NASA Micro-g NExT Challenge

Orion Crew Safety

Search and Rescue Platform for Optical Target Recognition (SPOTR)

Background

NASA has been challenged to go forward to the Moon with our Artemis Program, using Orion as the spacecraft to transport crew. During the ocean capsule landing sequence, multiple items are jettisoned from the capsule, which for safety reasons, creates a large keep-out area around the capsule landing zone. An autonomous system that is capable of imaging and identifying objects of interest while the capsule is in the water will help improve the situational awareness of Search and Rescue and response personnel. Primarily, the concepts designed in this year's SPOTR challenge will be used to identify items of interest as would be present during an unassisted egress scenario from the Orion capsule (astronauts floating wearing an underarm life preserver, astronaut mulit-person life raft, etc).

Objective

Supporting open-ocean search and rescue situational awareness, design a stationary autonomous system capable of meeting the following requirements:

Functional

- Capable of autonomously identifying and tracking objects of interest including:
  - Orange colored life-ring
  - Mannequin wearing orange-colored life preserver unit (LPU)
  - Multi-person life raft
  - Orion capsule mockup (WEST) located on far end of pool
- Providing a live video stream to an operator laptop via wired ethernet or Wireless Wifi Connection
- Provide "short data burst" notification of object detection to an operator laptop
  - Text message – "<BLANK OBJECT> located" and picture of object detected

Physical

- Camera fixture mounted on tripod no greater than 36 inches in height from pool deck
- Include commercial-off-the-shelf camera (i.e. GoPro, Web Camera, etc)
- Electronics / processing elements fit on a folding table on the pool deck and accept 120V AC power input

Focus Areas

This challenge is primarily an electrical engineering/ software engineering-focused effort, including the following focus areas and disciplines:

- **Software Engineering / Coding** – students should be proficient in free/open-source software tools such as Python, C++, etc.) and be able to utilize toolsets within such programming languages appropriate for image detection, processing and characterization of full-motion video (FMV) or static images taken by student camera systems
- **Single-Board Computer Programming** – students should have some basic experience with single board computers such as Raspberry Pi, Arduino, etc. for physical hosting of software scripts and image processing due to portability requirements
- **Image / video Object Recognition & Artificial Intelligence** – students will learn via this challenge basic image processing and recognition techniques such as You Only Look Once (YOLO) and other deep learning techniques
- **Basic Electronics Circuitry** – basic electrical engineering skills for prototype circuit board development may be required for overall system packaging, etc.

Team composition should include students strong in electrical engineering and software coding, as the challenge is primarily electrical engineering/software engineering focused.

Open source/free resources are available online and teams are encouraged to experiment with novel low-cost techniques for object recognition and characterization. Software Developer Kits (SDKs) and Python programming toolboxes include (but are not limited to):

- https://gopro.github.io/OpenGoPro/demos/python/sdk_wireless_camera_control
- https://www.youtube.com/watch?v=Z2Hq4jDWunk
- https://towardsdatascience.com/yolo-object-detection-with-opencv-and-python-21e50ac599e9

Assumptions

This challenge assumes that NASA will provide the following items:

- Photo library of target items for training of image recognition scripts
- Floating items in Neutral Buoyancy Laboratory (NBL) during test week

Cost/Project Management

- Utilize commercial-off-the-shelf hardware/software to largest extent possible, for example using laptops, Raspberry Pi / Arduino for on-board computing, etc.
- Teams should focus on programming and electrical engineering elements of the design challenge, requiring some undergraduate-level experience in programs such as Python and You Only Look Once (YOLO) image processing techniques.

Anticipated Costs/Supplies Needed

- Single Board Computer (Raspberry Pi, Arduino, etc) - ~$100.00 – $150.00
- Camera (GoPro, webcam) - $100.00 - $300.00
- Pelican Case - ~$60.00
- Camera Tripod - ~$40.00

Requirements

Safety	
1	Camera systems shall use commercially available tripod systems with demonstrated stability appropriate with any student-developed camera systems
2	Camera and processing hardware shall be splash proof for poolside use
3	Camera / sensing systems shall not use laser / sonar or other radiofrequency (RF) techniques for object detection
4	The SPOTR control system shall power on and begin operations via single switch throw/actuation
Operational	
1	Capable of autonomously identifying and tracking objects of interest including: • Orange colored life-ring • Mannequin wearing orange-colored life preserver unit (LPU) • Multi-person life raft Orion capsule mockup (WEST) located on far end of pool
2	Provide image detection of selectable item within 60 seconds of user selection i.e. user selects “life raft” and system should provide detection of liferaft, notice of detection, and image of selected life raft with life raft outlined in photo within 60 seconds
3	Provide “short data burst” notification of object detection to an operator laptop • Textual message – o “<BLANK OBJECT> located” o Timestamp Photo of item
4	The SPOTR control system shall not require external calibration or warmup time greater than 60 seconds from control system power-on
5	The SPOTR system shall prioritize each known object based on the prioritization table provided by NASA.
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.

Test Setup

Students will place camera on tripod on one end of the NBL, oriented such that the pre-placed Field of View (FOV) centerline marker is in the center of the camera's field of view. Various items such as an orange life ring and mannequin wearing an orange life preserver will be either placed or already floating in the NBL and the camera system will autonomously detect, characterize, and report on items.