

Orchestar: Teaching the Color/Temperature Relation through Sound



Sóley Hyman¹, Allyson Bieryla¹, Daniel Davis², Wanda Diaz-Merced³

- 1. Department of Astronomy, Harvard University, Cambridge, MA, United States
- 2. Harvard Natural Sciences Lecture Demonstrations, Harvard University, Cambridge, MA, United States
- 3. IAU Office for Astronomy Development, Cape Town, South Africa

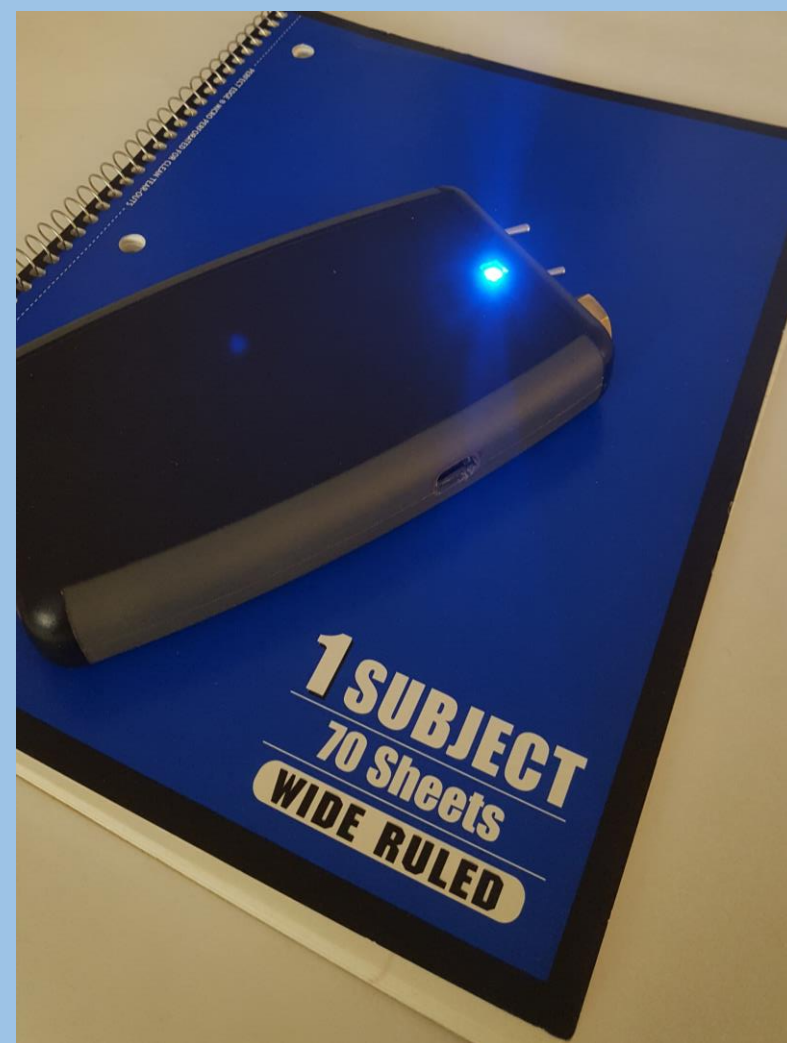
1 Background

The relation between color and temperature is one of the fundamental concepts of an introductory astronomy course. However, for non-visual learners, the association – which is typically taught with visual aids – can be difficult to make. Orchestar is an Arduino-based device that has been developed at Harvard University and uses a process known as "sonification" to convert color and brightness to sound with an RGB color sensor and MIDI board.

2 The Device

Orchestar is an Arduino device with a sensor that measures color and converts it to sound using an Adafruit Flora board and a MIDI synthesizer board. The device has the following features:

- A micro-USB port in the Flora for uploading code and recording data. The data may be recorded via a Python pipeline (provided) or the Arduino IDE, and sonified at a later date for subsequent use and analysis.
- A white LED on the color sensor that can be switched on to allow the sensor to measure reflected light (as opposed to transmitted light)
- A NeoPixel LED that indicates the color detected by the sensor, which is useful for troubleshooting and for sighted users (see picture to right)

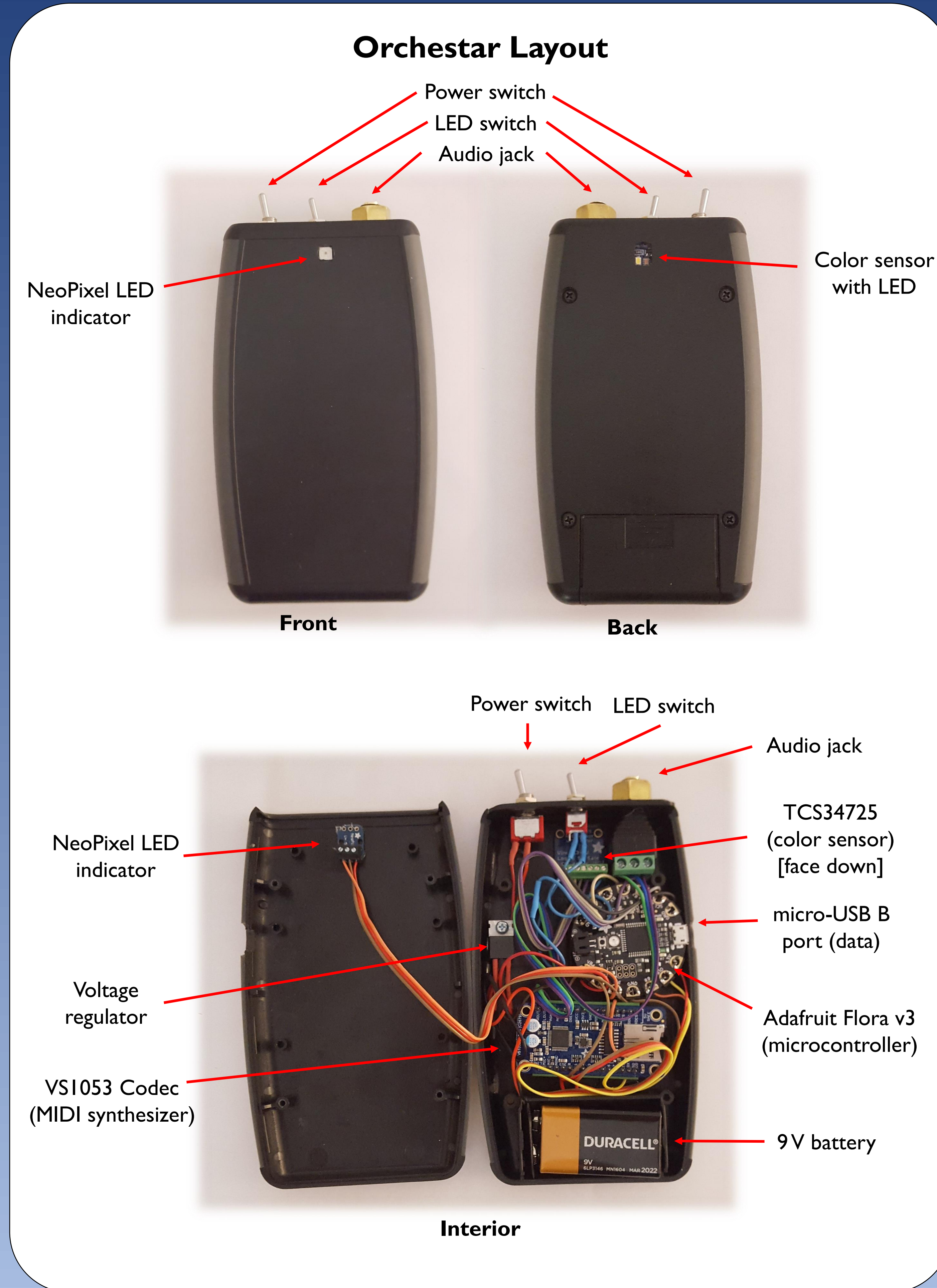


The documentation and code for Orchestar, which costs around \$90 to build, is freely available online so that others may build their own (and modify the code, if they wish). See "More Information" section at bottom of poster for links.

3 Use in the Classroom

To use the Orchestar, users must train their ears. Typically, this is done by learning the sounds that correspond to benchmark colors (e.g. red, green, blue), before trying to hear the more subtle color changes.

Orchestar is designed to be used in a laboratory setting for teaching concepts such as spectra or the relationship between wavelength and frequency. Work is underway to adapt the device for use on a telescope.



4 The Sounds

The Orchestar sonifies two aspects of the data collected by the sensor: color "value" and intensity. Color is determined numerically using the RGB readings from the color sensor.^[1] Brightness (in units of lux) is calculated via a built-in function from the color sensor library.^[2]

These values are mapped onto a range of integers, which determine the characteristics of the note played:

- Color and pitch
 - Redder colors correspond to lower pitches and bluer colors correspond to higher pitches
- Brightness and volume
 - Brighter colors correspond to louder notes

5 Improvements and Future Work

Future improvements to the Orchestar include a haptic (vibrational) feedback motor for deaf-blind individuals, as well as an auto-adjusting gain and integration time function to allow for measurements in low-light settings.

Other areas of work include experimentation with the MIDI sound library to convey various measurements with different instrument sounds (e.g. specific sounds for white light, saturated measurements, etc).

6 Other Sonification Work

LightSound is a similar sonification device that uses a high-sensitivity brightness sensor to sonify the changes in ambient light. The project recently received funding from IAU100 to build and distribute 24 devices to locations in Chile and Argentina for the upcoming solar eclipses in 2019 and 2020.^[3]

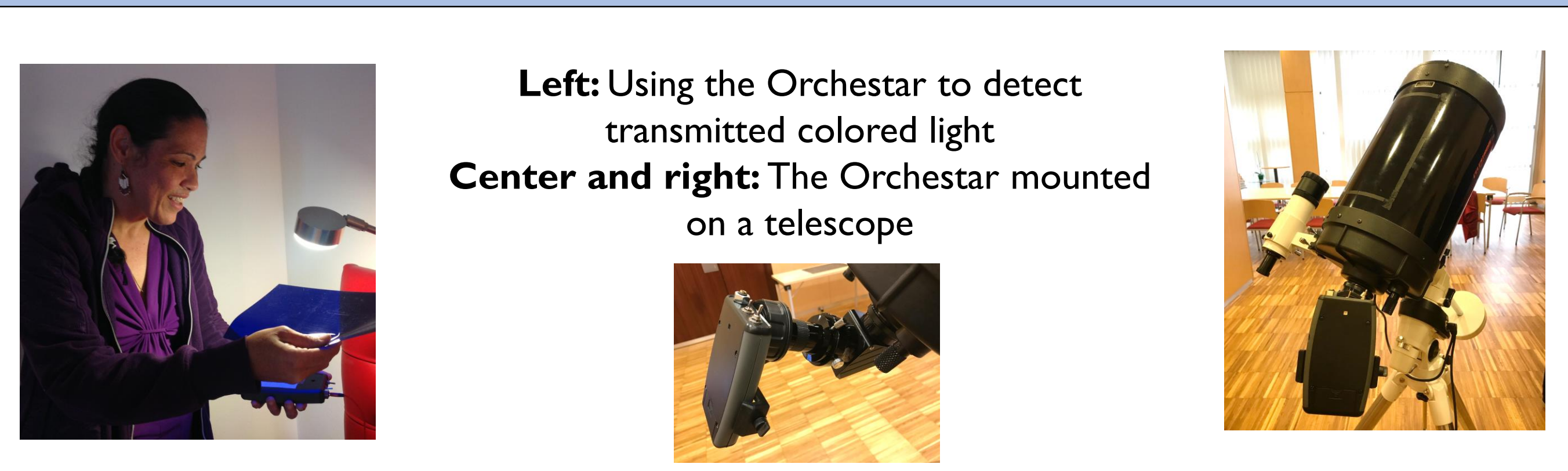
Train your ears!

(hover over each color with the Orchestar)



Test your ears!

(eyes closed, scan this strip with the Orchestar)



References:

- [1] Color calculation: <https://learn.adafruit.com/pianoglove/program-it>
- [2] TCS34725 Library: https://github.com/adafruit/Adafruit_TCS34725
- [3] IAU100 LightSound: <http://astrolab.fas.harvard.edu/LightSound-IAU100.html>



More Information:

Visit the Harvard Astronomy Lab's Accessibility page for the instructions and code to build your own Orchestar or LightSound at:

<http://astrolab.fas.harvard.edu/accessibility.html>

or scan the QR code to the left.



Contact Information:

Sóley Hyman, solehyman@gmail.com