OmniMouse - Piezoelectric Sensor Mouse

ECE 445 Senior Design
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Table of Contents:

Introduction

Objective:

Computing technologies has become an important aspect of daily life for many people across the world, an estimated 3.5 billion people are connected to the internet, and there are likely many more who have access to a computer that is not connected. For those using devices such as desktop or laptop computers, one of the most common ways to interface with a computer is through the use of a mouse. The operating a standard mouse crosses the user's ulna and radius bones and requires repetitive motions such as clicking and moving the device to give input. Over time, these movements can lead to discomfort or permanent damage. This is a result of the repetitive motions that the user undergoes, which leads to strain and microscopic tears throughout the utilized regions [1]. Research has suggested that to minimize these kinds of injuries, one should minimize wrist movement, offload strain to multiple locations, have a light grip, and avoiding positions that prevent proper circulation [2].

Our goal is to create a mouse that minimizes strain and injury for the user through varied non-repetitive motions and lessened hand pressures. We plan to address the various points of stress for using a mouse individually to create a final product that will hopefully help prevent and reduce the prevalence of stress due to computer mouse use.

Background:

The main issues that we want to address are the minimization of wrist movement, strain being offloaded to multiple locations, the use of a light grip, and providing a position that promotes proper circulation. Our design is a stationary mouse with piezoelectric sensors around the base of the mouse, allowing the user to keep their hand in one position, minimizing any wrist movement. Since the mouse is stationary, little grip from the user is needed. Movement input is done through touching the piezoelectric sensors, which causes the mouse cursor to move in the direction of the touch input. This offloads strain to multiple locations since every direction the user goes can be controlled with a different part of the hand. The angle and shape of the mouse will be optimized to provide the user with a neutral resting position while using the device, which allows for the best circulation within the whole arm.

High-level requirements list:

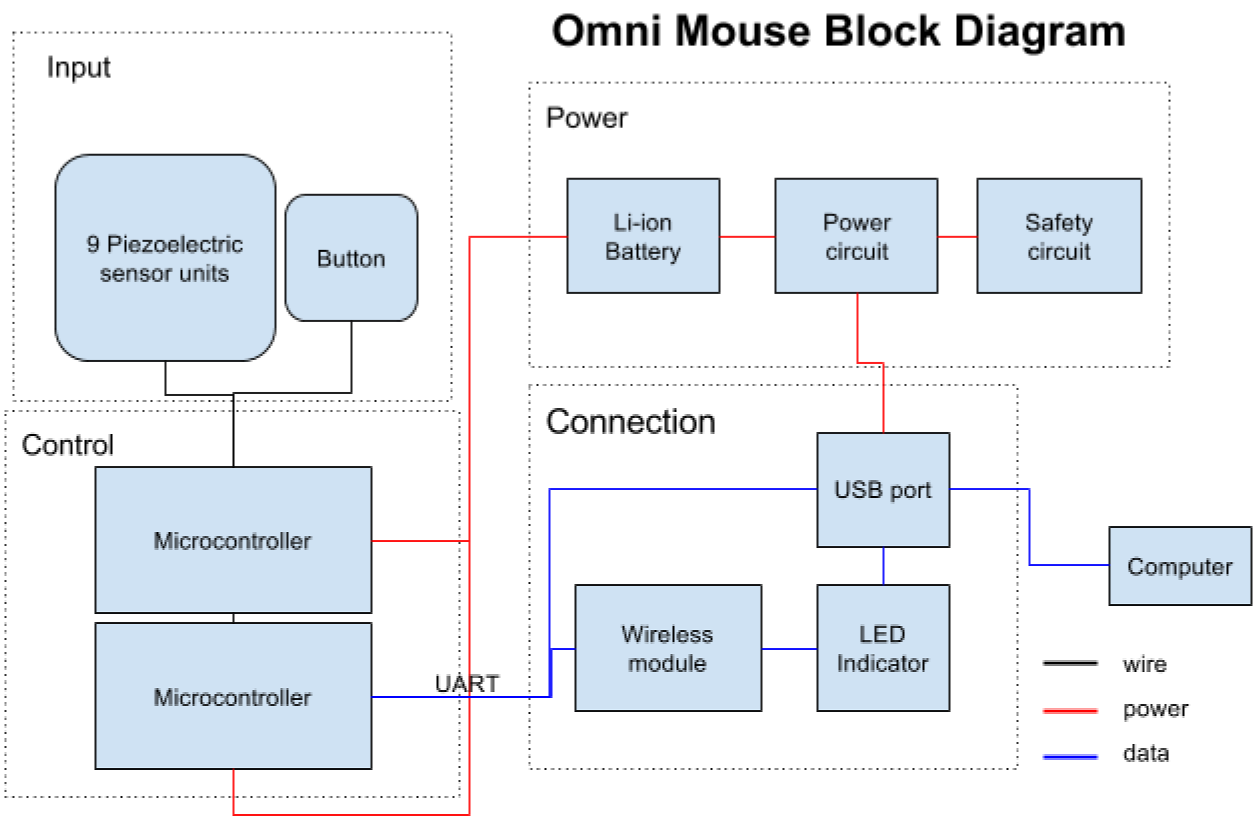
A list of at most three quantitative characteristics that this project must exhibit in order to solve the problem. Each high-level requirement must be stated in complete sentences and displayed as a bulleted list.

Mouse must work as expected for a computer input device (similarly to that of a standard mouse, expected 400 DPI and 100Hz polling rate).

Mouse must provide good ergonomics for the user (more comfortable, less strain over time).

Design

Block Diagram:



In our design, there are four major components to be implemented, Power, Control, Connection and Input. The power supply and power circuit have the functionality of working with and without charging. Our control unit consists of two microcontroller since we will fetch multiple input signals from the sensor array. The Input section is designed to track the hand movement. An algorithm will be designed to process data from this sensor array. Finally, the connection module can switch between wired connection and wireless connection. For connection between remote and the mouse, Bluetooth LE and USB OTG are used. The detail description of our design are introduced in following section.

Functional Overview

Input:

Our input consists of the 9 piezoelectric sensor units and a gesture button.

The sensor array takes input from the user and sends it to the microcontrollers, which process the input into mouse movements that can be sent to the computer. We have arbitrarily decided on 9 for now but expect that further research will lead to revisions on this. The gesture button will be located near the mouse center, and will be actuated to enable the use of gestures. These gestures will activate mouse inputs such as click, right click, and scroll (the basic inputs, additional inputs can also be created and implemented through other gestures).

Requirement 1: The piezoelectric sensor must be sensitive and the physical button should be responsive.

Control:

Our control consists of two microcontrollers.

The microcontrollers process the input from our sensor array and processes it into mouse movements and button actions for the mouse driver. We expect to use two microcontrollers in parallel due to the high amounts of IO that our project will require. We plan to use a power efficient controller to maximize the battery life of the product.

Requirement: The microcontroller must sink or source 10mA on all GPIOs at 3.3V.

Connection:

Our connectivity block consists of a wireless module, an indicator light, as well as the microUSB OTG port.

The USB port is shared between connection and power since when plugged in the mouse will recharge and work as a wired device (USB provides separate data and power connections). We will use wireless module such as bluetooth of 2.4ghz to wirelessly connect our device to a computer. These are connected and controlled by the microcontrollers.

Requirement: Must be able to connect over UART.

Power:
Our power circuit consists of an li-ion battery, a charging circuit, and a safety circuit.

The power block consists of our battery, which is used to power the device while in wireless mode, and charges when it is in wired mode. The charging circuit takes care of the charging through the USB port, and the safety circuit monitors the temperatures and voltages to make sure they are within safe usage levels.

***Requirement 1*:** Must charge the Li-ion battery to 4.16-4.23V with a continuous >300mA charge current, from USB connection, and stay below 125°C (the maximum operating temperature).
Requirement 2: The battery must be able to store enough charge to provide at least 150mA at 3.7-4.2V.

Risk Analysis:

We expect that the most challenging and risky part of our project would be to precisely lay out the button and 9 piezoelectric sensor array so that synchronized signals could be caught and fed into the microcontroller. There is a probability that the signal be attenuated and contaminated through the amplifier and A/D converter stage. Therefore, careful selection of the sensor chip model and delicate design of intermediate circuitry is required. Even if the piezoelectric sensors do not provide the expected precision, there is a substitute sensor type for this project: temperature sensors. The working principle is similar: control the cursor by sensing the temperature change brought by a user’s hand.

Ethics and Safety

There are a few safety issues that we must address in our project. The first and foremost being the ergonomic issues that we are aiming to solve. Thorough research on ergonomics of the human hand and the ideal positioning and angles of movement will be done for the design of the shell of the mouse. So while the original idea envisions an almost half-sphere dome for the shell, it is very likely that the best shape may be more ovular and raised at an angle from the horizontal. The movement as well as gestures must be non-fatiguing, or at least minimally fatiguing for the user to fit in with our objective.

Since we plan to utilize a li-ion battery into our mouse to allow for wireless connectivity through bluetooth, we must take battery safety into consideration. Li-ion batteries are well known to be explosive if exposed to the wrong conditions. To combat this, we will make sure to keep the battery temperature and voltage within safe ranges as well have a hardware option to entirely turn off the wireless mode (and therefore bypassing the need for the battery, if the user so chooses). Additional measures, such as shielding and isolating the power circuitry will eliminate the risk of electric shock. These precautions should allow for the same operation of our li-ion battery by itself, and in conjunction with our charging circuit.

Bibliography:

[1] Scott, Clay. ‘Repetitive Strain Injury’, 2014. University of Michigan. Web.
https://web.eecs.umich.edu/~cscott/rsi.html

[2] Hedge, Alan. ‘Ten Tips for Using a Computer Mouse’, 2011. Cornell University. Web.
http://ergo.human.cornell.edu/cumousetips.html