Home-Cage Monitoring Device for Rodent Learning and Memory Studies

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Background

Alzheimer's disease (AD) exacts a heavy toll on our health care system, with an estimated 5.7 million patients in the United States alone. Great efforts have been dedicated to finding the genetic causes of AD and dozens of genes were identified to be closely associated with AD progression. Recently, through both whole genome and transcriptome studies, we have identified *GNB5* as a novel genetic risk factor for AD. Mouse models of *Gnb5* gene showed aggravated pathologic characteristics in mouse hippocampal and entorhinal brain regions. The next step is to evaluate if the learning and memory of these mice are also affected.

Learning and memory studies for mice typically rely on traditional methods such as water mazes and fear conditioning tests. These methods require the mice to be taken out of their home-cage which can induce stress and affect the accuracy and reliability of the results. To minimize these potentially adverse effects and improve the quality of the learning and memory tests, we set out to develop a new device that can be used to monitor mouse learning and memory activities from within their home-cages. This device will present the mouse with 2 feeding hoppers, one that shocks the mouse and one that doesn't. Electronics will automatically record mouse feeding activities and report how long it takes for mice to learn to prefer the control hopper and how long it takes to forget that learned preference.

Key Specs

- All hardware fits inside the standard Thoren brand home-cage used by NIDDK collaborators
- 2 custom food hoppers
  - One hopper configured to shock the mouse and a second hopper to serve as a control
  - Shocking and control hopper location can be swapped
  - Hoppers located on opposite sides of cage for spatial separation
  - Food only accessible from bottom so mice can't climb on bars
- Module to hold water bottle
- Module to hold electronics
- Ability to sanitize hardware with isopropyl alcohol
- Cage electronics powered by rechargeable battery pack
- Wireless data transmission from cage to data collection hub
- Wireless communication using a Bluetooth mesh network for multi-cage studies

Mechanical Design

The hoppers are fixed to specially designed cage insert, along side compartments for water and circuitry. All electronics are enclosed so they are protected from the mice. The cage insert will be laser cut from acrylic while the individual modules will be 3d printed.

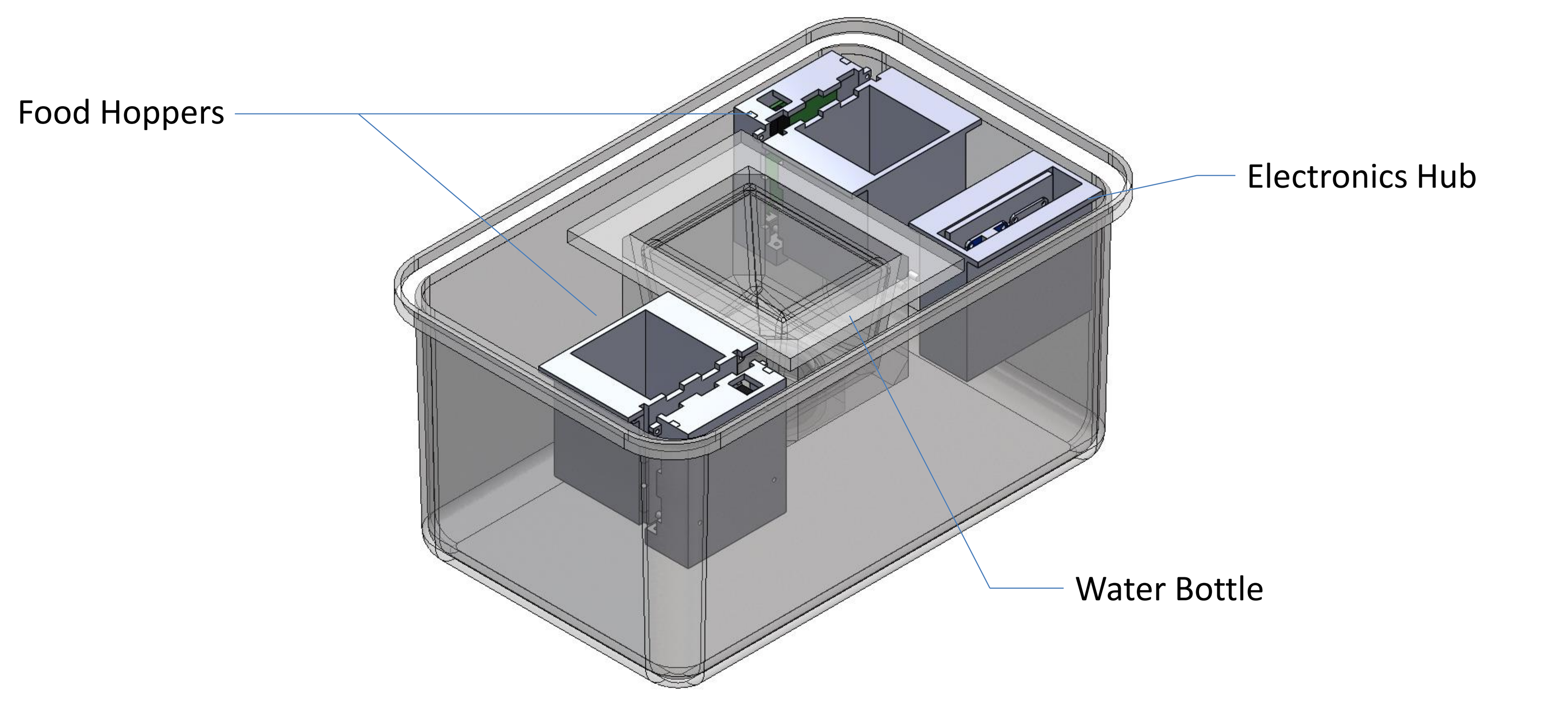

Figure 1: Cage design

Electronics

Shocks are monitored in each hopper using a INA219 High Side DC Current Sensor Breakout connected to a Particle Xenon microcontroller. When mice eat from the shocking hopper they stick their snouts between two metal bars, one powered and one ground. Their snouts complete the circuit and current flows to administer a shock. This flow of energy is then picked up by the current sensor and reported to the Xenon. The non-shocking hopper works in the same fashion, with significantly less current, allowing the sensor to recognize the feeding event without delivering the noticeable shock to the mouse.

Data from each Xenon is transmitted to a central Particle Argon which receives the data and stores it to a SD card. We connect the central Argon to an Adafruit 2.4" Color TFT Touchscreen Breakout to give live output of the system and to provide connections for the SD card.

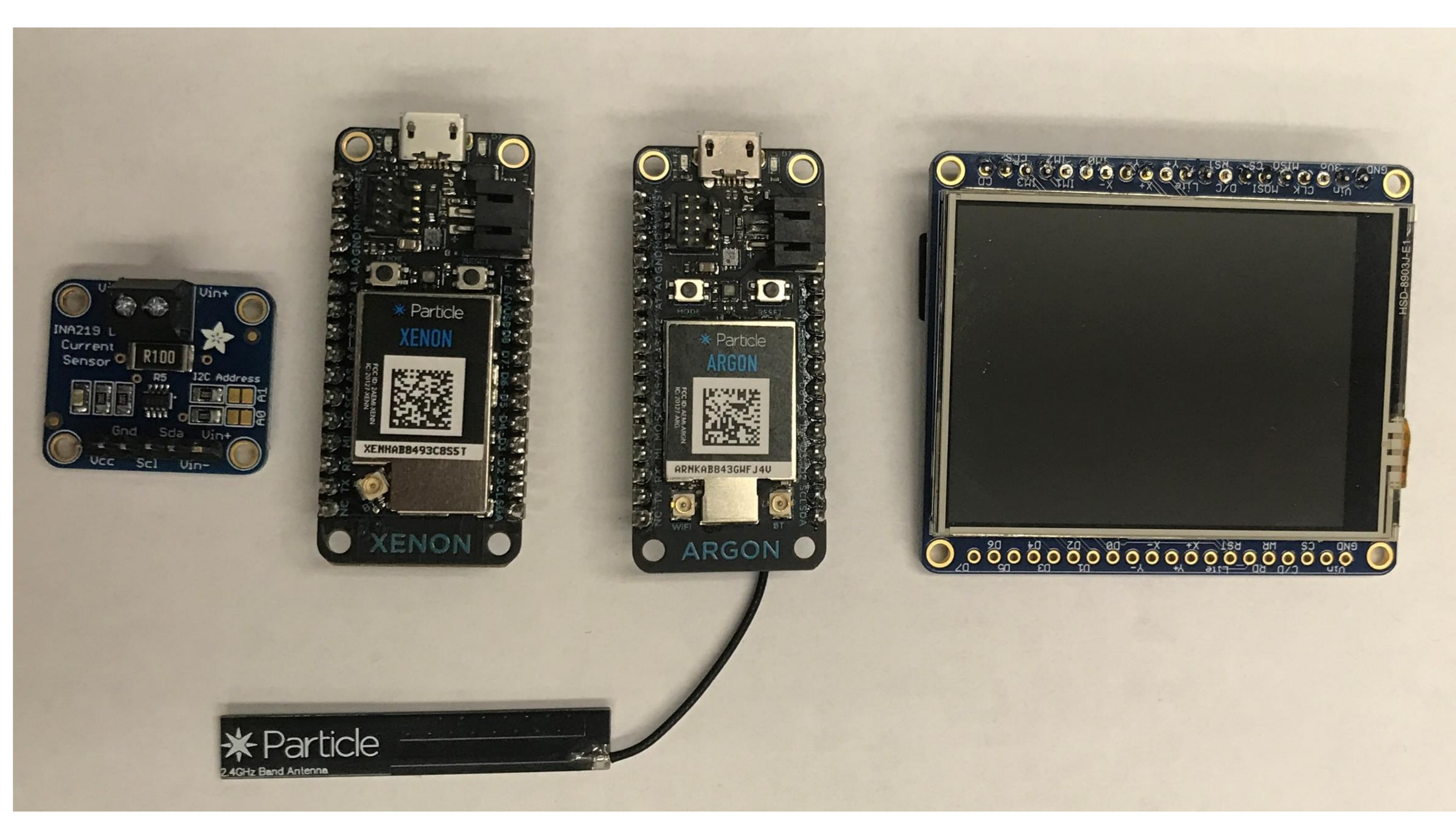

Figure 2: Current monitor, Particle devices, and screen

Wireless Communication

The Xenons in each cage are connected to the central Argon using a Bluetooth mesh network. This allows for easy access of data at one unified point. Using Bluetooth 5.0, the Xenons are able to connect and transfer data over each other's networks all to a single Particle Argon board which can display the data on an attached screen and save it to an SD card. In the future, we hope to connect the Argon to a cloud service to enable remote data access.

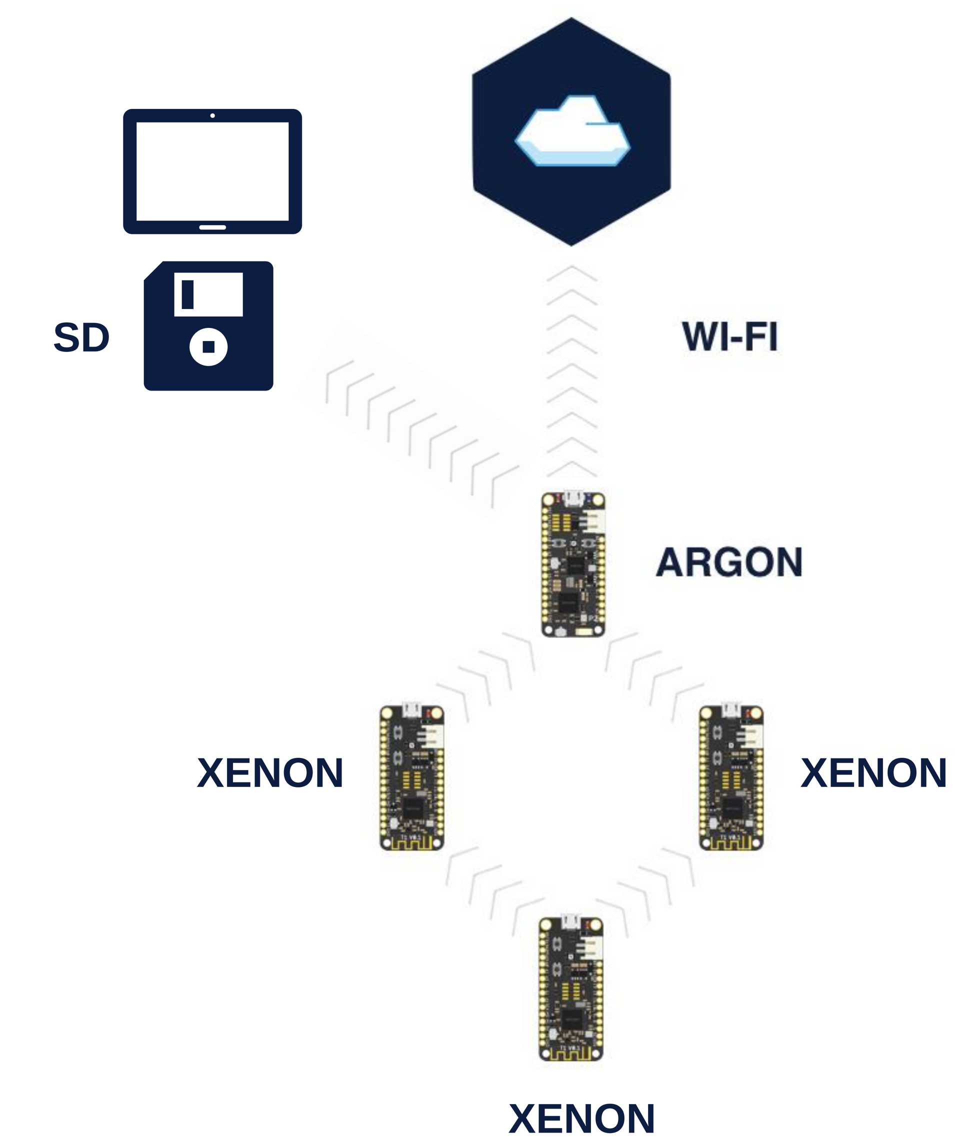

Figure 3: Mesh network diagram

Future Work

- Finalize design
- Obtain approval via collaborator's protocol
- Build and test single hopper module as proof of concept and validate using video monitoring
- Once validated, build and test full unit
- Scale up to 8-10 pairs of devices for higher throughput studies
- Enable cloud connectivity for remote data access

Acknowledgement

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