Kyle Kizirian
Dr. Erick Maxwell
Bowling Form Facilitator
Microcontroller Boards for Wearable Electronics

Introduction

As microprocessors have decreased in size and cost, a market has developed for electronics worn on the body. Analysts have estimated that the wearable technology market is worth $14.0 billion today and that number is predicted to more than double to $34.2 billion by 2020 [1]. Wearable technology has become so popular that companies have begun selling microcontroller boards designed specifically for wearable technology. These microcontroller boards come with built-in microprocessors, RAM, and I/O ports and are built to be easy to program and use to read sensors and control wearable electronics. Microcontroller boards suited for wearable electronics vary in size, weight, clock speed, memory, and cost. This paper is a review of microcontroller boards suited for wearable electronics applications.

Commercial Applications for Wearable Microcontrollers

Already, roughly 20% of American adults own some form of wearable device [2] with the most common products today being fitness trackers, such as Fitbit, and smart watches, such as the Apple Watch. Fitbit, the best selling fitness tracker [3], uses accelerometers, gyrometers, and GPS to track movement, estimate calories burned, and measure sleeping habits [4] and the various models range in price from $50 to $250. The best selling smart watch is the Apple Watch [5]; in addition to fitness tracking the Apple Watch also has a 38mm or 42mm OLED display, Bluetooth and Wi-Fi connectivity, and the ability to run third-party applications and the various models range in price from $270 to $1050. Due to the emphasis on low-power operation for a long battery life, the Fitbit uses an ARM microprocessor [6] and the Apple Watch uses a custom variant based on an ARM microprocessor [7].

Technology of Wearable Microcontrollers

Size and Weight

Size and weight are an important factor in wearable technology as the smaller and lighter a product is, the less cumbersome it is to the user. However, reducing size and weight often comes at the cost of reducing memory and processing power. The Adafruit Trinket weighs only 1.85 grams with dimensions of 31 mm x 15.5 mm x 5 mm [8] while the Adafruit Trinket Pro, which has twice the clock speed and almost four times the flash memory, weighs 2.6 grams and measures 38 mm x 16 mm x 2 mm [9]. For microcontrollers with a circular form factor, the Adafruit FLORA has a 44.5 mm diameter, 7 mm

thickness, and weighs 4.7 grams [10] while the Adafruit GEMMA has a 28 mm diameter, and weighs 3.3 grams [11].

Clock Speed

Higher clock speeds allow for greater processing and I/0 operations on a wearable device but come at the cost of requiring more power and thus a shorter battery life. The small and lightweight Adafruit Trinket and Adafruit GEMMA both have processors with clock speeds of 8 MHz [8][12]. The slightly larger Adafruit Trinket Pro and Adafruit FLORA both have clock speeds of 16 MHz [9][10]. It has been demonstrated that 16 MHz is sufficient clock speed to read accelerometer and gyrometer sensors and transmit the data over Wi-Fi in order to do accurate gesture recognition [13].

Memory

Microcontoller boards vary in both flash memory and RAM size. More flash memory allows for larger programs to be stored on board and more RAM allows for more simultaneous data processing. Both the Adafruit Trinket and Adafruit GEMMA have 8 KB of flash memory with 512 bytes of SRAM [8][11]. The Adafruit Trinket Pro has 28 KB of flash memory and 2 KB of SRAM [9] while the Adafruit FLORA has 28 KB of flash memory and 2.5 KB of SRAM [13].

Programming and Power Microncontroller Boards

The Adafruit Trinket, Trinket Pro, GEMMA, and FLORA can all be programmed using the Arduino IDE [8][9][10][11]. The Arduino language is based on C/C++ with special-purpose functions for analog, digital, and serial I/O operations [14]. The Arduino IDE is open-source and runs on Windows, Mac OS X, and Linux. Additionally, each board can be loaded and powered via micro-USB. Alternatively, each board has the capability to be powered by a battery in order to operate without the need for a USB connection. The Adafruit Trinket and GEMMA both operate at 3.3 V and the Adafruit Trinket Pro and FLORA operate at 5 V, however, each has an onboard regulator that allows up to 9 V batteries to be connected [8][9][10][11].

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