Week 1

1. What software is on our current drone? (Summary of the next 5 weeks)
   NVIDIA Jetson Orin Nano (onboard computer), WIFI antenna, GPS receiver x2/other sensors, Cube (flight controller), 360 auto-stabilize gimbal camera

   Week 2: Aerial imagery/stitching
   Week 3: Object detection
   Week 4: Flight controller
   Week 5: Onboard computer

2. What kinds of challenges/projects can YOU work on as a Software team member?

- Improve flight controller
- Computer vision
- Application
- Random thing

3. What's the "industry standard" for drone software in 2025?

- Flight software: ROS 2-based, highly modular, PX4 for FC
- Real-time autonomy: Advanced SLAM, path planning, AI inference
- Compliance and Safety: Automated risk assessments, airspace alerts
- Data Integration: Cloud stuff
- Now BVLOS

4. How does one *learn* about drones effectively in 2025?

- Ask ChatGPT
- Office hours
- Reach out

Week 2

1. How are drones used for aerial imagery purposes?

- Search and rescue, agriculture, law enforcement, environmentalism, competition

2. How is OpenCV used for computer vision purposes? How do we use it as a club?

- Feature detection
- Featuring matching
- Image manipulation

3. What are some pre-made alternatives to writing our own aerial imagery code, and how do they work? What are the drawbacks?

- OpenDroneMap
  - Do the work for you
  - Need geo data

4. What's the next steps forward as a club?
   - Use opencv to run real-time on the drone
   - Use OpenDroneMap to do real-time automatically

Week 3

1. What are some methods used for blob detection?

- Laplacian of Glausian
    - Gaussian Blur
    - Laplacian Operator

2. How can blob detection be used to find objects in a field? What are its benefits and limitations?
- It can identify where objects are in a field without needing complex models
- Simplicity and efficiency
- Sensible to noises
- Lighting and contrast dependence

3. What are the underlying mechanics of the convolutional neural network used in the YOLO model?
- Linear classifier and perceptron
- Deep Neural Networks
- Convolution and pooling

4. How can our club leverage our manpower to label many images in a short amount of time on roboflow? (Teach them how to use roboflow so that when we need to label a bunch of images quickly, we can use the built in roboflow tools to mobilize quickly)
- Training, validation and test data
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5. What are some upsides and downsides to using YOLO for our competition vehicle?
- YOLO uses one shot CNN so faster though less accurate

6. What other techniques might there be for object detection?
- Semantic segmentation
- Classical CV approaches
- Transformers for vision
- Multi-sensor fusion

Robox Flow
- Website training yolo
- Label images

Week 4
1. What is the role of a flight controller in a drone system, and how does it differ from an onboard computer (like a Jetson)?
- Maintain drone stability using sensor data, autopilot
- Different from onboard computer as that makes the drone smart and capable of advanced autonomy

2. What sensors are typically connected to a flight controller?
- IMU's and Barometer
- Magnetometers and GPS modules
- Drone cameras
- RCTransmitters and receivers

3. What are the key communication protocols between flight controllers and peripherals (e.g. I2C, CAN, MAVLink)?

- Serial (UART)
- Communication between two devices (flight controller and onboard computer, GPS modules, telemetry radios)
- CAN
    - device group chat
    - used in car a lot
- I2C/SPI
    - low-speed communication
    - multiple devices listening to one or one speaking at the time
- MAVLink
    - Way to encode thing
    - Communication between drone and the drone station
    - Drone language for commands and telemetry
    - DDS

4. How does firmware (e.g. Betaflight) influence the capabilities of the flight controller?
- PID inside the flight controller

Week 5

1. How do we communicate with the drone while it's in the air?
- radio and ground station
- Two main types of internet communication protocols: UDP and TCP
    - UDP: through a bunch of data
    - TCP: make sure you have a user connection first
- RC transmitters and receivers

2. What is the role of the onboard computer system and how does it complement the flight controller? How does it communicate?
- run complex tasks
- a lot of connectors
- flight controller need to be optimized to the basic
- can run ai model vision
- Use Linux (Ubuntu)

3. What are the trade-offs between different data links (WiFi, radio, LTE)?
- WIFI
    - short range comms
    - dont need router
    - wifi != internet connection
- Radio
    - kind of opposite of wifi
    - long range but less data can be sent
- LTE
    - currently used on Skydio drones
    - best bet if want long distance video
4. How does the onboard computer connect to the ground station or other devices over WiFi? (SSH tutorial)

Week 6

1. What are the benefits of simulating a drone with software/hardware-in-the-loop before flying?
- huge mess in person
- software testing
- expensive to crashing real drones

2. How is machine learning used to improve drone autonomy (navigation, obstacle avoidance, etc.)? What benefits does it have over traditional guidance systems like PID loops?
- Discovery in simulation but problem in real life

3. What is ROS, and why is it universal in autonomous robotics?
- ROS is not an operating system
- Pretty much every framework for building and running robotic software
- Almost every fundamental framework exists there so no need for you to write again
- standardize data
- bag file - annoying to open the bag

4. What are the steps/challenges of deploying ROS on embedded systems like the drone?
- Install ROS 2
- Cross-compile packages
- Real-time performance
- Networking
- Sensor drivers
- Testing via simulation

5. Thanks and final thoughts