Final Project Proposal: Anomaly Tracking for Visual Aversion (ATVA)

Team members: Juan-Diego Florez

Project title: Anomaly Tracking Vision Aversion System

Problem statement and goals:

Motivation ("What are you doing, and why?"): This project is inspired by a fictional military operation from a short film, wherein visual contact with a subject is hazardous and potentially lethal. The subject, a creature referred to as SCP-096, is provoked into a frenzy when visual contact is made with its face under any circumstance. Field operatives in the short film are tasked with securing 096 for containment after it escapes the facility it was held in, and to do so, a bag must be placed over its head so that attacks are not provoked.

The goal of this device is to allow the user to track the distance and angle to the subject such that it can be secured without risk of provoking an attack. While based on fiction, this device has several potential military and law enforcement applications in which line-of-sight (LOS) cannot be guaranteed or is hazardous.

Overview ("What will the system do?"): The proposed system, Fig. 1, will use a pair of motors (a) to allow a camera (b) to find and track a target identified with a fiducial marker, which will be kept centered on the video feed. An IR distance sensor (c) mounted on the camera will be used to measure the distance to the target. An IMU (d) will be used to track the pose of the user's head such that the homogenous frame transform between the user's head frame and the camera frame can be calculated. The system should provide the user with the angular displacement (in pitch and yaw) and the distance to the target so that the user can track the target without needing visual contact.

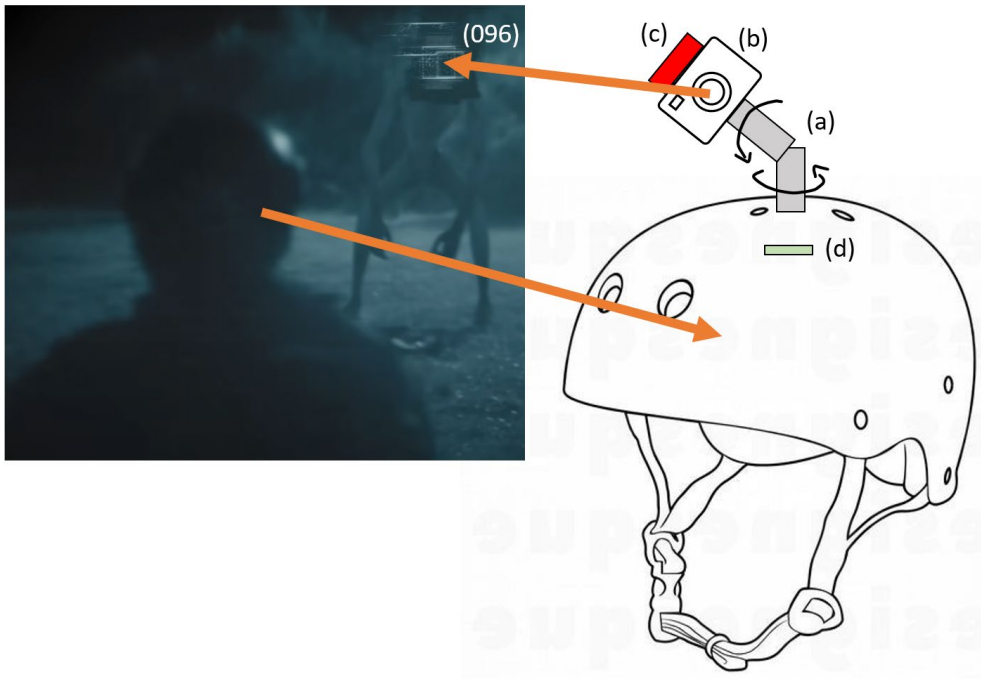

Fig. 1: On the left is a screenshot from the short film, in which visual contact with SCP 096 was lethal but nearly unavoidable while trying to secure it. The ATVA device (right) will help operatives to operate safely within close quarters of SCP 096 so they may secure it for containment. The device uses a tracking turret (a), on which a camera (b) and IR distance sensor (c) are mounted, to track the subject. An IMU (d) will be used to track the pose of the user's head.

Performance Goals: The performance goals of the system include:

- Create a 2-DOF motor driven turret for visual subject tracking
- Develop a control algorithm to minimize motor position error
- Process the digital image to track a fiducial marker and keep it in the center of the frame
- Develop a search/calibration protocol to find the subject if contact has been lost
- Implement an algorithm that relates subject's angular displacement to the user's FOV

Breakdown of the project components:

Mechanical design: The mechanical design will require:

- Two servo motors
- Two-axis turret mechanism to mount the camera
- Head mount

Electrical design: The electrical design will include:

- Digital camera
- Motor encoders/potentiometers
- Motor driver circuit
- IMU
- Display for sensor output

Software and Control Theory: The software and control will involve these main components:

- Image processing to identify fiducial targets in the environment
- Motor control algorithm to minimize position error (both for camera tracking and desired visor deployment)
- User FOV threshold estimation algorithm for relevant angular displacements

Project Milestones and strategies for handling anticipated challenges:

Milestone 1: Head-mounted camera turret mechanism

- Goal: Design and run a turret mechanism capable of pan and tilt
- Potential challenge 1: Head mounting; Solution; will use a bicycle helmet capable of housing electronics and serving as a base for the turret
- Potential challenge 2: Motor position error; Solution; will use potentiometers as encoders for feedback control
- Potential challenge 3: Motor and sensor power draw; Solution; optimize component mass and placement to minimizes load on motors, and turn off IR sensor when object not in center of frame

Milestone 2: Image processing and subject detection

- Goal: Find the subject and estimate the FOV threshold for visual contact
- Potential challenge 1: Finding the subject; Solution; implement a search/scanning algorithm to find the subject
- Potential challenge 2: Estimate FOV angular displacement; Solution; create a model of the FOV of the user, and user angular displacement from center of frame to transform angles to angular displacement from FOV edge (Fig. 2)

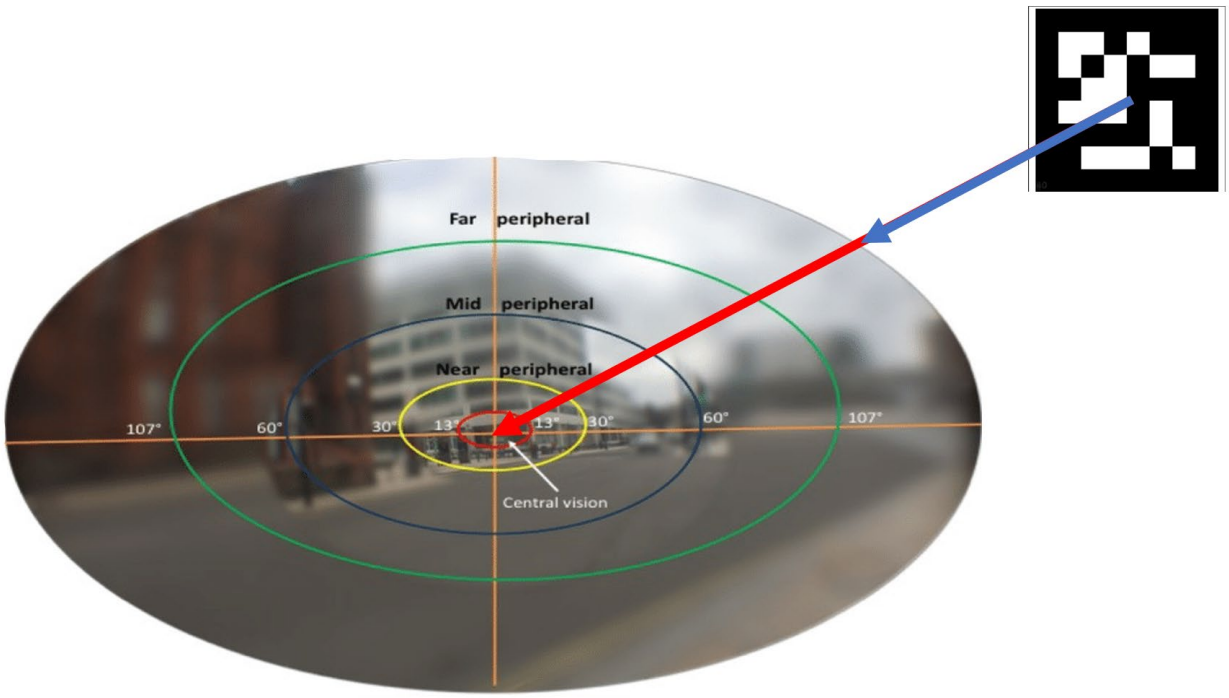

Fig. 2: On the left is a visualization of human FOV using both eyes, which has an ellipse-like shape. The fiducial marker tracking the subject will be related to the center of the FOV (red arrow), which corresponds to the z-axis of the frame of the user's head. This will then be transformed to the edge of the ellipse, where the corresponding angular displacements can be calculated such that visual contact can be completely avoided.

Method of Evaluation and Failure Modes:

Evaluation: The system will be tested by successfully finding and tracking a fiducial marker around the user without the user needing to make visual contact with the subject. The angular displacements and distance to the object should be output to a screen that the user can use to be aware of the object tracking.

Potential Failure Modes:

- The computer vision elements fail to identify the target
  - The target has a specific color/marker that the system will be looking for. Other objects will be ignored
- The user moves their head too quickly for the turret to track the target or the target is hidden or moved rapidly
  - The search/scan object finding protocol will be enacted when the camera loses the object