Skate me a Rainbow: Generating Art from an Athlete's Movements

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Abstract

This project details the design and development of a system that generates art from an athlete's movements. The system is based on wearable electronics that integrate motion sensors and bluetooth connection to devices with more processing power. The hardware for this project is comprised of a bluetooth transmitter and an inertial measurement unit that senses acceleration, velocity, and heading. The software interprets the motion data to produce graphics that represent the motion. The application was tested with a figure skater. Further improvements include increasing the range and refining the visuals to more directly represent the figure skater's motion.

Introduction

The motivation for this project was to combine athletics and art with coding to attract girls to STEM. The proposed combination was a hardware device coupled with software that would generate an artistic representation of a figure skater's motions. The final product needed to be reliable and visually appealing so that it could be showcased on live TV. The project explores serial communication and contributes to the research and development being done on wearable electronics.

Background

In the past few years wearable electronics have become increasingly popular. Two of the main categories that existing wearable projects focus on are communication and fitness monitoring. For example, the pebble smartwatch, moto 360, and apple watch are all electronic watches that also allow their users to read texts and track their steps. Fitbit is a technology that focuses only on the fitness category and allows users to keep track of sleep and fitness habits (fitbit.com). Although each of these wearables has a different application, they all have commonalities in their designs and requirements. Each of them must be small enough not to interfere with their user's movements, and each of them must have a way to exchange data with another device with more processing power such as a phone, tablet, or computer.

One project that was similar to the project presented in this paper is Lesia Trubat's Etraces for ballet. Trubat designed pointe shoes for ballet with pressure sensors built into the soles. The pressure sensors were connected to an arduino lilypad and used bluetooth to send pressure data to an iOS app. The app then interpreted this data and generated calligraphy strokes that represented the ballerina's movements. The integration of Trubat's system into the athlete's shoes meant that it was limited to ballet dancers only (Trubat).

Another similar project is the wearable wireless inertial measurement system developed at University College Cork in Ireland. The research team developed inertial measurement unit (IMU) wearables that tennis players could use to track their motion. The IMUs measured acceleration and angular velocity. Multiple IMUs were placed at different points on a tennis player's arm.The data was collected and analyzed to help the athlete improve their swing. (Gaffney et. al)

Development & Techniques

The general requirement for this project was it needed to generate a visual interpretation of a figure skater's movements. In addition the finished product needed to perform well live, which meant it had to be consistent and visually appealing. The output had to be representative of the figure skater's movements and unique for different figure skating routines. The athlete's movements could not be inhibited by the hardware device, and the device could not be integrated into the ice skate.

The final product was a combination of hardware and software systems powered by a 9 volt battery (Figure 1). The hardware included the sparkfun 9 degrees of freedom razor IMU (Figure 2) and the RN-41 Bluesmirf gold bluetooth module (Figure 3). The razor IMU includes an accelerometer, gyroscope, and magnetometer. It senses these 3 forces in the x, y, and z directions, comprising 9 degrees of freedom. The razor also has processing power. The razor collects the 9 degrees of sensor data, packages it into a byte, and sends it through a wired connection to the Bluesmirf module.

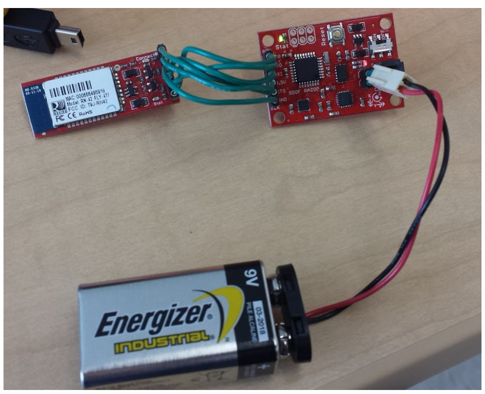

Figure 1.

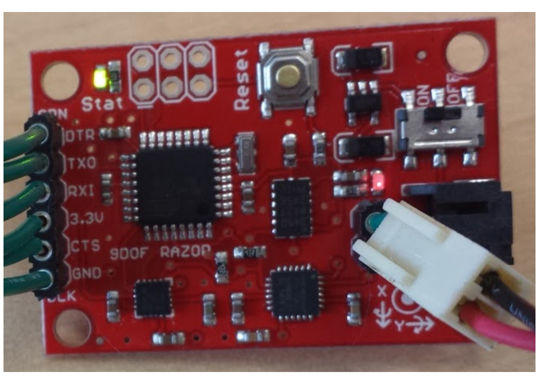

Figure 2.

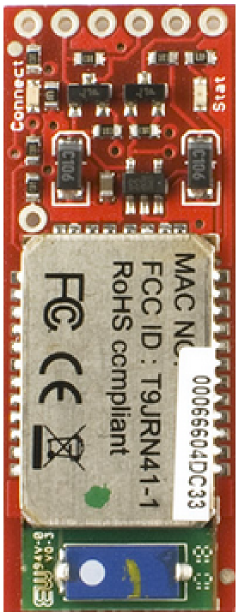

Figure 3.

The RN-41 Bluesmirf Gold is a class one bluetooth module, so it has a maximum potential range of 100 meters. The Bluesmirf pairs with the computer and opens up a channel for serial communication at a specified rate called the baud rate. It passes the bytes of sensor data at that rate to the computer where they can then be interpreted by the software.

The software for this project was written using Processing 2, a development environment and programming language designed for use with graphics. Classes were defined for strokes and spirals so that they could be used to create graphics from the incoming data. Spirals have properties that include radius, speed, and color. Strokes have a direction to move across the screen and are made up of multiple connected spirals. New strokes are instantiated in the code when the average of the acceleration values for each axis spikes above a specified threshold. The x, y, and z acceleration values are then mapped to red, green, and blue values respectively for a new stroke (Figure 4).

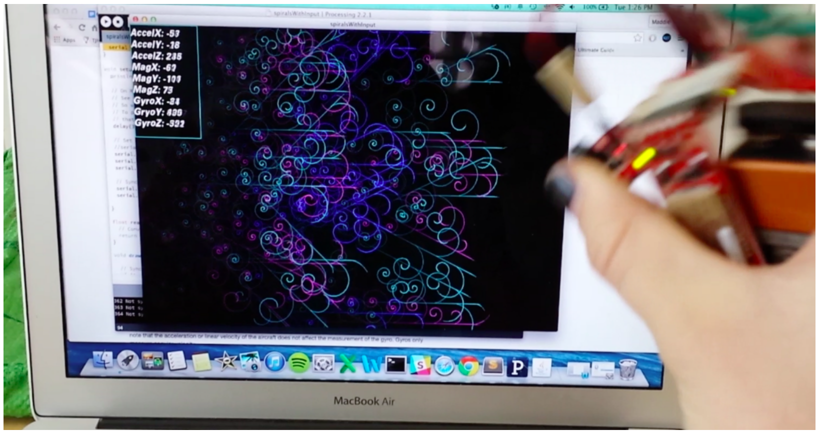

Figure 4.

One of the most significant limitations for this project was the size and weight of the hardware. An athlete needs to be able to wear the hardware on their body and not have it interfere with their movement. The hardware needed to be small, light, and strategically placed on the athlete's body. Another limitation was the range of the bluetooth module. Although the maximum range of the Bluesmirf was 100 meters, in reality the device lost connection at half that distance. This limited the area that the athlete could use to skate when testing.

The evaluation plan for this project included testing with a live figure skater. The first prototype of the design was completed and tested within the first month of the project. Testing of the prototype revealed several issues with the preliminary design. The hardware for the prototype was heavy, bulky, and fragile (Figure 5). The prototype collected only acceleration data and generated graphics by drawing concentric circles with radii corresponding to the magnitude of the acceleration (Figure 6). The graphics did not have the flexibility and variation required of the final product.

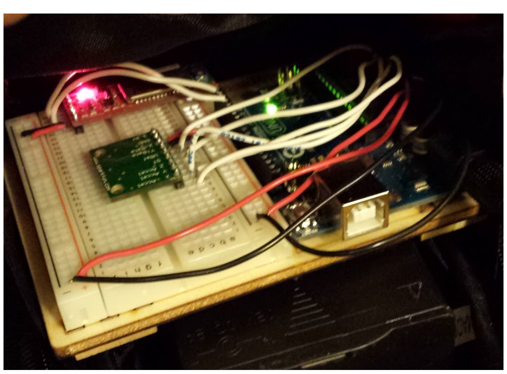

Figure 5.

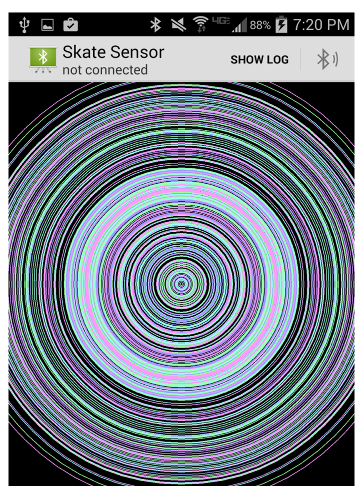

Figure 6.

After the first phase of testing the prototype was refined to be lighter and more compact. The Razor IMU was purchased and wired to the Bluesmirf using female-to-female connector cables. The hardware was powered by a single 9 volt battery instead of a bulky battery pack. This new version of the hardware was used in the second phase of testing in order to refine the graphics. The stroke and spiral classes were written during the second testing phase. In addition, code was written to collect and save data to a file separate from the graphics to aid in testing.

In the third phase of testing the new hardware and graphics were tested with a live figure skater on a larger rink than the first test. The lighter, smaller hardware was more effective and convenient. In addition, the graphics were more unique and flexible. One problem that was revealed in the third phase of testing was the limited range of the Bluesmirf. The computer lost connection to the Bluesmirf before the skater was halfway across the rink.

Results & Conclusion

The final product was successful in generating a visual representation of an athlete's motion. Over the course of the research much was learned about the design and development of wearable systems. The research demonstrated the importance of compact hardware and careful consideration of range when designing wearables. In addition the details of bluetooth and serial communication were explored. The results of this research have implications for the field of wearable electronics as well as applications for sports coaching and physical therapy.

In the future the software graphics should be refined to give a more direct interpretation of the athlete's movements. For example, using the integrals of acceleration and velocity data to get the athlete's direction and then creating a stroke in the graphics that moves in that direction. In addition, multiple sensors should be used on different body parts of the skater in order to fully capture the nuances of the motion. The footprint of the hardware should be reduced by milling a custom board that combines both the IMU and the wireless communication. The range of communication should be increased by substituting a wifi module for the Bluesmirf.

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