Image 1
Centroid: (3171, 444), Diameter: 42
Angle: 74.2deg, Distance: 5.24m
Centroid: (3212, 396), Diameter: 47
Angle: 73.6deg, Distance: 4.68m
Centroid: (3026, 387), Diameter: 47
Angle: 76.2deg, Distance: 4.68m
Centroid: (646, 356), Diameter: 32
Angle: 108.7deg, Distance: 6.88m
Centroid: (995, 347), Diameter: 44
Angle: 104.0deg, Distance: 5.0m
Centroid: (700, 327), Diameter: 35
Angle: 108.0deg, Distance: 6.29m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	104	5	107	6.12
C1L2	108	6.29	115	6.41
C1L3	108.7	6.88	114	6.14
B1L1	74.2	5.24	68	5.92
B1L2	73.6	4.68	69	6.32
B1L3	76.2	4.68	74	6.01

Image 2
Centroid: (2867, 541), Diameter: 47
Angle: 78.4deg, Distance: 4.68m
Centroid: (3086, 516), Diameter: 69
Angle: 75.4deg, Distance: 3.19m
Centroid: (453, 483), Diameter: 37
Angle: 111.4deg, Distance: 5.95m
Centroid: (2879, 479), Diameter: 56
Angle: 78.2deg, Distance: 3.93m
Centroid: (514, 446), Diameter: 39
Angle: 110.5deg, Distance: 5.65m
Centroid: (823, 448), Diameter: 50
Angle: 106.3deg, Distance: 4.4m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	106.3	4.4	107	6.12
C1L2	110.5	5.65	115	6.41
C1L3	111.4	5.95	114	6.14
B2L1	78.4	4.68	73	4.77
B2L2	75.4	3.19	70	5.11
B2L3	78.2	3.93	72	5.26

Image 3
Centroid: (3167, 453), Diameter: 61
Angle: 74.3deg, Distance: 3.61m
Centroid: (3212, 401), Diameter: 53
Angle: 73.6deg, Distance: 4.15m
Centroid: (3025, 394), Diameter: 53
Angle: 76.2deg, Distance: 4.15m
Centroid: (647, 362), Diameter: 37
Angle: 108.7deg, Distance: 5.95m
Centroid: (994, 350), Diameter: 52
Angle: 104.0deg, Distance: 4.23m
Centroid: (698, 328), Diameter: 43
Angle: 108.0deg, Distance: 5.12m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	104.0	4.23	107	6.12
C1L2	108.0	5.12	115	6.41
C1L3	108.7	5.95	114	6.14
B1L1	74.3	3.61	68	5.92
B1L2	73.6	4.15	69	6.32
B1L3	76.2	4.15	74	6.01

Image 4
Centroid: (2866, 506), Diameter: 71
Angle: 78.4deg, Distance: 3.1m
Centroid: (3086, 475), Diameter: 81
Angle: 75.4deg, Distance: 2.72m

Centroid: (453, 439), Diameter: 47
Angle: 111.4deg, Distance: 4.68m
Centroid: (2877, 434), Diameter: 62
Angle: 78.2deg, Distance: 3.55m
Centroid: (509, 399), Diameter: 53
Angle: 110.6deg, Distance: 4.15m
Centroid: (821, 405), Diameter: 59
Angle: 106.3deg, Distance: 3.73m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	106.3	3.73	107	6.12
C1L2	110.6	4.15	115	6.41
C1L3	111.4	4.68	114	6.14
B2L1	78.4	3.10	73	4.77
B2L2	75.4	2.72	70	5.11
B2L3	78.2	3.55	72	5.26

Image 5
Centroid: (2781, 500), Diameter: 53
Angle: 79.5deg, Distance: 4.15m
Centroid: (2985, 476), Diameter: 67
Angle: 76.8deg, Distance: 3.29m
Centroid: (400, 446), Diameter: 34
Angle: 112.1deg, Distance: 6.48m
Centroid: (2781, 434), Diameter: 48
Angle: 79.5deg, Distance: 4.59m
Centroid: (455, 411), Diameter: 38
Angle: 111.3deg, Distance: 5.79m
Centroid: (765, 413), Diameter: 49
Angle: 107.1deg, Distance: 4.49m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	107.1	4.49	107	6.12
C1L2	111.3	5.79	115	6.41
C1L3	112.1	6.48	114	6.14
B2L1	79.5	4.15	73	4.77
B2L2	76.8	3.29	70	5.11

B2L3	79.5	4.59	72	5.26

Image 6

Centroid: (2435, 82), Diameter: 43
Angle: 84.3deg, Distance: 5.12m
Centroid: (2514, 87), Diameter: 40
Angle: 83.2deg, Distance: 5.5m
Centroid: (1100, 385), Diameter: 37
Angle: 102.5deg, Distance: 5.95m
Centroid: (988, 417), Diameter: 29
Angle: 104.1deg, Distance: 7.59m
Centroid: (2767, 418), Diameter: 48
Angle: 79.7deg, Distance: 4.59m
Centroid: (1310, 442), Diameter: 65
Angle: 99.7deg, Distance: 3.39m
Centroid: (2970, 459), Diameter: 66
Angle: 77.0deg, Distance: 3.34m
Centroid: (2769, 485), Diameter: 53
Angle: 79.7deg, Distance: 4.15m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	99.7	3.39	107	6.12
C1L2	102.5	5.95	115	6.41
C1L3	104.1	7.59	114	6.14
B2L1	79.7	4.15	73	4.77
B2L2	77.0	3.34	70	5.11
B2L3	79.7	4.59	72	5.26
A1L1	83.2	5.5	80	8.62
A1L2	-	-	79	8.89
A1L3	84.8	5.12	81	8.70

Image 7

Centroid: (2409, 115), Diameter: 44
Angle: 84.6deg, Distance: 5.0m
Centroid: (2489, 122), Diameter: 44
Angle: 83.5deg, Distance: 5.0m
Centroid: (1064, 407), Diameter: 39
Angle: 103.0deg, Distance: 5.65m

Centroid: (953, 441), Diameter: 35
Angle: 104.5deg, Distance: 6.29m
Centroid: (1280, 464), Diameter: 72
Angle: 100.1deg, Distance: 3.06m
Centroid: (2486, 573), Diameter: 62
Angle: 83.6deg, Distance: 3.55m
Centroid: (2712, 627), Diameter: 89
Angle: 80.5deg, Distance: 2.47m
Centroid: (2454, 666), Diameter: 87
Angle: 84.0deg, Distance: 2.53m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	100.1	3.06	107	6.12
C1L2	103.0	5.65	115	6.41
C1L3	104.5	6.29	114	6.14
B3L1	84.0	2.53	79	4.33
B3L2	80.5	2.47	74	4.43
B3L3	83.6	3.55	79	4.29
A1L1	83.5	5	80	8.62
A1L2	-	-	79	8.89
A1L3	84.6	5	81	8.70

Image 8
Centroid: (2436, 184), Diameter: 57
Angle: 84.3deg, Distance: 3.86m
Centroid: (2520, 191), Diameter: 54
Angle: 83.1deg, Distance: 4.08m
Centroid: (1163, 447), Diameter: 43
Angle: 101.7deg, Distance: 5.12m
Centroid: (1054, 485), Diameter: 34
Angle: 103.2deg, Distance: 6.48m
Centroid: (1376, 505), Diameter: 73
Angle: 98.7deg, Distance: 3.02m
Centroid: (1401, 550), Diameter: 33
Angle: 98.4deg, Distance: 6.67m
Centroid: (2565, 609), Diameter: 61
Angle: 82.5deg, Distance: 3.61m
Centroid: (2789, 662), Diameter: 88
Angle: 79.4deg, Distance: 2.5m

Centroid: (2532, 702), Diameter: 87
Angle: 82.9deg, Distance: 2.53m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C1L1	98.4	6.67	107	6.12
C1L2	101.7	5.12	115	6.41
C1L3	103.2	6.48	114	6.14
B3L1	79.4	2.50	79	4.33
B3L2	82.5	3.61	74	4.43
B3L3	82.9	2.53	79	4.29
A2L1	83.1	4.08	81	8.08
A2L2	-	-	79	8.29
A2L3	84.3	3.86	82	8.71

Image 9
Centroid: (2358, 149), Diameter: 59
Angle: 85.3deg, Distance: 3.73m
Centroid: (2444, 157), Diameter: 54
Angle: 84.1deg, Distance: 4.08m
Centroid: (1677, 513), Diameter: 50
Angle: 94.6deg, Distance: 4.4m
Centroid: (1497, 518), Diameter: 34
Angle: 97.1deg, Distance: 6.48m
Centroid: (2484, 587), Diameter: 65
Angle: 83.6deg, Distance: 3.39m
Centroid: (1673, 644), Diameter: 106
Angle: 94.7deg, Distance: 2.08m
Centroid: (2708, 643), Diameter: 91
Angle: 80.5deg, Distance: 2.42m
Centroid: (2448, 680), Diameter: 88
Angle: 84.1deg, Distance: 2.5m
Centroid: (1678, 700), Diameter: 38
Angle: 94.6deg, Distance: 5.79m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
C2L1	94.6	5.79	98	5.46

C2L2	94.6	4.4	97	6.20
C2L3	97.1	6.48	99	5.88
B3L1	80.5	2.42	79	4.33
B3L2	83.6	3.39	74	4.43
B3L3	84.1	2.5	79	4.29
A2L1	84.1	4.08	81	8.08
A2L2	-	-	79	8.29
A2L3	85.3	3.73	82	8.71

Image 10

Centroid: (2301, 292), Diameter: 71
Angle: 86.1deg, Distance: 3.1m
Centroid: (2396, 301), Diameter: 51
Angle: 84.8deg, Distance: 4.32m
Centroid: (1778, 621), Diameter: 51
Angle: 93.3deg, Distance: 4.32m
Centroid: (1598, 631), Diameter: 38
Angle: 95.7deg, Distance: 5.79m
Centroid: (2590, 682), Diameter: 66
Angle: 82.2deg, Distance: 3.34m
Centroid: (2819, 733), Diameter: 94
Angle: 79.0deg, Distance: 2.34m
Centroid: (1775, 752), Diameter: 107
Angle: 93.3deg, Distance: 2.06m
Centroid: (2556, 776), Diameter: 90
Angle: 82.6deg, Distance: 2.45m
Centroid: (1783, 811), Diameter: 42
Angle: 93.2deg, Distance: 5.24m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
A3 L1	84.8	4.32	84	7.33
A3 L2	86.1	3.1	83	7.62
A3 L3	-	-	83	8.16
B3 L1	-	-	79	4.33
B3 L2	82.2	3.34	74	4.43

B3 L3	82.6	2.45	79	4.29
C3 L1	93.2	5.24	91	4.53
C3 L2	93.3	4.32	89	4.88
C3 L3	95.7	5.79	91	4.92

Image 11
Centroid: (2282, 204), Diameter: 78
Angle: 86.4deg, Distance: 2.82m
Centroid: (2378, 210), Diameter: 53
Angle: 85.1deg, Distance: 4.15m
Centroid: (1752, 531), Diameter: 58
Angle: 93.6deg, Distance: 3.8m
Centroid: (1573, 537), Diameter: 40
Angle: 96.1deg, Distance: 5.5m
Centroid: (1749, 660), Diameter: 112
Angle: 93.7deg, Distance: 1.97m
Centroid: (1760, 723), Diameter: 44
Angle: 93.5deg, Distance: 5.0m
Centroid: (2400, 782), Diameter: 86
Angle: 84.8deg, Distance: 2.56m
Centroid: (2698, 796), Diameter: 102
Angle: 80.7deg, Distance: 2.16m
Centroid: (2536, 914), Diameter: 108
Angle: 82.9deg, Distance: 2.04m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
A3 L1	85.1	4.15	84	7.33
A3 L2	-	-	83	7.62
A3 L3	86.4	2.82	83	8.16
B4 L1	82.9	2.04	79	3.46
B4 L2	-	-	76	3.77
B4 L3	84.8	2.56	83	3.73
C3 L1	93.5	5	91	4.53

C3 L2	93.6	3.8	89	4.88
C3 L3	96.1	5.5	91	4.92

Image 12
Centroid: (1939, 207), Diameter: 39
Angle: 91.1deg, Distance: 5.65m
Centroid: (2046, 215), Diameter: 68
Angle: 89.6deg, Distance: 3.24m
Centroid: (1779, 506), Diameter: 52
Angle: 93.2deg, Distance: 4.23m
Centroid: (1612, 517), Diameter: 45
Angle: 95.5deg, Distance: 4.89m
Centroid: (1781, 645), Diameter: 128
Angle: 93.2deg, Distance: 1.72m
Centroid: (1789, 690), Diameter: 105
Angle: 93.1deg, Distance: 2.1m
Centroid: (2410, 752), Diameter: 89
Angle: 84.6deg, Distance: 2.47m
Centroid: (2687, 773), Diameter: 104
Angle: 80.8deg, Distance: 2.12m
Centroid: (2531, 879), Diameter: 116
Angle: 83.0deg, Distance: 1.9m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
A4 L1	89.6	3.24	90	7.41
A4 L2	-	-	88.5	7.16
A4 L3	91.1	5.65	88	7.51
B4 L1	-	-	79	3.46
B4 L2	83	1.9	76	3.77
B4 L3	84.6	2.47	83	3.73
C3 L1	93.1	2.1	91	4.53
C3 L2	93.2	4.23	89	4.88
C3 L3	95.5	4.89	91	4.92

Image 13

Centroid: (1974, 185), Diameter: 29
Angle: 90.6deg, Distance: 7.59m
Centroid: (2073, 193), Diameter: 59
Angle: 89.2deg, Distance: 3.73m
Centroid: (2435, 735), Diameter: 70
Angle: 84.3deg, Distance: 3.15m
Centroid: (2726, 752), Diameter: 79
Angle: 80.3deg, Distance: 2.79m
Centroid: (1667, 760), Diameter: 30
Angle: 94.8deg, Distance: 7.34m
Centroid: (1894, 778), Diameter: 57
Angle: 91.7deg, Distance: 3.86m
Centroid: (2576, 867), Diameter: 92
Angle: 82.3deg, Distance: 2.39m
Centroid: (1727, 991), Diameter: 141
Angle: 94.0deg, Distance: 1.56m
Centroid: (1658, 1000), Diameter: 33
Angle: 94.9deg, Distance: 6.67m

ShipA/B/C Laser1/2/3	Algo Angle	Algo distance	Actual angle	Actual distance
A_ L1	89.2	3.73	80	8.62
A_ L2	-	-	79	8.89
A_ L3	90.6	7.59	81	8.70
B4 L1	82.3	2.39	68	5.92
B4 L2	-	-	69	6.32
B4 L3	84.3	3.15	74	6.01
C4 L1	91.7	3.86	107	6.12
C4 L2	94.8	7.34	115	6.41
C4 L3	94.0	1.56	114	6.14

Classification Accuracy

Image	Error
1	None
2	None
3	Partial
4	None
5	None
6	Partial
7	Partial
8	Partial
9	All
10	None
11	All
12	None
13	All

Image Processing:

```
import cv2
import math
import numpy as np

def detect_bright_regions(image_path, threshold=200):
    # Read the image
    image = cv2.imread(image_path)

    # Convert the image to grayscale
    gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)

    # Apply a threshold to identify bright regions
    _, binary_image = cv2.threshold(gray,8, 255, cv2.THRESH_BINARY)

    # Find contours in the binary image
```

```
    contours, _ = cv2.findContours(binary_image, cv2.RETR_EXTERNAL,
cv2.CHAIN_APPROX_SIMPLE)
    centroids = [(contour, np.mean(contour, axis=0)[0]) for contour in contours]

    # Sort contours based on their centroids
    sorted_centroids = sorted(centroids, key=lambda x: (x[1][1], x[1][0]))

    # Extract sorted contours from the sorted_centroids list
    contours = [item[0] for item in sorted_centroids]
    for contour in contours:
        # Approximate a polygon around the contour
        epsilon = 0.04 * cv2.arcLength(contour, True)
        approx_polygon = cv2.approxPolyDP(contour, epsilon, True)


        # Get the bounding circle of the contour
        (x, y), radius = cv2.minEnclosingCircle(contour)


        # Calculate the centroid of the circle
        centroid = (int(x), int(y))

        # Calculate the diameter of the circle
        diameter = int(2 * radius)

        # Print the centroid and diameter

        angle= centroid[0]*55.12/4032
        if diameter>18:
            print(f"Centroid: {centroid}, Diameter: {diameter}")
            distance= (4032*0.057/(2*diameter*math.tan(math.radians(27.56))))
            print(f'Angle: {round(180-(angle+62.44),1)}deg, Distance: {round(distance,2)}m')


    # Draw the contours on the original image
    result_image = image.copy()
    cv2.drawContours(result_image, contours, -1, (0, 255, 0), 2)

    # Display the result
    cv2.imshow("Result", result_image)
    cv2.waitKey(0)
    cv2.destroyAllWindows()

# Example usage
```

```
image_path = "test.jpg"
detect_bright_regions(image_path)
```