

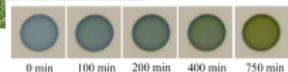
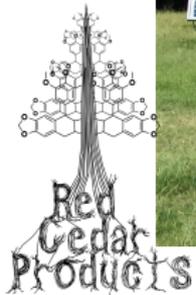
Low-cost Open-source Hardware Development for Nocturnal Migration Quantification by 'Moonwatching'

Wesley T. Honeycutt

Society for Integrative & Comparative Biology 2022
Pheonix, AZ

January 7th, 2022

A Chemist Building Robots for Biologists



How many birds migrate?

Many. Often at night.

How can we measure this?

Youtube Link

The Lowery Method

Youtube Link

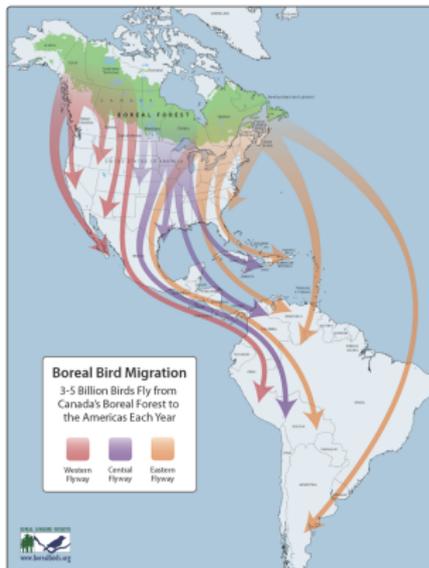
George H. Lowery. *A Quantitative Study of the Nocturnal Migration of Birds*, volume 3. Univeristy of Kansas Publications, Museum of Natural History, Lawrence, KS, June 1951



There Has to be a Better Way!



Citizen Science and International Accessibility



Boreal Songbird Association

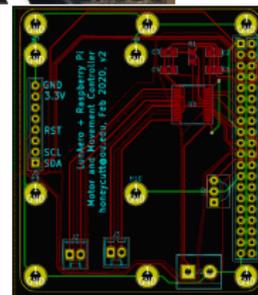
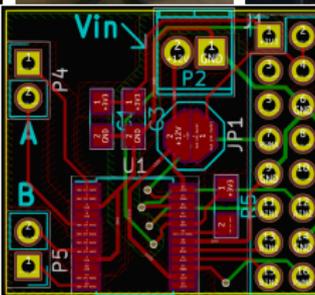
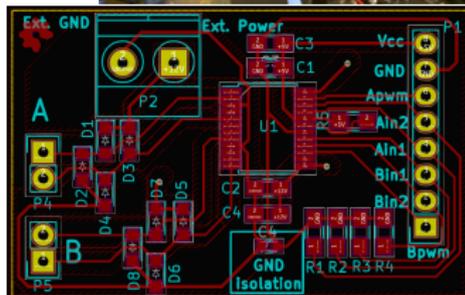
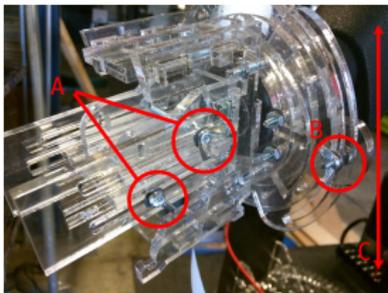
Cheap and Plentiful → Law of Large Numbers



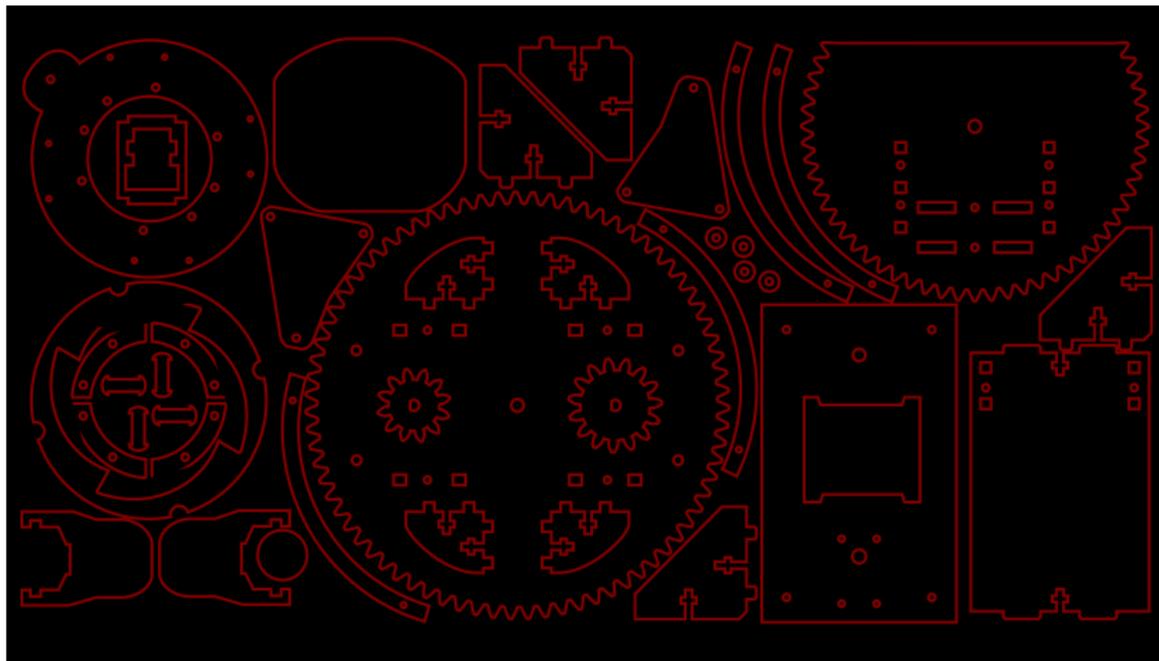
Testing Hardware Can be Difficult



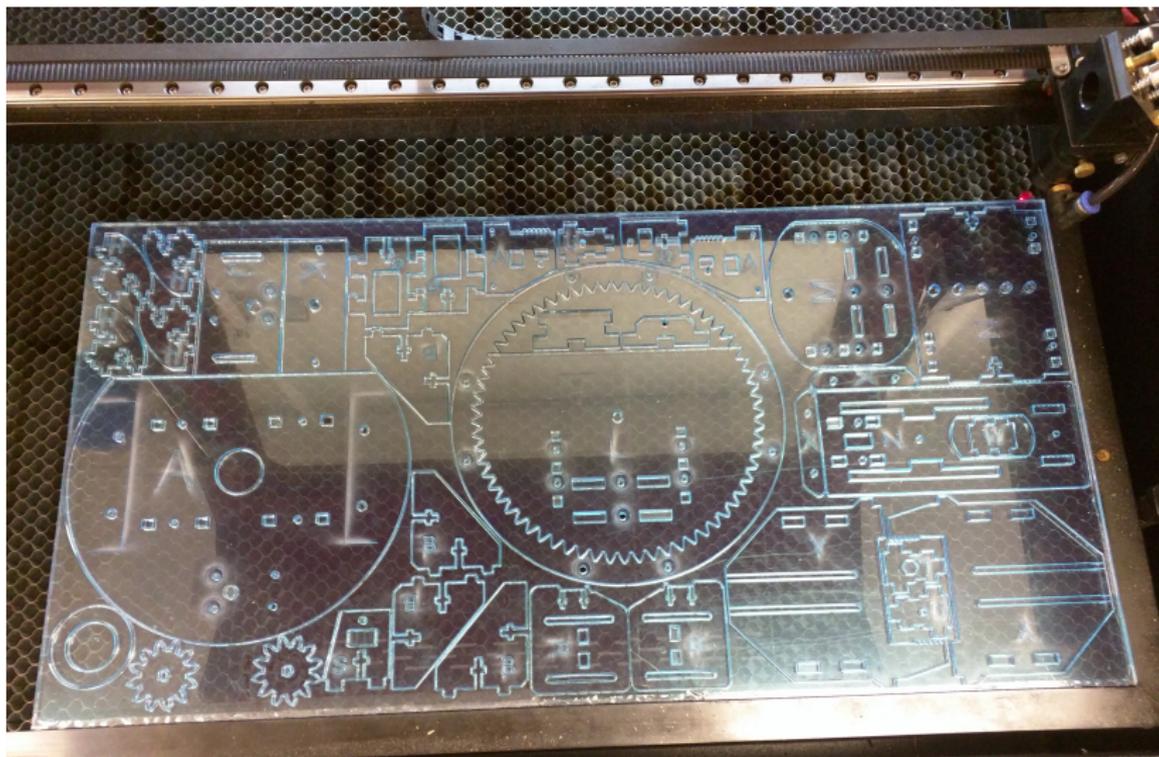
A Million Little Versions



The Challenges of Limited Tooling



The Challenges of Limited Tooling



Technology Improvements for Data Transfer

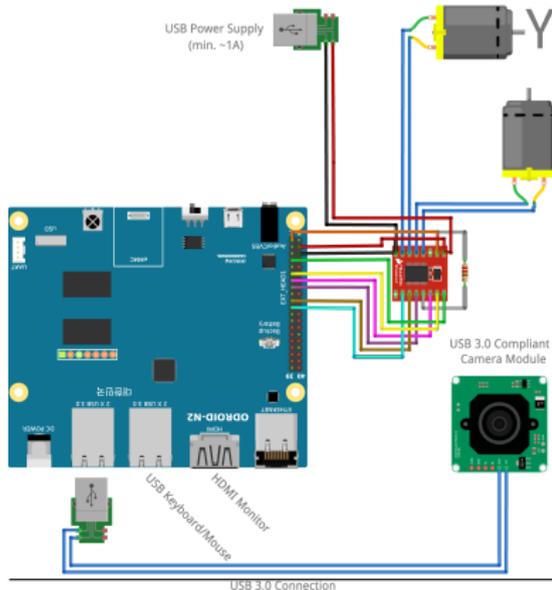
USB 2.0 Spec:

$$DSR_{max} = 480 \frac{\text{Mbit}}{\text{s}}$$

1080p 25fps:

$$\begin{aligned} DSR_{max} &= 1080 \frac{\text{px}}{\text{frame}_y} \times 1920 \frac{\text{px}}{\text{frame}_x} \times 25 \frac{\text{frame}_{xy}}{\text{s}} \times 8 \frac{\text{bit}}{\text{byte}} \times 3 \frac{\text{byte}}{\text{px}} \\ &= 1245 \frac{\text{Mbit}}{\text{s}} \end{aligned}$$

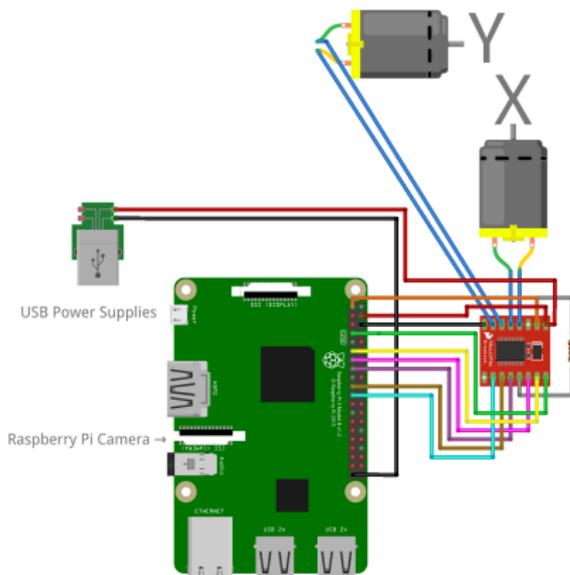
Technology Improvements for Data Transfer



Wesley T. Honeycutt, Alyse V. Heaston, Jeffrey F. Kelly, and Eli S. Bridge. LunAero: Automated "Smart" Hardware for Recording Video of Nocturnal Migration. *HardwareX*, 7:e00106, April 2020. ISSN 2468-0672. doi: 10.1016/j.ohx.2020.e00106



Technology Improvements for Data Transfer



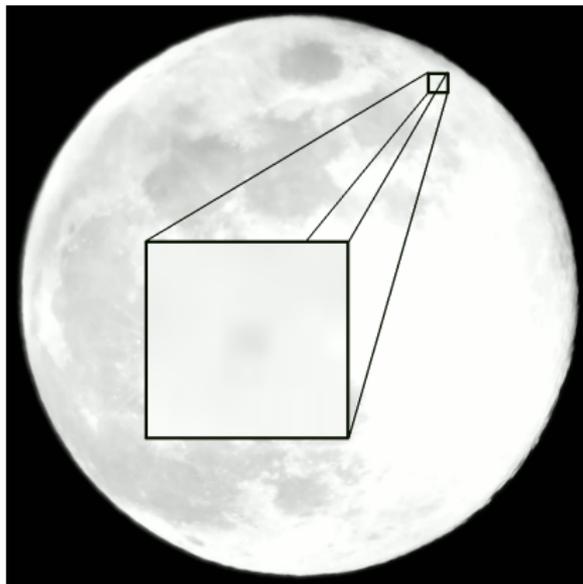
Who Wants to Watch That Much Video?

1.75 TB

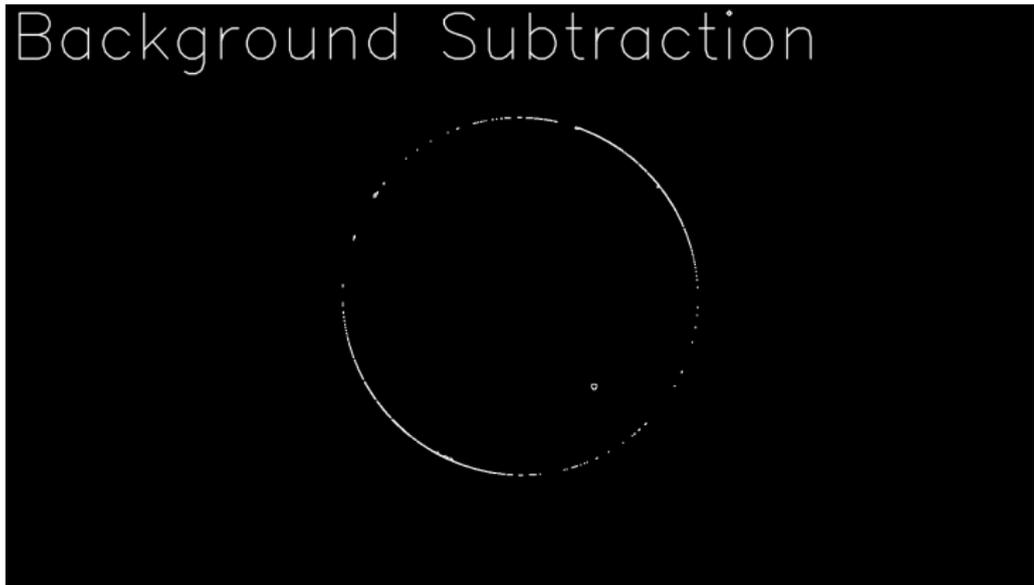
or

20.25 days of 8 Mbit s^{-1} video

Who Wants to Watch That Much Video?

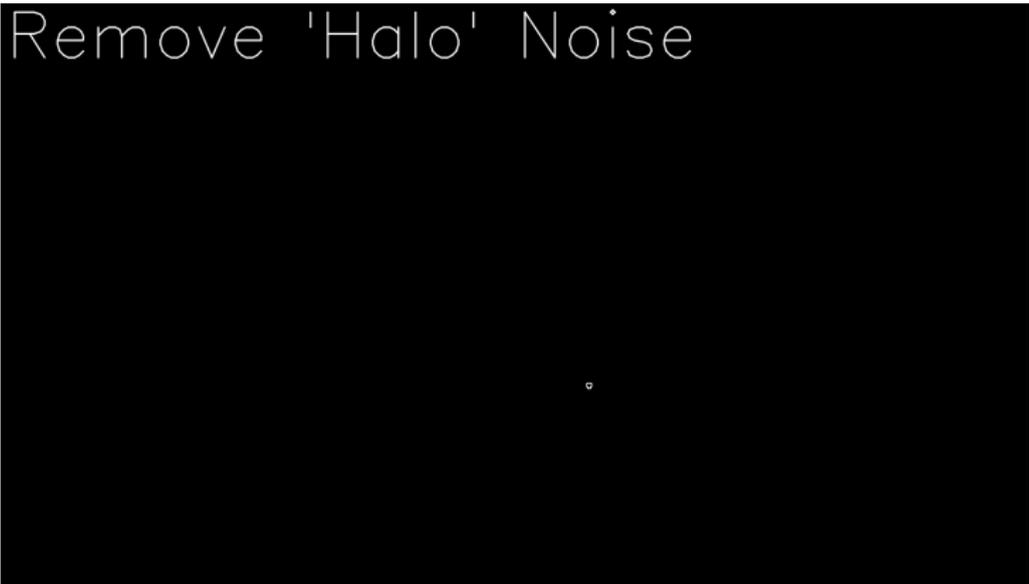


OpenCV: Strengths and Limitations

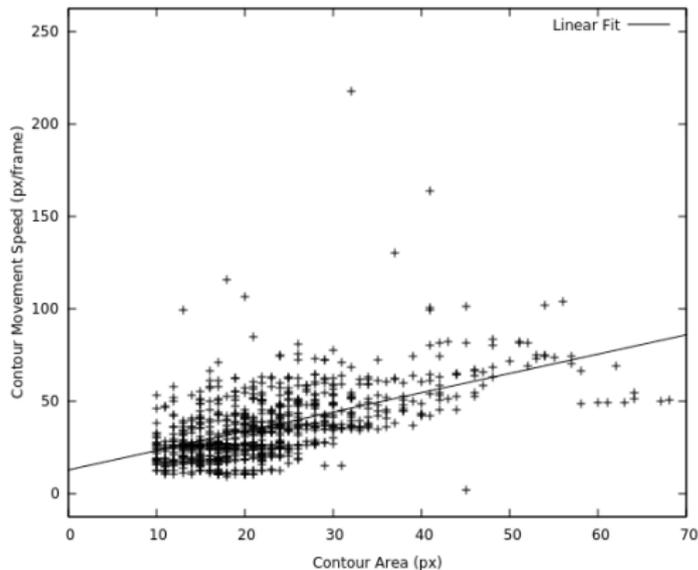


OpenCV: Strengths and Limitations

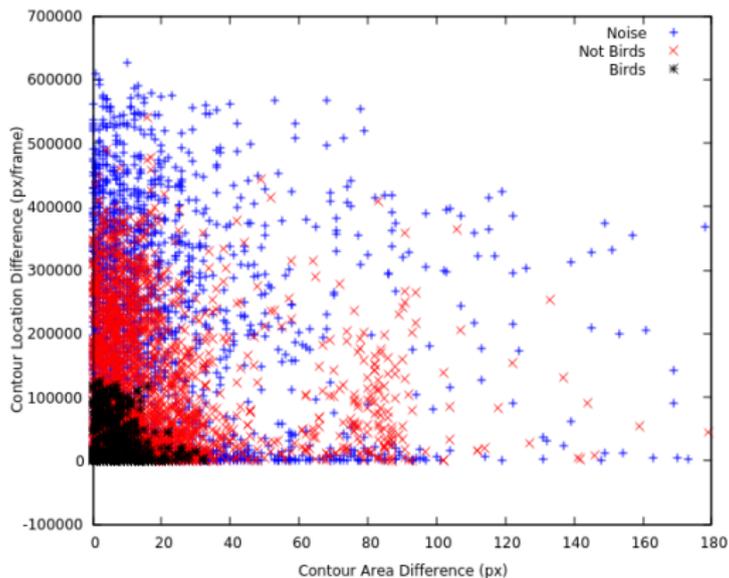
Remove 'Halo' Noise



OpenCV: Tracking After Subtraction



OpenCV: Tracking After Subtraction



OpenCV: UnCanny

Adaptive Thresholding:

5×5 Gaussian Blur then Niblack binarization

$$M' = G(M_x, M_y) - \overline{G(M_x, M_y)} + 255$$

Laplacian Difference:

Left and right 11×11 Laplacian operators are blurred (11×11 Gaussian) then subtracted

$$M'_n = \Delta M_n$$

$$G_{M'_n} = G(M_{nx}, M_{ny})$$

$$M''_n = G_{M'_n} - G_{M'_{n-1}}$$

Wesley T. Honeycutt and Eli S. Bridge. UnCanny: Exploiting reversed edge detection as a basis for object tracking in video. *Journal of Imaging*, 7(5), 2021. ISSN 2313-433X. doi: 10.3390/jimaging7050077

OpenCV: UnCanny

Difference between two frames is blurred, split by Sobel operators, squared, added, and the root is taken prior to Zhang-Suen thinning

$$M' = M_n - M_{n-1}$$

$$M'' = G(M'_x, M'_y) - \overline{G(M'_x, M'_y)} + 255$$

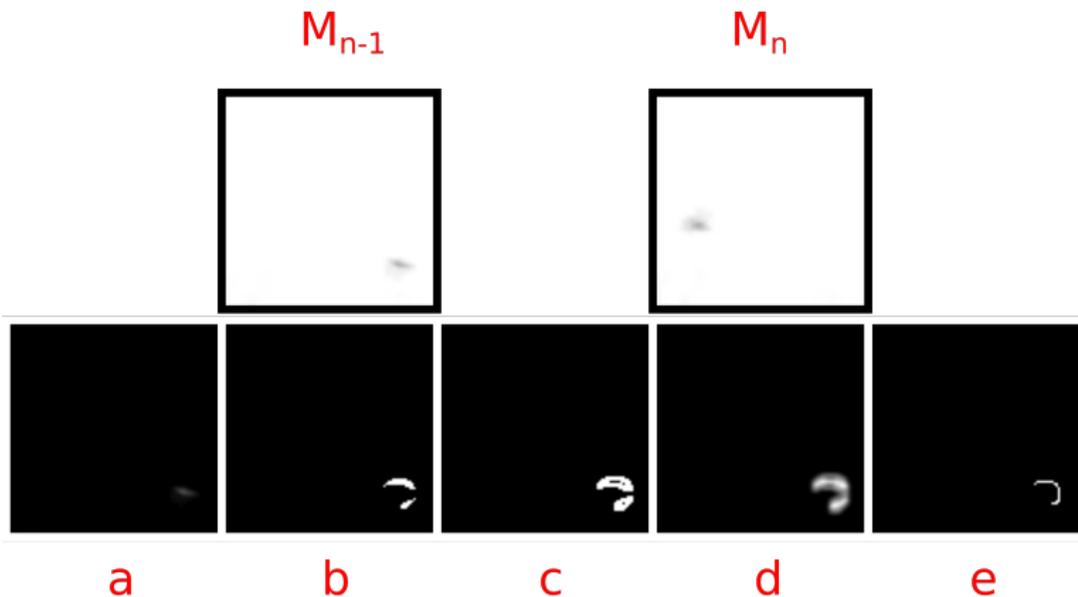
$$S_x = \begin{bmatrix} 1 & 0 & -1 \\ 2 & 0 & -2 \\ 1 & 0 & -1 \end{bmatrix} \times M'', \quad S_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \times M''$$

$$S' = \sqrt{S_x^2 + S_y^2}$$

$$U = Z(GS')$$

Wesley T. Honeycutt and Eli S. Bridge. UnCanny: Exploiting reversed edge detection as a basis for object tracking in video. *Journal of Imaging*, 7(5), 2021. ISSN 2313-433X. doi: 10.3390/jimaging7050077

OpenCV: UnCanny

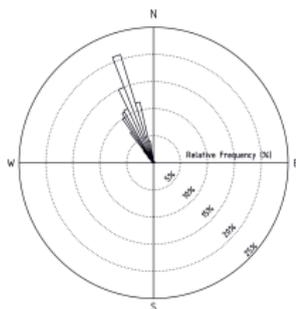
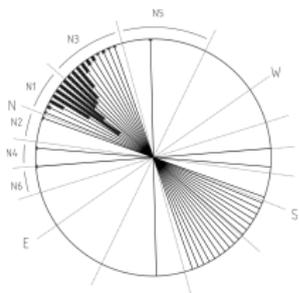


Wesley T. Honeycutt and Eli S. Bridge. UnCanny: Exploiting reversed edge detection as a basis for object tracking in video. *Journal of Imaging*, 7(5), 2021. ISSN 2313-433X. doi: 10.3390/jimaging7050077

Modernizing Lowery

How many birds do we estimate this way?

14 193 birds/kmh



Wesley T. Honeycutt, Alyse V. Heaston, Jeffrey F. Kelly, and Eli S. Bridge. **LunAero: Automated “Smart” Hardware for Recording Video of Nocturnal Migration.** *HardwareX*, 7:e00106, April 2020. ISSN 2468-0672. doi: 10.1016/j.ohx.2020.e00106



Contacts/Thanks

Colleagues

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Dr. Claire Curry

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*OU Thousands Strong

OU XGEM Big Idea Challenge

NASA GeoCarb

OCAST IP

Wesley T. Honeycutt

: wesleyhoneycutt.com

: *Please don't call me.*

: honeycutt@ou.edu

: <https://github.com/BlueNalgene>