Project Deliverable G: Prototype II and Customer Feedback

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Introduction

This is a documentation of a second prototype bat box and what it took to create and test it, because of the findings and objectives of the first. This second bat box is a subvention of the overall final design bat box, which is intended to work with the other pieces designed. This second bat box is going to confirm the legitimacy of moving forward with design through refinement based on the three most important elements from the feedback assessment of the first bat box. Where the first bat box was built to assess its feasibility of function for something larger scale, this will assess its feasibility of specific elements through specific testing and results to better obtain quantifiable results and qualitative feedback. This will help the entire rest of the project be refined for a final design.

Part 2: Experimental models

Test	What	Analytical, numerical or experimental model
Validate laser sensor's detection accuracy+ range and alignment	Test laser sensor with controlled interruptions to simulate bats entering/exiting the box. Verify sensor detects each interruption accurately.	Set up a test environment with objects placed at known distances from the sensor. Measure the actual amount of triggers depending on the distance and type of movement and speed. Calculate the error % per distance.
Confirm Arduino data logging	Test data logging functionality by recording sensor data to the SD card in real time, ensuring reliable storage of visit counts and time stamps.	Run the system in real-world conditions and verify that data is being logged. Connect the Arduino to check real time recording
Evaluate data retrieval and storage efficiency	Test reading data from the SD card by retrieving recorded visit data to assess ease of data handling.	Connect the Arduino to the SD card and check whether the data is being saved correctly by unplugging it and connecting the SD card to the computer will also help us

		know the type of output we get.

Part 3 Results and problems

Test	Result and problems
Validate laser sensor's detection accuracy+ range and alignment	The code was theoretically correct however in practice some components were missing, and some weren't coded with the right parameters we will work on our code and since all the components are here it'll be easy. We have also checked that our sensor was working and it does with another code (it is only functional). There also might have been a circuiting problem. It was also not accurate (see confirm Arduino data logging). See annex. A second code was made but the continuous number logging problem persisted. However, the laser light problem was solved.
Confirm Arduino data logging	The data logging was also a problem since the code didn't feature the receiver it kept showing multiple numbers one after the other without any triggering done on our part, the sensor was also not on (the beam was not visible which is another one of our problems) meaning that as long as the sensor was plugged in it would continue logging numbers
Evaluate data retrieval and storage efficiency	Could not evaluate the retrieval since inputing was not successful both in our code and a tested code found online (see annex).

Part 4: Feeding

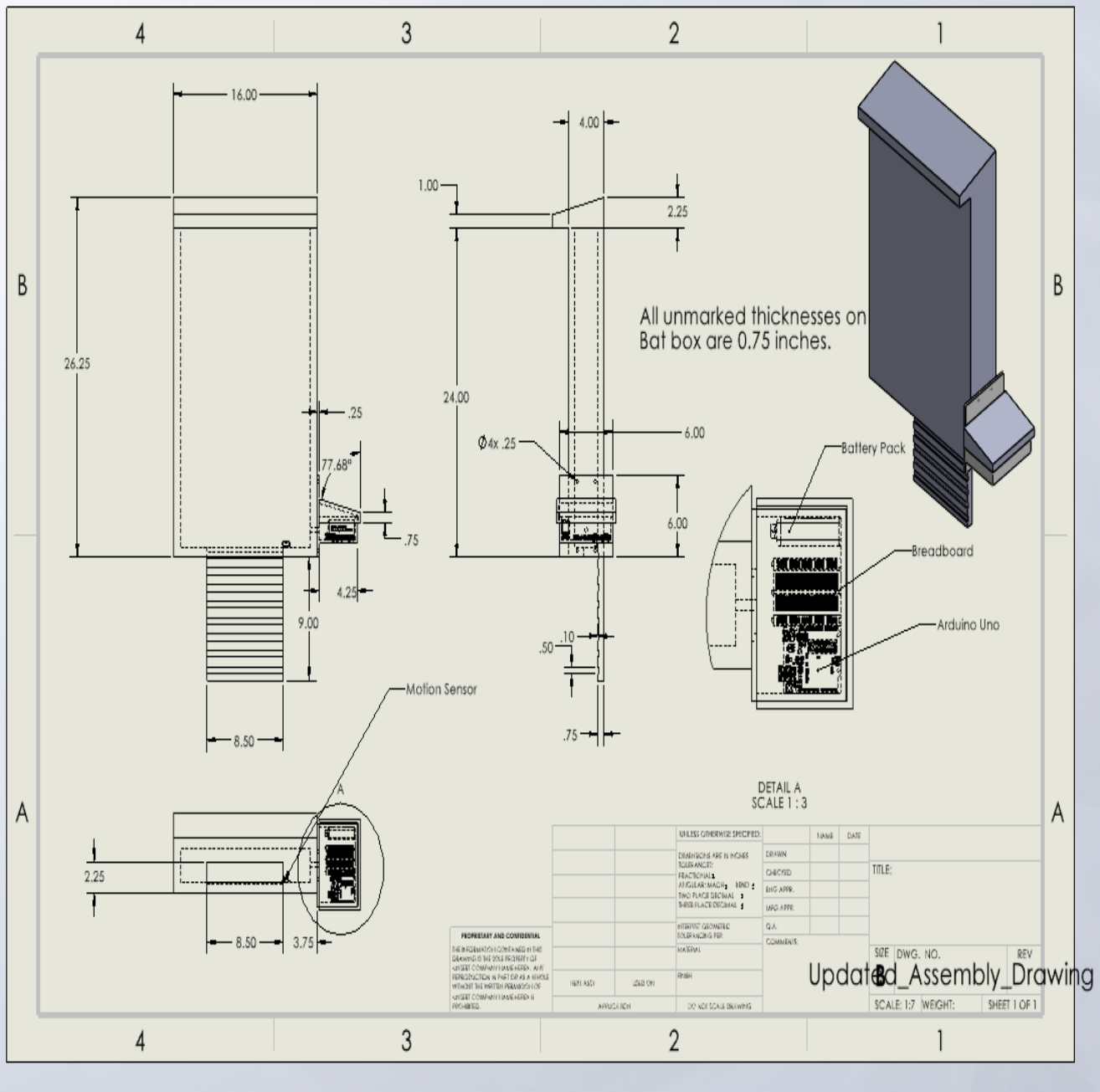
In order to collect feedback about your bat box prototype, which employs a laser sensor to monitor bat visits, your team reached out to different potential users and stakeholders who could benefit from the device. Among these individuals was a biologist who specializes in urban wildlife habitats. She valued the bat box's capacity for non-intrusive bat monitoring and proposed that the sensitivity of the laser sensor be adjustable to cater to various light and movement conditions in urban environments, where stray light or other animals could disrupt tracking accuracy. What's more, she suggested simplifying the sensor's data output to make it more understandable for non-specialists who might not require highly detailed metrics.
Your team also connected with EcoHaven, a nonprofit dedicated to bat conservation. One of their field technicians assessed the bat box prototype, pointing out that the design of the device was suitable for easy installation in a variety of natural settings. He advised adding a weather-resistant coating to the sensor housing to ensure the device can endure more extreme outdoor conditions. He noted that EcoHaven's staff would find additional metrics, such as temperature and humidity, valuable for researching bat behavior in relation to environmental changes.

Besides, feedback was obtained from a local environmental studies teacher, who shared her insights from an educational standpoint. She emphasized that her students would find the bat box engaging for learning about local wildlife and recommended that data outputs be presented in a straightforward, visual format to make the information accessible for younger users. She also stressed the significance of a user-friendly setup, as students would be responsible for installation and monitoring under her guidance.

Part 5: Updated design and updated

Bill of Materials				
Item #	Item Description	Quantity	Unit Price	Amount
1	Micro SD Card Module	1	$ 10.98	$ 12.41
2	Battery 3.7V - 150mAh	1	$ 4.00	$ 4.52
3	Arduino Datalogger	1	$ 9.99	$ 11.29
4	Arduino	1	$ 15.25	$ 17.23
5	Laser Sensor	1	$ 15.99	$ 18.07
6	Micro SD Card 64GB, SD Adapter	1	$ 13.99	$ 15.81
7	Bread Board	1	$ 5.00	$ 5.65
8	Battery Connector 9V	1	$ 2.00	$ 2.26
9	Cord	1	$ 2.75	$ 3.11
10	20cm Male-Male Jumper Cables	10	$ 1.00	$ 1.13
11	USB Wall Adapter	1	$ -	$ -
12	Screws	1	$ -	$ -
13	Wood	1	$ -	$ -
			Total	$ 91.47

Updated Detailed drawing



- Made the cover of the electronics box slanted. This will allow water, snow and other objects to be easily removed from the system and electronics.

Part 6: Prototype test plan for prototype III (after completing prototype II test plan)

Test ID	Test Objective (Why)	Description of Prototype and Basic Test Method (What)	Description of Results to be Recorded and Usage (How)	Stopping criterion	Estimated Test Duration and Start Date (When)
3	Check RTC functionality for timestamp accuracy	Test RTC module for maintaining accurate time while Arduino is powered and unpowered to ensure reliable time stamps.	Compare recorded time stamps with actual time over a 24-hour period. Ensures that each bat visit is accurately time-marked, critical for tracking visit patterns.	Doesn't vary for more than 1 minute (if the data is recorded / hour)	2 hours, Start on 11/13
4	Assess battery life under prototype load	Run prototype continuously to measure battery duration with the laser sensor and Arduino active, to predict maintenance frequency for field deployment.	Record power levels before and after 24h of usage. Key to estimating how long the device can function autonomously.	Since a 24h test will be done and it'll need to be performed for 30-31 days (35 days for safety) it shouldn't use more than 2.86% of the battery	24 hours, Start on 11/15
5	Test for interference from environmental factors	Expose the prototype to low-light conditions and simulated environmental factors (e.g., wind, insects) to check for false detections.	Record instances of false detections and correlate with environmental conditions to adjust sensor sensitivity. Ensures accurate bat counting in real-world settings.	As long as regular wind and small ojectecs don't offset the sensor in a systematic way	3 hours, Start on 11/16

6	Prototype assembly and integration	Assemble the laser sensor, RTC, SD card module, and Arduino to confirm integration and ease of assembly. Test that components fit securely within the bat box enclosure.	Document assembly steps and note any fitting issues. This will highlight potential redesign needs for better integration and ease of maintenance.	When every component is in its place	4 hours, Start on 11/22
9	Test for enclosure protection in outdoor settings	Simulate outdoor conditions (e.g., humidity, dust) to evaluate the enclosure's durability and ability to protect internal electronics.	Record any ingress or damage to components. Ensures the enclosure protects the system from environmental elements, crucial for long-term outdoor use.	NA	2 hours, Start on 11/19
10	Soldering practice and component resilience	Practice soldering connections for laser sensor, RTC, and SD card module to ensure strong, durable connections.	Inspect soldering quality under light stress and verify connection stability. Essential to prevent disconnections in field conditions, improving durability.	NA	3 hours, Start on 11/22
11	Collect user feedback on usability	Gather feedback from potential users (e.g., wildlife researchers) on ease of use, data retrieval, and overall functionality.	Document user suggestions and identify areas for improvement. User insights will guide final adjustments for usability in the field.	10 people outside of our team (and ideally outside of our class)	2 hours, Start on 11/21

Conclusion

This was an important milestone for the creation and validation of this second prototype because the team was left in a good place going forward. We know the changes and adjustments to make going forward, we have feedback from others, and we have tested that the most critical subsystem of our design can operate as intended with more thorough testing. This milestone is important for any future developments because it creates an effective direction of progress, takes us closer to project aims, and solidifies all critical components of the following phase. We appreciate this milestone of the creation of a prototype because it offered critical features that support operation and features that require adjustment. Therefore, we know this is going to set us up for the future appropriately.

ANNEX

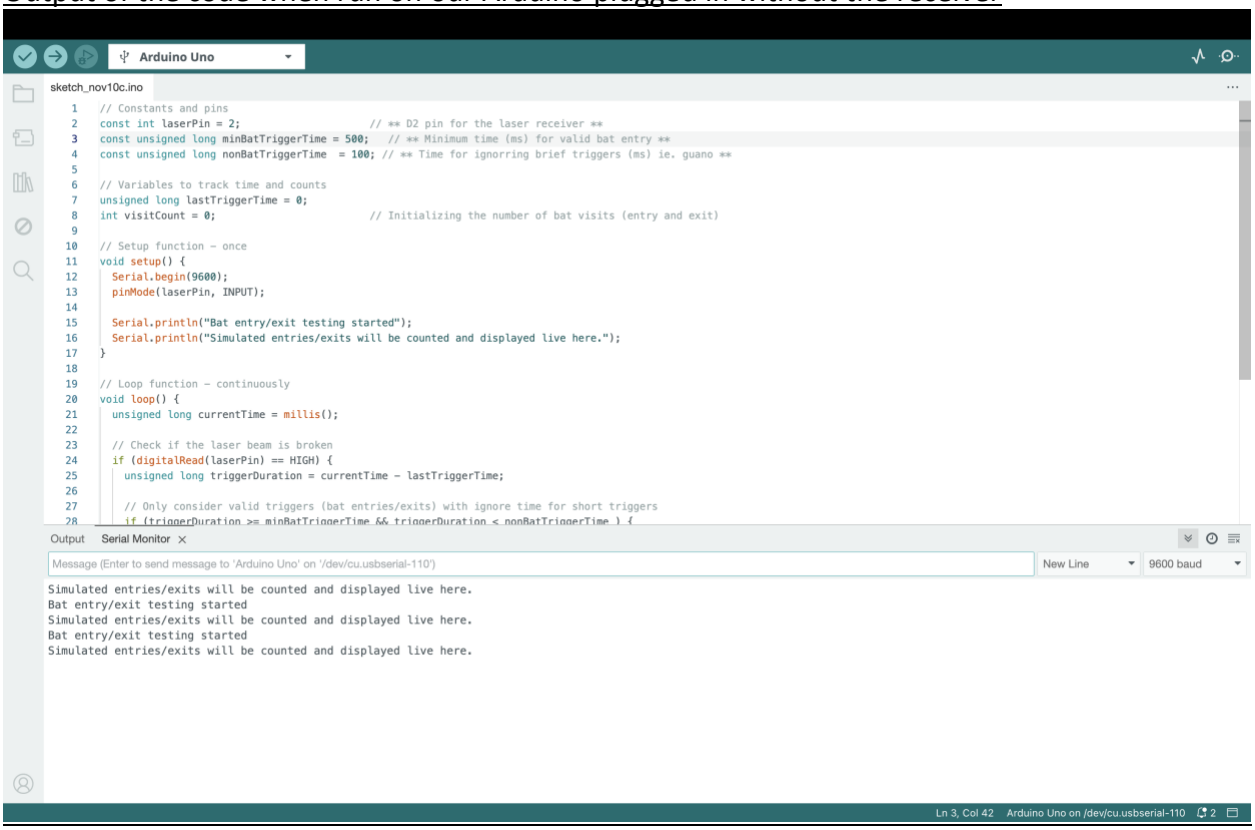
Validate laser sensor's detection accuracy+ range and alignment

Code (ours for sensor only)

```
// Constants and pins
const int laserPin = 2;                    // ** D2 pin for the laser receiver **
const unsigned long minBatTriggerTime = 100;   // ** Minimum time (ms) for valid bat entry **
const unsigned long nonBatTriggerTime  = 500; // ** Time for ignorring brief triggers (ms) ie. guano **

// Variables to track time and counts
unsigned long lastTriggerTime = 0;
int visitCount = 0;                        // Initializing the number of bat visits (entry and exit)

// Setup function - once
void setup() {
  Serial.begin(9600);
  pinMode(laserPin, INPUT);

  Serial.println("Bat entry/exit testing started");
  Serial.println("Simulated entries/exits will be counted and displayed live here.");
}

// Loop function - continuously
void loop() {
  unsigned long currentTime = millis();

  // Check if the laser beam is broken
  if (digitalRead(laserPin) == HIGH) {
    unsigned long triggerDuration = currentTime - lastTriggerTime;

    // Only consider valid triggers (bat entries/exits) with ignore time for short triggers
    if (triggerDuration >= minBatTriggerTime && triggerDuration < nonBatTriggerTime ) {
      visitCount++;                  // Increment visit count for each entry/exit
      lastTriggerTime = currentTime;  // Update last trigger time

      // Print each pair of entry/exit as a single bat visit
      if (visitCount % 2 == 0) {
        int batVisitCount = visitCount / 2;
        Serial.print("Current bat visit count: ");
```

```
      Serial.println(batVisitCount);
    }
  }
 }
}
```

Output of the code when run on our Arduino plugged in without the receiver

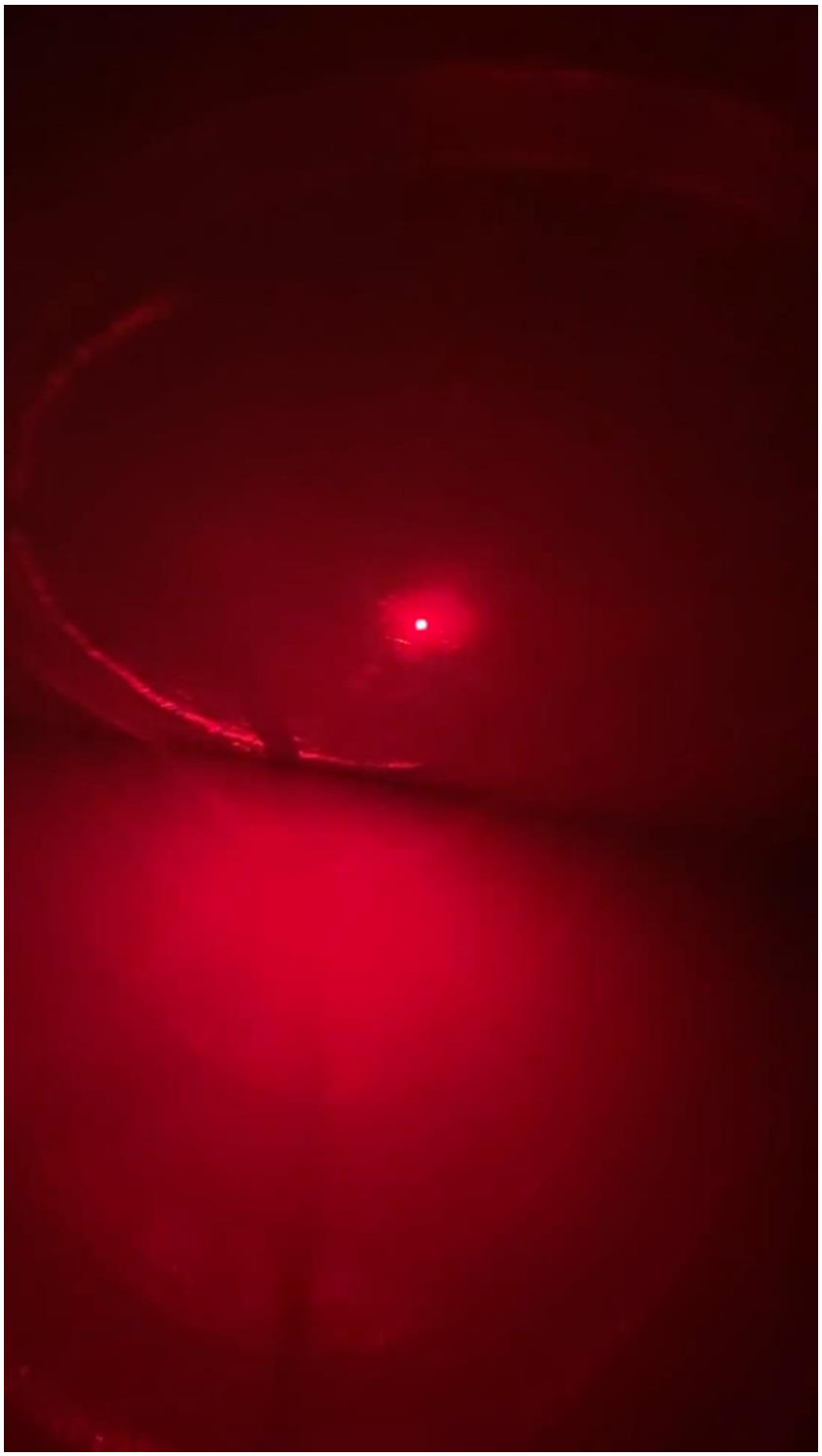


Code to check if the sensor wasn't faulty and its result : https://www.instructables.com/Keyes-KY-008-Laser-Transmitter-Demystified/

```
// KY-008 Laser Transmitter Demo by Brad White 12/09/2015

int Laser = 2; // creating a variable named Laser and assigning it to digital pin 2

void setup() {

pinMode (Laser,OUTPUT); // designating pin 2 as output (we can use "Laser" instead of the pin # because we assigned "Laser" to pin 2 above)

digitalWrite(Laser,LOW); // making sure the laser is off at startup or reset

}

void loop() {
```

digitalWrite(Laser,HIGH); // turning the laser on

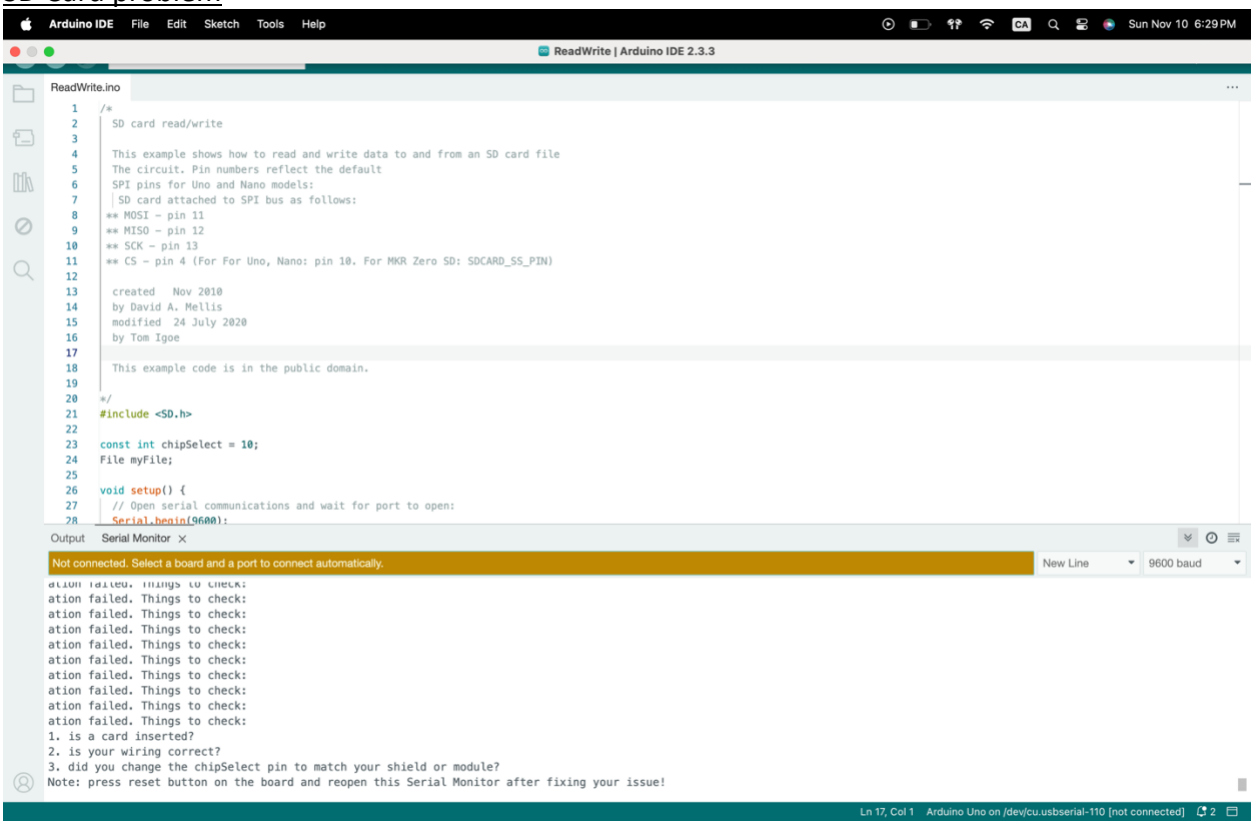
delay(250); // waiting for 1/4 of a second



digitalWrite(Laser,LOW); // turning the laser off

delay(250); // waiting for 1/4 of a second

SD Card problem

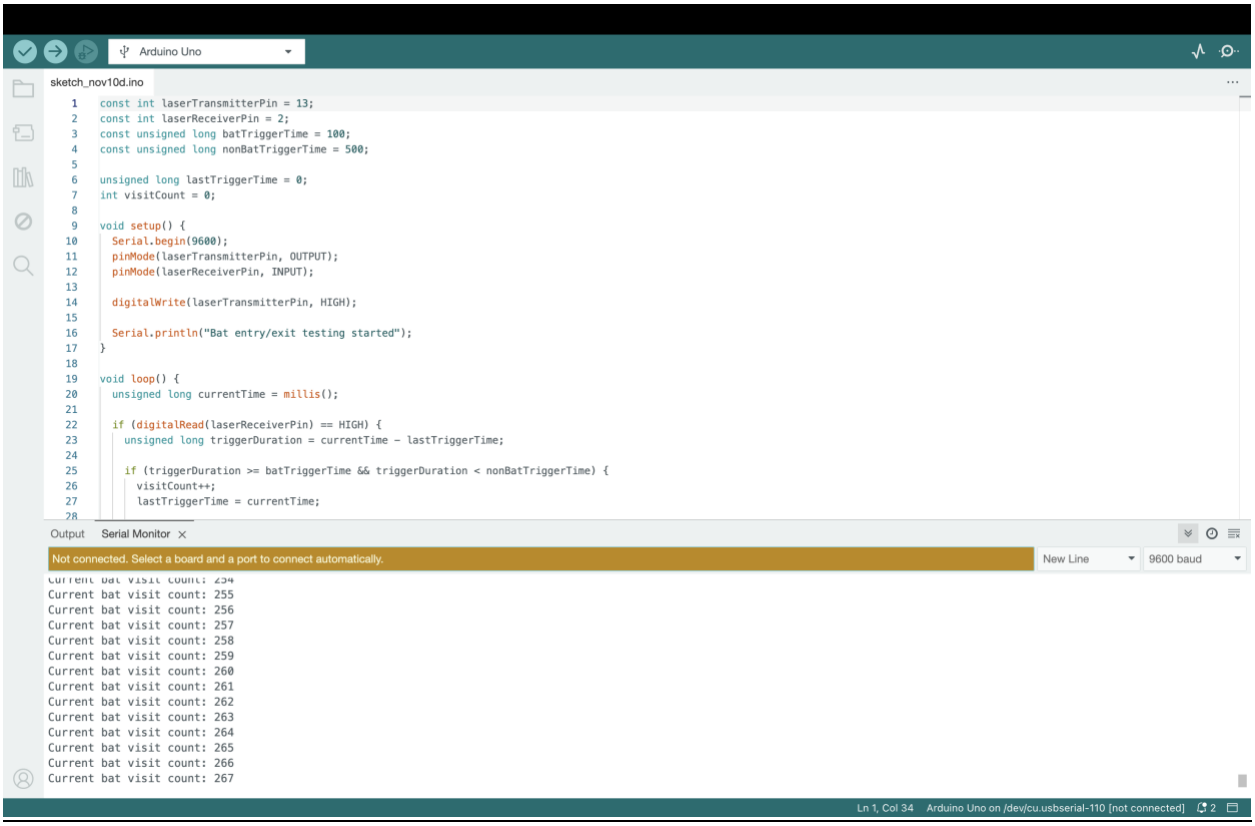


New code (for sensor only and receiver)

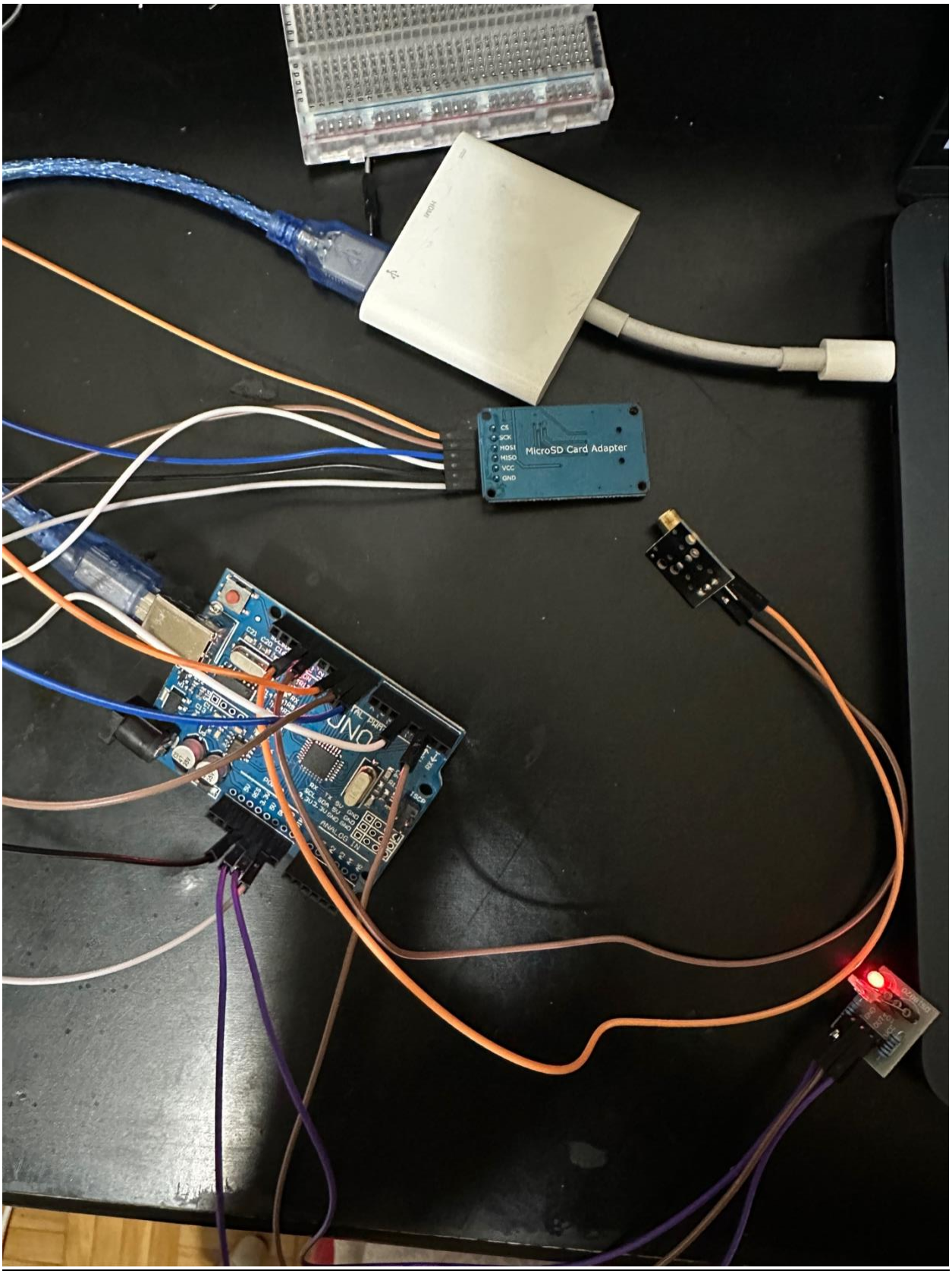
```
const int laserTransmitterPin = 3;
const int laserReceiverPin = 2;
const unsigned long batTriggerTime = 100;
const unsigned long nonBatTriggerTime = 500;

unsigned long lastTriggerTime = 0;
int visitCount = 0;

void setup() {
  Serial.begin(9600);
  pinMode(laserTransmitterPin, OUTPUT);
  pinMode(laserReceiverPin, INPUT);
```

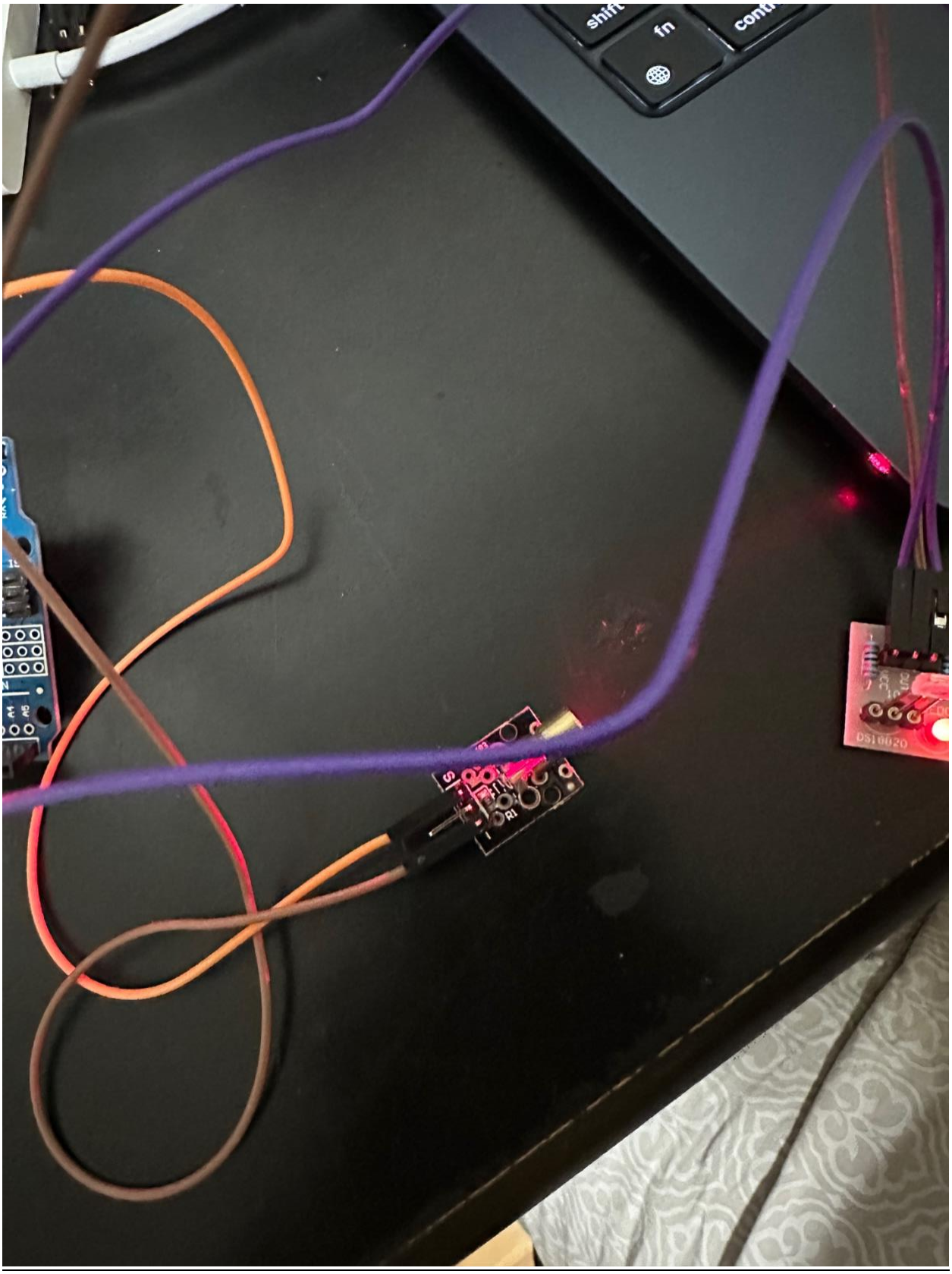
```
  digitalWrite(laserTransmitterPin, HIGH);

  Serial.println("Bat entry/exit testing started");
}

void loop() {
  unsigned long currentTime = millis();

  if (digitalRead(laserReceiverPin) == HIGH) {
    unsigned long triggerDuration = currentTime - lastTriggerTime;

    if (triggerDuration >= batTriggerTime && triggerDuration < nonBatTriggerTime) {
      visitCount++;
      lastTriggerTime = currentTime;

      if (visitCount % 2 == 0) {
        int batVisitCount = visitCount / 2;
        Serial.print("Current bat visit count: ");
        Serial.println(batVisitCount);
      }
    }
  }
}
```

Output with undesired number logging



Pictures of the circuits


CS
SCK
MOSI
MISO
VCC
GND
MicroSD Card Adapter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