Artificial Fingernails for a Humanoid Robot

Abstract/Problem Statement

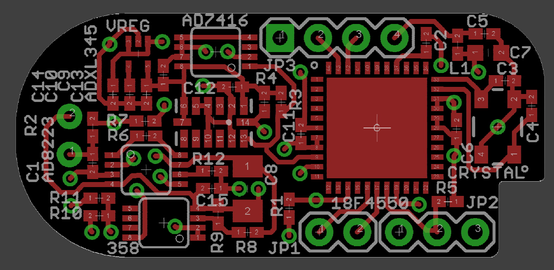
- The ability to scratch objects and surfaces plays an important role in human development and learning. Scratching is facilitated by the sense of touch and the presence of nails. While most animals have some form of nails (or hoofs) this concept does not even exist in robotics.
- The general solution approach is about designing artificial finger nails for a humanoid robot that are suitable for identifying surfaces and material properties of objects simply by scratching them. The nails are equipped with sensors for sound, temperature and accelerations. Aesthetics were important in this project, so miniaturization was a key. The nails fit the three-finger Barrett hands of the Upper-torso humanoid robot in the Developmental Robotics Lab. A printed circuit board was designed to control and read the input of three finger nails per hand at the same time. Finally, control software was written for the finished product and demonstrated a working hardware and software prototype.

Concept Sketch

Technical Details

Hardware Specification:

There is a microcontroller, an accelerometer, a microphone and a temperature sensor on each of the fingers .The microcontrollers transmit data from the sensors via a USB cable that is run along the robot's arm to the computer.



- **Microcontroller:** PIC18F4550 by Microchip was selected based on the number of ports, communication standards(I^2C), speed, memory, power consumption, and size.
- **Accelerometer:** ADXL345 by Analog Devices met the accelerometer requirements which were that it should be small, low-power, digital 3-axis with high resolution and high output data rate and also accessible through an I^2C digital interface.
- **Microphone:** CMA-6542PF made by CUI Inc. has a leveled response across frequencies of interest, is small in size, has a high quality and high sensitivity and low cost was selected for the project.
- **Temperature Sensor:** Analog Devices, part number AD7416 is small, I^2C serial interface compatible and has a fast output rate.

Software Specification:

Additionally, software to log the data from the microcontroller via USB was also created. The software facilitates correlating the data from scratching with movement data logged from a separate movement controlling software. The software parses incoming data and logs it in a delimited format.

Testing

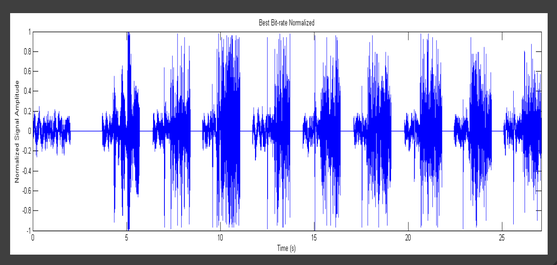
Hardware Testing:

Accelerometer:

A prototype using an Arduino Duemilanove microcontroller and the accelerometer was created. Test data was recorded and processed. The results are shown below.

Microphone:

The analog part of the circuit was breadboarded and analyzed using an oscilloscope. Test data was recorded and is available at http://seniord.ece.iastate.edu/may1026/files/Test_Code/.



Design Requirements

Functional Requirements:

- The nail shall be capable of transmitting vibration to the associated accelerometer for that finger.
- The electronics shall be able to sample vibrations at a minimum of 1000 Hertz.
- The system shall be able receive accelerometer data from 3 accelerometers simultaneously.
- The electronics shall be able to transmit all sensor data to the attached computer via the USB port.
- The electronics and nail unit shall be removable from the robot hand.
- The software shall log the sensor data delimited by sensor and finger.
- The software shall associate time-stamps with each data set.
- The software shall detect what nails are connected.

Nonfunctional Requirements:

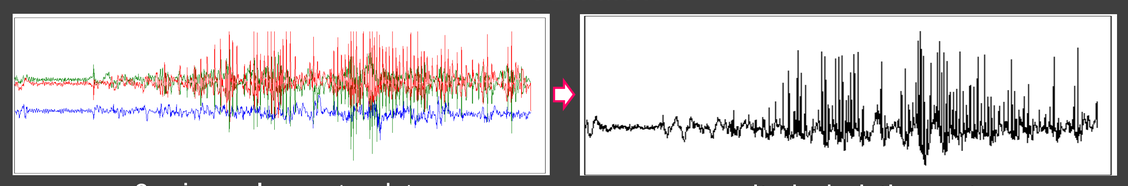
- Nail unit shall look similar to a human nail.
- The electronics shall be integrated into the robot hand such to not limit existing robotic capabilities.
- Microcontroller firmware shall be coded in C.
- Nail shall be detected as a USB device in Linux and Windows.

Results

Accelerometer Results:

The results of the preliminary study is shown below:

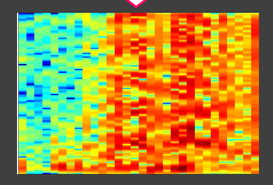
Feature Extraction



3-axis accelerometer data

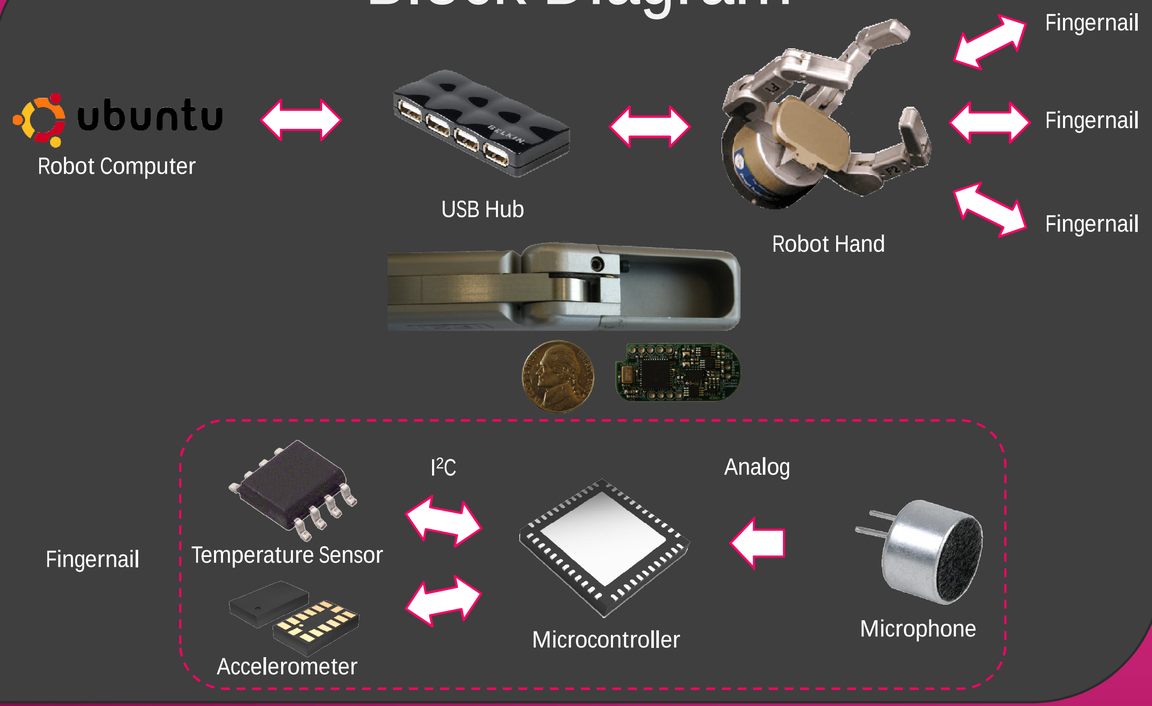
magnitude deviation vector

histogram



spectrogram

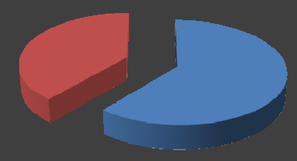
Block Diagram



Resources

Part#	Qty	Price / part	Shipping	Price
Accelerometer	3	6.16	5.37	23.85
Instrumentation Amplifier	2	2.45		4.90
Voltage Regulator	2	1.37		2.74
Voltage Reference	2	1.01		2.02
Crystal Osc (Surface Mount)	2	1.95	5.37	9.27
PIC 2550	4	6.56		26.24
Crystal Osc	10	0.45		4.50
Switch	10	1.04	9.72	20.09
Mic	2	0.81		1.62
Light Sensor	2	2.98		5.96
PIC 18F26J50	2	4.28		8.56
USB Ports	2	2.00	5.02	9.02
Debugger	1	52.49	6.78	59.27
Printed Circuit Board	1	66.00	10.00	76.00
Assembly	1			139.54

Name	Hours
Joseph Coleman	365
Ritika Sahai	232



Summary

By expanding the ability of the humanoid robot to process sensory information, we will allow the robot to more closely emulate the experiences of an infant human. Our design adds a few more sensory inputs to allow the robot to receive additional sensory information from the outside world. These new abilities will be dominant in allowing the robot to emulate the learning processes of an infant human. In being able to emulate more human sensations, the robot will become closer to being able to learn like a human infant.

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