Piezo Micro-Sensor Reader

DESIGN TEAM 1
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Sensor developed by MSU Adaptive Integrated Microsystems Laboratory (AIMLab)

- Accurately records strain data
- Roughly the size of a penny
- Extremely Low Power (1uW)
- Harvests 100% of power from piezo membrane
- this means little to no maintenance
Real World Application

• Concussions among athletes has become a serious area of concern over the last few years
• Implant the sensors into athlete's helmets
• Sensors can predict if a player has suffered a head injury
Interfacing with Sensor

- PFG Sensor
- National Instruments Data Acquisition Device
- Computer Running MATLAB Computational Software
Sensor Pinout

Piezoelectric Floating Gate (PFG) Sensor

- **Piezo +**
- **Piezo -**
- **GND**
- **Digital Out**
- **Analog Out**
- **Erase**
- **Next**
- **Program**
- **Reset**
- **2V**
Design Specifications

- Initiate sensor functions via input/output commands
- Log and organize retrieved data into a universal format
- Voltage applied to sensor must be regulated between 1.8-2.5 V
- Portable design
- Develop a plug-and-play connector that can connect to the 8 sensor pins
Design Solution: Raspberry Pi

Characteristics

- Low Cost Minicomputer ($35)
- 700 MHz CPU
- 512 MB RAM
- General Input/Output Pins
- 2 USB 2.0 Ports
- Programmable in Python or C
Additional Components

4D Systems 3.2” TFT LCD Display
- Resistive Touchscreen
- Developed specifically for Raspberry Pi
- Programmable smart screen

Adafruit 4400 mAh Battery Pack
- 5V @ 1A (13 Hour lifecycle)
- USB port
Material Costs

Total Prototype Cost: $206.42

- Raspberry Pi Module B: $40.00
- 4D Systems 3.2" Touch-screen: $76.27
- 5V, 4400 mAh Battery: $29.95
- Cables and Connectors: $29.95
- 3D Printed Enclosure: $49.20
- Remain: $11.00

$293.58
Prototype Production Overview

1) Power Distribution
2) Software Development
3) Enclosure
1) Power Distribution

- Battery Provides 5 V
- Raspberry Pi pin outputs 3.3 V
- Voltage divider produces 1.8 V – 2.5 V to power the sensor
- Sensor connected via 8-pin ribbon cable

**1) Power Distribution**

2) Software Development

3) Enclosure
2) Software Development

- 4D Systems touchscreen to interface with the Raspberry Pi
- Press function buttons → C – Program → output data to file → Analyze data via Matlab etc.
- Algorithm samples current pin state (logic high/low) and records the value to a file
- Matlab can analyze leading edge of each pulse

1) Power Distribution

2) Software Development

3) Enclosure
Software Flowchart

Software on the Raspberry Pi

Data Analysis on a Matlab enabled computer
Data Acquisition Algorithm

Measurements of each individual sample of the sensor

Total data coming out of the sensor (10K samples)
3) Enclosure

- Digital design create in Siemens NX 8.5 CAD software
- Capable of housing all reader components in a compact design
3) Enclosure

- Printed using Makerbot 3D printer
- Composed of PLA plastic

1) Power Management
2) Software Development

3) Enclosure
Completed Sensor Reader
Customer Requirements Revisited

- Interface with sensor pins
- Log and organize retrieved data into universal format
- Voltage applied to sensor must be regulated between 1.8-2.5 V
- Portable design
- Develop a plug-and-play connector that can connect to the 8 sensor pins
- Wireless access to the Raspberry Pi
Project Conclusions

• The reader is a standalone device that requires fewer components compared to the current method of data acquisition

• More practical for real world implementation

• Device maintains all functionality of its predecessor, but reduces overall size and improves portability

• Promotes future innovation in the health research field
Demonstration