Columbia SEE LION:

Search and Emergency Equipment for Life-saving Identification and Optical Network

Search and Rescue Platform for Optical Target Recognition (SPOTR) Challenge

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Concept Video Pitch: [https://youtu.be/fKSr4juW23U]

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A. Abstract

As NASA rises to the challenge of advancing to the Moon with the Artemis program, crew safety and emergency preparedness remain of paramount importance. In the case of an unexpected water landing after launch, debris from the capsule, such as safety gear, may be dispersed throughout the impact site, indicating the presence of crew members outside the capsule waiting to be rescued. To safely and efficiently handle search and rescue efforts to collect the astronauts with as much ease as possible, authorities should be equipped with enough information to quickly identify the whereabouts of the crew members at the capsule area of impact. Autonomous techniques can provide reliable, rapid assistance to inform authorities of potential crew locations in the water, efficiently rescuing all members of the Artemis crew.

The Columbia SEE LION, a Micro-g NExT search and rescue target recognition system designed by the Columbia Space Initiative, is a camera system that utilizes image recognition model techniques to identify objects of interest near the crash site of the Orion capsule in the Pacific Ocean. The system relies on the You Only Look Once (YOLO) image recognition model to identify objects of interest, such as orange-colored life rings and mannequins wearing life preserver units. The operator can select an object of interest via a built-in interface, which then prompts the image recognition model to run on the live camera video feed. Once an object of interest is detected, a data burst containing text with the object detected and an image of the object is returned to the operator within 60 seconds to search suspected areas where astronauts can be found quickly.

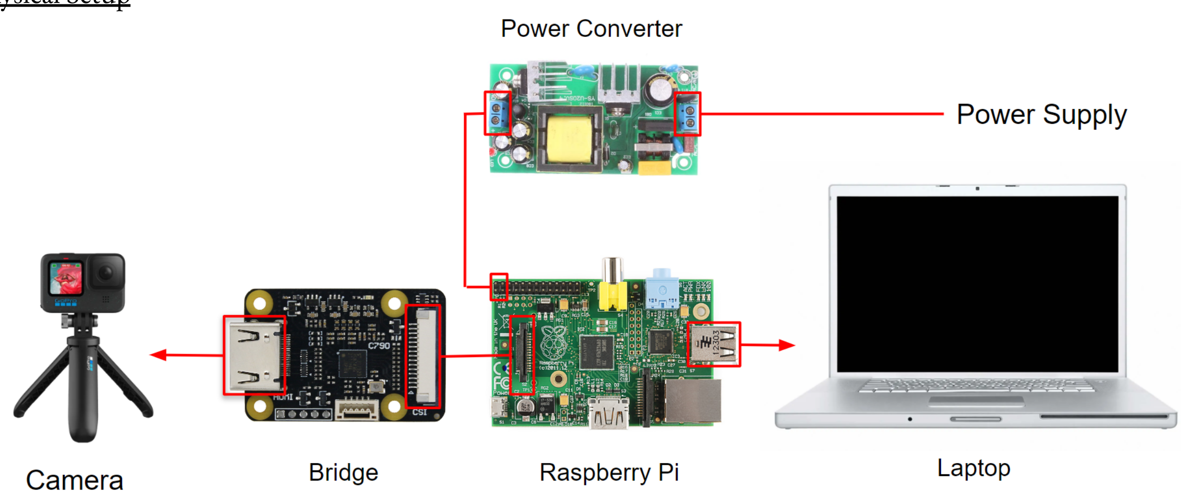
B. Design Description

<u>Overview</u>

A GoPro HERO10 Black camera will provide the SEE LION with live feed and images through its connection to a 2GB Raspberry Pi 4 Model B so that the Raspberry Pi can conduct object detection and display any alerts on the connected operator laptop. Though there are various wireless options for connectivity between the camera and the Raspberry Pi, as well as between the Raspberry Pi and the operator laptop, the team has opted for a completely wired approach with the SEE LION's robustness in mind, as a wired USB connection could provide power supply alongside live video streaming, so that hardware components like the camera would not have to rely on its own battery for power supply, which might be depleted after some time.

As such, an HDMI-to-CSI-2 bridge will be used to connect the camera to the Raspberry Pi, a wired ethernet cable to connect the Raspberry Pi to the operator laptop, and a power converter will be utilized to step down the 120 V AC power input to its recommended voltage for the Raspberry Pi. The SEE LION's camera systems will use only commercially available, off-the-shelf hardware. These specific items are listed and linked in *Appendix B: Component Specifications*.

<u>Physical Setup</u>



Camera

The GoPro HERO10 Black was selected due to its small size and weight, allowing for a more portable system design. Although this model has a possible Wireless Application Programming Interface (API) in the Open GoPro Software Development Kit (SDK), allowing video feed to be shared with the Raspberry Pi and streamed to a laptop via Bluetooth and Wi-Fi, the team opted for a USB connection from the Raspberry Pi to the camera, as Wi-Fi may not always be available and Bluetooth alone cannot support live video streaming.

Camera Tripod

The camera tripod will be a splashproof aluminum alloy tripod system for poolside use. Though it can be extended to a maximum height of 50 inches, the camera tripod will be shortened to meet the challenge requirements of a tripod-mounted camera fixture no greater than 36 inches from the pool deck.

HDMI-to-CSI-2 Bridge

The HDMI-to-CSI-2 bridge will be used to interface between the camera and the Raspberry Pi by converting the HDMI video stream to CSI-2 format, which is required for the Raspberry Pi to accept HDMI live video streams and process them as incoming data sources. As such, the bridge will receive a HDMI input from the camera's USB port and produce a 15-pin output connected to the Raspberry Pi. The recommended power supply for the bridge is 20 W, 5 V, 4 A, to be powered by a USB Type-C connection. The bridge is connected to the Raspberry Pi via an FPC cable connected to the camera port of the Raspberry Pi attached with included spacers and screws.

Single-board Computer

The 2GB Raspberry Pi 4 Model B was selected as the SEE LION's single-board computer to handle the computing required for the image recognition model. It will accept a 15-pin CSI-2 input from the bridge and be connected to the laptop via ethernet cable. The recommended voltage for the Raspberry Pi is 5.1 V via USB Type-C connection. Wiring is not expected to pose a significant problem, but wiring harnesses and zip ties will be used to organize wiring.

Step-Down Power Converter

The step-down power converter will only be necessary if the provided 120 V power source is a power supply with positive-negative terminals, as opposed to a wall power outlet. In this case, the power converter will receive a 120 V AC input and convert it to 5 V DC. The power converter will be connected to the Raspberry Pi through positive-negative wires in pins 2 and 4 – the 5V pins – using positive and negative female cables. The power converter will connect to the power supply through positive and negative male cables. To make the connections between the Raspberry Pi and the power converter more stable and permanent, a soldering iron will be used to solidify the connections. A multimeter will be used to check the voltage of the power converter, ensuring it does not exceed safe levels.

Electronics Enclosure

To minimize the space occupied by the SEE LION, a custom enclosure module will be designed to house the Raspberry Pi, the bridge, and the power converter, with the power converter housed separately from the other components in the enclosure to prevent overheating. The enclosure will be designed using the SolidWorks computer-aided design software and manufactured with talc-injected polylactic acid (tPLA) using a 3-D printer. tPLA is stronger than typical PLA used in 3-D printing, preventing any damage or shattering of the enclosure, which might result in debris entering the pool at the NBL.

Heat Sink

To make the SEE LION more durable by decreasing the effects of thermal throttle, a heat sink will be attached directly over the processor of the Raspberry Pi with adhesives.

Hardware and Software Integration

The Open GoPro Python SDK will be used to interface with the camera by managing live feed from the camera and collecting data such as video and images to meet the challenge requirements of identifying and verifying objects detected by the SEE LION. Though the Open GoPro API is compatible with the GoPro HERO10 Black, allowing Bluetooth, Wi-Fi, and USB connectivity between the camera and the Raspberry Pi, the SEE LION will primarily use USB connections, with Bluetooth and Wi-Fi connections as contingency options. The Open GoPro libraries will be used when coding in Python to send HTTP commands to control the camera. After the GoPro is connected with its specific initial packages, the Raspberry Pi will interface with the camera using the Asyncio package. This library enables asynchronous syntax, which allows code to be run without following the sequence in which it was compiled, managing when events occur in the SEE LION's code. The code snippets below show how the Asyncio package is used for USB connections and its Bluetooth and Wi-Fi contingency options in the SEE LION, including comments highlighted in green font to explain each line of code:

For the initial setup:

```
# acquiring the libraries necessary to use the package
import asyncio
```

For USB connection:

```
from open_gopro import WiredGoPro

# connecting to the gopro asynchronously
hero10= WireGoPro()
await hero10.open()
```

For Bluetooth and Wi-Fi contingency options:

```
from open_gopro import WirelessGoPro

# connecting to the gopro asynchronously
hero10= WirelessGoPro()
await hero10.open()
```

For both USB or Bluetooth and Wi-Fi connections:

```
# check if the camera has turned on the correct settings
settings= await hero10.ble_command.get_camera_settings()
print(settings)

# turn on live preview
# a new task needs to be made while multiple tasks are running asynchronously
# and concurrently
hero10.set_preview_stream
async def our_main_task:

# a conditional to launch the object detection model:
	asyncio.create_task(secondary_task())

	# sleep time represents the Raspberry Pi detecting objects
	# when this runs, another secondary task (i.e. notifying the user of
	# detected object) would run before the main task (i.e. the object
	# detection model) stops running
	await asyncio.sleep(10)
	print("we are still recording and feeding stream to Pi")
async def secondary_task():
	if item_detected.getcondition() == true:
		print("We have detected", item_detected.getName())

		# check the date and time on goPro
		hero10.get_date_time()
```

Object Detection

Pre-processing

To convert the photo library of target items that will be provided by NASA into a dataset to train image recognition scripts, Roboflow will be used to preprocess images in any format, such as VOC XML, COCO JSON, TensorFlow Object Detection CSV, or any other formats used in object detection. These pre-processing steps would include auto-orienting images and resizing images to 416 pixels by 416 pixels, as YOLO presumes images in multiples of 32. Should the NASA-provided photo library of target items be unlabelled, annotations would be added to images during this pre-processing phase. Upon generating a version of these images that can be loaded into a Jupyter Notebook environment like Google Colab, the images, including any annotations, will be exported in the Darknet format using a sample of the code below:

```
from roboflow import Roboflow
rf = Roboflow(api_key='API KEY')
project = rf.workspace("2024-csi-microg-next").project("sample-project")
dataset = project.version(1).download("darknet")
```

You Only Look Once (YOLO) Model

The SEE LION's object detection and image tracking system primarily uses the You Only Look Once (YOLO) algorithm. The YOLO algorithm is an end-to-end neural network detector that can use raw live video directly as input data without any manual feature extraction to identify relevant features and implement solutions to extract those features. As the YOLO algorithm is also a single-stage detector, it can not only identify target items by making predictions of bounding boxes to define the location of the object within the image but also categorizes detections with only a single forward pass through a single fully connected neural network layer into the classes of objects this project aims to detect. At this phase, these include:

1. Orange colored life-ring
2. Mannequin wearing orange-colored life preserve unit (LPU)
3. Multi-person life raft
4. Orion capsule mockup (WEST) located on the far end of the pool

The SEE LION's YOLO model will divide the input image into an S x S grid, with S representing the number of grids along each image dimension. As common values of S range from 7 to 13, the team opted for a preliminary value of S = 13 as an initial starting point for the SEE LION's YOLO model. Though a higher S value would risk increased false positives due to being overly sensitive to variations within each grid cell, the team designed the SEE LION to prioritize precise predictions within each grid cell by using a finer grid to detect far-away objects.

If the center of an object falls within a grid cell, that grid cell is tasked with detecting that object. Each grid cell predicts B number of bounding boxes and its corresponding confidence score, indicating the probability that a target item is present and the accuracy of the bounding box. The team opted for a preliminary value of B = 2 as an initial starting point for the SEE LION's YOLO model, as this value provides the flexibility to capture variations in object sizes and positions without producing too many false positives as redundant predictions. The SEE LION's YOLO model will then train each grid cell to specialize in predicting target items by tasking grid cells based on which prediction has the highest IoU with the ground truth bounding box label so that each bounding box improves its recall of object attributes like size, aspect ratios, and classes.

Compared to two-shot object detection models (which first make predictions about the presence and location of the object and then second identify the regions of interest through bounding boxes), the SEE LION's YOLO algorithm provides high accuracy and efficiency important for fast real-time object detection, as it does not have to generate a set of proposals or potential object locations in the first pass to detect possible regions of interest using the Region Proposal Network then make final recognitions in the second pass separately. One-shot detection is superior to two-shot detection as it requires one instance or 'shot' of the object for accurate identification and localization, making it more efficient and faster. One-shot detection models (like YOLO) are better at discriminating between different possible classes with just one instance of the object.

The Darknet neural network framework was selected to train the SEE LION's YOLO models, as it is a helpful tool to run YOLO models efficiently without worrying about computational time. YOLO achieves this by simultaneously processing the entire image and predicting the object bounding boxes and class probabilities in a single pass, significantly reducing computational time compared to other methods involving multiple processing stages. Though the YOLOv8 is the latest object detector used for image classification, open-source versions of these more recent YOLO models are less well-developed for real-time object detection. Hence, the YOLOv4 model was selected, as it is currently the most well-established open-source version of the YOLO model.

The specific procedure for object detection is coded and framed as follows:

```
def image_detection(image_or_path, network, class_names, class_colors, thresh):
       width = darknet.network_width(network)
       height = darknet.network_height(network)
       darknet_image = darknet.make_image(width, height, 3)
        if isinstance(image_or_path, str):
               image = cv2.imread(image_or_path)
        else:
               image = image_or_path
        image_rgb = cv2.cvtColor(image, cv2.COLOR_BGR2RGB)
#use different colors to draw squares for the detected object
        image_resized = cv2.resize(image_rgb, (width, height),
 interpolation=cv2.INTER_LINEAR)
       darknet.copy_image_from_bytes(darknet_image, image_resized.tobytes())
       detections = darknet.detect_image(network, class_names, darknet_image,
                                          thresh=thresh)
       darknet.free_image(darknet_image)
       image = darknet.draw_boxes(detections, image_resized, class_colors)
       return cv2.cvtColor(image, cv2.COLOR_BGR2RGB), detections
```

Framing Detected Object

Once an object has been detected, the object will be displayed with bounding boxes surrounding the object. Below is a snippet of code showing how the SEE LION will achieve this operation, including comments highlighted in green font explaining each line:

```
# we import the OpenCV library to make bounding boxes
import cv2

# defining a function to display the detected image
def display_detected_image( ):

       # Drawing a bounding box around the detected object
       cv2.rectangle (image, (x, y), (x + width, y + height), (0, 255, 0), 2)
       # x and y represent the coordinates of the top-left corner of our image
       # (0, 255, 0) = RGB data format, 2 = thickness of the bounding box

       label = f"(classes[class_id]}: {confidence: .2f}"
       # this generates a label for the detected image with its class label and
       # a confidence interval rounded to 2 decimal places
```

```
        cv2.putText(image, label, (x,y-10), cv2.FONT_HERSHEY_SIMLEX, 0.5,
        (0,255,0), 2)
        # this adds the label to our image using this particular font, setting
        # the font scale factor to 0.5
        # we place the label at the top left corner of our image, adjusting the
        # y-coordinate by 10 units down

        # Bounding the image with a box
        cv2.imshow(image)
        # this displays our image with the label, confidence interval, and
        # bounding box onto the Raspberry Pi

display_detected_image(image)
# This runs the function on every new image of the detected object
```

Sending Detected Object

If the detection within the time frame returns true, the following pseudocode will run to send a python pop-up using the tkMessageBox package.

```
from Tkinter import*
import tkMessageBox
# when object detection returns true and image is framed and saved under
# a specific location, this generates a pop-up message box
# option 0 means an "Ok" button will be placed in the pop-up message box

tkinter.messagebox.askquestion(title="Object Detected!"
                               ,message=message(location)
                               ,**0)
def message(location):
        global my_img
        top = Toplevel()
        top.title("Image Detected")
        my_img = ImageTk.PhotoImage(Image.open(location))
        Label(top,image=my_img).pack
```

Timer for Object Detection

In compliance with challenge requirements to provide "short data burst" notifications of object detection to an operator laptop as well as a timestamp photo of the target item, the snippet of sample code including comments highlighted in green font below shows how the SEE LION will perform this operation:

```
from time import perf_counter
# from Python's time module, we import the perf_counter function as it counts
# short time intervals with high precision

def run_model(model):
# we define a function to run a prediction on our model, but it starts a
# timer before the prediction is made and stops after the prediction ends
        t_initial = perf_counter () # counts time in short resolutions
        y_pred = model.predict()
        # makes a prediction using the .predict( ) method
```

```
        t_final = perf_counter() # stop timer when object is detected
        elapsed_time = t_final - t_initial
        # find the delta between the two timers

        print("Objected Detected: ")
        # this lets the user know an object has been detected

        print("Time to detect" + str(elapsed_time))
        # this will print the total detection time in our Raspberry Pi

run_model(yolo_v4)
# calling on our function run_model( ) with our specific model, yolo_v4
```

Object Detection Pipeline with User Interface

As per the challenge requirements, the user can select their object out of the four classes. The SEE LION interface on the computer will be a simple and efficient number input system, where the user will need to input 1 for the orange colored life-ring, 2 for the mannequin wearing the orange-colored LPU, 3 for the multi-person life raft, and 4 for the Orion capsule mockup (WEST) located on the far end of the pool. The terminal will ask users for an input, and the user will be able to select their class by inputting the integer (the key will also be displayed on the screen).

- Model Prediction: Once the user selects their object of interest, the YOLO model will run on the input video stream to get predictions for all classes.
- Filtering Predictions Before Display: After getting the predictions, we will filter out the predictions by only retaining the bounding boxes and scores for the selected class.
- Display: The display will include the bounding box for the selected object only, the confidence of that prediction, and the time to make the prediction will also be outputted.
- Reset: To reset and start a new user selection, the operation will be kept simple and users will simply press the spacebar to select a new object.

Post-Processing

Non-maximum suppression is a technique we plan to use after the model is done making its predictions. Object-detection models often make overlapping bounding box predictions for the same object due to variations in scale, orientation, and location. We will select the most confident and accurate bounding boxes while deleting the duplicate or less confident ones. This helps declutter the output with redundant detections. The NMS pipeline will work as follows:

1. Input: NMS will take as input the bounding boxes (the results of our model) with its associated class label and confidence score.
2. Sorting: NMS will then sort the bounding boxes from highest confidence to lowest confidence.
3. Selection: NMS will pick the bounding box with the highest confidence as a starting point. Overlapping boxes with an Intersection over Union (IoU) threshold exceeding our predefined threshold (see the 'Metrics' section for more details) are iteratively removed. Thus, what remains ultimately are the most confident and non-overlapping bounding boxes.

Prioritization

As per challenge requirements, the SEE LION will prioritize object detection based on the NASA prioritization table by changing the weights of the YOLO model. After receiving the prioritization table, the team will add higher weights to the objects with higher priority, ensuring that they will be detected with more priority than the objects with lower weights and thus lower priority.

Object Detection Performance Metrics

The team will use two key thresholds for object detection: the confidence threshold and the Intersection over Union (IoU) threshold. The confidence threshold filters out low-confidence detections from the SEE LION's YOLO model, while the IoU threshold is used in the YOLO model's post-processing techniques.

The team initially set a preliminary confidence threshold at the standard 0.5 as a starting point. As the confidence threshold value will critically depend on the dataset and the quality of the images, slightly higher and lower confidence threshold values will be used on the SEE LION's YOLO model to determine their impact on the model's balance between precision and recall. For instance, the confidence threshold would have to be increased if there are any critical or rare classes that might cause a data imbalance.

The team will initially set a preliminary IoU threshold at the standard 0.5, so that objects with a confidence greater than or equal to 0.5 would have a positive detection. Objects with a confidence lower than 0.5 would have a negative detection. Though this preliminary IoU threshold would initially produce a lower precision that might detect more false positives compared to stricter IoU thresholds, the team designed the SEE LION's YOLO model with a lower IoU threshold to prioritize recall over precision, rather than missing key life-saving detections due to a high precision. However, upon receiving NASA's photo library of target items for training our image recognition scripts, the confidence threshold will be increased to reflect a balance between precision versus recall that is optimized with more data. More details on how the team defined and calculated precision, recall, and IoU values are described in *Appendix C: Object Detection Performance Metrics*.

Challenges

The team anticipates detecting objects far away in the pool to be challenging for the SEE LION's YOLO model. As such, the team expects to try strategies such as multi-scale detection, where the model processes images at different resolutions and scales, allowing the model to detect objects of different sizes (including distant objects). After initial testing using the photo library of target items provided by NASA, if detecting far-away objects remains a source of error for the SEE LION's YOLO model, the team anticipates using this strategy to mitigate it as a data augmentation and preprocessing step.

Additional mitigation strategies the team intends to try include focal loss (changing the loss function to give more weight to the hard-to-detect objects, especially the distant ones, helping the model focus on the most challenging examples); ensemble methods (potentially combining the results of a few different YOLO models with different configurations to improve performance); or even using a Zoomed-in Region of Interest strategy (zooming into the region of interest before feeding the data to the model).

Requirement Compliance:

List requirements from the challenge description and describe how each requirement is fulfilled.

1. The device is capable of autonomously identifying and tracking objects of interest.

The SEE LION will be able to autonomously identify and track objects of interest using the YOLO object detection model and the NASA photo library.

2. The device provides image detection of selectable items within 60 seconds of user selection.

Our single-shot object detection model, YOLO, is known to be quite fast and deliver outputs in a few seconds. In addition, we have a streamlined system from power on to user selection of objects to object detection. For instance, to select an object, users only have to select the objects of interest. To reset the program and select a new object, the operator can simply press the spacebar at the end of the prediction. Post-processing techniques also filter through the multiple predictions quickly to output the prediction of the selected object.

3. The device provides a "short data burst" notification of object detection to an operator laptop.

Python tkMessageBox package's pop-up messages appear within seconds. It also supports continuous pop-ups even if the last data burst was unresolved.

4. The SPOTR control system shall not require external calibration or warmup time greater than 60 seconds from control system power-on.

The SEE LION will not utilize wireless communication protocols between the setup hardware, minimizing the time required for the system to calibrate and begin operation. The Python program containing the object selection interface, image recognition model, and data collection protocol will be pre-booted onto the Raspberry Pi to be run from the control system power-on.

5. The SPOTR system shall prioritize each known object based on the prioritization table provided by NASA.

The YOLO model will have weights based on the prioritization table provided by NASA, with higher weights for higher-priority objects (and lower weights for lower-priority objects), ensuring that prioritized objects are detected quickly.

6. The SPOTR system shall visually track items of interest, based on their priority, and stream video to an operator laptop via wired ethernet cable between processing hardware and laptop.

The SEE LION will visually track items of interest based on the weights of its YOLO model, which will be set to reflect the priority of each known object based on the prioritization table provided by NASA. The live video of the detected objects, including any predicted bounding boxes, will be streamed to an operator laptop via a wired ethernet cable between the Raspberry Pi and the operator laptop.

A. Operations Plan

<u>Phase I: Preparation (to be done pre-testing)</u>

1. Communicate with the NBL staff about safety hazards to ensure the safe handling of the system for all parties involved. Familiarize the staff with the "on" button on the Raspberry Pi and the GoPro camera to ensure both can be easily powered on for the system.
2. Upload the system code to the Raspberry Pi to be compiled and run when the computer is turned on. Assemble all electronic components and secure them inside the custom enclosure.
3. Place all hardware components and cables into the pelican case carefully for safe transportation to and from the NBL poolside setup area.

<u>Phase II: Usage of the device</u>

1. Open the pelican case and set up the tripod-mounted camera fixture on the pool deck, not to exceed 36 inches above the height of the deck, and place the electronics enclosure on the folding table on the pool deck, with the necessary wires being connected between both sets of hardware during this step. Connect the Raspberry Pi to the setup laptop via an ethernet cable.
2. Familiarize the staff with the "power" button on the Raspberry Pi to turn the system on once it is connected to the 120 V AC power source and the "power" button on the camera. Instruct the staff to turn on both the Raspberry Pi and the camera.
    a. If there are issues with the power-on sequence for the Raspberry Pi, instruct the staff or manually turn on the Raspberry Pi via Secure Shell (SSH) connection.
3. Turn on the laptop to view the video stream after the camera is turned on.
4. Select the object to be detected by the SEE LION.

<u>Phase III: Data Collection</u>

During the system testing, the model will collect data on precision and recall and general data for each object that the operator requests to be detected in the NBL. The Python program containing the model will collect the following data while testing takes place:

1. The object of interest selected by the operator

2. Time expended to find the object after the object of interest is selected
3. Timestamp of when the object is found
4. The file name of the snapshot of the object when it is found
5. A boolean True if the object found is the same object requested by the operator, and False if the object does not match the object of interest as determined by the operator
6. The number of times the SEE LION correctly detected the target item out of all the times it detected an object, which represents precision.
7. The number of times the SEE LION detected an object out of all the times it should have detected an object, which represents recall.
8. Repeat the data collection using different IoU thresholds between 0.5 to 0.95 on each object class to be detected.

Phase IV: Analysis

From the data collected in accordance with the parameters listed above, the team can quantify the SEE LION's deficiencies and locate improvements. The Python program containing the model will analyze the data collected in the following steps:

1. Plot a precision-recall curve using the data points of precision and recall at different IoU thresholds.
2. Find the area under the graph of the precision-recall curve, which represents the average precision of the SEE LION's YOLO model.
3. Find the area under the graph of the precision-recall curves for each object class to be detected.
4. Calculate the average area under the graph of the precision-recall curves of all the objects to be detected, representing the mAP of the SEE LION's YOLO model.

Phase V: Results

Based on the precision-recall curves of each class of object to be detected and the mAP of the SEE LION model, the CSI team can examine the trade-off between precision and recall from the precision-recall curves that show that as precision increases, recall decreases, and vice versa. In doing so, the team can determine the specific IoU threshold value that achieves the desired balance between precision and recall according to challenge requirements.

B. Safety

Overview: The SEE LION is a complex system that is heavily reliant on electronic components, so it is worthwhile to address some concerns related to its design. The team has addressed the safety requirements of the challenge, as listed below, and has also highlighted potential safety concerns when running the system. These concerns will be addressed by the team through extensive testing and calibration of the hardware and software systems, both in the development lab and the testing area in Columbia's Uris Pool. Discussions with Micro-g organizational staff will also take place throughout the year to ensure the SEE LION is fit for safe and effective use in the NBL.

Safety Requirements and Compliance

1. **Requirement #1:** Camera systems shall use commercially available tripod systems with demonstrated stability appropriate with any student-developed camera systems.
   Compliance: The SEE LION will use a commercially available tripod offered by eCostConnection, which utilizes rubber feet to provide sufficient stability for the camera system.
2. **Requirement #2:** Camera and processing hardware shall be splashproof for poolside use.
   Compliance: The camera will be enclosed using a commercially available water-proof, transparent plastic case to prevent the lens from being covered with water droplets. The processing hardware will be enclosed in a waterproof casing developed using TPLA for increased durability and strength.

3. **Requirement #3:** Camera/sensing systems shall not use laser/sonar or other radio frequency (RF) techniques for object detection.
   Compliance: The SEE LION camera system will not utilize laser, sonar, or other radio frequency techniques to detect objects.
4. **Requirement #4:** The SPOTR control system shall power on and begin operations via single switch throw/actuation.
   Compliance: The SEE LION camera system will be powered on via a switch connected to the Raspberry Pi to turn on the single-board computer and initiate the sequence for running the camera system. Our wired setup would ensure that the GoPro will be ready to go without worrying about the camera taking a long time to establish the initial BLE/Wifi connection.

<u>Safety Concerns and Mitigation</u>

1. **<u>Electrical Short Circuits or Failures</u>**
   Description of Concern: The electrical equipment used in the SEE LION is on the pool deck close to the water, which could lead to short circuits if there are splashes or spills. Additionally, since the pool is an enclosed space, humidity levels increase due to the presence of the water and thus could damage the hardware. The team would use a multimeter to check the voltage of the power coming from the buck converter to prevent the Pi from being fried
   Mitigation Plan: An industrial waterproof casing will protect the Raspberry Pi to ensure the inside components remain dry. Additionally, raising the equipment to an elevated platform will ensure that the water on the deck does not interfere. Insulating exposed wires with rubber or silicon will prevent direct contact with the wires. Having the wires form drip loops also ensures that any excess moisture does not stay on the wiring.
2. **<u>Misidentification or Non-Detection</u>**
   Description of Concern: The SEE LION's YOLO model could produce false negative detections where the target item is not detected when it is present. Additionally, different objects could be wrongly classified, and variable conditions such as reflections and ripples in the water could make object detection more difficult.
   Mitigation Plan: While using OpenCV, images can be enhanced to counteract the obstacles faced with open water lighting inconsistencies. Since the visibility of objects in the water is muddled by open water inconsistencies, increased contrast can help distinguish objects. Using contrast adjustments can help distinguish the brightness between objects or regions, enhancing distinguishability. Color normalization and histogram equalization are two other techniques that can be used to distinguish objects in a multitude of lighting and color changes. Color normalization adjusts the color of images to a standard scale, which can help when the color of the water interchanges between bluish and greenish tints. Finally, histogram equalization can be used, which adjusts pixel intensities to enhance the contrast. By equalizing the histogram, it can spread out the most frequent intensity changes, increasing contrast. By implementing color normalization, contrast adjustments, and histogram equalization, the images should be much clearer and easily detected by the algorithm.
3. **<u>Overheating of Electronic Components</u>**
   Description of Concern: Electronic devices such as computers and cameras could produce heat during operation, leading to overheating with limited airflow or high humidity. Overheating can reduce efficiency and cause data loss or hardware damage.
   Mitigation Plan: The use of heat sinks made of aluminum will be attached to electronic components to dissipate heat and work on devices that produce significant amounts of heat. This ensures that the components that produce heat have appropriately sized heat sinks that dissipate the heat generated. Additionally, component spacing can be set up inherently to ensure that effective air circulation around each component prevents overheating. By spacing out each component to minimize the ambient temperature while maximizing safety in wiring, a safe setup can be met while reducing the temperature of each component. Additionally, a temperature monitor for some components can be used to measure the temperature of critical components and set up alerts if temperatures exceed safe levels.

4. **<u>Trip Hazards</u>**

Description of Concern: Using equipment such as our tripod and wires on the pool deck could be a substantial risk for anyone who could trip over it. Any personnel unfamiliar with the setup of the SEE LION may overlook the wiring and fall.

Mitigation Plan: Area demarcation can show where wires, equipment, and other hazards are located. By using brightly colored tape, visual delineation of where equipment and wires are made can improve visual safety. Wiring organization can be done via zip ties, where loose or hanging wires are tied together, along with drip loops to prevent water from congregating. Additionally, periodic checks of inspection on the setup area will ensure that no equipment or wiring has been displaced. Thus, a visual aid delineates where wiring and loose equipment are, while regular safety checks are made to ensure loose debris or equipment.

E. Technical References

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F. Appendix

Appendix A: Figures

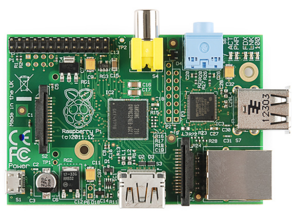
Below is a set of pseudocode to load in images to be used for the image recognition model:

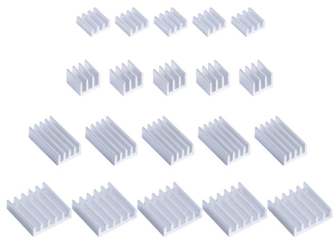
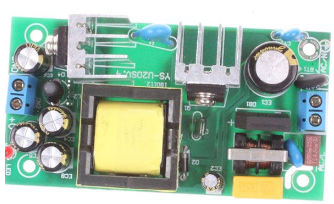
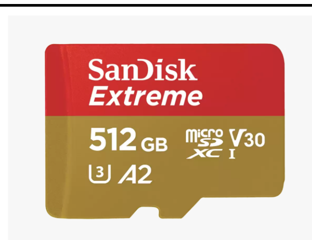
```
def load_images(images_path):
# this is the method to load the image and display it for detection
"""
if image path is given, return it directly
For txt file, read it and return each line as image path
In other case, it's a folder, return a list with names of each
    jpg, jpeg and png file
    """
input_path_extension = images_path.split('.')[-1]
#split the image original path to extract its type
    if input_path_extension in ['jpg', 'jpeg', 'png']:
        return [images_path]
    elif input_path_extension == "txt":
        with open(images_path, "r") as f:
            return f.read().splitlines() #use read to read the extracted type
    else:
        return glob.glob(
            os.path.join(images_path, "*.jpg")) + \
            glob.glob(os.path.join(images_path, "*.png")) + \
#using join function to create new paths for image
            glob.glob(os.path.join(images_path, "*.jpeg"))
```

Below is an alternative portable method, imShow, to display the detected image:

```
import cv2 # import cv2 to do the graph detection
import matplotlib.pyplot as plt
%matplotlib inline
def imShow(path):
       image = cv2.imread(path)
       height, width = image.shape[:2]
       resized_image = cv2.resize(image,(3*width, 3*height), interpolation =
                                 cv2.INTER_CUBIC)
       fig = plt.gcf()
       fig.set_size_inches(18, 10)
       plt.axis("off")
       plt.imshow(cv2.cvtColor(resized_image, cv2.COLOR_BGR2RGB))
       plt.show()
```

Appendix B: Component Specifications

Component Name	**Image**	**Purchase Link**	**Technical Specifications**
A. GoPro HERO10 Black		GoPro HERO10 Black	• Dimensions: ○ 2.8 x 2.2 x 1.3 in. • Weight: ○ 5.6 oz / 158 g • Battery powered: ○ (80 -120 minutes) or USB connection (5 V, 2 A, 2 to 5 hour charging)
B. Raspberry Pi 4 Model B		Raspberry Pi 4 Model B	• RAM: ○ 2 GB RAM
C. Raspberry Pi 15W USB-C Power Supply		Raspberry Pi 15W USB-C Power Supply	• 96 - 246 AC input range • 5.1 V, 3.0 A DC output • USB-C Output
D. HDMI-to-CSI-2 Bridge		Geekworm Raspberry Pi X630 1.5V HDMI-CSI2 Module	• Physical Dimensions (L*W): ○ 1.65 x 1.16 in.
E. Camera Tripod		eCostConnection 50" Aluminum Camera Tripod	• Minimum height of 23 in. • Maximum height of 50 in.

G. Raspberry Pi Heat Sink		[Raspberry Pi 4 Heat Sinks]	• Material: ○ Aluminum • Each heat sink includes thermal conductive adhesive for simple assembly
USB C to HDMI Cable		[USB C to HDMI Cable]	• Length: ○ 6 ft.
120 AC to 5V Step Down Buck Converter		[NOYITO AC to DC Buck Power Supply Module AC 120V 100V-264V to 5V 3A 3000mA]	• Physical Dimensions: ○ 3.43 x 1.81 x 0.98 in
Micro SD Card		[Sandisk Extreme® microSDXC™ 512 GB UHS-I CARD]	• Storage: ○ 512 GB • Includes a microSD adapter

Pelican Case		[1400 Protector Pelican Case]	• Interior Dimensions (L*W*H):
			  ○ 11.81 x 8.87 x 5.18 in.
			• Exterior Dimensions (L*W*H):
			  ○ 13.37 x 11.62 x 6.00 in.
			• Weight with foam:
			  ○ 4.41 lbs
			• Weight without foam:
			  ○ 3.97 lbs

Appendix C: Object Detection Performance Metrics

To calculate the IoU between the (x1, y1) coordinates – which represent the top left corner of the predicted bounding box – the (x2, y2) coordinates – which represent the bottom right corner of the bounding box – and the ground truth bounding box labels, the area of intersection between the predicted and ground truth bounding box labels are first calculated. Next, the area of the union of both the predicted and ground truth bounding box labels is calculated. The IoU is defined as the intersection area between the predicted and ground truth bounding box labels divided by the area of the union of both the predicted and ground truth bounding box labels.

$$Intersection\ over\ Union\ (IoU) = \frac{Area\ of\ Intersection}{Area\ of\ Union}$$

Precision was defined as a measure of how many times the SEE LION's YOLO model correctly detected an object out of all the times it detected an object, while recall was defined as how many times the model detected an object out of all the times it should have detected an object. Based on the Confusion Matrix:

		Ground Truth Labels	
		Positive	Negative
Predicted Labels	Positive	True Positive (TP)	False Positive (FP)
	Negative	False Negative (FN)	True Negative (TN)

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

To measure the performance of the SEE LION's YOLO model for object detection, the mean average precision (mAP) metric will be used. To calculate the mAP of the SEE LION, a precision-recall curve will be plotted by iteratively increasing the IoU threshold from 0.5 to 0.95, calculating the precision and recall values for each threshold value, and plotting these data points on a graph. The average precision of the model is represented by the area under this precision-recall curve. By classifying all the SEE LION's detections into groups based on the class of the detected object, the mAP of the SEE LION's YOLO model can be calculated by computing the AP of each class and calculating its mean.

II. STEM Engagement Section

A. Introduction & Background

Columbia's Micro-g NExT team operates as a part of the Columbia Space Initiative (CSI), a larger student-run organization on campus dedicated to space science and engineering. Each year, CSI facilitates robust educational outreach efforts in underserved schools in the greater New York community by volunteering directly in local middle and high schools. This year, as in the past, the micro-g team has been hard at work to continue CSI's legacy of highly successful outreach programming. Micro-g specifically provides a unique opportunity for CSI to educate and engage students on topics such as human spaceflight, engineering for low-gravity environments, autonomous vehicles, and the upcoming Artemis programs. Many of the students that CSI serves are a part of the "Artemis generation," making the team's efforts of particular relevance to the future of spaceflight and humanity's return to the moon.

The team has developed several plans related to outreach throughout NYC, the largest of which involves a partnership with Sophie Gerson Healthy Youth (SGHY), a local non-profit dedicated to supporting underserved middle schoolers in the city. Through this partnership, CSI has visited five middle schools in the area several times over the past few years, with a number of visits already planned for this year. Each visit consists of a space-focused STEM lesson, complete with an interactive activity to allow students to directly engage with the topic. Throughout each educational lesson and activity, CSI emphasizes the hands-on nature of STEM, and works to convey every club member's deep passion for space exploration.

Outside of these recurring visits, the team also spearheaded a new model rocketry program this past year to great success, and plans to build upon those efforts in the coming year. The program includes a digital curriculum focused on model rocketry, which includes volunteer-created video lessons and interactive activities. These lessons provide instruction on aerodynamics, propulsion, and the impetus behind space exploration (including information about the Artemis program). Students work on these lessons throughout the semester, and the program culminates with a model rocket launch where they get to showcase what they've learned. Designs created by students in the program will be modeled and manufactured by Columbia volunteers, allowing them to make their rockets flight-ready and launchable. Thanks to an additional partnership and further funding from the Columbia Center for Science and Society, these same programs will also be implemented at Eagle Academy, a middle and high school in the Bronx.

Below, you will find further information on a number of formally planned outreach events with SGHY and Eagle Academy in the next year, as well as smaller, one-time supplemental events that CSI will also be hosting. Additionally, correspondences with relevant parties are included, many with Kristian Breton, the Columbia Engineering Outreach Director. Taken together, the following two sections provide an outline of the steps being taken to meet the team's STEM Engagement goals for this year, and to continue CSI's record of enthusiastic space-centered outreach.

B. Planned Events with SGHY & Eagle Academy

<u>Auditorium Programs</u>

The cornerstone of CSI's outreach in local middle and high schools are so-called auditorium programs: large group activities, often with an entire grade level of students, dedicated to a specific space topic. The team has planned 1-2 auditorium programs at each of five middle schools in New York for the fall of 2023, and the same number at the Eagle Academy. 2-3 programs at each school are tentatively planned for the spring semester.

Objective: To engage students with STEM topics, promoting an enthusiasm for space exploration through hands-on activities; to leverage the experience of Micro-g volunteers to push students to consider all facets of spaceflight (e.g.: rescue and recovery); to broaden participants' understanding of what goes into space exploration.

Audience Type: Middle and high school students across six schools in Manhattan and the South Bronx. All schools served consist primarily of students living at or below the poverty line, who would not otherwise have access to STEM programming or exposure to the topics discussed.

Number of Participants: 100-130 students per event; ~1000 for the fall semester depending on recurring enrollment

Dates: Programming is due to start in the last week of October, and to continue throughout the school year. Different schools host programs on different days of the week, but they will often be facilitated on Fridays.

Specific Activity Plans: Some of the proposed lectures and their accompanying activities are described below. Both activities have had great success in prior years.

1) Gravity Lecture & Water Balloon-Drop Activity: A school-preferred version of the classic egg drop design challenge, this program will focus on near-Earth gravity, and how it differs from gravity in space. Microgravity environments like the moon will be discussed, as will gravity conditions on the International Space Station. Following this discussion, students will participate in a water balloon-drop activity to demonstrate the effects of gravity and challenge them to apply STEM principles to safely return their eggs to the ground. This lecture aligns with New York curriculum standards MS-PS2-4 and MS-PS2-4, which discuss gravitational interactions and the existence of fields between objects that allow contactless interference. Applying these standards to space is an engaging way for students to consider the effects of gravity (or the lack thereof). Moreover, this lesson connects directly to the return of astronaut capsules, which is particularly relevant to the SPOTR challenge. The team plans to directly address some of the ways astronauts are kept safe as they land, and will challenge students to apply these principles to their designs and their water balloons.
2) Aerodynamics/Flight Lecture & Paper Airplane Activity: In this lecture, students will learn about flight (both here on Earth and in space), including information surrounding drag, spacecraft design, and propulsion. Ties will be made to how the atmosphere affects flight, as well as how the same principles apply to fluids, like in the case of astronaut rescue and debris distribution during landing. The lecture will be followed by CSI's returning (and very popular) paper airplane activity, where students will have a chance to build paper airplanes, and put their designs to the test as they attempt to strike a drone with the planes. The activity will provide students with a chance to engage with New York standard MS-ETS1-3, which concerns the analysis of data from tests to improve an engineering solution. Students will be able to iteratively create paper airplanes and test them as they go, bettering their design each time.

Last year's CSI volunteers hosting Auditorium programs at SGHY partner schools.

Model Rocketry Program

Outside of the in-person auditorium programs described above, the team is building upon CSI's rocketry curriculum for implementation in the aforementioned partner schools. This program includes digital programming, lessons for teachers, and culminates in a launch event where CSI volunteers help students launch the rockets that they created. This entire project is closely aligned with all standards under the "Engineering Design" category of NY state science standards, as it guides students through a true iterative design process from inception to completion.

Objective: To allow students to engage in a longer-term engineering project through the iterative design process; to encourage enthusiasm for human spaceflight and the Artemis missions; to instruct on the value and challenges of spaceflight.

Audience Type: Middle and high school students in the same schools mentioned in the previous section.

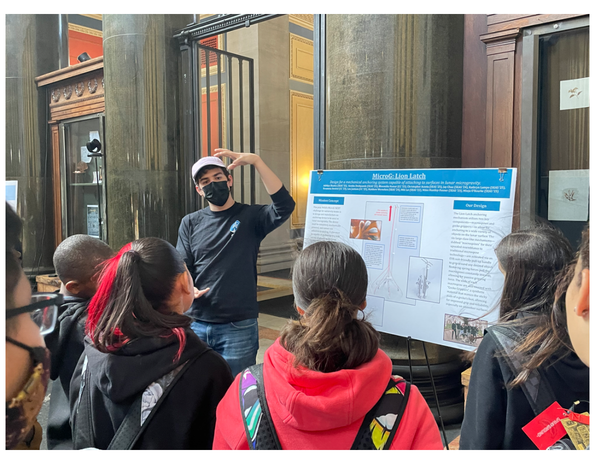
Number of Participants: Depends on the school and the method of implementation. Some schools have indicated a desire to use the curriculum with students in a club, while others are more inclined to use it in a classroom setting. An estimated cohort of 600–800 students across all six schools.

Dates: Design and manufacturing will take place during the fall with lessons and launches projected for mid to late spring.

Specific Activity Plans: As mentioned above, the rocketry curriculum consists of both written instruction and volunteer-created video lessons and activities. It is built to be flexible, allowing for delivery in both classroom and afterschool settings. The hybrid nature of the curriculum allows CSI to increase the amount of lessons that students will experience, and removes limitations on physical presence of volunteers. The current lessons include a kickoff, a lesson on the history and impetus for spaceflight, an ideation session, a construction session, and an in-person launch event. This year, volunteers plan to work to expand upon and improve these lessons, making them more widely accessible through digital publishing.

For the actual construction, design, and launch part of the program, the team plans a close partnership between CSI volunteers and the students that are a part of the program. The model rockets themselves will be propelled by A8-3 Engines, which are designed for flights in vehicles weighing less than 3 ounces, including the engine. Students will be given a central casing that is pre-designed to hold the engine by CSI volunteers. Students will be able to use this base template and their learned knowledge of aerodynamics to design and decorate rockets for launch.

Photos from last year's first launch



Former Outreach Director and Micro-g Co-Lead Matthew Werneken presents Columbia's AY 2021-2022 Micro-g project to middle school students during Spaceposium.

C. Additional Outreach Events

SGHY Summer Camp Astronomy Counseling

Objective: To send CSI volunteers to a Summer camp hosted by SGHY to further engage CSI outreach program participants in a non-academic setting; to inspire an interest in space science and exploration.

Audience Type: Middle school students in the same schools mentioned in the previous section.

Number of Participants: About 120 campers.

Dates: Mid-to-late August for a week.

Specific Activity Plans: At SGHY Summer Camp, CSI volunteers serve as astronomy counselors, guiding students through astronomy activities, model rocket launch, space-themed jeopardy, drone flying, and more. The Outreach team recently purchased a telescope to enhance this program, and plans to send student volunteers back this coming Summer.

Visits to Intrepid & The American Museum of Natural History

Objective: To further engage students in CSI's outreach programs by bringing science and space to life; to promote practical applications of STEM concepts taught during auditorium programs and in class.

Audience Type: Middle school students in the same schools mentioned in the previous section.

Number of Participants: About 500 students.

Dates: Several times during the year with different cohorts of students.

Specific Activity Plans: As part of CSI's partnership with SGHY, volunteers will attend other outreach events with participants, including museum trips. These events bring space to life in a particularly tangible way, enhancing outreach programming.

Spaceposium

Objective: To show middle school students some of the cool projects that can be done in the space industry by presenting CSI's 11 technical and nontechnical missions.

Audience Type: Middle school students in the same schools mentioned in the previous section.

Number of Participants: About 120 students.

Dates: Mid-to-late April

Specific Activity Plans: Spaceposium is an annual science symposium hosted by CSI which attracts students and faculty from Columbia University interested in aerospace engineering. At the event, CSI will present the results of the Micro-g project with a poster presentation alongside the work of other teams in the club. SGHY students will have the chance to visit Columbia, see the projects we do, talk to our resident former astronaut Mike Massimino, and engage with fun engineering and space related activities.

CubeSat

Objective: To introduce middle school students to novel and relevant technologies in space science and engineering

Audience Type: Middle school students in the same schools mentioned in the previous section.

Number of Participants: About 500 students.

Dates: 2024 - 2027

Specific Activity Plans: As a part of a new program devised by volunteers within CSI, the outreach team will shortly be launching a new curriculum centered around cube satellites. This content will include digital lessons, school visits, and external partnerships, and will be one of CSI's most ambitious outreach projects to date. These lessons will be developed in conjunction with CSI's cubesatellite team as part of their NASA funded project .

Engineering Club at Eagle Academy

Objective: To help facilitate the creation of an engineering club for high school students at Eagle Academy, using modified elements of the aforementioned programming

Audience Type: High school students.

Number of Participants: 5-20

Specific Activity Plans: As a part of our growing partnership with Eagle Academy, CSI plans to help an excited science teacher who reached out about starting an engineering club at Eagle Academy. CSI would share and modify its various programs and activities for the more advanced setting of a high school engineering club, including paper airplane design, egg drops, and rocketry. These programs would aim to build on excitement for STEM and help build some important skills of engineering including prototyping and CAD.

D. Press & Social Media

CSI is very active in the broader Columbia community, and has a significant social media presence across several platforms. The team often participates in media efforts spearheaded by Columbia Engineering, including sharing posts, collaborating on press, and creating other media relevant to CSI's accomplishments. Additionally, CSI has an active website and Instagram account, as well as a Slack channel (which is home to over 2,400 members, alumni, and advisors) that is used to share news and updates on a regular basis. The team plans to continue these media efforts this year, sharing accomplishments regarding both Outreach and Micro-g to both the CSI community and the larger Columbia community. The team's members will have a chance to share their work with the wider Columbia audience. Some other examples of CSI's media presence are linked below:

- CSI Website (Micro-g Specific Page)
- CSI Introduction Video (including last year's Micro-g team)
- New York Times article on the spinoff project of last year's Columbia Micro-g effort
- Columbia profile on a CSI experiment on the ISS
- Columbia profile on CSI call with the ISS
- CSI Linkedin Page, which is home to a budding alumni network

E. Contacts, Letters, & Agreements

Email screenshots from several of the team's partners detailing plans for this year's programs are included below. While much communication takes place during meetings and face-to-face, these correspondences offer a glimpse into CSI's outreach plans for the year. The relevant persons are:

- AP Davis and Mr. Andrew Peterson, educators at Eagle Academy for the Young Men of Harlem
- Alan Gerson, Director of Sophie Gerson Healthy Youth

I. Emails concerning plans for programming with Eagle Academy

Columbia Space Initiative - Space Science @ Eagle Academy
11 messages

Kathryn Lampo <kel2169@columbia.edu> Sun, Jul 23, 2023 at 6:50 PM
To: Andrew Peterson <apeterson@eagleharlem.org>, Assistant Principal Davis <cdavis@eagleharlem.org>
Cc: William Lawrence Specht <wls2128@columbia.edu>

Hi AP Davis and Mr. Peterson,

I hope you both are doing well! This is Kate Lampo--I know it's been a while, but I'm the Columbia student that helped coordinate our aerodynamics program last spring. I wanted to reach back out on behalf of the Columbia Space Initiative to see if you'd be interested in reconnecting for more space science enrichment programs this year!

Our outreach team has some cool new initiatives in the works, including lessons and activities centered around a small satellite we are currently building, as well as a model rocketry program we tried out for the first time a few months ago. Some of this may be more conducive to an afterschool/club format as we discussed at one of our early meetings, if that's something you're still interested in.

CC'd on this email is my Outreach co-lead for the year, Will Specht. If you're interested in this type of programming, let us know and we can set up a meeting in the coming weeks to chat about options! Looking forward to hearing from you.

Best,
Kate

Assistant Principal Davis <cdavis@eagleharlem.org> Mon, Jul 31, 2023 at 8:00 AM
To: Kathryn Lampo <kel2169@columbia.edu>
Cc: Andrew Peterson <apeterson@eagleharlem.org>, William Lawrence Specht <wls2128@columbia.edu>

Hi Kate
We would be very interested in reconnecting & meeting with you to continue what we started last year! The students, and adults, had a blast, no pun intended.

Mr. Peterson is on summer break so I am unsure of his availability. What would you suggest for a timeframe for preliminary discussions?

Thank you.

Nurturing Our Future Leaders,

Catrice M. Davis, Assistant Principal
Eagle Academy for Young Men of Harlem
212-694-6051
cdavis@eagleharlem.org
cdavis20@schools.nyc.gov
https://linktr.ee/APDAVIS

"Tu Sabe..."

[Quoted text hidden]

Kathryn Lampo <kel2169@columbia.edu> Wed, Aug 16, 2023 at 11:21 AM
To: Assistant Principal Davis <cdavis@eagleharlem.org>
Cc: Andrew Peterson <apeterson@eagleharlem.org>, William Lawrence Specht <wls2128@columbia.edu>

Hi AP Davis!

Our meeting started at 10:30 this morning, but we were able to chat with Mr. Peterson about some of our upcoming projects for the year, and we're excited to work with you all again! I've attached a document with our offerings, and I'm sure he can fill you in on any holes and some of the potential modifications we discussed.

If we could circle back once the school year starts to talk about some potential dates for our programs, that'd be great. Let me know if there's some days/times that would work for you and we can get something on the calendar!

Thanks,
Kate
[Quoted text hidden]

Eagle Academy Interest Plan.pdf
195K

I. Emails concerning plans for programming with SGHY

LIONMAIL @COLUMBIA

Kathryn Lampo <kel2169@columbia.edu>

Camp Zeke wrap-up and year plans

6 messages

William Lawrence Specht <wls2128@columbia.edu> Fri, Aug 25, 2023 at 11:06 AM
To: alan jay gerson <alanjgerson@gmail.com>
Cc: Kathryn Lampo <kel2169@columbia.edu>

Dear Alan,

I hope that you are doing well and found some rest in what was certainly a busy summer. Thank you again for inviting us up to camp, I know all the CSI counselors had a great time. As we are about to begin the next academic year, Kate and I were hoping to discuss a few things, and hopefully meet at some point in early to mid September. Please let us know of your availabillty in the coming weeks so we can get that set up!

First, with regards to your hope to get SGHY immersion students up to campus for a telescope viewing in Pupin, we reached out to Kathryn Johnston from the astronomy department. She has let us know that she will speak with appropriate department contacts, and will be able to give an answer on the feasibility of this program once the semester begins.

Second, in terms of Camp Zeke wrap up stuff, I have attached a document with our final activity descriptions and schedule for use for counselors next year. It's Kate and I's hope that it can act as the starting point for next year's planning, allowing us to streamline the process. I have also attached a link to a Google Drive with the photos we took at Camp Zeke. We unsuccessfully attempted to collect the photos taken by counselors and teachers, so if you have an email chain with them it might be worthwhile to try on your end. Specifically, if you want the banner photo, I believe both the camp and at least one teacher have it.

Third is an exciting new potential addition to the CubeSat project if you are interested. This past week, we talked with a member of the Teachers In Space nonprofit (https://tis.org/), who run educational workshops teaching teachers how to build CubeSats and other space science and engineering concepts. They also provide cool CubeSat models for classes to work on (and to launch from high altitude balloons) that could complement our own lessons and in-class visits well. This is pretty tentative at this stage, but if there are teachers in SGHY who would be interested in that sort of workshop, it would be a great opportunity to get them involved. If you are interested, we can connect you with our contact at Teachers In Space, Noah. We can also talk more about details at our upcoming meeting.

Finally, as we briefly showed you at Camp Zeke itself, we made an outline of the science-based activities that SGHY offers to share with schools, so that we can accurately gauge interest for the different CSI-related activities. We thought that it would be easiest to just include all of the science activities that you offer, but left the activities that we didn't know the full details of highlighted in yellow for you to fill in. We decided to keep the Extended activities category in order to clearly distinguish that they are optional and that they can either be for a general or immersion audience depending on the school. We also updated the letter to make this distinction more clear to any school reading. As a final piece, we were wondering if you had a timeline for sending out and hearing responses from schools on the interest form (between your budget and I'm sure plenty of other administrative components).

Looking forward to the coming school year, and to continuing to grow our partnership and our work!

Best,

Will and Kate

Photo drive link -> https://drive.google.com/drive/folders/1d7Rl2-akJHn84v9EFGHHpwuhqKRo_yTE?usp=sharing

2 attachments

School interest plan _ email.docx
179K

Camp Zeke_ Proposed Space Science_Astronomy Schedule.docx
20K

alan jay gerson <alanjgerson@gmail.com>
To: William Lawrence Specht <wls2128@columbia.edu>
Cc: Kathryn Lampo <kel2169@columbia.edu>

Sat, Aug 26, 2023 at 11:50 PM

Hi William, Kathryn,

Thank you so much for your very thoughtful, as always, communication. But, I hope that both of you take some significant time off from all academic, including extracurricular, endeavors before the start of the new school year!

That being said, your timing is perfect as I need to put together a photo album from camp. However, when I click on the link I get a message "Drop Files Here." Then, when I download the file and open it I get the message "File is Empty." Please advise. I will follow up with the teachers for their photos, and with camp administration, but if you have any counselor email addresses please let me know and I'll follow up with them as well.

After Labor Day, we will meet with all of our schools to review the entirety of the Sophie Gerson Healthy Youth program for the school year. Our programs begin in mid-October. We will certainly use your very well organized outline and summary for space science and CSI. Two questions for your advice on CubeSAT:

~ The only way to involve the same students in CubeSAT for all three years would be to start with the 6th grade. Usually we do space science with 7th or 8th grades and environmental science with 6th or 7th. I would have to run any change by the schools, which prefer to align our activities with their mandated curricula. So, how important is it to have the same group over the three years? And, do you think 6th graders can tackle CubeSAT at any event?

~ I guess I overlooked the CubeSAT mission pertaining to galaxy gas. We always like to integrate the different components of a program. And, galaxies provide way cool subjects for students at any grade. So, do you think we can incorporate galaxies in our presentations and activities - the vast number, different times, distances, our own Milky Way, and some fanciful speculation about time warp travel to different galaxies and civilizations we might encounter, etc.? We can certainly ask the Planetarium and Aerospace Center to include galaxies in our visits

Copying Dr. G. for his thoughts on the above two queries, as well.

Thank you for reaching out to Kathryn Johnston. Could you provide contact information for her. It might help if I filled in some detail with how we interacted with the Astronomy Department pre-COVID.

I'm glad that all CSI enjoyed camp. You certainly provided lifelong memories for the campers. They evinced palpable joy in your activities I witnessed. They commented overwhelmingly positively in the questionnaire's questions about space science. You may have generated some future scientists and astronauts!

All the best,

Alan.

[Quoted text hidden]

III. Emails concerning miscellaneous programming with the Columbia Engineering Outreach Office

Science Honors Program Kickoff at 11 on 9/30
8 messages

Kristian Breton <kb3265@columbia.edu> Wed, Sep 20, 2023 at 9:43 AM
To: Columbia Space Initiative <columbiaspaceinitiative@gmail.com>, Kathryn Lampo <kel2169@columbia.edu>, William Lawrence Specht <wls2128@columbia.edu>
Cc: Teresa Gong <tg2847@columbia.edu>

Hello All,

Thanks so much for looping in Theo for yesterday. The teacher was very appreciative.

Looking forward the Science Honors Program kicks off its 66th year next Saturday. It would be great to have CSI present for 45 min and take questions for 15 at 11:00 on that day. There will be 250+ in attendance. We'll have you either in Pupin or Havemeyer.

I've attached an interesting summary on the history of SHP. Margaret Mead used to teach! There are lots of other luminaries mentioned too!

BTW, I emailed MM about it last week to invite him, but didn't get a response.

--

Kristian Breton *he/him*
Outreach Director
Engineering Student Affairs
Columbia Engineering

kb3265@columbia.edu | 646-745-8420 | Columbia Engineering

Have an emergency? Contact Public Safety at (212) 854-5555

Connect with us

Let's connect!

2 attachments

History of the Columbia University Science Honors Program.pdf
157K

History of the Columbia University Science Honors Program.pdf
157K

Kathryn Lampo <kel2169@columbia.edu> Sat, Sep 23, 2023 at 6:23 PM
To: Kristian Breton <kb3265@columbia.edu>
Cc: Columbia Space Initiative <columbiaspaceinitiative@gmail.com>, William Lawrence Specht <wls2128@columbia.edu>, Teresa Gong <tg2847@columbia.edu>

Will and I would be happy to come talk! Perhaps we'll rope some other speakers in too to share about some of our missions.

As for Massimino, I've asked Matt & Tycho to reach out to him on our behalf (they're TAing for him at the moment). No promises, but maybe we'll get a response.

Thanks!
Kate
[Quoted text hidden]

III. Administrative Section

A. Mentor Request

The team is not currently working with a point of contact at NASA, and would benefit from additional support in the next phases of the Micro-g NEXT challenge, if selected to continue.

B. Institutional Letter of Endorsement

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

October 9, 2023

Proposal Review Committee
Micro-g NExT 2023 Design Challenges
Microgravity University
Johnson Space Flight Center
Houston, TX 77058

Re: NASA Micro-g NExT 2024 Design Challenges

Dear Members of the Review Committee,

The Columbia Space Initiative is a student-led organization within Columbia University in the City of New York. Its faculty sponsor is Michael Massimino, a Professor in the Department of Mechanical Engineering.

The Fu Foundation School of Engineering and Applied Science endorses the team's participation and commits to support the participation of the Columbia Space Initiative in their challenge.

Please do not hesitate to contact me or Professor Massimino should you have any questions or concerns.

Sincerely,

James Hone
Wang Fong-Jen Professor of Mechanical Engineering
Chair, Department of Mechanical Engineering

The Fu Foundation School of Engineering and Applied Science

C. Statement of Supervising Faculty

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

October 9, 2023

Dear Microgravity University Committee,

As the faculty advisor for an experiment entitled "SEE LION: Search and Emergency Equipment for Life-saving Identification and Optical Network" proposed by a team of undergraduate students from Columbia University, I concur with the concepts and methods by which this project will be conducted. I will ensure that all reports and deadlines are completed by the student team members in a timely manner. I understand that any default by this team concerning any Program requirements (including submission of final report materials) could adversely affect selection opportunities of future teams from Columbia University.

Sincerely,

Michael J. Massimino
Professor of Professional Practice

D. Statement of Rights of Use

COLUMBIA | ENGINEERING
The Fu Foundation School of Engineering and Applied Science

October 9, 2023

As a team member for a proposal entitled "SEE LION: Search and Emergency Equipment for Life-saving Identification and Optical Network" proposed by a team of undergraduate students from Columbia University, I will and hereby do grant the U.S. Government a royalty-free, nonexclusive and irrevocable license to use, reproduce, distribute (including distribution by transmission) to the public, perform publicly, prepare derivative works, and display publicly, any data contained in this proposal in whole or in part and in any manner for Federal purposes and to have or permit others to do so for Federal purposes only.

As a team member for a proposal entitled "SEE LION: Search and Emergency Equipment for Life-saving Identification and Optical Network" proposed by a team of undergraduate students from Columbia University, I will and hereby do grant the U.S. Government a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States an invention described or made part of this proposal throughout the world.

Sincerely,

Michael J. Massimino
Professor of Professional Practice

DARYL CHOO

Julio Ramirez

Yiyang Peng

Mingyuan Zhao

Hiba Altaf

KHONDOKER FARIHAH AHMED

K. Farihah Ahmed

Maryam Agboola

Michael Cai

E. Funding and Budget Statement

Funding for Columbia's previous Micro-G NExT teams has come from the Activities Board at Columbia, the Columbia Mechanical Engineering Department, and the School of Engineering and Applied Science (SEAS) Dean Travel Fund. The team plans to use the same sources for expenditures this year. While some of the costs below are estimates, many specific items are also listed and linked in *Appendix B: Component Specifications*.

Item	**Projected Cost**
Materials and Supplies	
Single Board Computer (2GB Raspberry Pi Model 4B) (qty. 1)	$150.00
Camera (GoPro HERO10 Black) (qty. 1)	$300.00
Pelican Case (qty. 1)	$60.00
Camera Tripod (qty. 1)	$40.00
HDMI-CSI Bridge (qty. 1)	$34.00
Raspberry Pi 15W USB-C Power Supply (qty. 1)	$8.00
Raspberry Pi 4 Heat Sinks (qty. 1)	$6.00
HDMI Cable (qty. 1)	$12.00
Micro SD Card	$32.00
Pelican Case	$116.00
Materials and Supplies Total	$758.00
Travel	
Airfare for Six Students	$3,000.00
Hotel Stay (2 rooms, 3 nights)	$1,500.00
Car Rental (4 days)	$500.00
Food	$800.00
Miscellaneous	$400.00
Travel Total	$6,200.00
GRAND TOTAL	$6,958.00

F. Parental Consent Forms

All team members are 18 or older, so there are no parental consent forms required.