* Implement **Computer Vision** to visualize constellations and trajectories while viewing through laptop

Computer Vision for Constellation and Object Detection

* The Canon EOS 6D Mark 2 is good for astrophotography but will need another camera with wider FOV. A standard webcam or USB camera mounted on the telescope could capture live video.
* **Capture Sky image**
  + Use another camera to capture real-time images or video of the sky
    - Can use raspberry pi or laptop for interfacing w Camera
* **Sky Map Database**
  + Get a star map (digital version of the sky / star catalog) that contains coordinates of stars and constellations. Can use libraries like **ASTROQUERY** or **ASTROPY** to get star positions in real time based on location and time of year
* **Computer Vision Processing**
  + Use OpenCV, process camera feed, detect and match stars and constellation patterns. Match star coordinates from database to the sky images
  + Can apply image thresholding, contour detection, and template matching to identify objects like stars and planets. For detecting satellites or airplanes, you can use motion detection algorithms to find moving objects in the sky
* **Satellite and Airplane Detection**
  + To detect moving objects, you can analyze movement in video feed by comparing consecutive frames and identifying objects that are moving
  + Pre-existing databases like Heavens-Above for satellite trajectories. Then, overlay the predicted paths onto the camera feed in real-time
* **Overlay Detection Lines**
  + Once the constellations, or moving objects, are identified you can use OpenCV’s drawing functions to overlay lines around constellations or paths of moving objects. This can be done in real time as the camera captures images
* **Display Results**
  + Use laptop to display processed results on a screen
    - Constellation lines
    - Satellite paths
    - ~~Airplane Flight Trajectories~~
    - The live feed from the camera

Tools and Libraries

* Hardware – need a USB Camera or Webcam for real-time sky video feed
* Software
  + OpenCV for computer vision processing (detecting stars, identifying moving objects)
  + AstroPy for astronomical calculations and working with star database
  + Heavens-Above API, CelesTrak, or NORAD for satellite tracking
  + TensorFlow or PyTorch to use deep learning for object detection

Process Pipeline

Image Capture -> use RaspPi to interface with camera and capture images at regular intervals

Preprocessing -> use OpenCV to preprocess the image by removing noise, adjusting contrast, and isolating bright spots

Object detection -> stars/constellations will use star catalogs or machine learning models to identify patterns and match them with know constellations. Moving objects will use optical flow (Lucas-Kanade method) to detect objects in the sky, which would be satellites or space debris

Trajectory Prediction -> For satellites, if they are tracked via known paths, you can overlay this on the image or live-feed

Overlay Lines -> once objects are detected, you can overlay lines on the live feed or image to show constellations, satellite trajectories, etc. using OpenCV or some other more advanced graphics library

Tools and Libraries to Use

OpenCV: For real-time image processing, object detection, and overlaying lines on the image.

AstroPy: For star catalog integration, astronomical calculations, and converting between celestial coordinates.

TensorFlow/PyTorch (optional): If you want to use deep learning for identifying constellations or satellites, you could train a model to detect these objects in the sky based on star patterns or use pre-trained models.

CelesTrak API: For getting real-time satellite tracking data (positions and trajectories).

ADS-B Data (for airplanes): You can use APIs like FlightAware or ADS-B Exchange for tracking airplanes.

Integration with Telescope Movement

Once you detect a target, you can program the Raspberry Pi to communicate with the motorized telescope to point it toward the detected object. This can be done by calculating the right ascension (RA) and declination (DEC) coordinates of the object and moving the telescope accordingly using the motorized mount.

**Displaying Lines and Trajectories**

Once the moving objects and constellations are detected, you can overlay lines:

* **Constellation lines:** Match the stars in the image to a pre-defined constellation map and draw lines connecting them.
* **Satellite and Airplane trajectories:** Based on the object's movement in consecutive frames, predict its trajectory and display it as a line on the screen.
* **Real-time tracking:** Use a moving window to adjust the lines as the objects move across the sky.

**Step-by-Step Plan:**

1. **Camera Integration:** Set up the Canon EOS camera to take regular photos of the sky using the Raspberry Pi.
2. **Image Processing:** Use OpenCV to identify stars in the photos.
3. **Constellation Recognition:** Use a star catalog or machine learning model to identify constellations.
4. **Moving Object Detection:** Track satellites and airplanes using real-time data and optical flow techniques.
5. **Overlay Trajectories:** Draw lines over the image to represent constellations and moving object paths.
6. **Telescope Integration:** Point the telescope at the detected objects using motorized mounts controlled by Raspberry Pi.