Optimote Bio-Adaptive Media Controller –

Product Developed by Donovan Magryta

Tags:

- Assistive Technology
- User Experience
- Embedded Systems
- Software Development
- Product Development
- Video Production

Applicable Industries:

- Healthcare
- Education
- Entertainment

Quick Links:

https://youtu.be/NnIlliJMYvg

https://github.com/donovanmagryta/optimote

Summary:

Situation: According to the CDC, kids now spend 7.5 hours a day on screens. For many such as those with autism this can lead to sensory overload where little learning or engagement can occur. There is a need for improving engagement, focus, and relaxation in sync with a person's biology especially in schools, healthcare, and entertainment industries.

Action: User research was conducted to find needs and the data collected was analyzed. Ideation led to a potential solution and a hardware / software solution was developed that can optimize screen time media in real time by adapting music and video elements based on heart data. UX testing was then conducted to evaluate the invention and improvements were iterated forming a working product.

Results: A working product was developed to solve the initial problem by adapting video to sync with bodily rhythm with calm or thrill boosts when optimal.

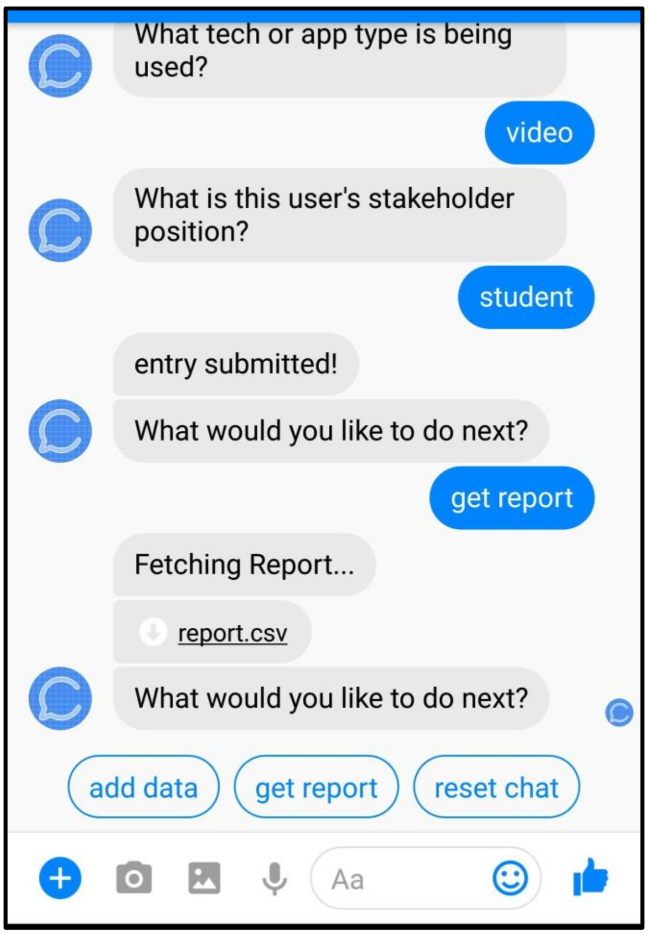
Need Finding

According to a statistic cited by the CDC from the Kaiser Family Foundation, “Kids ages 8-18 now spend on average 7.5 hours per day on screen media, not including screen time spent at school."

Needfinding research was performed to explore how this high-volume screen time might affect people positively or negatively - particularly in the education industry.

For the need finding research a group of school students were observed in their environments naturally for 20 minutes daily over the course of a week. The goal was to learn about their interactions with technology and how those interactions affected and related to their behavior.

For capturing notes, a field study chatbot was developed and used for conversational, streamlined data entry with spreadsheet data export. After color coding the resulting data by tags, this became a way to visualize and understand the data.



Shown below is a snippet of some of the data collected through the chatbot during an observation session when students were watching educational videos on computers. Rows have been colored coded by tags to spot similarities. As insight, it shows how the unintentional behavior of few students correlated to sensory overload, or boredom, seems to have snowballed into preventing more than one student from learning and being entertained.

anon name	**tech**	**stakeholder**	**Observation**	**tag 1**	**tag 2**
TM	Edu movie	Student	stares blankly at screen - unknown if attentive or daydreaming.	focus	Entertainment (not enough)
JR	Edu movie	Student	Is more attentive to peer interactions than media.	focus	Social
CL	Edu movie	Student	Student is attentive	focus	Attentive
MR	Edu movie	Student	attentive but is easily distracted by room noise	Focus	Distracted
TR	Edu movie	Student	asks many questions to clarify media info.	initiative	Attentive
GS	Edu movie	Student	As video progresses and picks up in pace and stimuli, student seems to become agitated	Stimuli (too much)	Escalation
TB	Edu movie	Student	distracted by GS' visible agitation.	Social	Focus
IH	Edu movie	Student	appears extremely bored	Bored	Entertainment (not enough)
GS	Edu movie	Student	is now very escalated and is not learning which required teacher intervention that distracted the other students.	Overload	Stimuli (too much)

Distilled based on this data, the three main categories of interest are:

1. **Entertainment** – Students either have not enough or too much at different times.
2. **Focus** – Students lose focus when either not entertained enough or are over stimulated by the technology.
3. **Calm** – Some students become over stimulated and need de-escalation or prevention.

Ideation

Now that clear needs were found, it was time to brainstorm ideas for media technology innovation to positively improve these points.

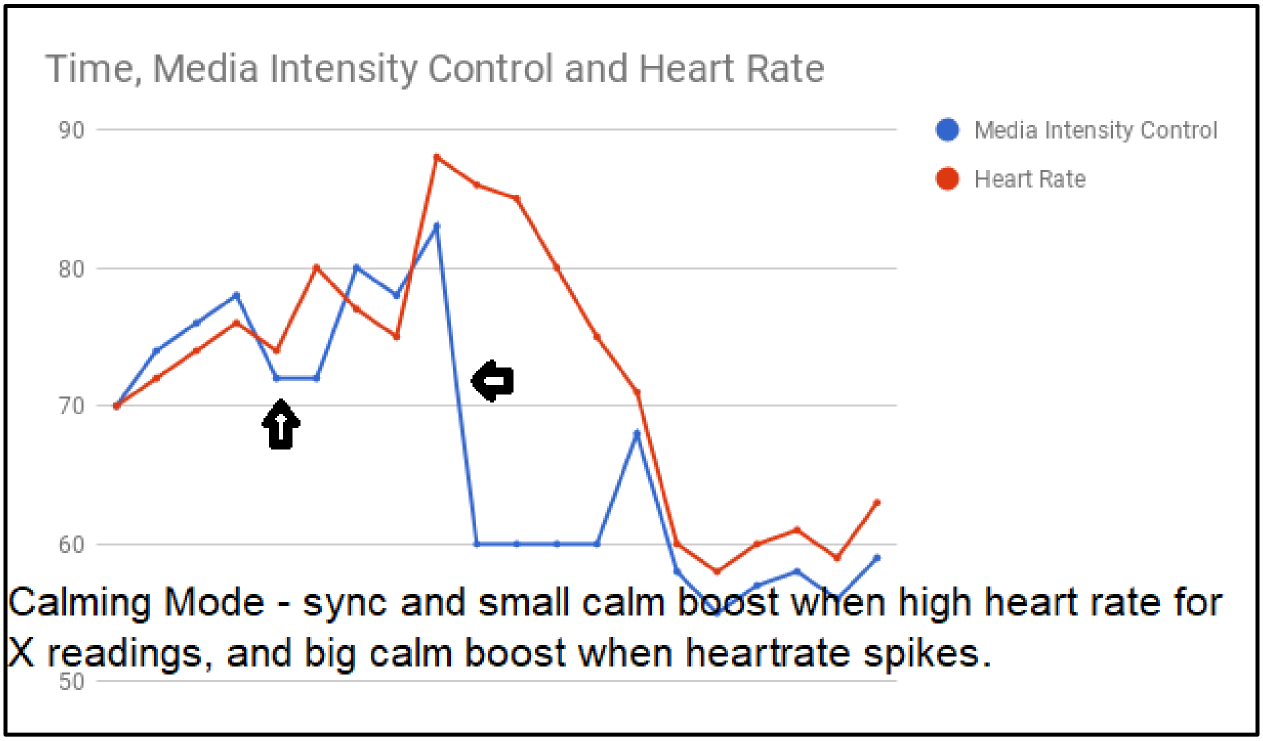
The question was:

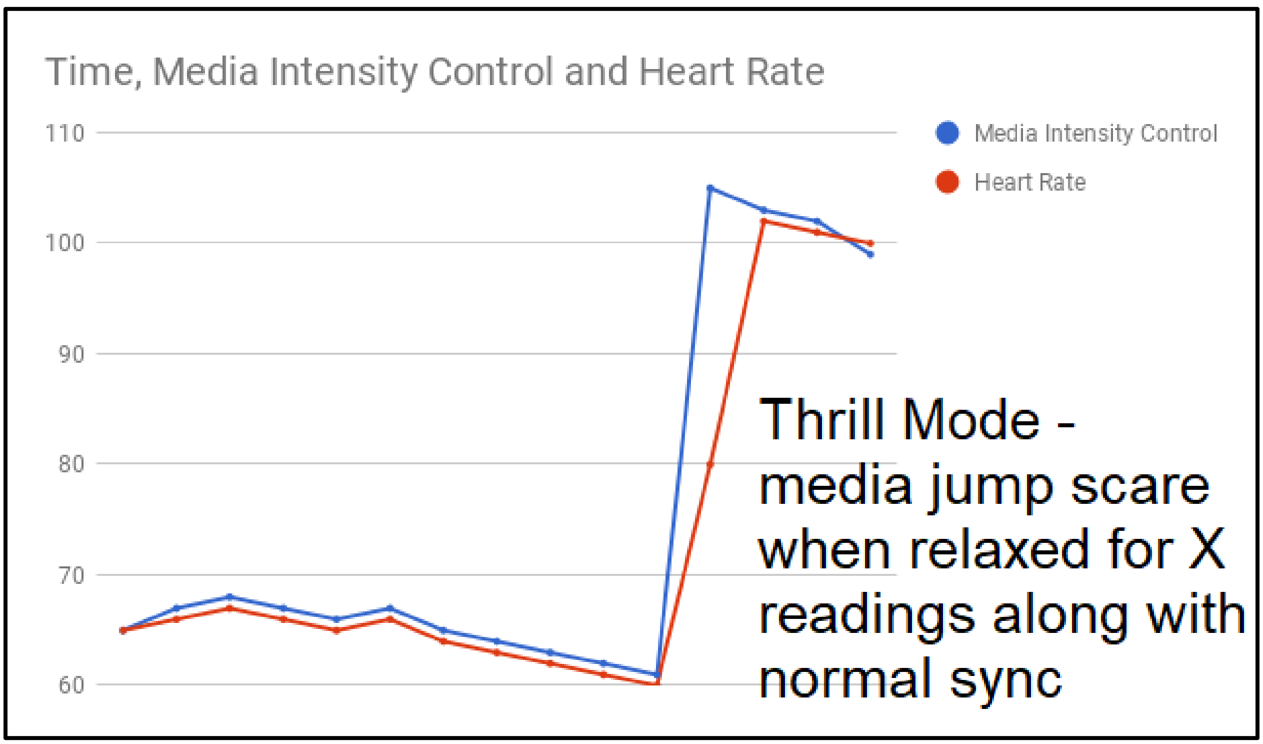
What device can be made to control media in tune with or intelligently leading each student's body rhythm to improve calmness, focus, and entertainment?

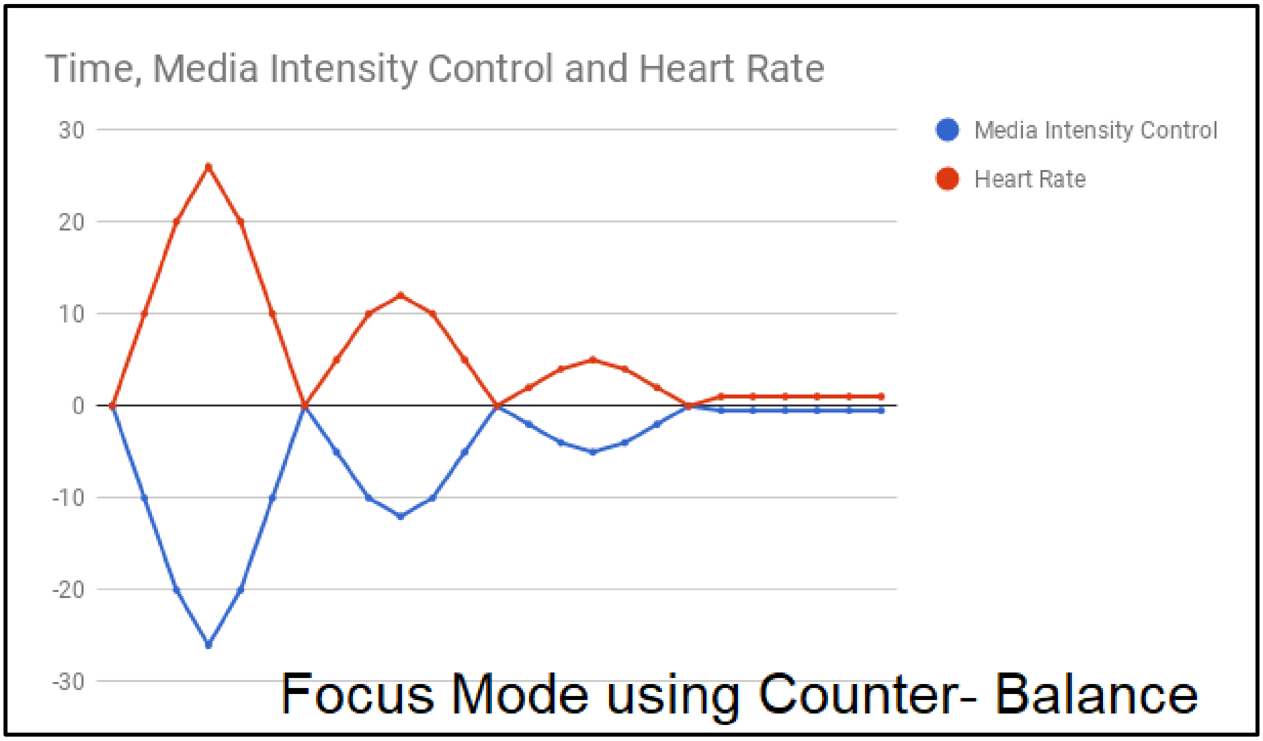
Below is a list of potential ways an electronic device could read the psychological status of a student using aspects of certain existing sensor technology.

- brain wave sensor
- skin conductivity sensor
- heart beat sensor
- blood oxygen sensor
- breathing sensor
- motion sensor
- optical facial expression sensing
- sweat sensor

Theoretical methods that the device might utilize to induce certain effects onto a user were sketched out. The images below depict the three theoretical modes.


Time, Media Intensity Control and Heart Rate
90
80
70
60
50
Media Intensity Control
Heart Rate
Calming Mode - sync and small calm boost when high heart rate for X readings, and big calm boost when heartrate spikes.


Time, Media Intensity Control and Heart Rate
110
100
90
80
70
60
Media Intensity Control
Heart Rate
Thrill Mode - media jump scare when relaxed for X readings along with normal sync



Prototyping

Ultimately, an optical heart rate sensor was chosen which looks for miniscule skin color fluctuation caused by the heart pumping blood. Since heart rate is innately tied to feelings and brain activity, this is the method found to be most fitting.

For playing the media, a web app was developed that can play offline video. This web app works in conjunction with a heart pulse sensing device based on the atmega32u4 microcontroller chip. One benefit of this chip is that computers can recognize it as a HID (human-interface-device) without difficult-to-find drivers.

This is technology is familiar because these boards were previously used to make an automatic keyboard (USB Rubber Ducky) for bulk set up of student Chromebooks to act as an automated assistant to work alongside IT professionals. By simply plugging the board into the computer, it performs all the computer configuration, imitating a human typist with 2x to 3x teste human speed and zero typing errors, which freed me for specialized the IT professional to do human optimal work, as opposed to repetitive, time-constrained and human-error-prone tasks.

For Optimote, the chip reads heart sensor data and processes it through some clever algorithms then outputs keystrokes to control the media player app on each computer.

The components needed:

ITEM	QUANTITY	EST. COST	SOURCE
DIY Web App	1	$0.00	home-made
Magnetic Breakaway USB Cable	1	$4.00	ebay.com
Pro Micro Arduino Compatible Board	1	$5.00	ebay.com
SPDT Slide Switch	1	$1.00	ebay.com
Optical Pulse Sensor	1	$5.00	ebay.com

After acquiring the components needed the next step was prototyping the hardware and code which comprised the device.

Every evening over several days, code was written to implement the previous algorithms.

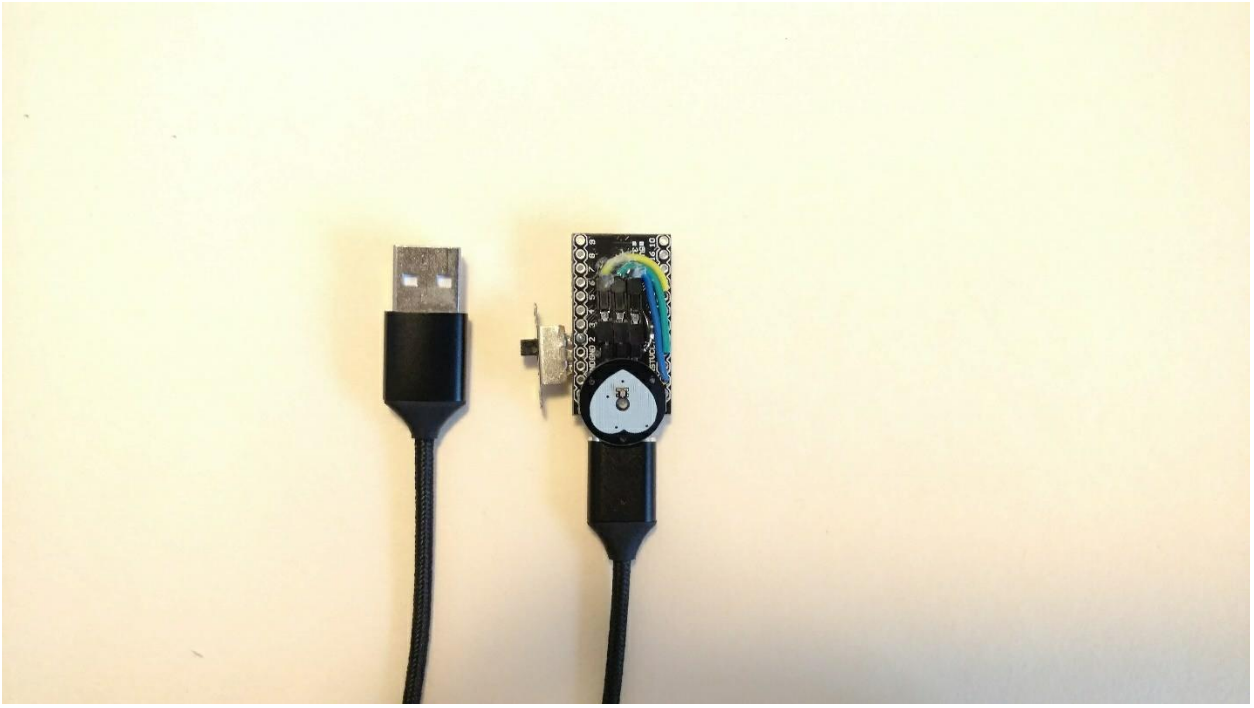
The circuit is simply:

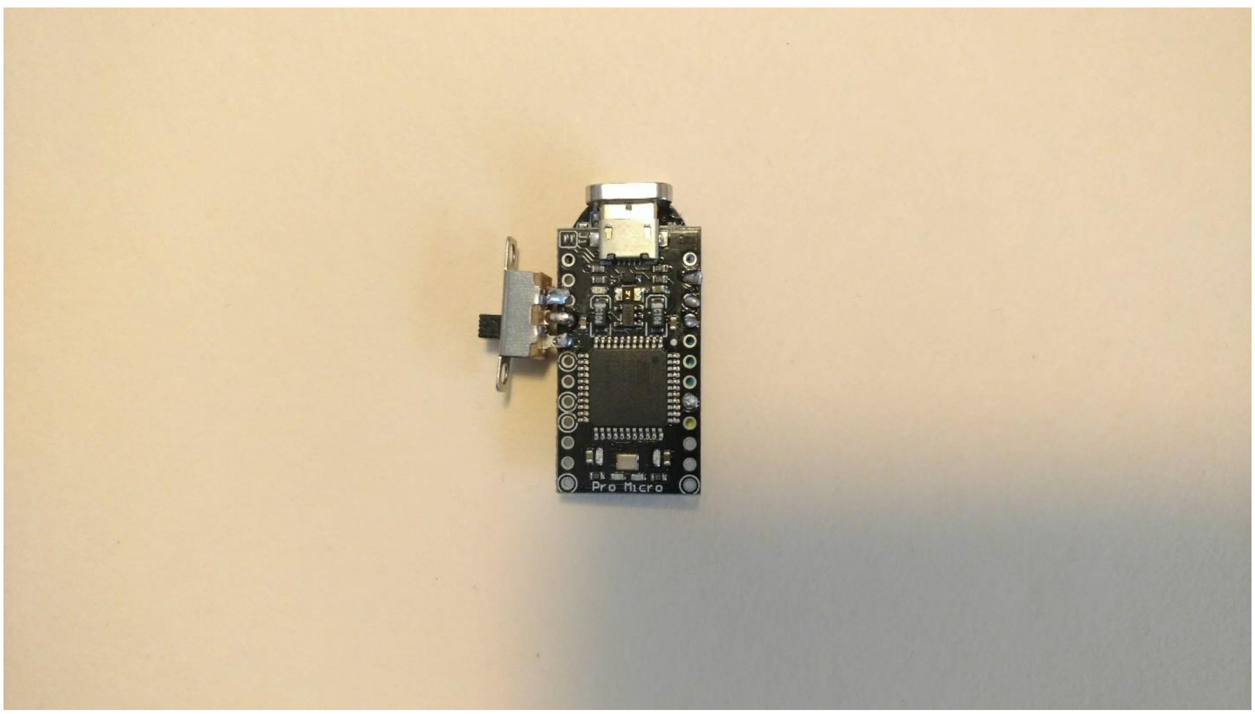
- MCU +5V to Sensor Vin
- MCU Ground to Sensor Ground
- MCU A0 to Sensor Signal
- Slide Switch Pole to D2
- Slide Switch Throw to Ground.

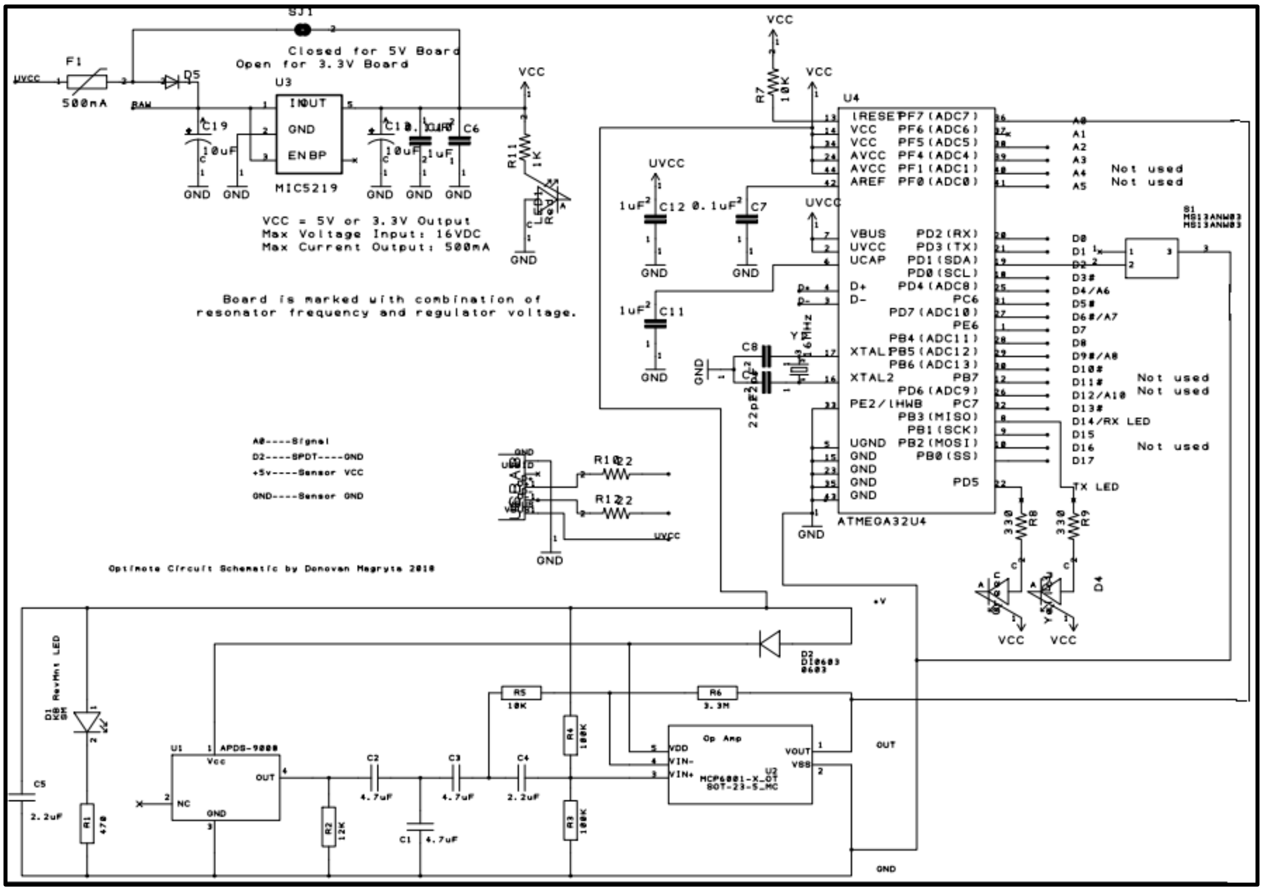
Listed below are license dependencies for Optimote.

- Pro Micro hardware is released under Creative Commons Share-alike 4.0 International.
- Pulse Sensor Amped hardware is licensed under the TAPR open source hardware license
- PulseSensorPlayground code library is licensed under the MIT License
- Arduino Environment is licensed under the GNU General Public License

Shown below are photos of the prototype and schematic.




Pro Micro


SJ1
Closed for 5V Board
Open for 3.3V Board
F1
500mA
D5
U3
MIC5219
VCC = 5V or 3.3V Output
Max Voltage Input: 16VDC
Max Current Output: 500mA
Board is marked with combination of
resonator frequency and regulator voltage.
U4
ATMEGA32U4
Not used
A0----Signal
D2----SPDT----GND
+5v----Sensor VCC
GND----Sensor GND
Optimote Circuit Schematic by Donovan Magryta 2018
APDS-9008
Op Amp
MCP6001-X_OT
SOT-23-5_MC


66
tempo adapted to 1.00
Set Peaks

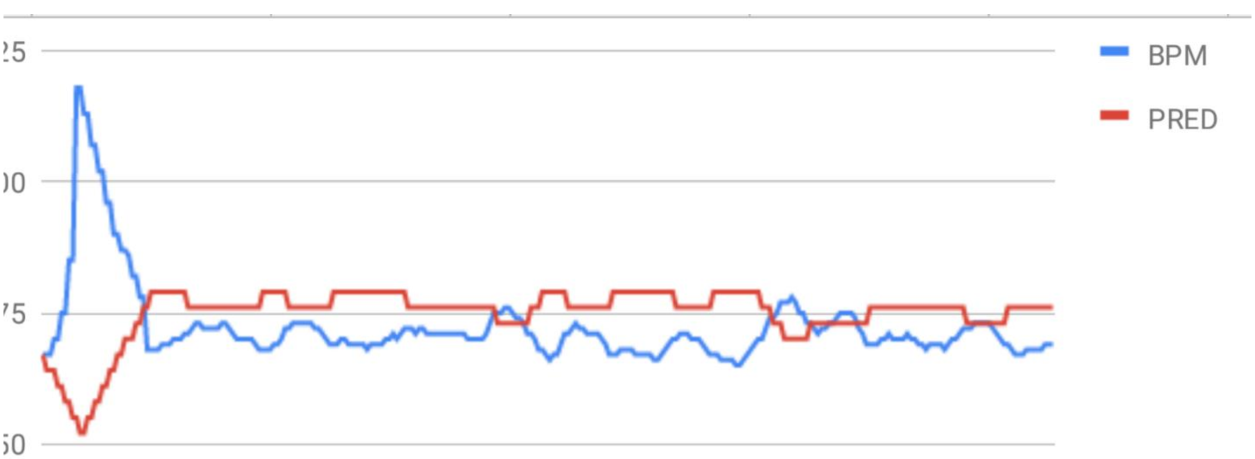
With the physical Optimote sensor connected to the web app over USB cable, you can load video media and program it graphically to react to a user's heart bio data. There is a button that generates an csv spreadsheet containing the raw biodata, which can be analyzed and graphed to further evaluate and improve Optimote

Testing

The next step was to test out the device on small scale with a couple testers to ensure it was at least usable enough for further testing with many testers.

Aside from user feedback, biometric heart rate data was collected using the biodata spreadsheet generator feature. There is a column for time, for heart rate, and for a prediction of the next heart rate based on the adjustments the web app makes to the video in response to heart beat behavior. Optimote effectiveness can be assessed by looking at the variability between actual heart rate and the prediction and which data leads or follows the other.

	A	B	C	D	E
1	USER	TIME	BPM	PRED	
2	djm	5	79	79	
3	djm	5	79	76	
4	djm	6	79	76	
5	djm	7	76	76	
6	djm	7	76	79	
7	djm	8	74	79	
8	djm	9	72	79	
9	djm	9	72	82	
10	djm	10	70	82	
11	djm	11	69	82	
12	djm	11	69	85	
13	djm	12	67	85	



Shown in the picture above is the graphed data. You can see that PRED (prediction of next heart rate and the reaction of the media player web app) lags slightly behind the actual heart rate data. This shows a need for performance optimization in the code to expedite reactivity on low-end computers.

Outcome

Based on feedback from the few users who tested Optimote, calm mode noticeably puts media volume and tempo in sync with heart rate, with mild calming boosts when triggered.

Thrill mode is especially fun with the use case made with custom media. The thrill mode media plays an eerie scene looping with the famous Jaws movie piano theme playing in the background, becoming louder and faster as the heart rate speeds up. When the user is sensed to be steadily decreasing in heart rate over X readings, it skips to a jump scare clip when they least expect it. Of course, frightful media would not be suitable for a classroom, but the mode would work just the same for different, non-scary media to keep users engaged.

Future large-scale user testing will be helpful to gather feedback in both raw bio-data and user feedback formats in order to assess and add more features to the technology. In the United States collecting health data such as the heart rate data requires a waiver to be signed and such a legal form must to composed in order to test Optimote for medical use purposes with additional demographics.