Personal Inquiry 02
Lee Patrick, BIO 668 B, 02-Aug-19

Introduction

Humans impact their environment in many ways, a number of which provide negative effects on ecosystems—air pollution, disruption of biogeochemical cycles, habitat clearing, and marine/waterway pollution (OpenStax College, 2013). Many of these negative effects affected the Coney Island Creek, a local waterway ecosystem in Brooklyn, New York, including illegal sewage dumping, toxic industrial pollution, and combined sewer overflow outfall (Making Waves Coalition, 2018). In recent years, however, many community efforts to clean up the Creek have taken place, especially after backdoor flooding effects from Superstorm Sandy (Making Waves Coalition, 2018). Despite these efforts, NYC is interested in bringing ferry service to the Creek (McShane, 2019a). Yet it’s not clear if an in-depth environmental impact assessment has been done on this waterway, and not all residents approve of bringing a ferry to this location (Katinas, 2019; McGoldrick, 2019; McShane, 2019b).

How can ferry service affect a local waterway ecosystem? While any ferry boat may be required to reduce its wake while in the Creek, past studies have still outlined negative effects from wave energy and other factors. These effects include shoreline erosion, poorer water quality, disruption of plant, avian, and aquatic wildlife habitat, emissions, and quality of life (Bilkovic, et al., 2017; Figurski, Malone, Lacy, & Denny, 2011; McKesson, Remley, & Karni, 2000; Rack, 2016). Not always mentioned is that motorized boating can affect opportunities around the Coney Island Creek for student research in local ecology (based on my own participation in co-teaching an Urban Naturalist Program along the Creek and speaking with Tanasia Swift of the Billion Oyster Project, where a test oyster reef may have to be moved due to the ferry). With this overall impact in mind, can low-cost tools be developed for students, citizen scientists, and local organizations to independently monitor wave energy if ferry service is inevitable? There is precedence for independent monitoring and low-cost data tools (New York City Water Trail Association, n.d.; The Public Lab, n.d.). This paper outlines an experiment conducted with an electronic hobby platform and hypothesizes that such a low-cost tool can be developed and can detect wave energy.

Methods

Wave energy is often calculated by buoys measuring wave height and other parameters with high-end accelerometer sensors (Coastal Data Information Program, n.d.). Accelerometers detect relative motion and are even found in personal cell phones to detect tilt and orientation. Researchers Figurski, Malone, Lacy, & Denny (2011) demonstrated an accelerometer-based wave energy tool that reduced costs from thousands of dollars to $80-plus dollars. This paper's method takes things further to reduce costs even more using a popular programming board in the maker/DIY community—the Circuit Playground Express (created and sold by Adafruit.com) (Egan, 2017). This device has an embedded accelerometer and runs custom-coded instructions, using a version of the Python coding language. Bill of materials and costs are listed below:

- Adafruit.com's Circuit Playground Express, Product ID: 3333, $24.95
- Adafruit.com's 3 x AAA Battery Holder with On/Off Switch, Product ID: 727, $1.95
- The above totals **$26.90**, not including tax or shipping.
- Also required: 3 triple-A batteries, rubber band, snack bag, plastic tupperware bin

I took the Circuit Playground Express (hereafter, "CPE"), connected it to a computer and wrote code (Appendix A) based on that provided here (Rembor, 2018). I hooked up the CPE to a battery pack, sealed the items in a plastic bag, and placed this water-resistant "sensor module" in plastic tupperware to float (Figure 1). For time and coding simplicity, I limited my experiment to detecting change in the z-axis (height/tilt change) and to have the CPE light up (blink) if change from a flat rest was detected.

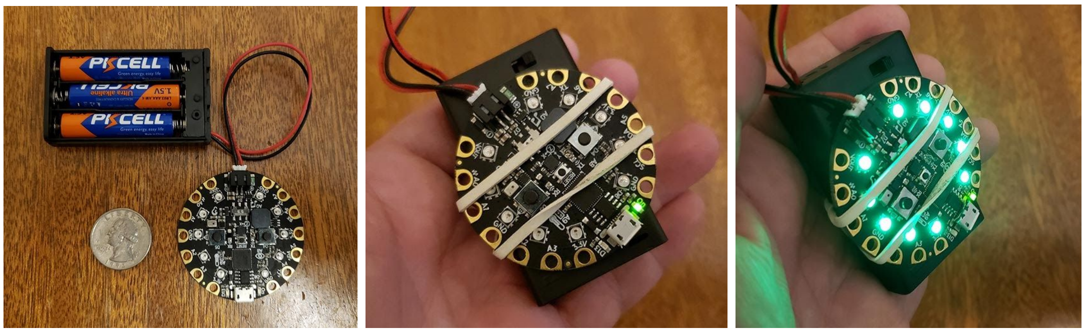

Figure 1
L-R: Circuit Playground Express ("CPE") with battery pack and quarter for scale; CPE and battery pack rubber-banded together; CPE tilted to show light-up property

Initially, placing the module in a baking pan filled with water did not work well, as there was no real room to generate waves. I then filled up my bathtub with water to about ¼ to ⅓ of the way full (Figure 2). I gently floated the sensor module, sat on the ledge of the bathtub, then started the timer on my Samsung cell phone to count down 30 seconds. During the 30 second period, I rocked on the tub ledge back-and-forth to bring my feet up to the water surface, then down to the bottom of the tub. The aim was to provide moderate force to generate steady wave motion. While the 30 seconds of the timer counted down, I counted the number of blinks from the sensor module. I repeated this process for six trials.

Figure 2

L-R: CPE module waterproofed and in plastic bin; attempt to float module within baking pan; second attempt in filled bathtub floating a fully enclosed module

Results

I recorded results from six trials of making waves and counting subsequent light blinks from the CPE sensor module. The module began tilting and blinking as the waves propagated. Each trial run yielded similar results as reported in Table 1, below.

Trial #	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
# of light blinks per 30 seconds	32	24	31	33	29	24

Table 1
Results of six trials of recording sensor module blinks for 30 seconds
Average # of blinks = 28.83, Median # = 30

Discussion

Set up at only a very basic level, the CPE sensor module was able to detect low-volume artificial wave energy, through the indication of multiple light blinks. However, while this demonstrates that the CPE sensor module reads and reacts to wave energy, the results have limitations—they do not let us know the actual measurements and direction of that energy, or its accuracy. To arrive at that kind of data, a more advanced set-up and comparison studies are required. Advanced steps would include writing code to read all accelerometer parameters of the CPE—i.e., changes in the x, y, and z-axes—along with equations to process that information. This is entirely possible using the CPE (implied in Nelson, 2016). Additionally, the CPE can be made to log numeric data to itself for later retrieval (Rembor, 2017). Some trial and error could produce data readings of greater resolution.

Once set up in the above manner, wave energy readings could be taken and compared to the results of the module developed by Figurski, Malone, Lacy, & Denny (2011) (taken at a municipal wharf in California). If the proposed ferry service is to come to Coney Island Creek without true environmental impact assessment, there exists the possibility for use of the even lower cost CPE sensor module by ecology students or citizen scientists (within logical safety requirements) to provide ongoing, independent monitoring of the local, ecological impacts of Coney Island Creek ferry service.

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Appendix A

(lines with # are comments that explain the code)

```
#accelerometer z value tracking, for use on Circuit Playground Express
#based in part off of:
#https://learn.adafruit.com/circuitpython-made-easy-on-circuit-playground-expre
      ss/acceleration
#Lee Patrick, August 02, 2019

#access required internal circuitpython libraries
import time
from adafruit_circuitplayground.express import cpx

#ensure LEDs are off at startup (might not be needed)
cpx.pixels.fill((0, 0, 0))

#---program loop, runs continuously---
while True:
    #set x, y, z as variables to hold accelerometer values
    x, y, z = cpx.acceleration
    #set R, G, B as variables to hold color values for LEDs
    R = 0
    G = 0
    B = 0

    #LEDs are off (current values are all zero)
    cpx.pixels.fill((R, G, B))

    #default z-axis value is 9.8 due to gravity
    #define variable 'delta' as absolute value of any change from 9.8
    #'delta' default now 0 and tracks a basic change in height/tilt up or down
    delta = abs(9.8 - z)

    #if change in height is greater than value of 1,
    #light up LEDs in green (not too bright though)
    if delta > 1:
        G = 10
    cpx.pixels.fill((R, G, B))

    #show delta values on serial console if connected to computer
    print("Delta: " + str(delta))

    #pause for quarter second (slows down data processing
    #for human readability, also lets LEDs 'blink')
    time.sleep(0.25)
```