**Problem I – Question 1: Attitude Determination**

***Part A) Extracting Body Frame unit vectors***

The first step was to make sure that Matlab was properly able to open the .png file. The following image shows that Matlab succefully opens the image, as shown in Figure 1.

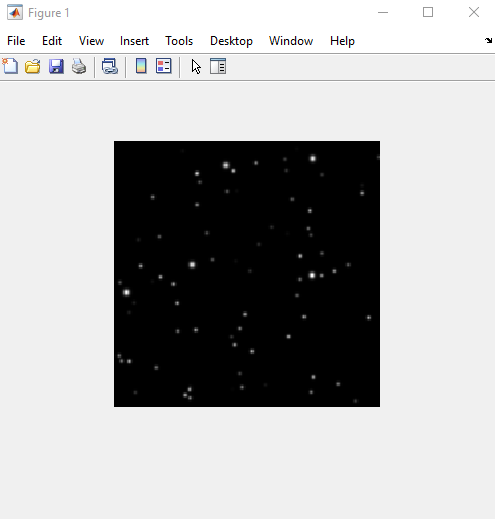


Figure 1. Raw image

The next step was to extract all the stars in the image, regardless of its brightness. The following image shows just that.

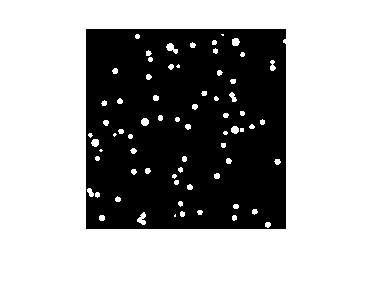


Figure 2. Identified stars

The next step is to find the centroid of each of these stars in the image. Specifically, the x & y pixel coordinates, whose origin is at the top left corner, were found. The following is that data:

However, we do not care about the coordinates of every star. We only want to analyze the ones labeled in this image:

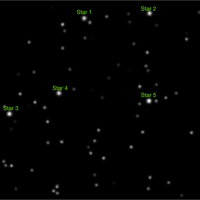


Figure 3. Image with the stars of interest labeled

A black background with white numbers and symbols

Description automatically generatedUsing Matlab’s built-in feature, the coordinates of these stars were approximately found as follows:

A black text on a white background

Description automatically generatedNext, these approximate coordinates were compared to the centroid found earlier to get more exact coordinates. This was done using the following equation:

This yields the following “exact” coordinates of the centroid of each star. These coordinates were overlayed onto the image to verify that we have identified the correct stars and compared to Figure 3.

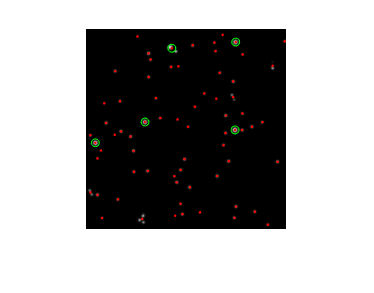


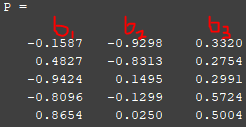
Figure 4. Centroid locations plotted

Table 1. Exact coordinates of the stars of interest

|  |  |  |
| --- | --- | --- |
| Star # | x | y |
| 1 | 86.3143 | 19.8000 |
| 2 | 150.1887 | 13.5660 |
| 3 | 9.7843 | 114.3137 |
| 4 | 59.5000 | 93.5000 |
| 5 | 149.5294 | 101.4314 |

A close up of a number

Description automatically generatedThe next step is to convert these pixel coordinates to actual, physical coordinates in the body frame. This is done using the following equation:

where P is the physical coordinate, W is the width of the image, and FOV is the field of view of the camera (4 degrees in this case). These coordinates were then normalized to become unit vectors and are summarized below, where each row is the respective star #.

***Part B) Inertial Frame Unit Vectors***

The inertial frame unit vectors of these five stars are known and were hard-coded as follows: