pins 1 and 5 of the Xbee are soldered to the 3.3V and gnd pins of the Arduino nano respectively. A schematic of the connections in the glove is show in figure 4

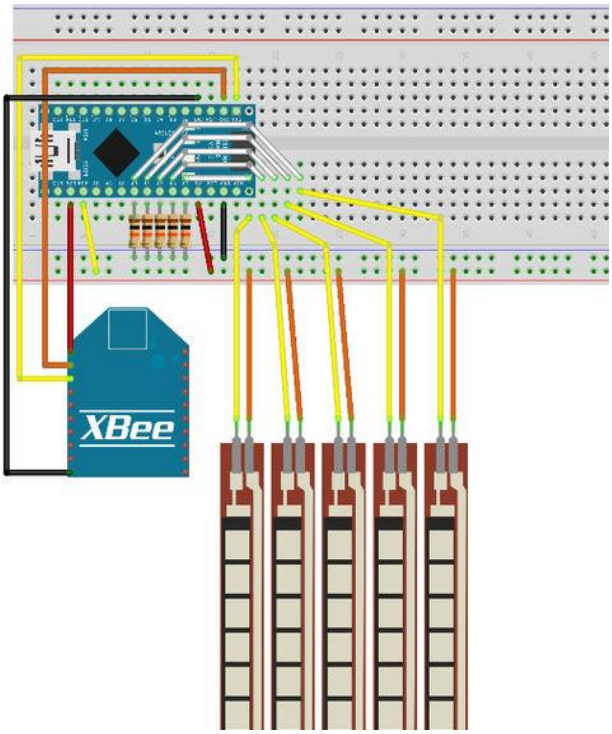

Figure 5: Connections of the control glove

IV. XBEES CONFIGURATION AND ARDUINO PROGRAMMING

Xbees can be configured in multiple ways, but for our project they are configured as radio modules. For the configuration, XCTU program is used. The 3 main settings are PAN ID, destination address high and destination address low. Both Xbees (transmitter and receiver) are required to have the same PAN ID since they share an exclusive area network. The destination address high is the same for all Xbees S1 (13A200) while the destination address low is different. Each Xbee need to be configured with the address from the other module so the transmission module has the address low from the receiver and vice versa. The programming of the Arduino nano which is placed in the control glove is shown below.

Easy transfer library is used for the serial communication between the two arduinos. As can be seen, the values of the voltage divider composed by the flex sensor and the 15Kohm resistance are read in the analog ports of the Arduino. Then, these values are mapped between 0-179 which is the range of rotation of each servo in the robotic hand. These values are finally sent through Xbee module by using serial communication.

```
#include <EasyTransfer.h>
EasyTransfer ET;

const int potpin1 =0;
const int potpin2 =1;
const int potpin3 =2;
const int potpin4 =3;
const int potpin5 =4;


struct SEND_DATA_STRUCTURE{
int servo1val;
int servo2val;
int servo3val;
int servo4val;
int servo5val;

};

SEND_DATA_STRUCTURE txdata;

void setup(){
  Serial.begin(9600);

  ET.begin(details(txdata), &Serial);
}

void loop(){

  int val1 = analogRead(potpin1);
  int val2 = analogRead(potpin2);
  int val3 = analogRead(potpin3);
  int val4 = analogRead(potpin4);
  int val5 = analogRead(potpin5);

  val1 = map(val1, 750, 1023, 0, 179);
  val2 = map(val2, 720, 1023, 0, 179);
  val3 = map(val3, 720, 1023, 0, 179);
  val4 = map(val4, 720, 1023, 0, 179);
  val5 = map(val5, 720, 1023, 0, 179);

  txdata.servo1val=val1;
  txdata.servo2val=val2;
  txdata.servo3val=val3;
  txdata.servo4val=val4;
  txdata.servo5val=val5;

  ET.sendData();
}
```

The programming of the Arduino Uno which is placed in the robotic hand is shown below:

```
#include <Servo.h>
#include <EasyTransfer.h>
EasyTransfer ET;

Servo Serv1, Serv2, Serv3, Serv4, Serv5;

struct RECEIVE_DATA_STRUCTURE{
  int servo1val;
  int servo2val;
  int servo3val;
  int servo4val;
  int servo5val;
};

RECEIVE_DATA_STRUCTURE txdata;

void setup(){
  Serial.begin(9600);

  ET.begin(details(txdata), &Serial);
  Serv1.attach(9);
  Serv2.attach(8);
  Serv3.attach(7);
  Serv4.attach(6);
  Serv5.attach(5);
}

void loop(){
  if(ET.receiveData()){
    Serv1.write(txdata.servo1val);
    Serv2.write(txdata.servo2val);
    Serv3.write(txdata.servo3val);
    Serv4.write(txdata.servo4val);
    Serv5.write(txdata.servo5val);
  }
}
```

Servo library and easy transfer library are used. First we define the number of servos to be controlled. Then, the values received from the arduino nano are stored in 5 int variables. Finally, using the “attach” and “servo.write” commands the values between 0-179 are sent to the servos through digital pins by PWM. The servomotors used are micro sg 90 which include a two-wire DC motor, gear, integrated circuit and an output shaft. The Arduino will route the servo motor to the specified angular positions by sending a coded signal, this encoded signal will be held on the input line to enable positioning of the servo motor.

V. RESULTS

It has been observed in the tests made that the flex sensors can measure the movements of the human hand smoothly. There are small differences in the motion of the robot hand and the human fingers. This mainly because the arduino read the resistance variation of the elasticity sensor based on the voltage divider principle. The performance of the system can be improved by using instrumental amplifiers and two sensors connected to each finger, but this increases the project budget and the size of the hand. In the first tests of the project, the servos and the arduino were fed by an external power supply in the laboratory. In order to improve the autonomy of the hand, a 2-cell lipo battery with a voltage of 7.4V and a rated current of 1.1A was used. This is more than enough taking into account that each servo consumes between 300 and 400 mA at full power. The grip of the hand is quite acceptable as can be seen in the following figures.

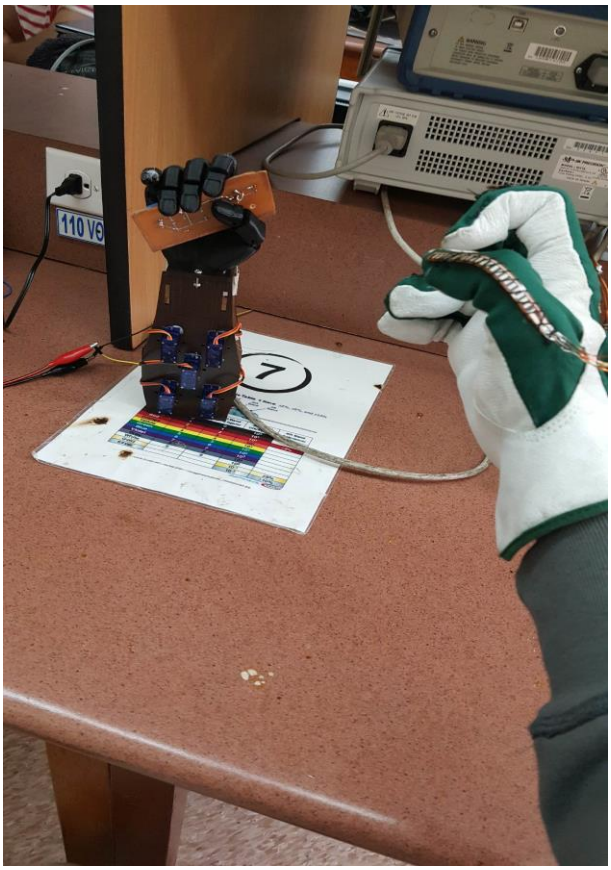

Figure 6: Hand gripping 1

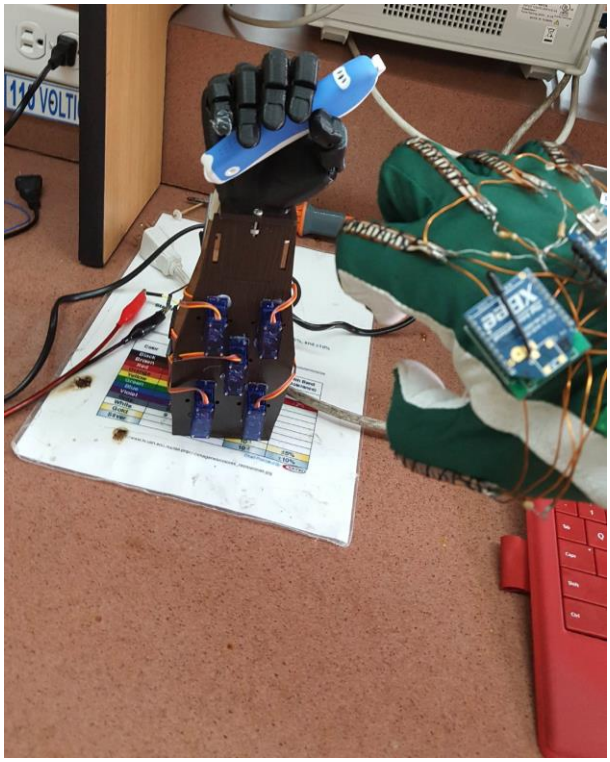

Figure 7: Hand gripping 2

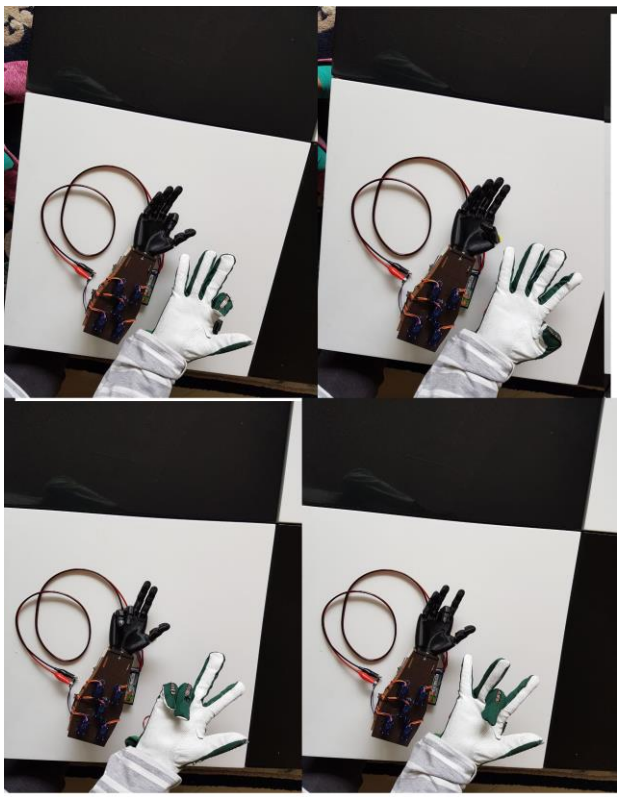

Figure 8: Hand following movements of human hand

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