Learning to Program a Drone

Utilizing Block and Python Coding for Autonomous Flight

David Alvarado
Drone Technology

- A professional drone pilot and imaging specialist, David is in his 8th year of teaching.
- David is the only educator in the region that focuses on drone technology and getting students certified to fly professionally by the Federal Aviation Administration.
- The Center for Career and Technology Education is an elective campus that focuses on career and technology subjects.
- David has coached competitive drone teams towards winning 1st place at regional, state, and national levels!

During the Summer...

I had the opportunity to participate in a Research group through UTEP and the Computer Science Department!

In this program, we were assigned to different research projects that were centered on the topics of Data Science, Cyber Security, and Artificial Intelligence.

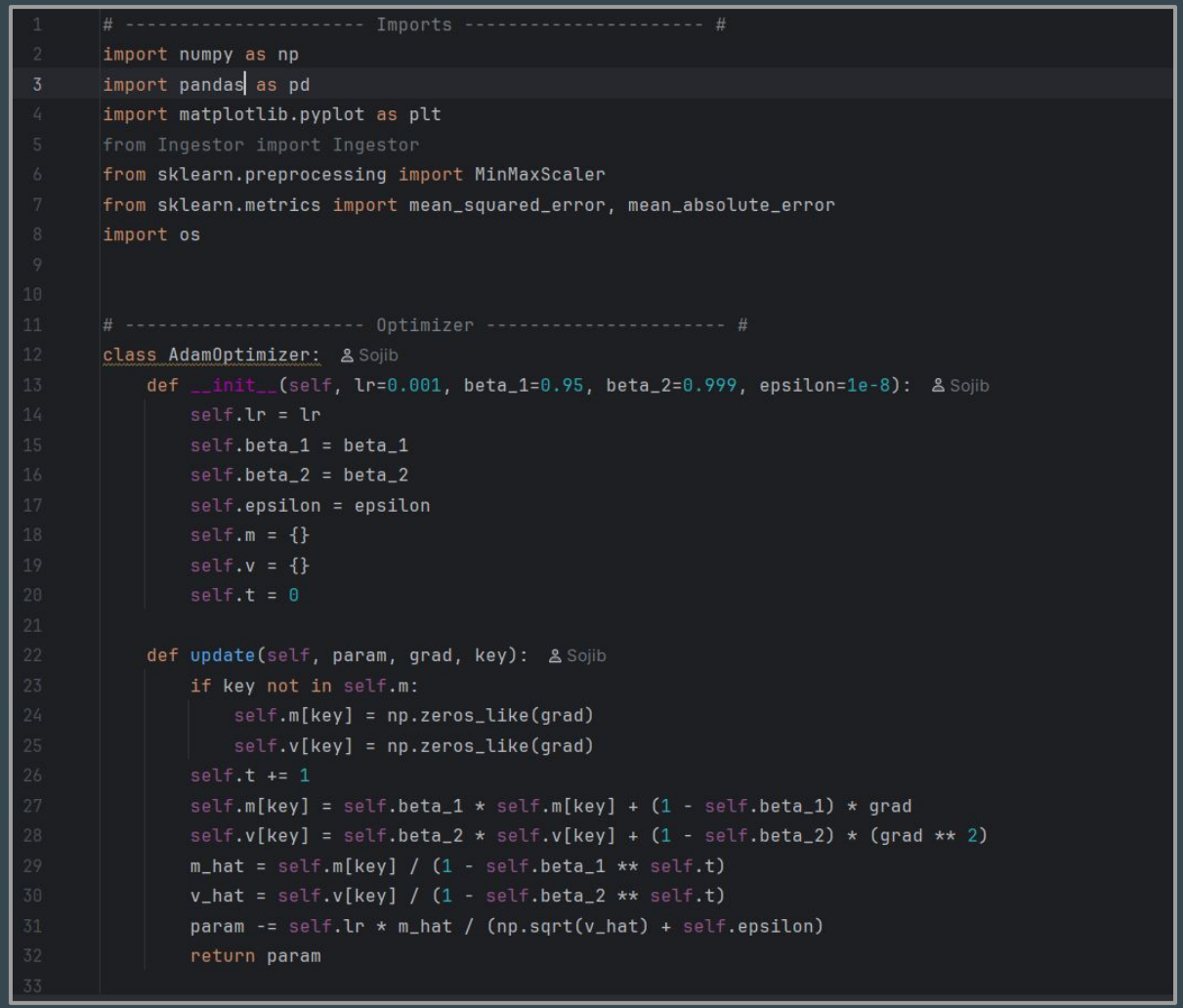
Our groups would contribute research for our specific projects, create a presentation showing what we researched, and a research poster that would be presented to the National Science Foundation.

My research group...

...focused on the topic of using an LSTM (Long Short-Term Memory) model to do predictive analysis using time series data.

Time series data is data that is collected over time.

LSTMs are great at remembering patterns in sequences, making them perfect for predicting what comes next in a series—like forecasting tomorrow's water levels or outflows based on the past 30 days.



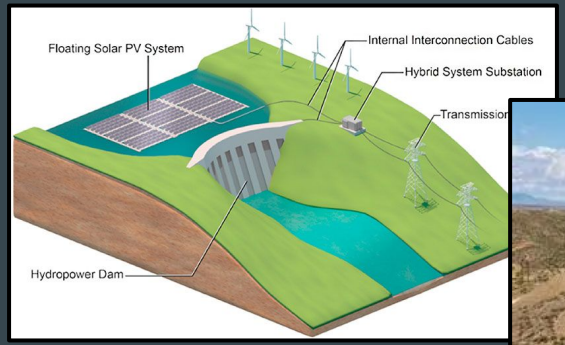
```python
# ---------------------- Imports ---------------------- #
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from Ingestor import Ingestor
from sklearn.preprocessing import MinMaxScaler
from sklearn.metrics import mean_squared_error, mean_absolute_error
import os



# ---------------------- Optimizer ---------------------- #
class AdamOptimizer:  Sojib
    def __init__(self, lr=0.001, beta_1=0.95, beta_2=0.999, epsilon=1e-8):  Sojib
        self.lr = lr
        self.beta_1 = beta_1
        self.beta_2 = beta_2
        self.epsilon = epsilon
        self.m = {}
        self.v = {}
        self.t = 0

    def update(self, param, grad, key):  Sojib
        if key not in self.m:
            self.m[key] = np.zeros_like(grad)
            self.v[key] = np.zeros_like(grad)
        self.t += 1
        self.m[key] = self.beta_1 * self.m[key] + (1 - self.beta_1) * grad
        self.v[key] = self.beta_2 * self.v[key] + (1 - self.beta_2) * (grad ** 2)
        m_hat = self.m[key] / (1 - self.beta_1 ** self.t)
        v_hat = self.v[key] / (1 - self.beta_2 ** self.t)
        param -= self.lr * m_hat / (np.sqrt(v_hat) + self.epsilon)
        return param

```

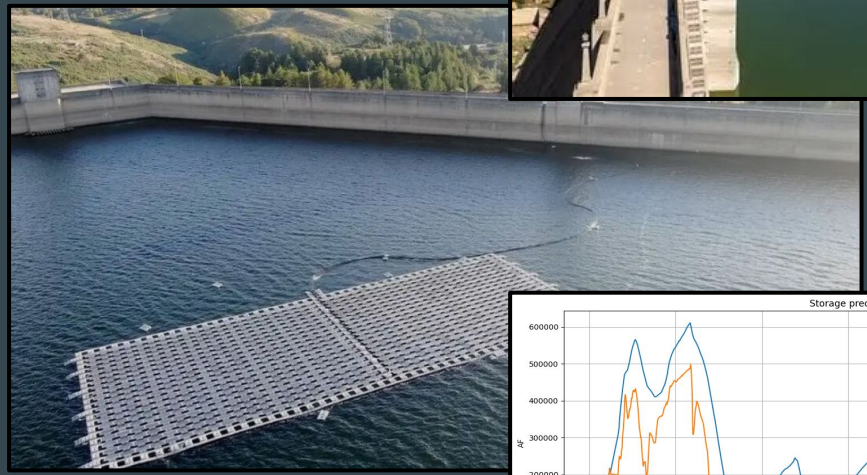
Monitoring the Dam Water

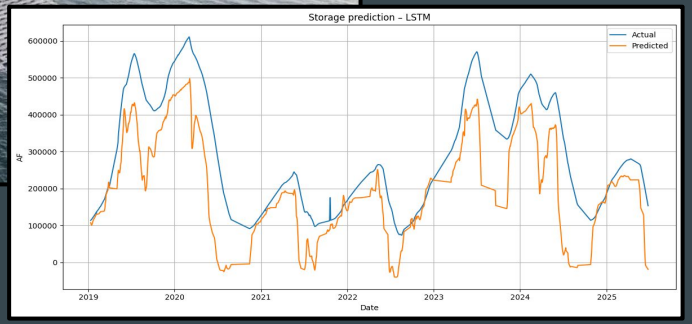
Our research team focused on using an LSTM to predict water levels at Elephant Butte Reservoir to see if Hybrid Floating Photovoltaic Hydro Power systems can be incorporated to supplement current hydropower systems already in use.

We used historical data collected from the dam from almost the past 100 years. Using this information, we tried to calculate optimal release amounts while staying within specific constraints the dam requires to remain operational.

Our project was successful in identifying trends that could be useful data for the dam and its release of water in the future.







Experience with Python

Entering this program, I felt very confident in my abilities to code and program. However, after the research program started, I realized it had been about 15 years since I had worked with programming and my skills were NOT where I wanted them to be.

Thankfully, the program had student mentors that were experts and helped our class work through our research problems.

The process of coding and using Python was a humbling and very interesting endeavor and one that I wanted to bring back to class and share with you!

How CREEDS has impacted me

CREEDS gave me the opportunity to be on the other side of the desk in the classroom.

Being the student was another humbling experience, especially being in a subject that my level of confidence and familiarity with was not in an ideal position.

I am teaching with a bigger emphasis on the student experience and understanding the student's position of sometimes being lost in the lesson.

The experience has also inspired me to explore my options in returning to college in pursuit of a master's degree.

Implementation Timeline

Day 1

Lesson 1 - Introduction to autonomous flight:

- *Introduce students to observe an autonomous drone flight.*

Day 2

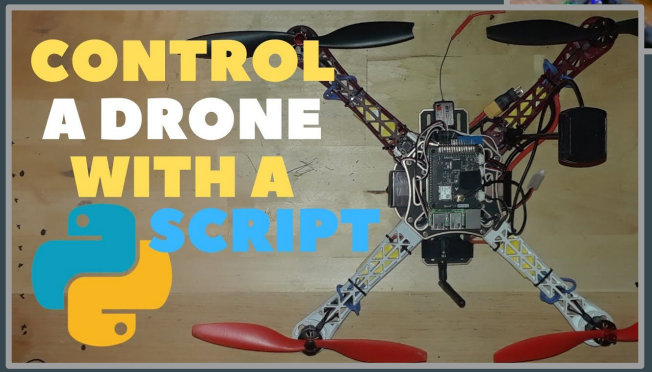
Lesson 2 - Conduct Project Using Block Coding:

- *Utilize block coding to have students program an autonomous drone flight*

Day 3 and 4

Lesson 3 - Conduct Project Using Python Coding

- *Utilize python coding to have students conduct an autonomous drone flight. Students will utilize their original code to conduct the same flight, but also a more complex autonomous flight.*



CREED Materials

CoDrone EDU:

The CoDrone EDU is a programmable drone for learning. Code it in Python or start from the basics with block-based coding. With its color sensors, a front range sensor, a bottom range sensor, and more, it's a great way to learn to code. The durable and safe frame, programmable lights, and access to 7 sensors make it an excellent learning tool and a great way to learn coding and engineering skills in the classroom and for competitions.

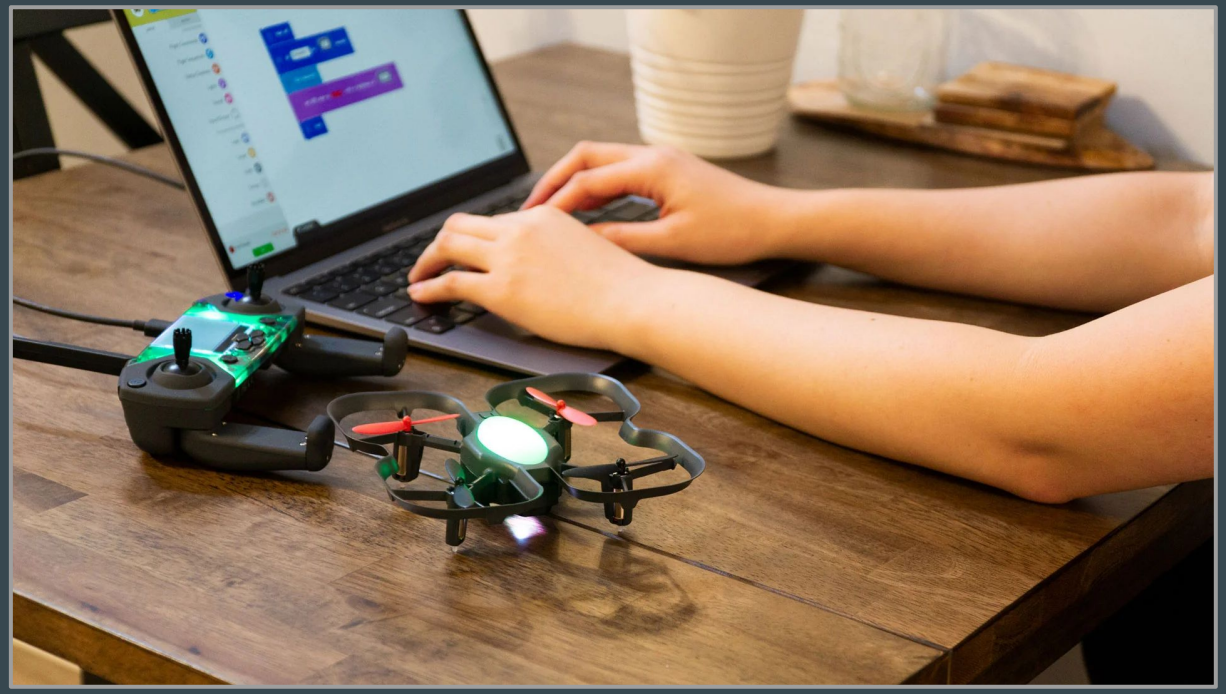
What is Autonomous Flight?

Autonomous comes from the word:

Autonomy - The ability to self-govern or act independently without external control.

Autonomous Flight would be the ability of the drone to fly under its own control without the influence of an external operator.

Instead of us putting in control inputs and manually controlling the drone, we are allowing it to fly itself as it follows a list of commands independently.

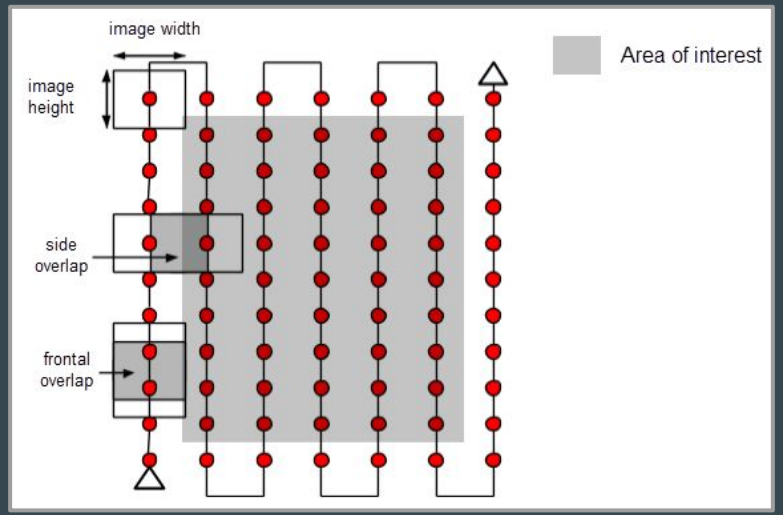


How is it used?

Autonomous flight is used with drones in instances where we have repetitive tasks that we want completed, but we want the tasks to be completed in a uniform and reproducible pattern.

An example would be using a drone to fly a specific pattern and taking pictures at a set interval over an object.

By having taking multiple smaller pictures and stitching them together, we can produce a large image with greater detail than an individual image.

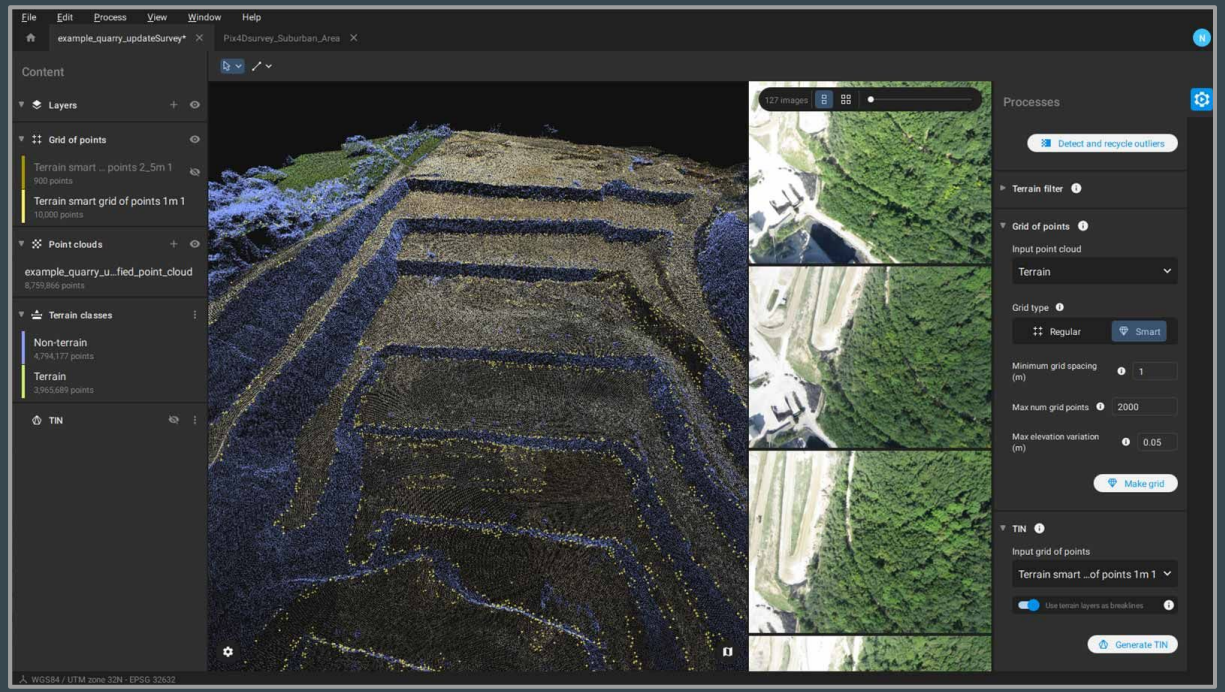


What does this look like?

Using programs like Pix4D, which is a photogrammetry software, we can collect data using key points across multiple pictures to find similarities and create a seamless picture.

We can also take measurements using this seamless picture to calculate distances across pictures, volumes of materials on the ground, and elevation information across the area.

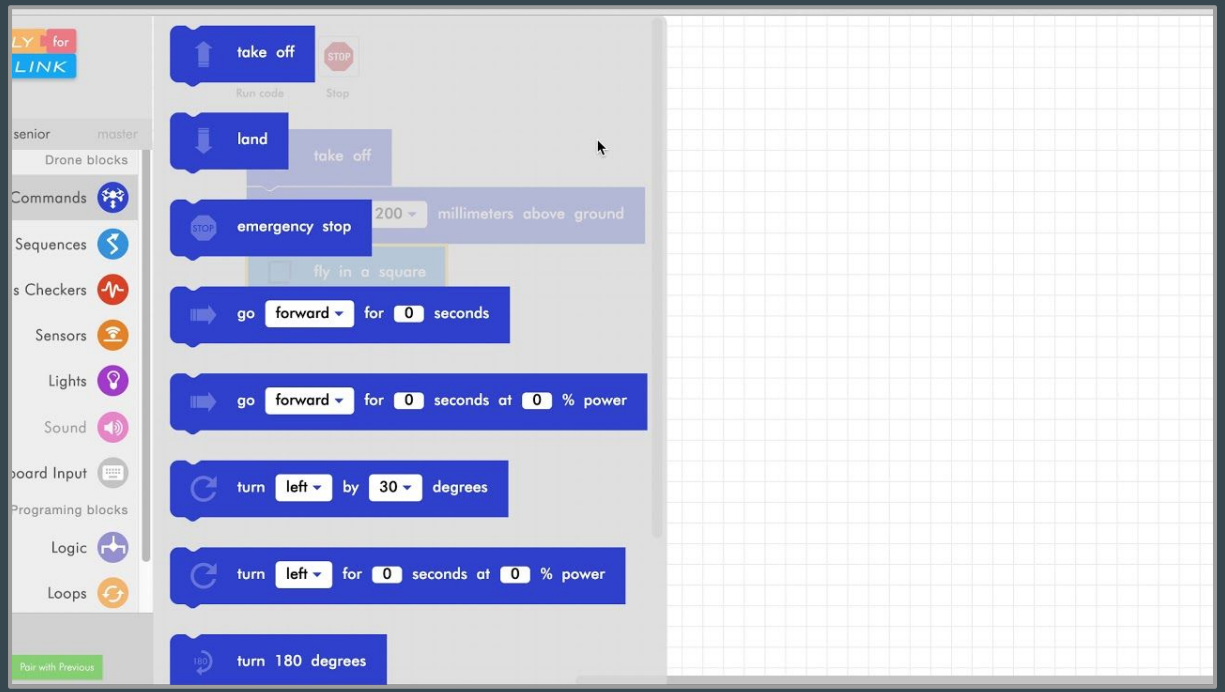
This information allows us to collect data at a much faster rate than traditional methods done on foot.



Starting with Block Coding

Block coding is a visual programming method where code is represented by colorful, interlocking blocks that can be dragged and dropped to create programs. This approach simplifies the coding process, making it more accessible to beginners.

The blocks that we use will have various commands for the drone that we can arrange step by step to get the drone to complete a task.



Let's Work Together

To start, I will set up some obstacles and as a class, we will talk our way through these.

I will show you the commands and we will select which ones to use and figure out the durations and power levels through trial and error.

Remember that we have to be very specific with our code, as the drone is relying on us completely to tell it what to do.

Otherwise, we can run into this...

You Take Control!

Now I will rearrange the obstacles and you will work together as a class to get the drone to complete the course.

Your code needs to have instructions for the drone to take off from the starting point. Navigate through the different race gate obstacles. And finally arrive at the end point.

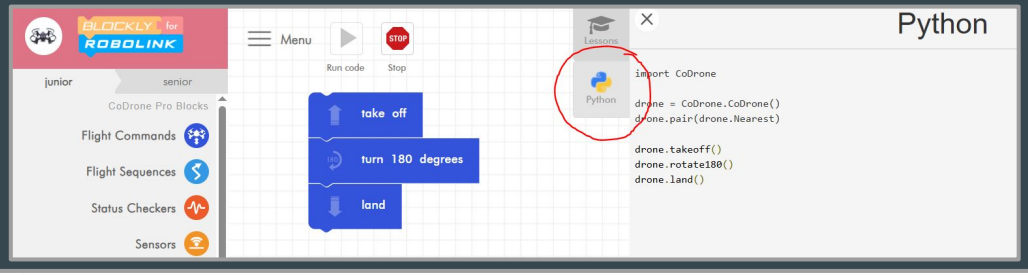
Take your time and be careful with the equipment! This drone is our competition one, so avoid crashes and letting the drone fall to the ground.

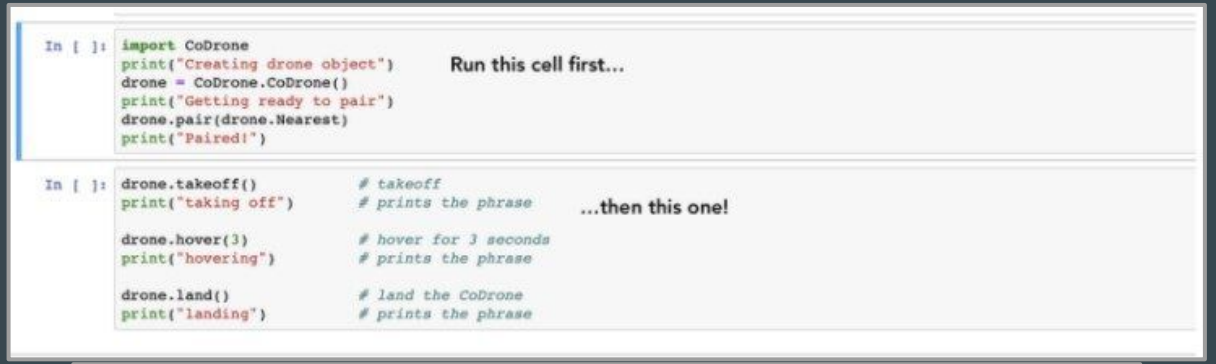
Training for Python Coding

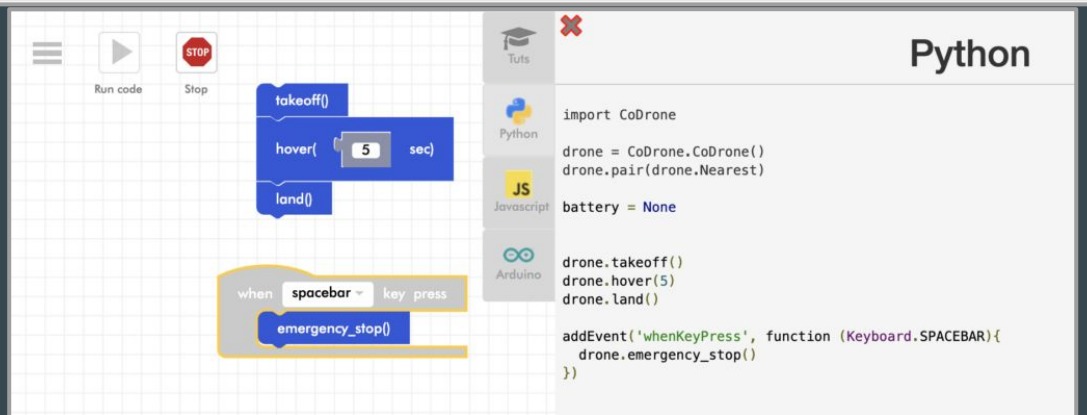
Upon completion of getting the drone to arrive at the end point, open up your code with the Python option and take a look at what your instructions look like but in python code.

See if you can decipher what are instructions for the drone and what needs to be changed if we wanted to have the drone reverse course.

Now I want you to have the drone take off from the ending point, and go through the course in the reverse order to land at the starting point using only the Python coding interface.





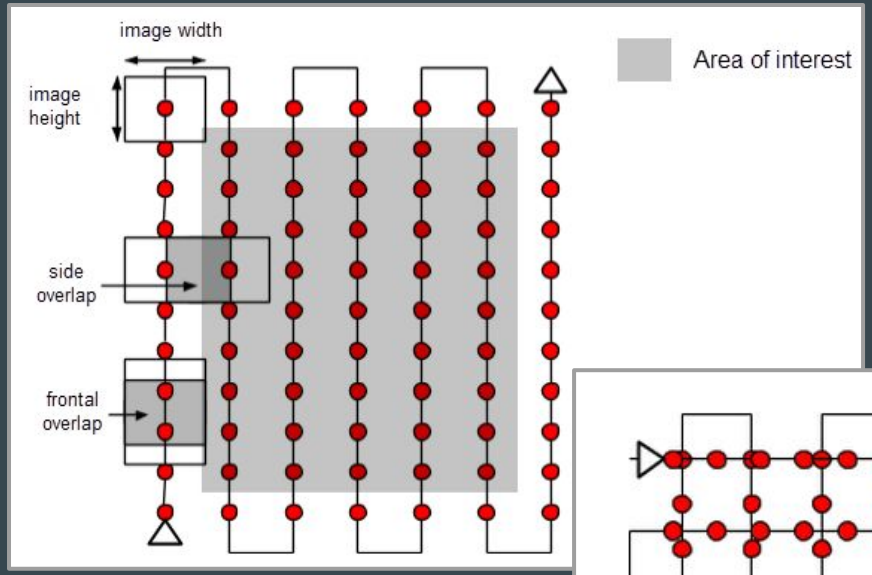


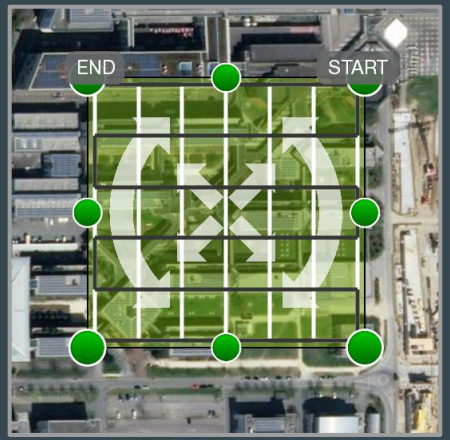
Program Challenge

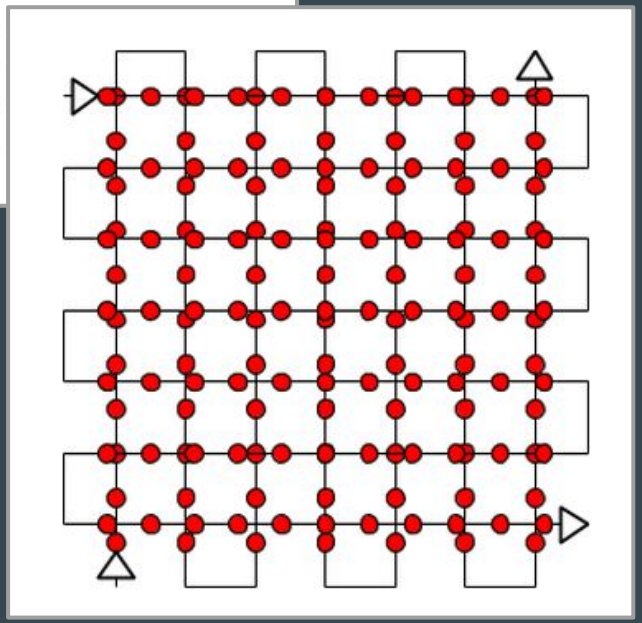
Your challenge for the day is to see if you can create an autonomous flight program for the drone and have it fly over the desks in the class in a grid pattern, and have it try to stop over every desk, hover for a second or two (this is simulating the drone taking a picture), then continue flying the path.

You can opt to have the path just do columns, rows, or if you are up for the challenge, BOTH!

Good luck!







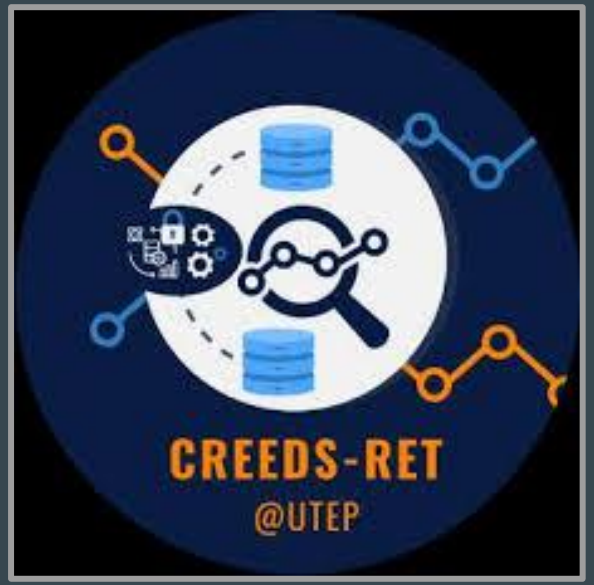
Concluding Remarks

Thank you to the CREEDS program for an enlightening and memorable summer!

The equipment for the classroom that the program has secured is greatly beneficial to my students allowing me to enter four teams into the annual Aerial Drone Competition held by the REC Foundation.

The program has provided an inspiration for my personal education and an excitement to share my experiences in coding with my students and to push them to enter several competitions this year!

CS SUMMER RESEARCH EXPERIENCE FOR TEACHERS



Any Questions?

Let’s get started!!!