BENCHMARKING OF PHOTONIC FENCE MONITORING DEVICE

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PHOTONIC SENTRY™

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Photonic Fence Monitoring Device (PFMD)

What is a PFMD?

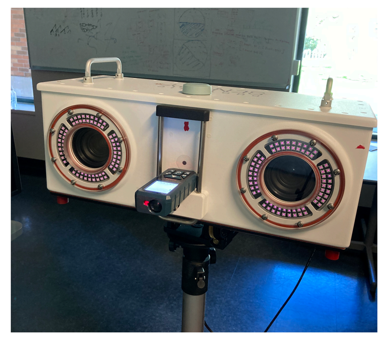
- The Photonic Fence Monitoring Device (PFMD) is an insect monitoring device built by Photonic Sentry to study the 3D flight behavior of mosquitoes and other insects.

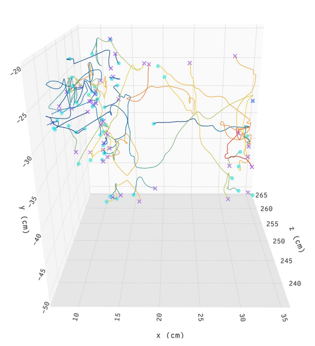
What is the PFMD for?

- The Photonic Fence is poised to revolutionize response to and monitoring of harmful insect incursions in agriculture, hospitality, government, military and residential pest controls market.
- This monitoring device is currently being deployed to users in more than a dozen countries, with particular interest among researchers, public health agencies, and companies seeking to develop better tools to fight malaria and other insect-borne diseases.

Benchmarking PFMD

- The PFMD currently does not have a quantified system of evaluating the accuracy and precision of the data it produces.
- Therefore, this project aims to create a benchmarking system to evaluate the data quality and to aid in responding to feedback from early adopters in the next iteration of PFMD

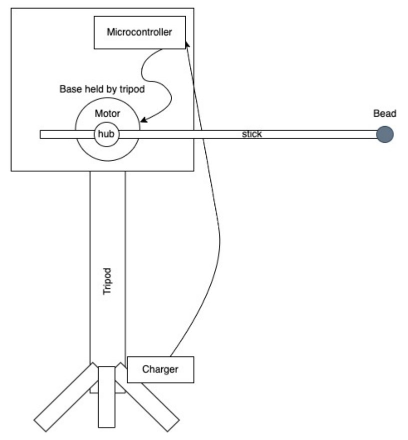


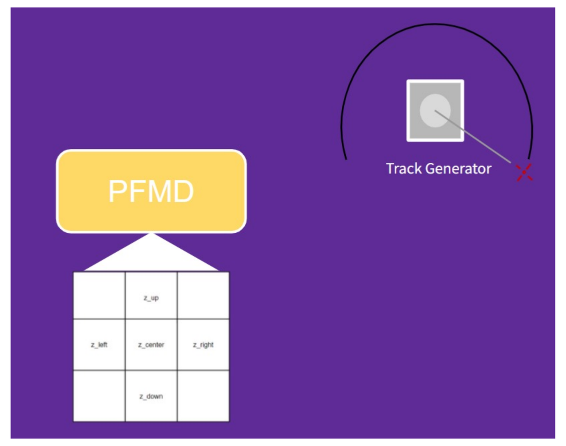


PFMD tracks of actual mosquitos

Track Generator

- To evaluate the PFMD we needed a track generator that moved a bug-like object in a known trajectory to measure ground truth from.
- The track generator rotated an aluminum rod with a ball attached at the end in a circular motion.
- This motion of the track generator allowed one axis (X, Y, or Z) to remain constant throughout the entirety of its motion. For example, we lined the aluminum rod up parallel to the PFMD, keeping the Z value constant.

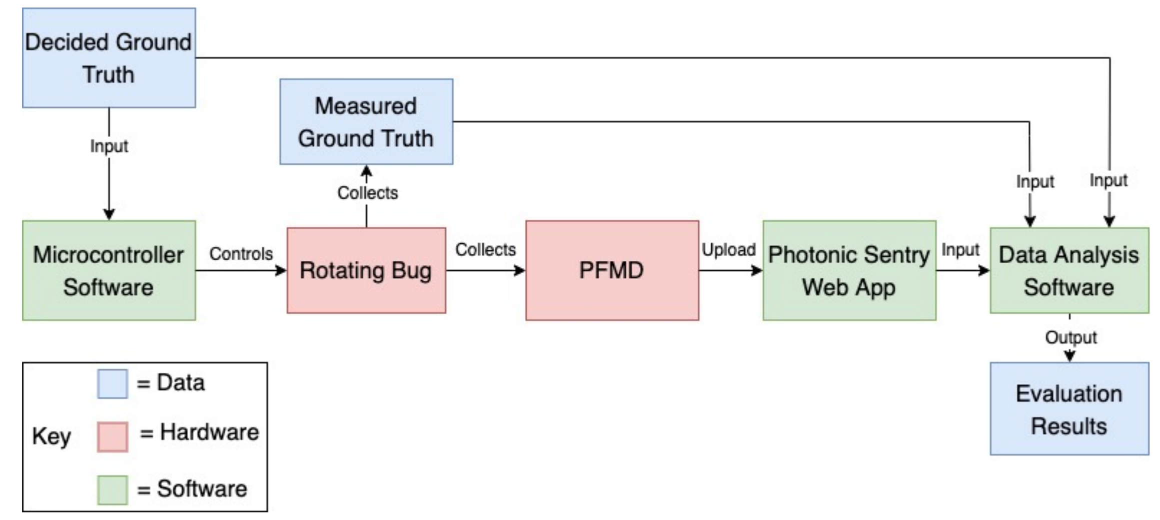




Experimental Procedure

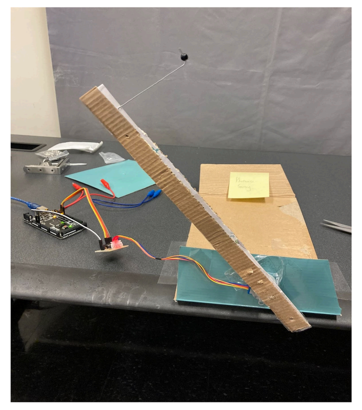
Throughout this project we conducted hundreds of experiments that followed this flow:

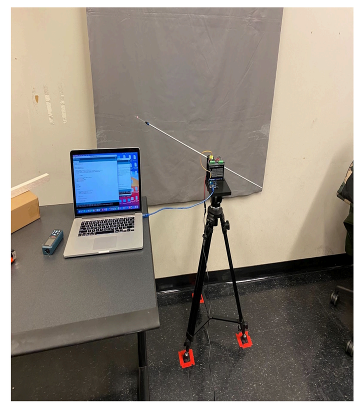
- Align the track generator and PFMD to hold one axis constant (X, Y, or Z):
- Measure the ground truth value for the constant axis and other parameters of the starting position.
- Run the software to make the track generator rotate, while recording on the PFMD.
- Process the PFMD measured data along with the ground truth data to generate statistics, visualizations, and error measurements of the PFMD measurements compared to ground truth.

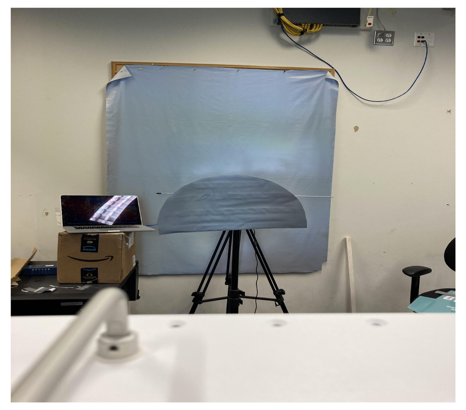


Obstacles/Progression

- We began by developing a track generator that consisted of a bead attached to a paperclip that rotated via a stepper motor.
- Through iteration we found which elements gave us consistent data measured by the PFMD at large scales.
- We then got a more professional design from the hardware designer at Photonic Sentry to speed up the data collection process.
- However, we ran into the issue that the PFMD would not detect the ball at typical brightness' used by PFMD clients.
- At lower (typical) brightness' the PFMD would detect the rod and ball to be one object that is too large to be a bug or mosquito.
- To fix this issue we tried using a semicircle of retro-reflective material to block the PFMD from seeing anything except the ball. However, this only worked to a limited degree.
- What worked the best was affixing retro-reflective material right behind the ball.





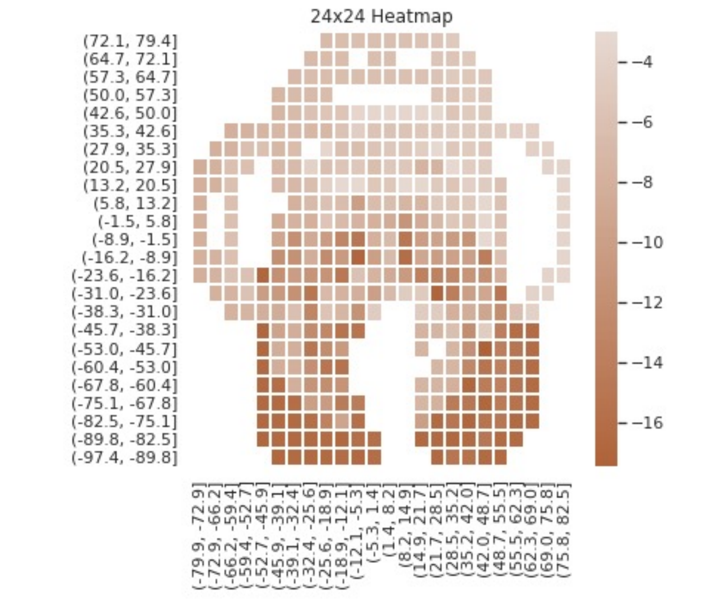


Results

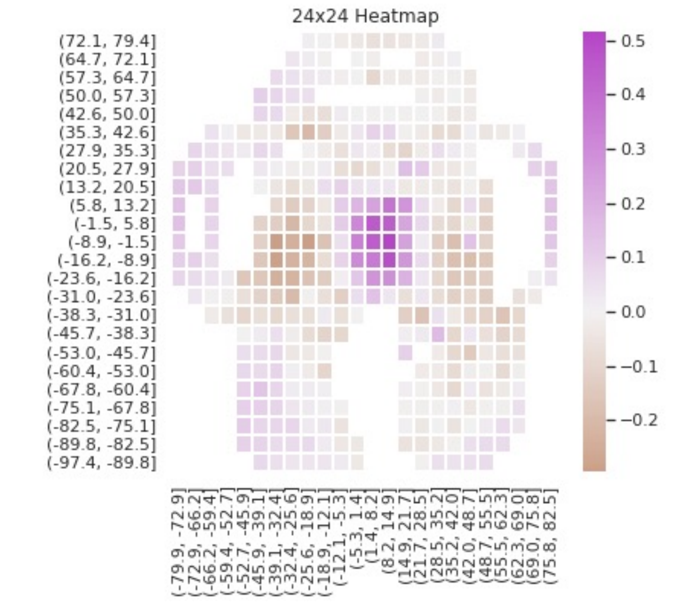
$$z\_model = \Theta_0 + \Theta_{1x}x + \Theta_{1y}y$$

z_model represents our measured Z error adjusted to account for displacement, pitch, and yaw biases

- Θ_0 is the 0th order displacement bias
- Θ_1 is the 1st order bias with respective components for X and Y

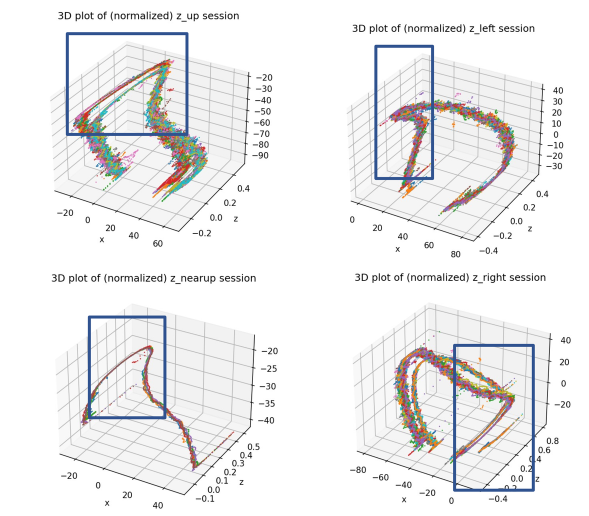


Heatmap of X vs. Y coordinates of all tracks holding the Z axis constant colored by measured Z error



Heatmap of X vs. Y coordinates of all tracks holding the Z axis constant colored by z error with z_model applied

We noticed a trend that couldn't be modeled by 0th or 1st order weights. Across many configurations we saw that the Z values increased as tracks approached the X, Y center. This was most likely due to PFMD bias because it was seen across many different configurations around the same X, Y coordinates.



Statistical Findings

Θ_0 is always smaller than the measured z (PFMD sees bug closer than it is)

- Mean value of -8.16 cm
- Standard deviation of 4.61cm
- Min constant (closest to measured) -2.80cm
- Max constant (furthest from measured) -17.2cm
- Possibly due to point of measurements differing between PFMD and our measured z

Θ_{1x} is always positive for all configurations (as x coordinate increases, so does z)

- Most likely due to PFMD bias because we would expect experimental bias here to be equally positively and negatively biased

Θ_{1y} has no overall trend across all configurations

Future Work, References, and Acknowledgements

- Categorize PFMD error with constant X and Y
- Statistically define overall 1st order weights
- Relay findings to researchers

All graphics and images on this poster were taken or generated by the members of the capstone group.

Photonic Sentry. (n.d.). Photonicsentry.com. Retrieved May 27, 2022, from https://photonicsentry.com/

Photonic Fence Monitoring App. (n.d.). Www.pfmd.net. Retrieved May 27, 2022, from https://www.pfmd.net/

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