User Manual - Multirotor CV

Cal Poly Computer Engineering Capstone

S.P.O.T: Search Plane Object Tagging

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March 15, 2018

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System Overview

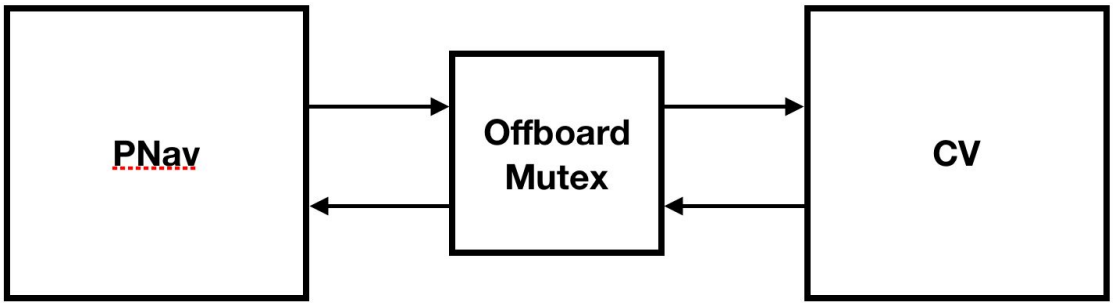


Figure 1: Blackbox Diagram

The Computer Vision Module interacts with the navigation module, PNav, through a mutex located in offboard. PNav initials the main CV loop, see Figure 2, through the mutex sending along its most up to date GPS location. The Computer Vision module then safely accesses this data, grabs the most recent image from the camera, and begins its analysis of the image. The image is converted into the HSV color space, thresholded to remove all but the red pixels, adjusted through morphological operations to clear up any circles, and finally the HoughCircles algorithm is applied to find any circle's center x, center y, and radius. While the drone is in the Quick Search role, if a possible ball is found from the CV algorithm, the drone's GPS, that was previously sent in at the beginning of the process, is returned. If the drone is in the Detailed Search role, it calculates the ball's GPS location based upon the drones GPS information detailed above.

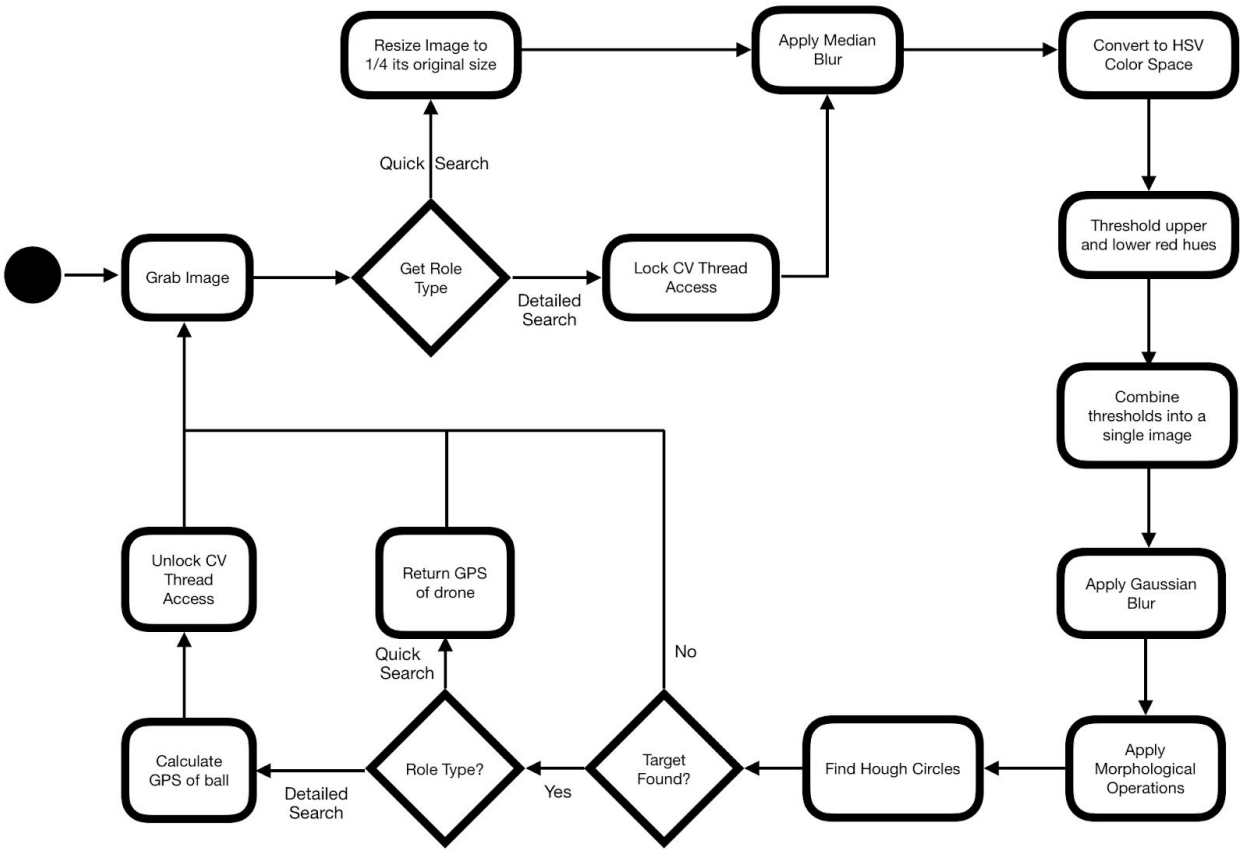
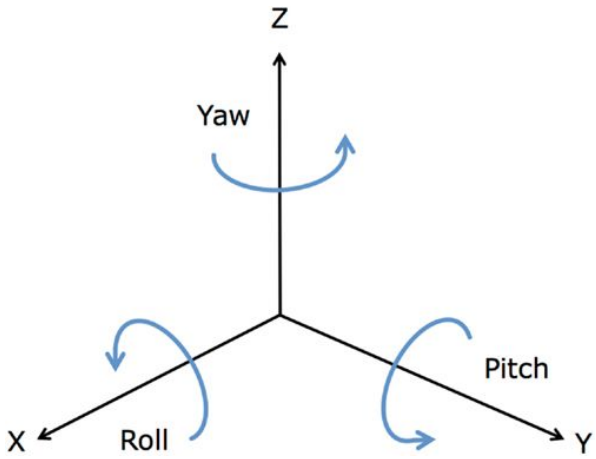


Figure 2: System Flowchart

System Implementation

The PNav module has been modified to grab the drone's local GPS data and forward it along to the mutex, so that the CV module may safely access it. The location data comes the from Mavlink Autopilot Interface:

- **Role**
  - The drone's current state, either Quick (0) or Detailed (1).
- **Latitude**
  - The current latitudinal position of the drone.
  - Passed around as an int, multiply by 1E-7 for its real value
- **Longitude**
  - The current longitudinal position of the drone.
  - Passed around as an int, multiply by 1E-7 for its real value
- **Height**
  - The current height above the drone.
  - Passed around as an int, multiply by 1E-3 for its real value
- **Yaw**
  - The degrees from north the drone is facing.
  - Passed around as an int, multiply by 1E-3 for its real value
- **Pitch**
  - The degree to which the drone is rotated around its Y axis
- **Roll**
  - The degree to which the drone is rotated around its Y axis



The Offboard mutex connects both the PNav and CV modules, and safely allows the setting of all data communicated between both modules. Once the main CV loop is started with the offboard function "CV_Start()", an image is grabbed and the process begins. If a ball is found during quick search, the drone's GPS is returned as the ball's position. If the drone is in its detailed search mode, the ball's GPS is then calculated and returned to the mutex. Finally in PNav, if the CV_found variable of the mutex is true, then the GPS of the ball is retrieved and sent along to the vehicle_status.gcs_update. Both the boolean value and the gps values are used to keep the PNav codebase changes to a minimum.

Functionality

How to Operate

- Run $make in NGCP/MAQSS git repository
- New code should build and run just like the old code.

How to Modify Values

- Change the target's color threshold (See Appendix for OpenCV
    - Identify which hue range you are looking for
    - Change the hue value in the Scalar object of the OpenCV function inRange()
    - If need be remove the second inRange function and addWeighted function. These are being used because red hue straddles the lowest and highest end of the HSV color scale.
- Change a Morphological Operation
    - Change the structuring element (ex: MORPH_ELLIPSE)
        - See Appendix 5 for OpenCV details on the subject.
    - Change the Open Operation
        - Change the final parameter, the number of iterations. The more iterations, the more white pixels get removed. To many iterations can actually remove the ball from the image, or make it undetectable.
    - Change the Close Operation
        - Change the final parameter, the number of iterations. The more iterations, the more white pixels get added to already white pixels. This is used to fill in any gaps with possible target locations.
- Change the HoughCircles Algorithm
    - See Appendix 4 for function details
- Change the GPS Calculations height parameter value.
    - The value is currently static at 25 feet, the average of the drone's flight height.
        - Change this value in code (in meters)
    - Use the dynamic value being entered into the offboard mutex.
        - Change the value to take in the height from the mutex

Troubleshooting

- A false negative happens (Ball is there but not detected)
    - Make sure the ball is actually in the original image and not warped
        - If image warped, check the camera's stabilizer and make sure it's fitted properly.
    - Check the thresholded image is pulling out the correct color.
        - If not, change the hue, saturation, or brightness values, in the OpenCV inRange() function (See Appendix 2).
    - The ball is being removed from the binary image
        - Check the number of open iterations and lower them to see if that fixes the problem
    - The ball is being combined with with other extraneous white pixels after the morphological operations.
        - Increase the number of Open iterations which will remove the extraneous pixels
        - Or, decrease the number of Close iterations while will not completely fill in the gaps between separate clusters of white pixels.
- A false positive happens (Ball is not there but is detected)
    - The color being thresholded out is not correct, leading to incorrect results
        - Change the hue, saturation, and/or brightness values in the inRange() OpenCV function.
    - Extraneous white pixels in the thresholded binary image, which are not the ball, are being enlarged and/or not removed.
        - Increase the number of Open iterations which will remove the extraneous pixels
        - Or, decrease the number of Close iterations while will not completely fill in the gaps between separate clusters of white pixels.
        - Increase the minRadius variable's value for the HoughCircles algorithm to throw away any radius under that value.
- Returned GPS is incorrect
    - Make sure the GPS being passed into the mutex from the PNav is up to date.
    - Make sure a false positive is not happening with the detection of the ball
        - See the false positive section in Troubleshooting to fix.
    - Make sure a false negative is not happening with the detection of the ball.
        - See the false negative section in Troubleshooting to fix.
    - Make sure, if using the dynamic height from the mutex, that the height is above ground, not above sea level.

Appendices

1. cv::medianBlur
   https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html?#medianblur
2. cv::inRange
   https://docs.opencv.org/2.4/modules/core/doc/operations_on_arrays.html?#cv.InRange
3. cv::GaussianBlur
   https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html?#gaussianblur
4. cv::HoughCircles
   https://docs.opencv.org/2.4/doc/tutorials/imgproc/imgtrans/hough_circle/hough_circle.html
5. cv::getStructuringElement
   https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html?#getstructuringelement
6. cv::morphologyEx
   https://docs.opencv.org/2.4/modules/imgproc/doc/filtering.html?#morphologyex