Lab 5 Report

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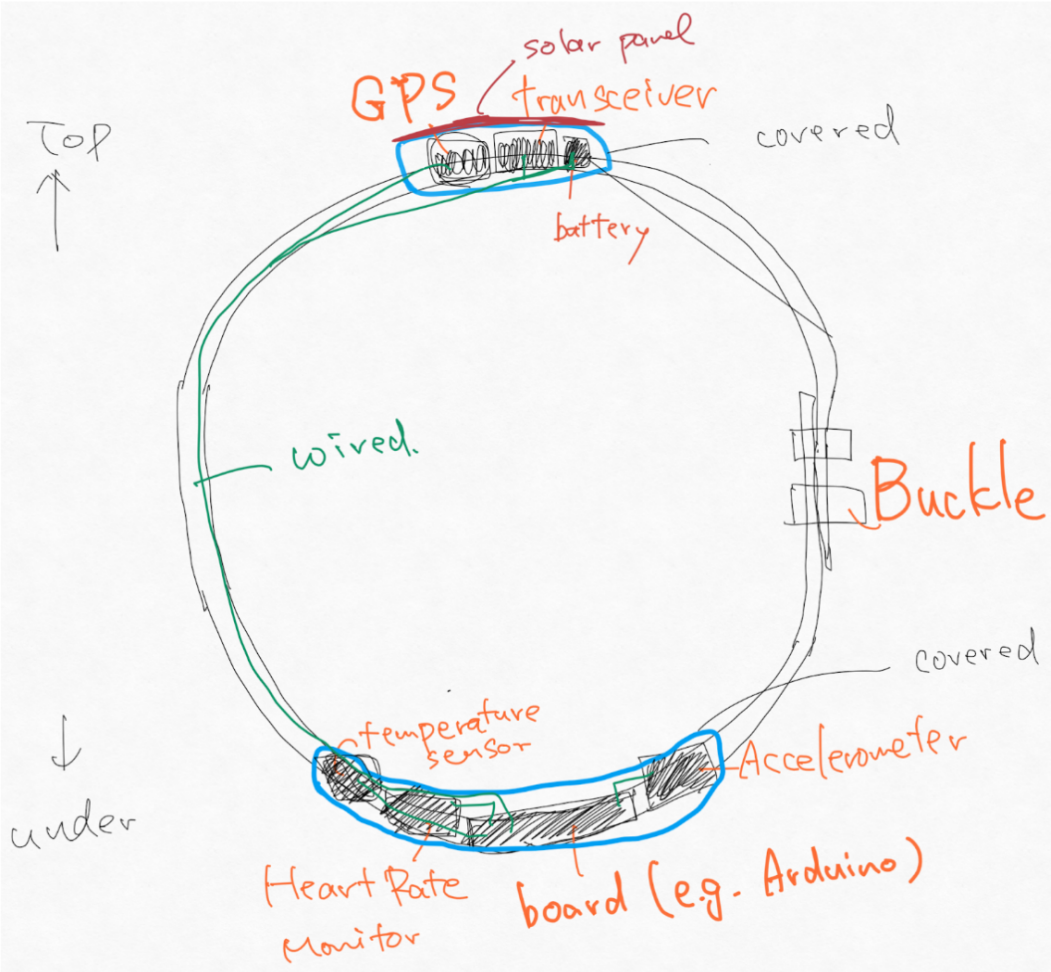
Late days used: 0
Video Link: Google Drive Link
Repo Link: UIUC Engr Gitlab Repo
Contribution: All members contributed equally to this lab.

Step 2a: Design Your Device

Here is our idea of a device to be placed on zebras to monitor their population, health, and movement.



> 1. What sensors would you need

A. GPS Sensor: To track the location and movement patterns of the zebras.
B. Heart Rate Monitor: To track the health and stress levels of the zebras.
C. Accelerometer: To detect sudden changes in movement or possible injuries.
D. Temperature Sensor: To monitor the zebra's body temperature and assess health.

> 2. How would they be connected

A. All the sensors are connected to a processor on the board via wires.
B. The satellite transceiver sends periodic updates to a centralized server for remote monitoring and data analysis.

> 3. What sort of code would you run on there

A. A function that processes incoming data from sensors
B. A function that transmits stored data to the satellite transceiver
C. A function that controls power-saving modes to conserve battery life.

> 4. Where would you put the sensors on the animal

A. GPS Sensor and Satellite Transceiver: On the top side of the collar to ensure clear sky visibility.
B. Heart Rate Monitor: On the underside of the collar, in contact with the zebra's neck for accurate readings.
C. Accelerometer and Temperature Sensor: Embedded within the collar to fix their position on the body.

> 5. Physical construction (waterproof? weight? where would you put it on the animal?)

A. Waterproof: The device should be covered and waterproof to protect it from rain, splashes, or immersion in water.
B. Weight: For a zebra collar, a weight limit of 3-5 lbs is recommended[1].
C. Where on the animal: Adjustable collar on the neck.
D. Battery: Rechargeable battery with solar charging capabilities.

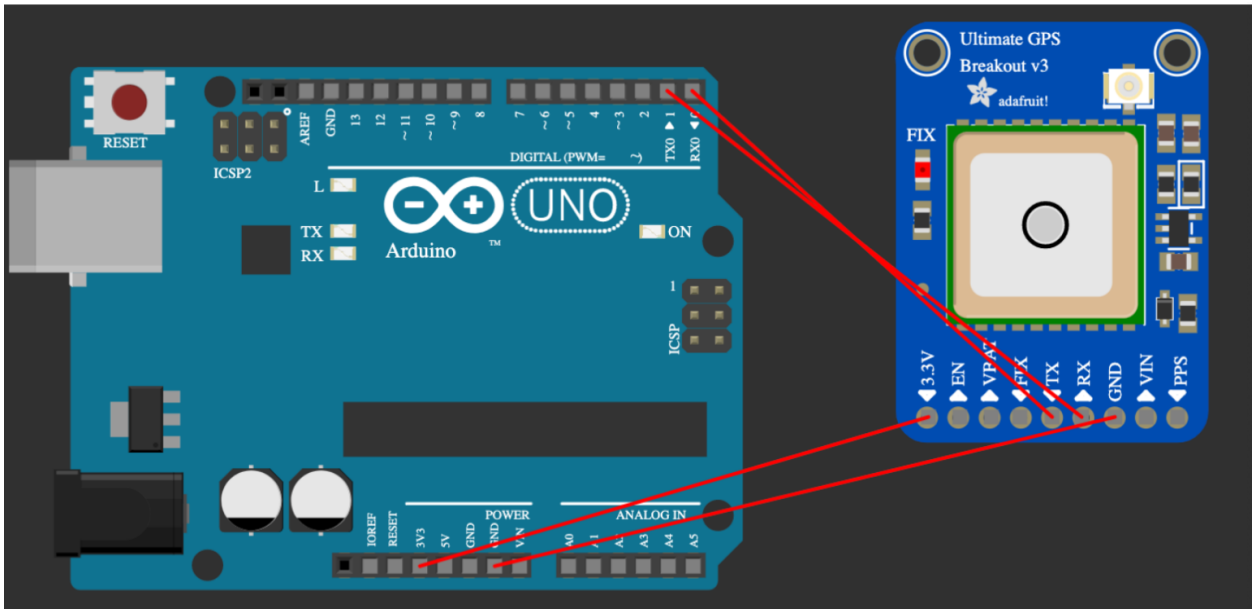
[1] Juang, Philo, et al. "Energy-efficient computing for wildlife tracking: Design tradeoffs and early experiences with ZebraNet." Proceedings of the 10th international conference on Architectural support for programming languages and operating systems. 2002.

Step 2b: Get familiar with the IoT Playground app

We encountered two bugs.

Bug 1

We should wire the 3V3 power pin of Arduino with the VIN pin of the GPS component, not 3.3V, which is different from the following image in the instruction. I understand VIN is the power input for Adafruit Ultimate GPS[2].



Bug 2

The following Arduino code for Sound Sensor in the instruction did not work.

```
int ledPin=13;
int sensorPin=7;
int val = 0;


void setup() {
  pinMode(ledPin, OUTPUT);
  pinMode(sensorPin, INPUT);
  Serial.begin (9600);
}
```

[2] https://learn.adafruit.com/adafruit-ultimate-gps/pinouts

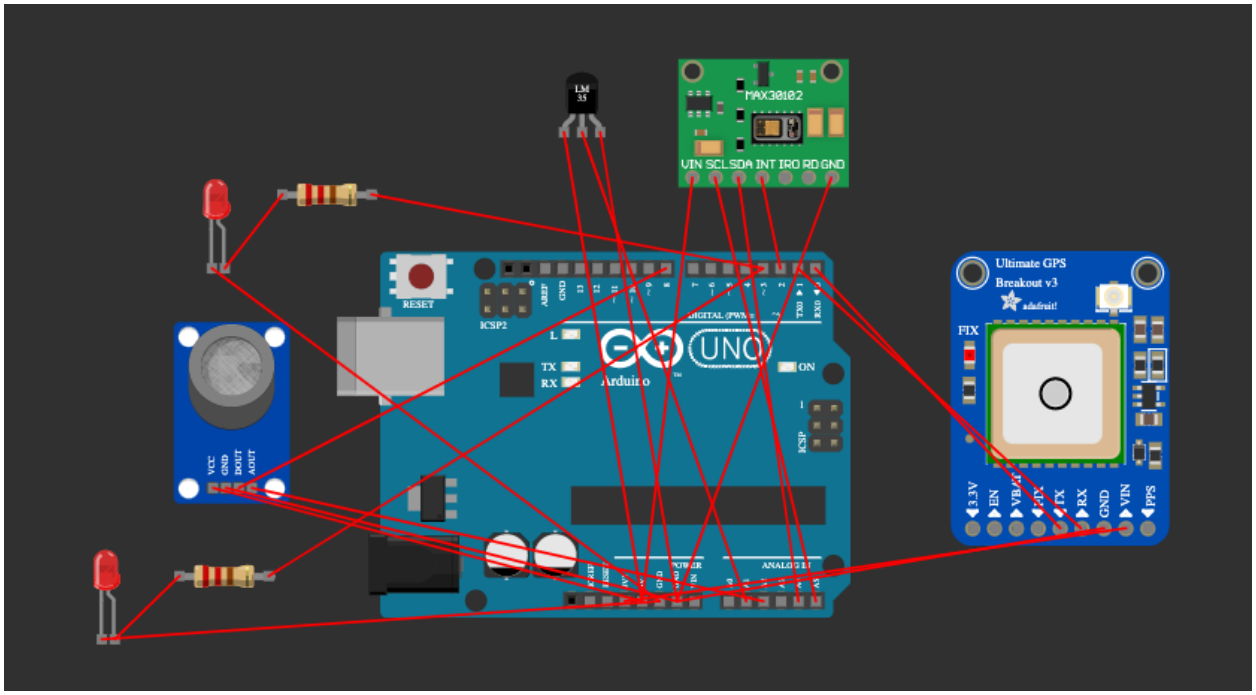
```
void loop() {
  val = digitalRead(sensorPin);
  if (val==HIGH) {
     digitalWrite(ledPin, HIGH);
  } else {
     Serial.println(val);
     digitalWrite(ledPin, LOW);
  }
  delay(100);
}
```

We need to add float or int keyword when defining val like below.

```
float val = digitalRead(sensorPin);
```

Step 2c: Implement your device

Here is our device with Arduino, GPS, Pulse Oximeter, Temperature, and Air Quality Sensor. We programmed the Arduino with sender.ino.



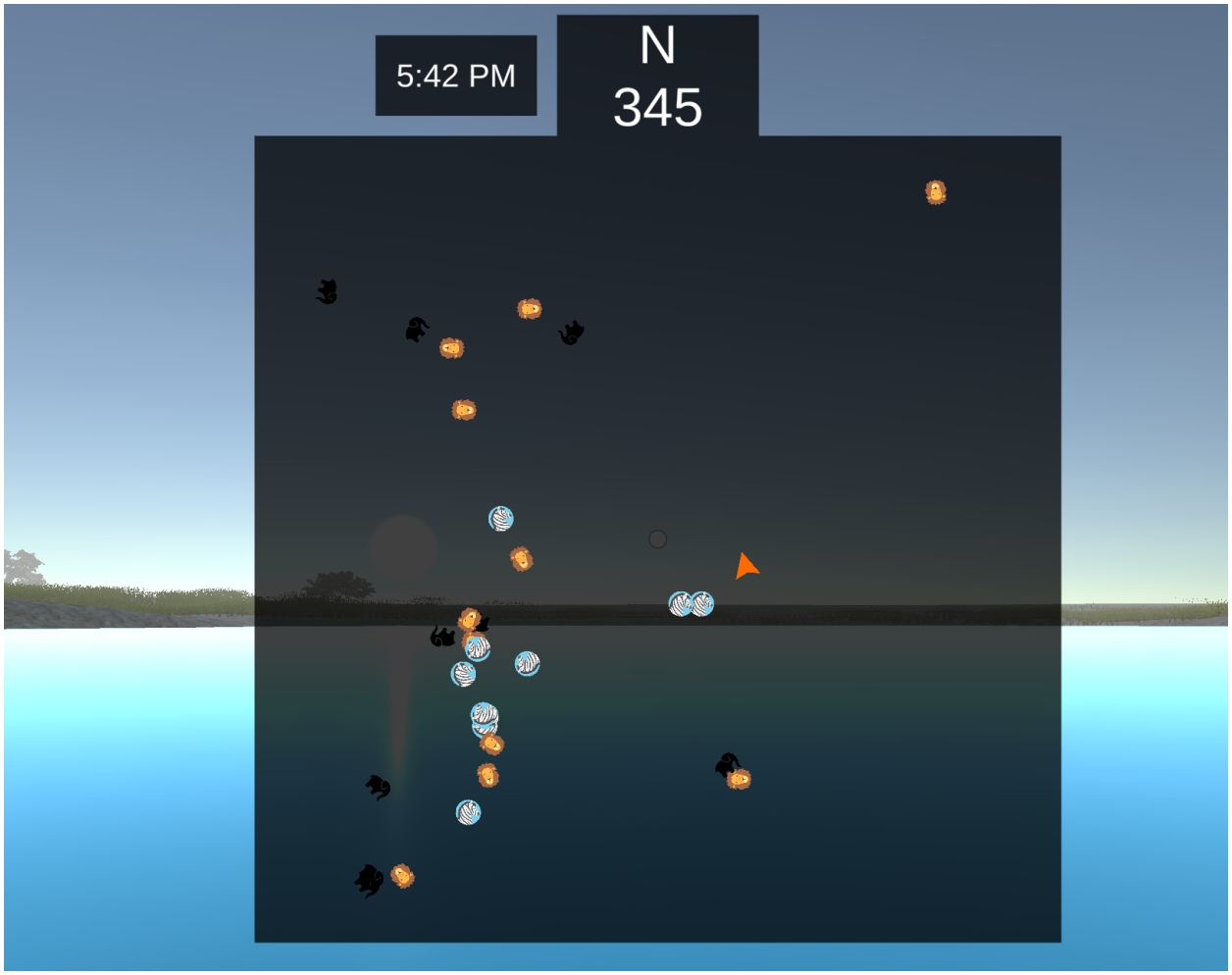
Step 2d: Network your devices (Extra Credit)

We confirmed the receiver (programmed by `receiver.ino`) obtained the message from the sender in the virtual world as follows.

Step 3: Deploy Your Device

See video.

We deployed the device on 8 animals for each species. The virtual world had 30 animals; 9 zebras, 11 lions, and 9 elephants. While we wanted to capture the information of as many animals as possible, attaching the device to all the animals was unrealistic. So we attached it to about 80% of their population. Then, we simulated for about 3 hours.



Bug 3

We encountered a bug that prevents us from logging in to the virtual world as posted on Campuswire, which was successfully solved thanks to Gabriella Xue.

Step 4: Analyze Your Data

The analysis was conducted in `01_Sim_logs_EDA.ipynb`.

> 1. Is the Zebra population healthy? Make a thoughtful case one way or another.

The following table shows the temperature, Oxygen, and Air Quality were stable while Heart Rate had a high standard deviation.

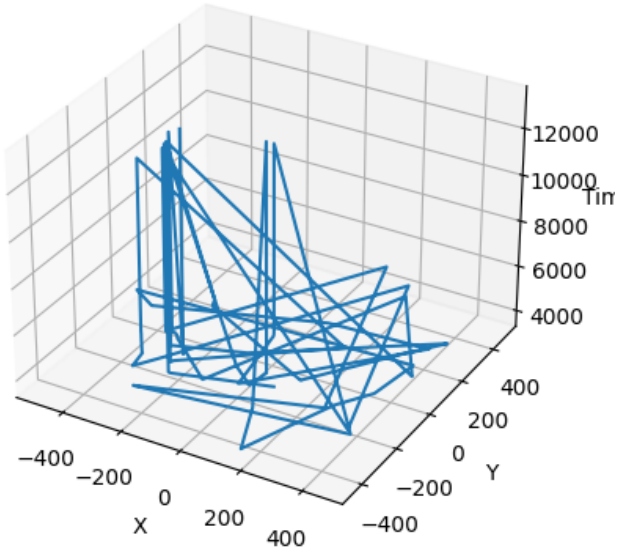
	Temperature	Oxygen Saturation	Heart Rate	Air Quality
count	6595.000000	6595.000000	6595.000000	6595.000000
mean	80.699985	0.971939	116.788476	29.069998
std	0.070469	0.009922	68.916371	0.007047
min	80.594670	0.960000	40.000000	29.059470
25%	80.641350	0.960000	60.000000	29.064130
50%	80.689760	0.980000	60.000000	29.068980
75%	80.749390	0.980000	200.000000	29.074940
max	80.879460	0.990000	200.000000	29.087950

We found two zebras with Animal_ID `08a6ce` and `a9004d` had high standard deviations, which indicated some health issues.

Animal_ID	count	mean	std	min	25%	50%	75%	max
08a6ce	9750.0	184.344615	44.182737	40.0	200.0	200.0	200.0	200.0
2ada3a	9862.0	61.299939	13.548617	40.0	60.0	60.0	60.0	200.0
627d7b	9824.0	60.000000	0.000000	60.0	60.0	60.0	60.0	60.0
6ffb08	9548.0	200.000000	0.000000	200.0	200.0	200.0	200.0	200.0
7704eb	9845.0	59.987811	0.493614	40.0	60.0	60.0	60.0	60.0
9a9f36	9918.0	198.217383	15.718108	40.0	200.0	200.0	200.0	200.0
a9004d	9677.0	182.757053	46.031472	40.0	200.0	200.0	200.0	200.0
b8565b	9904.0	64.808158	25.667373	40.0	60.0	60.0	60.0	200.0
d87ab5	9928.0	60.000000	0.000000	60.0	60.0	60.0	60.0	60.0

> 2. Do the Zebras have enough room to move around in?

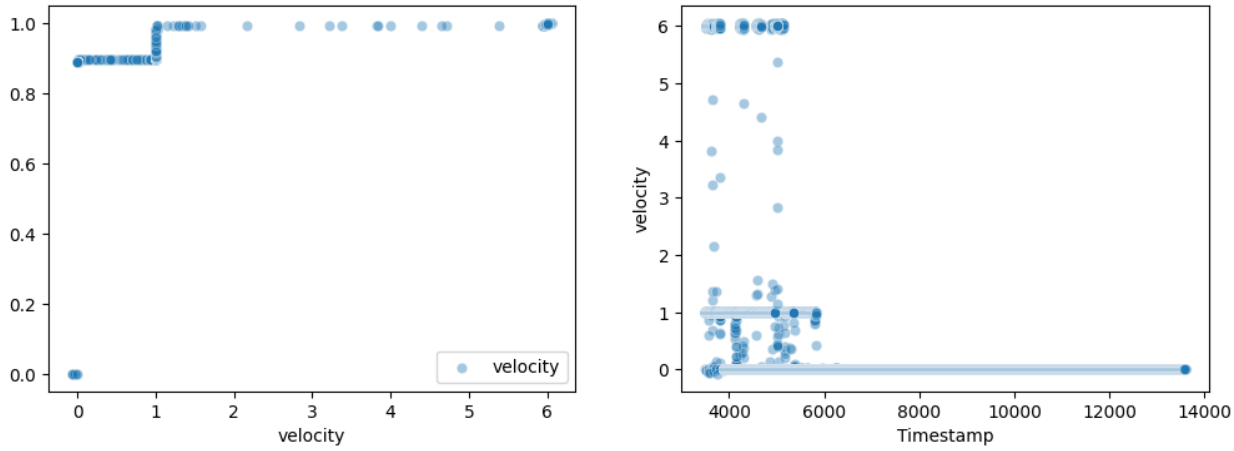
Yes, there appears to be plenty of room as the following graph shows.



> 3. Do you see any signs of poachers? If so, where are they?

The image above shows the zebras stayed at the same point around (-200, 0), indicating there could be poachers. However, we found they were just stuck on the hill.

> 4. Plot a CDF of the movement speed of Zebras. What do you observe?



The zebras stopped for most of the time because they were stuck on the hills as we mentioned. We found they started stuck around 6000 seconds after the simulation started. Also, the 1 and 6 of velocity were often measured, which poses a hypothesis that the application programs two patterns of movement, "walk" and "run" with velocities 1 and 6 respectively.

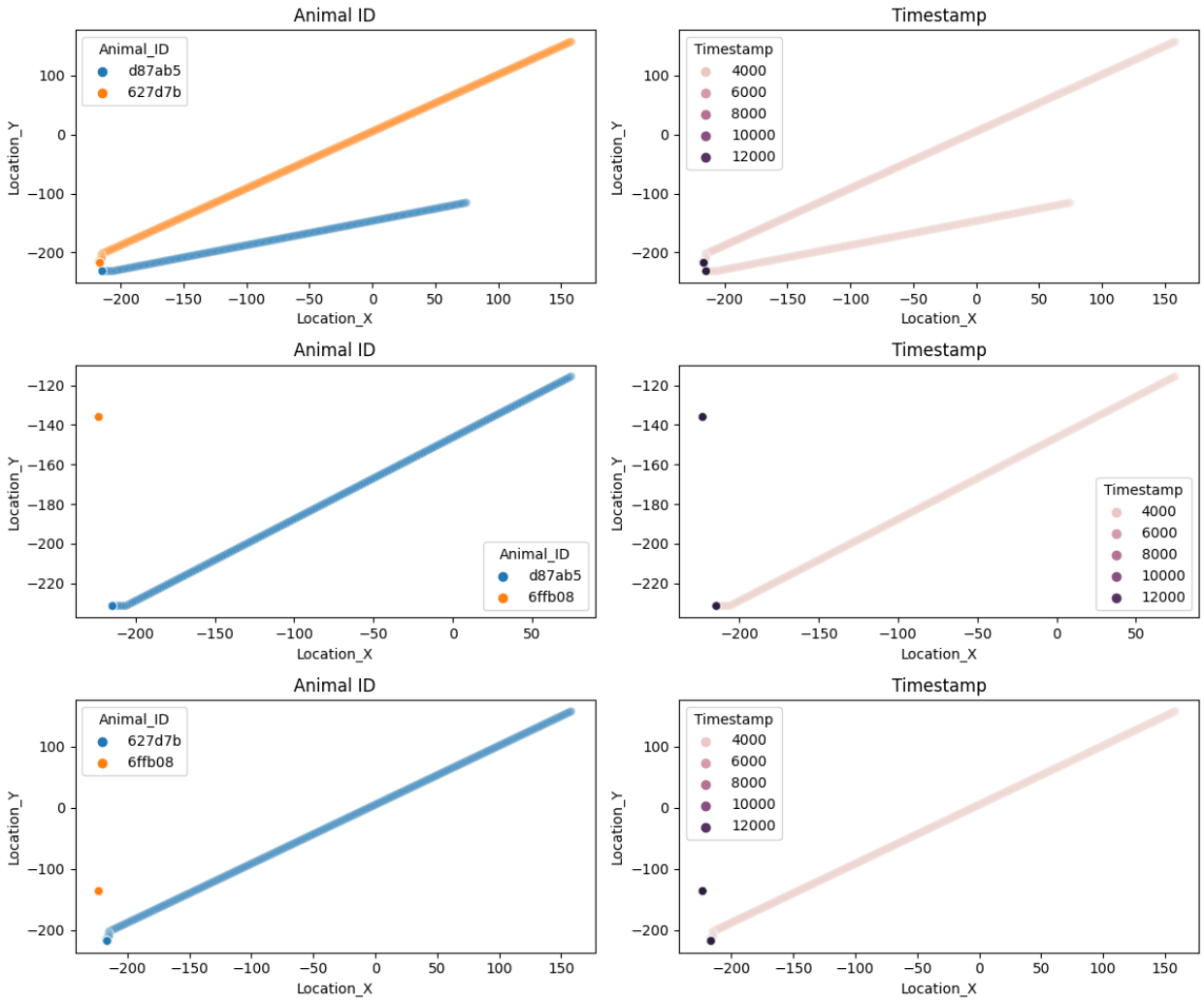
> 5. Do Zebras make friends? Do you see pairs that tend to stay together?

We reduced the records with Timestamp less than 5000 as they were stuck thereafter, and then calculated the average distance between animals.

Average distance between d87ab5 and 9a9f36: 251.7772343448541
Average distance between d87ab5 and b8565b: 447.9001422018421
Average distance between d87ab5 and 2ada3a: 423.296957520088
Average distance between d87ab5 and 7704eb: 540.4360071779382
Average distance between d87ab5 and 627d7b: 125.30798525426685
Average distance between d87ab5 and 08a6ce: 465.8119861343969
Average distance between d87ab5 and a9004d: 499.8366013360991
Average distance between d87ab5 and 6ffb08: 111.34944658726359
Average distance between 9a9f36 and b8565b: 313.1355993258413
Average distance between 9a9f36 and 2ada3a: 307.23253976077154
Average distance between 9a9f36 and 7704eb: 337.2092367720068
Average distance between 9a9f36 and 627d7b: 232.64397596014408
Average distance between 9a9f36 and 08a6ce: 279.00364334074317
Average distance between 9a9f36 and a9004d: 309.1946050875046
Average distance between 9a9f36 and 6ffb08: 252.44133399457723
Average distance between b8565b and 2ada3a: 422.1747434199476
Average distance between b8565b and 7704eb: 357.6817153477145
Average distance between b8565b and 627d7b: 401.82123543951695
Average distance between b8565b and 08a6ce: 346.6761085208067
Average distance between b8565b and a9004d: 364.0554546045891
Average distance between b8565b and 6ffb08: 407.4958555997307

Average distance between 2ada3a and 7704eb: 408.39618382623
Average distance between 2ada3a and 627d7b: 413.0703419143943
Average distance between 2ada3a and 08a6ce: 370.1201121450991
Average distance between 2ada3a and a9004d: 397.8314292310532
Average distance between 2ada3a and 6ffb08: 450.2865245558456
Average distance between 7704eb and 627d7b: 478.57390791871006
Average distance between 7704eb and 08a6ce: 324.02093252679725
Average distance between 7704eb and a9004d: 312.22767762853357
Average distance between 7704eb and 6ffb08: 513.3606711574112
Average distance between 627d7b and 08a6ce: 422.4515116706363
Average distance between 627d7b and a9004d: 450.11230673480514
Average distance between 627d7b and 6ffb08: 137.8236536340265
Average distance between 08a6ce and a9004d: 323.51884675836885
Average distance between 08a6ce and 6ffb08: 459.48310188737327
Average distance between a9004d and 6ffb08: 487.13424750627775
Overall average distance between animals: 365.1359404673946

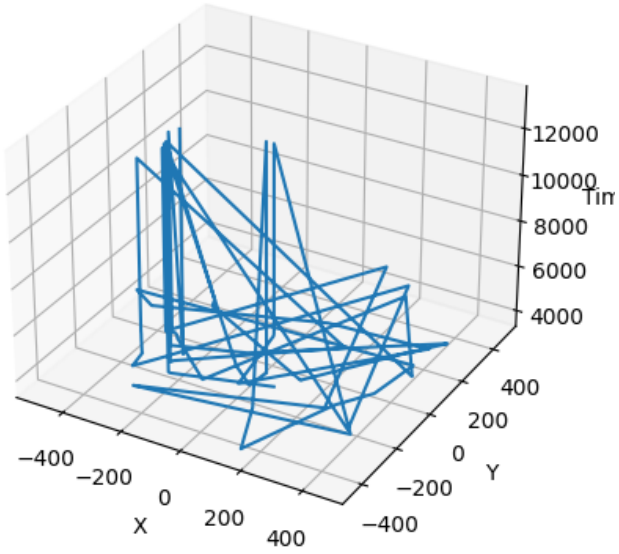
From the results above, d87ab5, 627d7b, and 6ffb08 tend to stay close.
Let’s find out what makes them stay close to each other by plotting the trajectories of these three animals in a pairwise fashion.



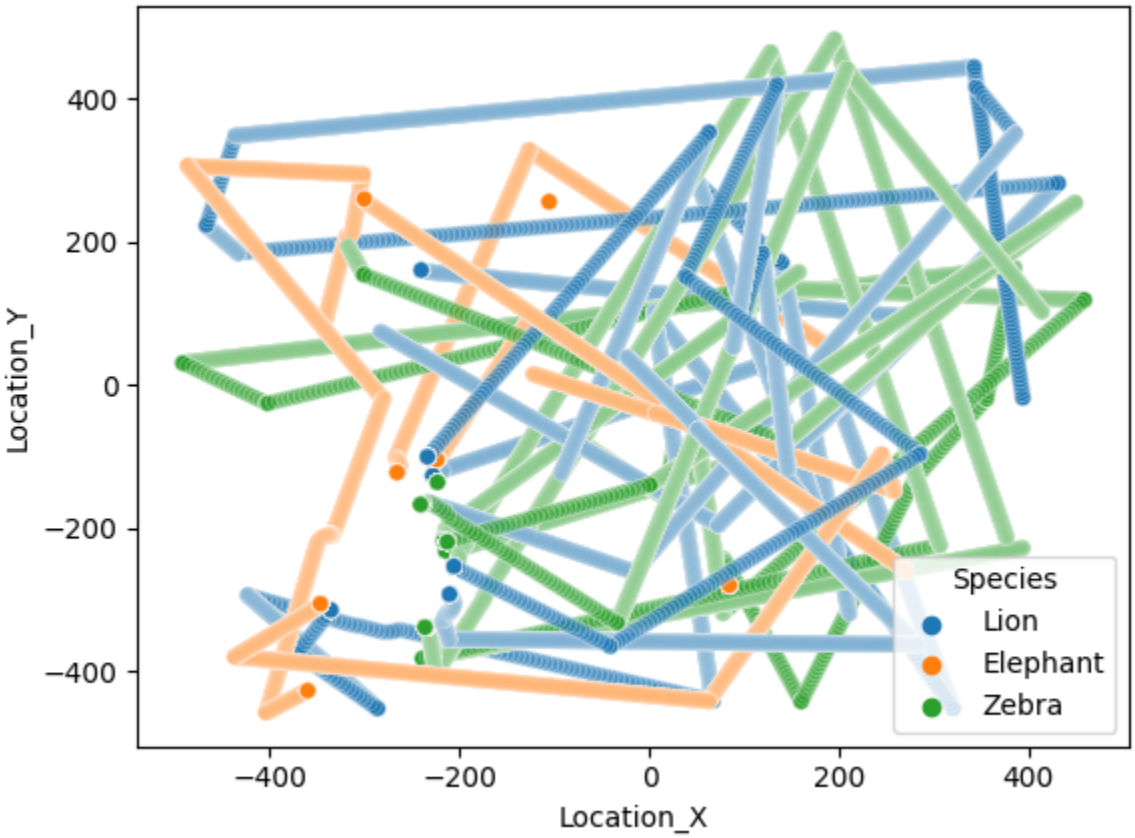
We can recognize that all three pairs either travel independently or and then get stuck in the hill or got stuck and then stayed. This is evident from the plot color coded for time.

> 6. What locations do Zebras tend to congregate at? Why do they tend to go there?

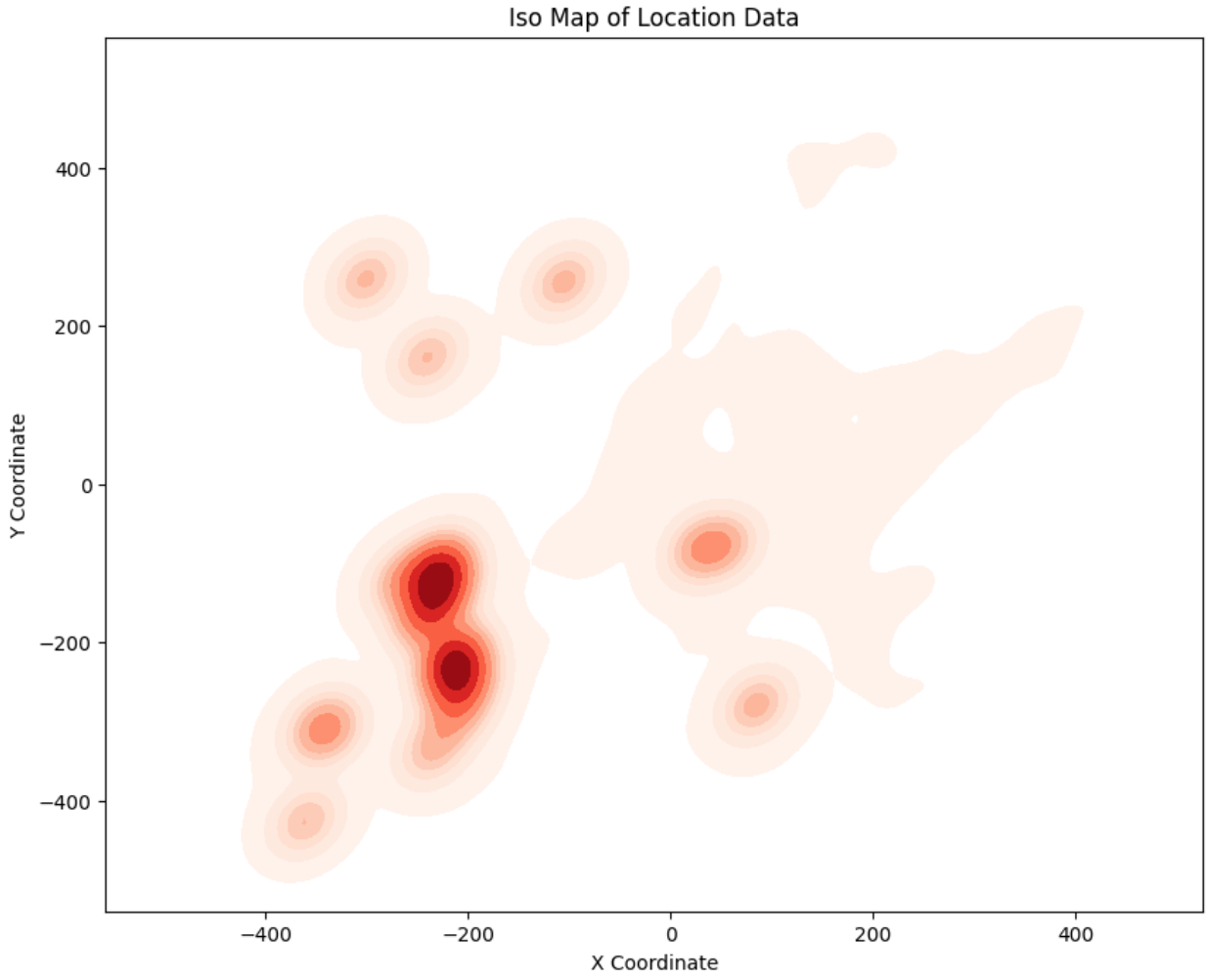
All the zebras congregated (I would say were stuck) at specific points, i.e., around (-300, 0) and (-100, 200) where hills were located.



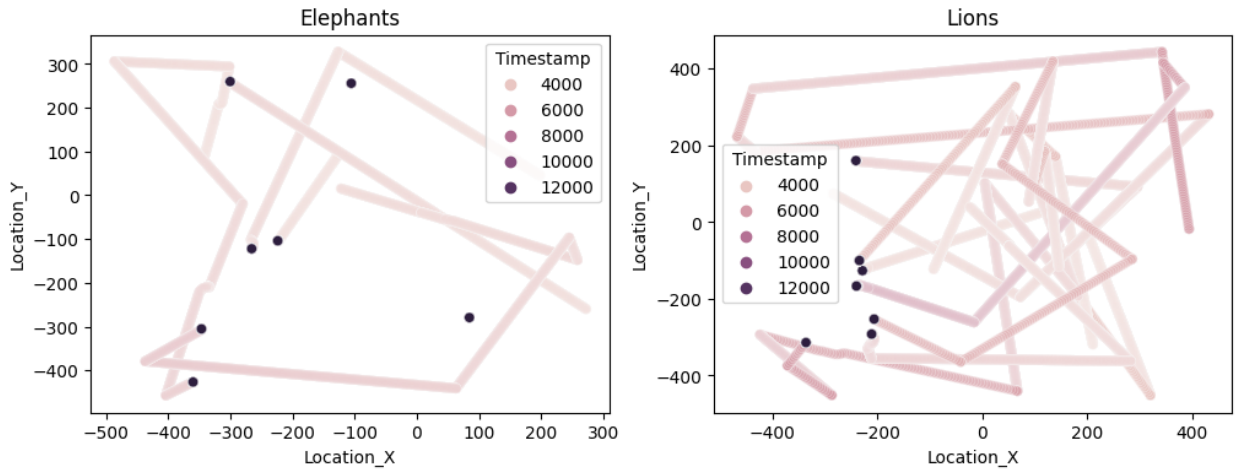
The next plot shows nicely where the animals got stuck. In the area (-400:-200 X, -100:-400 Y) there appears to be a hill the animals got stuck at. The other trajectories look more or less like random walks - approximately what you would expect from a simulation like this.



A kernel density map confirms this region around -200 in X and between -100 and -300 in Y to be most densely “populated”:

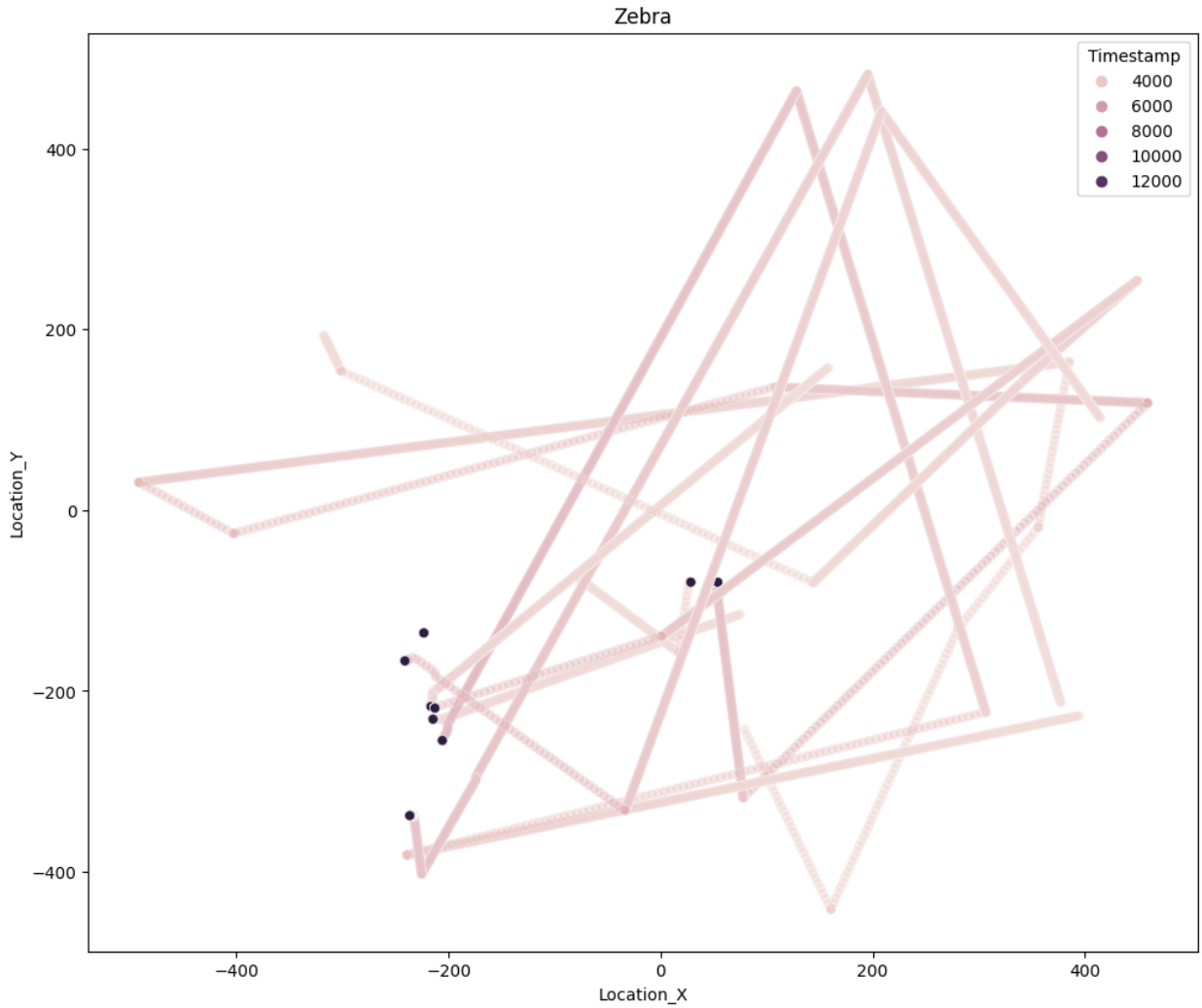


Also for predators the dominant movement pattern appears to be “walk until you hit a wall” - at least for those animals who move. Some lions or elephants did not move at all. Eventually, all motile animals got stuck.



> 7. Are there any locations Zebras tend to avoid?

Fewer zebras were present in the top left quadrant of of the observed space as follows.



> Additional question: What other questions do you feel should be answered? Do you want to investigate another species, like lions or elephants?

We investigated habitat utilization potentially through direct or indirect competition; *Are there habitat preferences and overlap of zebras, lions, and elephants, as well as how these species influence each other's habitat selection?*

According to the following density plot on average fewer zebras are present in the top left quadrant of of the observed space. However, due to the relatively small number of animals as well as short observation time we can not tell for sure if this observation was made due to random chance or if it is typical of the animal behaviour. During the observation period more lions were observed in that same quadrant. We could interpret this as zebra flight from lions. In the description we learned that zebras can pick up lion's scent. Since we do not know the wind direction we can not test this hypothesis. The strong presence of both species in the central region, however, may speak against it.