TESTING DOCUMENT

Project: Final DPM Project
Document Version: 1.0
Date: 20/10/2018
Author: Ashish
Edit history:
[18/10/2018] Ashish: Created Testing Document
[22/10/2018] Ashish: Completed some tests
[28/10/2018] Ashish: Added more tests
[30/10/2018] Ashish: Added results from previous tests and made changes to the structure of the document

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1.0 Requirements

1.1 Project requirements

see Requirements document

1.2 Testing Requirements

- Each test should note: date, testers, author, hardware version, software version, goal, procedure, expected result, test report, conclusion, action and distribution.
- Each test should have at least 10 trials.
- Weak points should be tested exhaustively
- Testers should have a clear expected outcome for each test.

1.3 General Test Procedures

- Test whether the hardware design is stable when moving and turning.
- Test whether the robot can light localize accurately
- Test whether the robot can ultrasonic localize accurately
- Test whether the robot can correctly detect the color of the ring.
- Test whether the robot can correctly turn to any direction
- Test whether the robot can correctly travel to any coordinate after localization

2.0 Testing Plan

2.1 Hardware

- Hardware stability (Incomplete)
    - The center of gravity needs to be center of the robot so that the robot has equal weight distribution and does not lean on one side, affecting navigation.
- Large EV3 motor performance (Incomplete)
    - The motors need to be accurate when moving around the field at different speeds. The motors that are selected need to be of similar performance to make sure the robot navigates properly.
- Ultrasonic sensor (Incomplete)
    - The ultrasonic sensor must be accurate to ensure the requirements of ultrasonic localization and obstacle avoidance are met

- Light sensor (Incomplete)

    - The light sensor must be accurate to ensure the requirements of light localization and ring color detection are met.

2.2 Software

- Navigation (Incomplete)
    - The navigation algorithm must accurately move the robot to any given co-ordinate on the field. The accuracy should be such that when the robot re-localizes, it should be at the correct co-ordinate
- Ultrasonic localization (completed)
    - The ultrasonic localization algorithm must have an accuracy of 10 degrees.
- Light localization (completed)
    - The light localization algorithm must have an accuracy of less than 2cm and an angle of less than 5 degrees
- Ring Color detection (Incomplete)
    - The color detection algorithm must accurately determine the color of the ring up to 5cm away from the light sensor.

3.0 Tests

Test 1: Ultrasonic localization (Falling edge)
Date: 20/10/18

Tester: Ashish

Author: Ashish

Hardware Version: 1.0

Software Version: N/A

Goal: Determine if the robot can localize properly using the ultrasonic sensor and 2 EV3 motors.

Procedure: Place the robot facing away from the wall on the left corner tile. Run ultrasonic localization and record the angle.

Expected result: The robot should turn clockwise and detect the wall when it is within 30cm and record it. Then the robot turns anticlockwise till it detects the wall again and record it. The robot will then compute 0 degrees and turn to it.

Test Report: the test was performed 10 times and the results are shown in the table below.

Run	US Angle(degrees)
1	6
2	-2
3	3
4	0
5	-5
6	4
7	-1
8	2
9	4
10	0
Mean:	1(deg)
Standard Deviation:	3(deg)

Conclusion: The robot always localized within 6 degrees which is within the acceptable margin of error. It should be noted that this test was done when the battery was outputting at 8.0V and accurate localization is not guaranteed for anything less than 8.0V.

Action: No further testing is required unless the hardware configuration is changed.

Distribution: Software Development, Project management

Test 2: Light localization (2 light sensors)
Date: 20/10/18

Tester: Ashish

Author: Ashish

Hardware Version: 1.0

Software Version: N/A

Goal: Determine if the robot can localize properly using the light sensor, ultrasonic sensor and 2 EV3 motors.

Procedure: Place the robot facing away from the wall on the left corner tile. Run the ultrasonic localization and record the angle. After ultrasonic localization finishes run the light localization and record angle and the distance.

Expected result: The values Zero.

Test Report: the test was performed 10 times and the results are shown in the table below

Run	US Angle(degrees)	Euclidean error(cm)	Final Angle(degrees)
1	6	0.1	2
2	-2	1.3	-3
3	3	0.4	4
4	0	0.6	1
5	-5	1.5	-2
6	4	1.1	6
7	-1	0.1	-4
8	2	1.9	5
9	4	0.3	3
10	0	1	2
Mean:	1(deg)	0.8(cm)	1(deg)
Standard Deviation:	3(deg)	0.6(cm)	3(deg)

Conclusion: The robot always localized within 5 degrees and 2cm from (0,0) which is within the acceptable margin of error. It should be noted that this test was done when the battery was outputting at 8.0V and accurate localization is not guaranteed for anything less than 8.0V.

Action: No further testing is required unless the hardware configuration is changed.

Distribution: Software Development, Project management

Test 3: Ring color detection
Date: 22/10/18

Tester: Ashish

Author: Ashish

Hardware Version: N/A

Software Version: N/A

Goal: To record the RGB values of each ring.

Procedure: Place the light sensor 2 cm away from the ring. Press any button on the robot and record the RGB values that are printed on the console. Collect 18 samples of RGB values . Repeat same procedure for the other 3 rings.

Expected result: The RGB values should give a gaussian distribution.

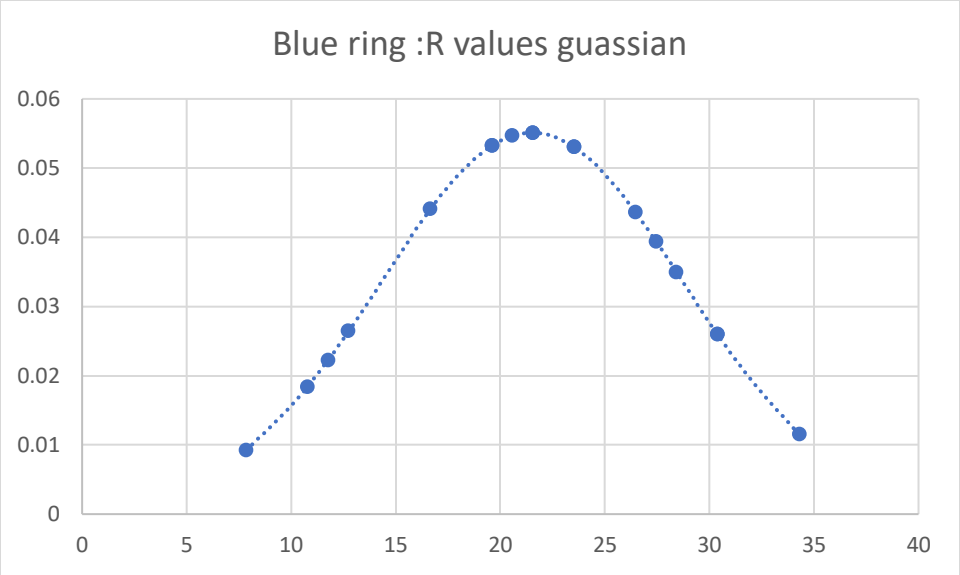
Test Report: The test was performed 18 times for each of the 4 rings. The mean and standard deviation was calculated using the following formulas:

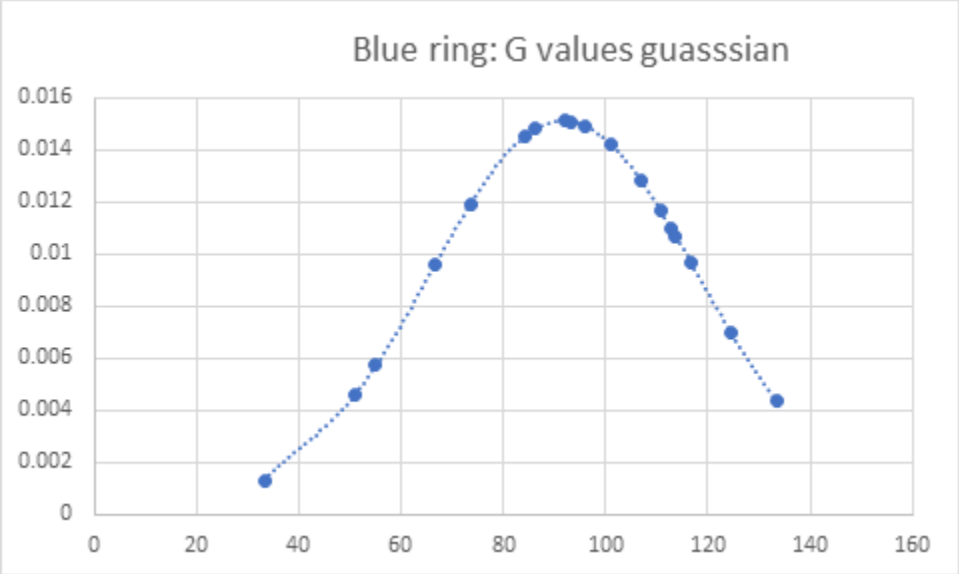
$$mean = \frac{\sum_{i=0}^{n} Si}{n} \qquad stddev = \sqrt{\sum_{i=0}^{n} \frac{(Si - mean)^2}{n-1}}$$

The tables and graphs below show the results:

For the blue ring:

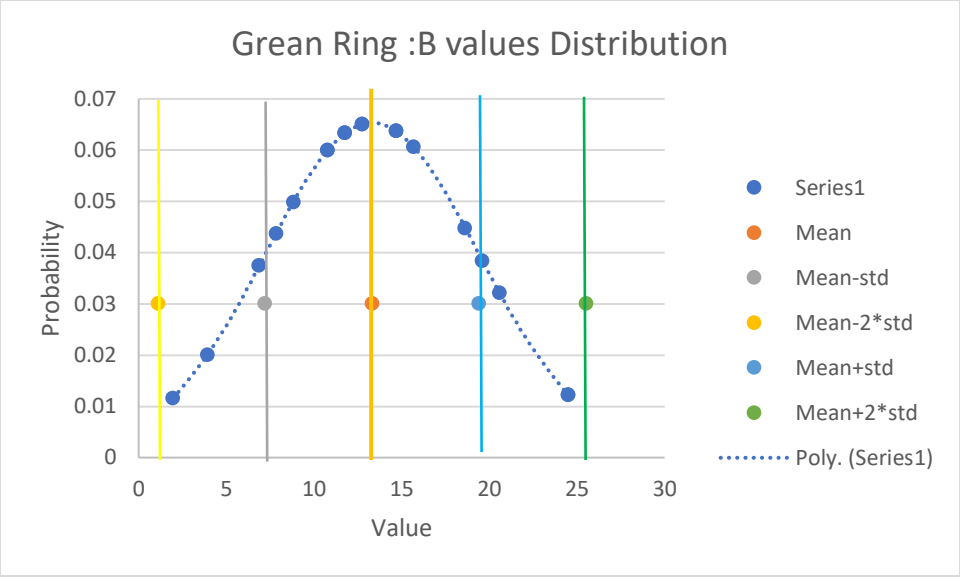
	R	G	B
1	11.76471	54.90196	53.92157
2	21.56863	92.15687	61.76471
3	7.843138	33.33334	29.41176
4	16.66667	73.52941	62.7451
5	19.60784	84.31373	54.90196
6	23.52941	106.8628	93.13726
7	27.45098	112.7451	95.09804
8	26.47059	113.7255	85.29412
9	12.7451	66.66667	50
10	21.56863	96.07843	72.54903
11	10.78431	50.98039	39.21569
12	28.43137	110.7843	100.9804
13	30.39216	124.5098	112.7451
14	34.31373	133.3333	112.7451
15	30.39216	116.6667	103.9216
16	23.52941	100.9804	90.19608
17	19.60784	86.27451	72.54903
18	20.58824	93.13726	74.5098
Mean	21.51416	91.72113	75.87146
Std.dev	7.237454	26.37606	26.37606

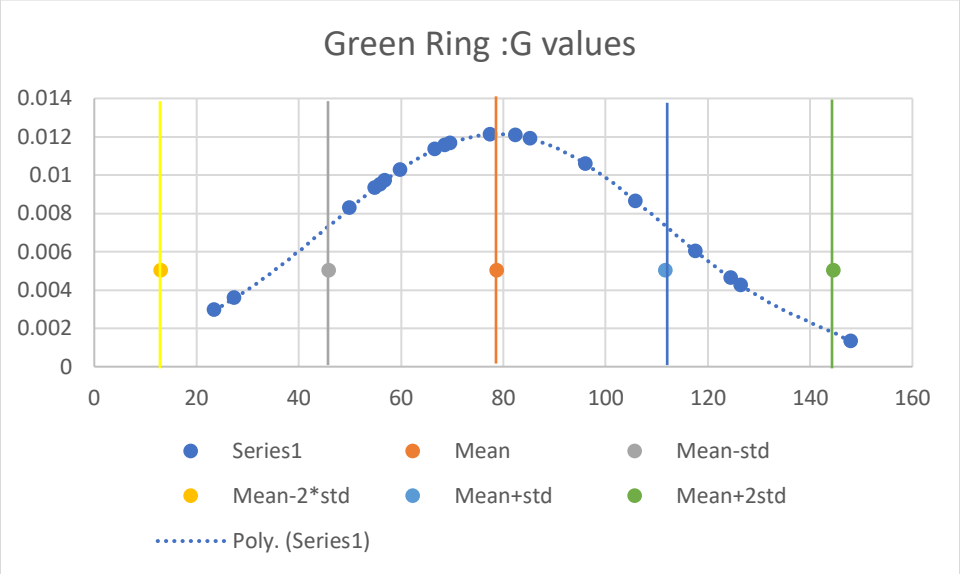

Blue ring :R values guassian
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
35
40

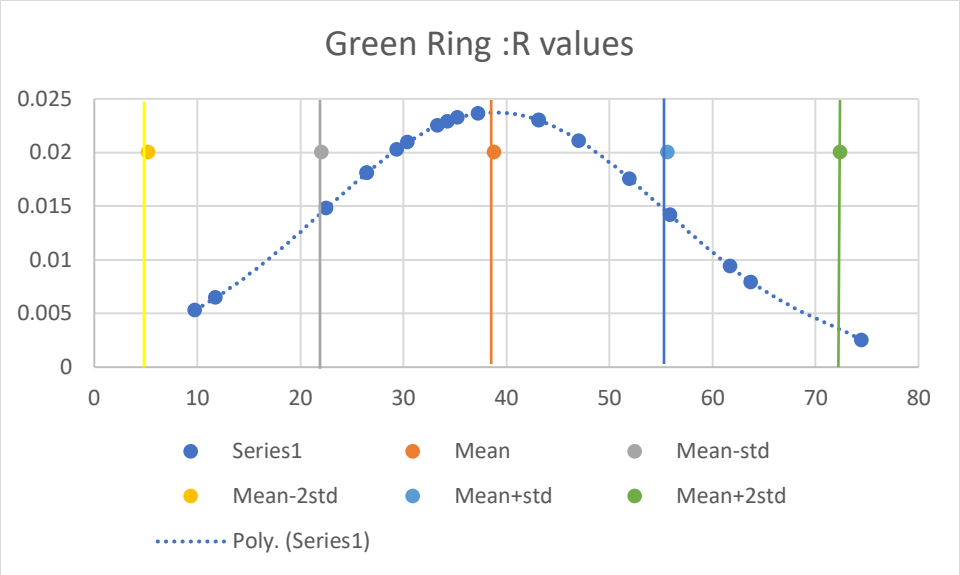

Blue ring: G values guasssian
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
20
40
60
80
100
120
140
160

For the green ring :

	R	G	B
1	43.13726	82.35294	14.70588
2	35.29412	66.66667	12.7451
3	61.76471	124.5098	18.62745
4	63.72549	126.4706	24.5098
5	43.13726	85.29412	14.70588
6	11.76471	27.45098	3.921569
7	26.47059	55.88236	6.862745
8	51.96079	105.8824	20.58824
9	33.33334	68.62746	11.76471
10	29.41176	56.86275	10.78431
11	55.88236	117.6471	19.60784
12	22.54902	50	7.843138
13	34.31373	69.60785	11.76471
14	30.39216	59.80392	10.78431
15	47.05882	96.07843	15.68628
16	37.2549	77.45098	12.7451
17	74.5098	148.0392	24.5098
18	26.47059	54.90196	8.82353
19	9.803922	23.52941	1.960784
Mean	38.85449	78.79257	13.31269
Std.Dev	16.79279	32.88598	6.104473

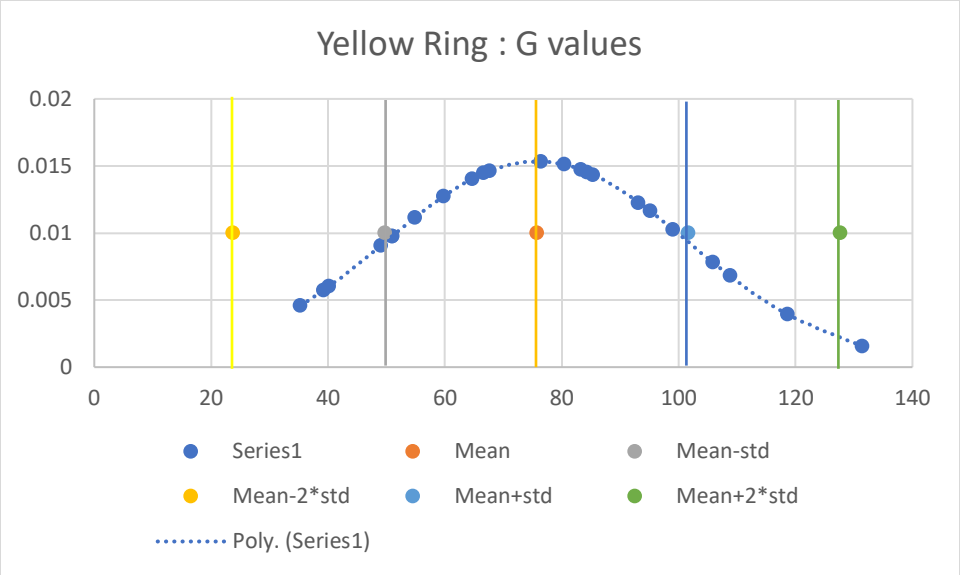

Grean Ring :B values Distribution
Probability
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
5
10
15
20
25
30
Value
Series1
Mean
Mean-std
Mean-2*std
Mean+std
Mean+2*std
Poly. (Series1)

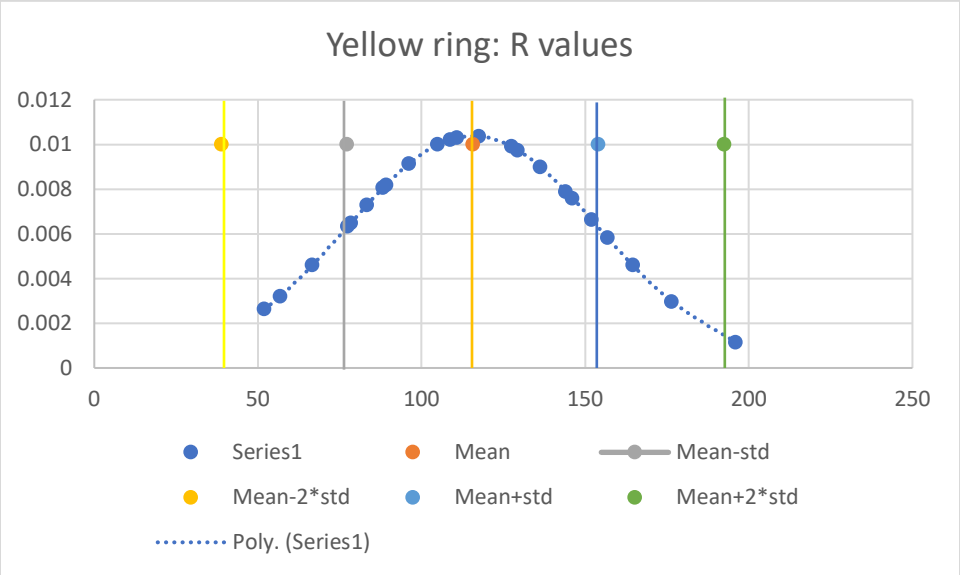

Green Ring :G values
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
20
40
60
80
100
120
140
160
Series1
Mean
Mean-std
Mean-2*std
Mean+std
Mean+2std
Poly. (Series1)

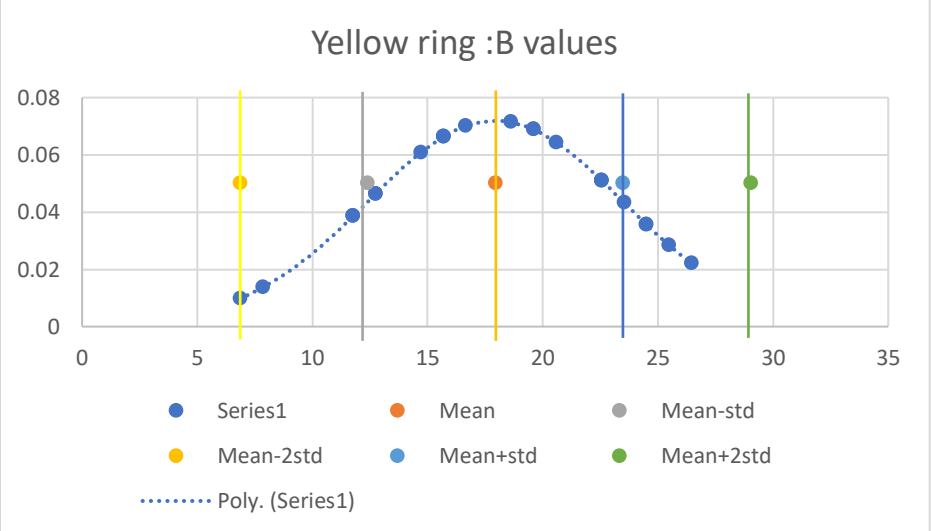


For the yellow ring:

	R	G	B
1	117.6471	80.39216	18.62745
2	127.451	83.33334	20.58824
3	88.2353	59.80392	12.7451
4	56.86275	39.21569	7.843138
5	51.96079	35.29412	6.862745
6	104.902	66.66667	16.66667
7	108.8235	67.64706	19.60784
8	96.07843	64.70589	14.70588
9	110.7843	76.47059	15.68628
10	156.8628	105.8824	22.54902
11	146.0784	93.13726	24.5098
12	66.66667	40.19608	12.7451
13	77.45098	50.98039	11.76471
14	78.43137	49.01961	11.76471
15	83.33334	50.98039	15.68628
16	89.21569	54.90196	15.68628
17	129.4118	84.31373	19.60784
18	176.4706	118.6275	25.4902
Mean	115.6437	75.70333	17.94544
Std.Dev	38.39451	25.98696	5.541675

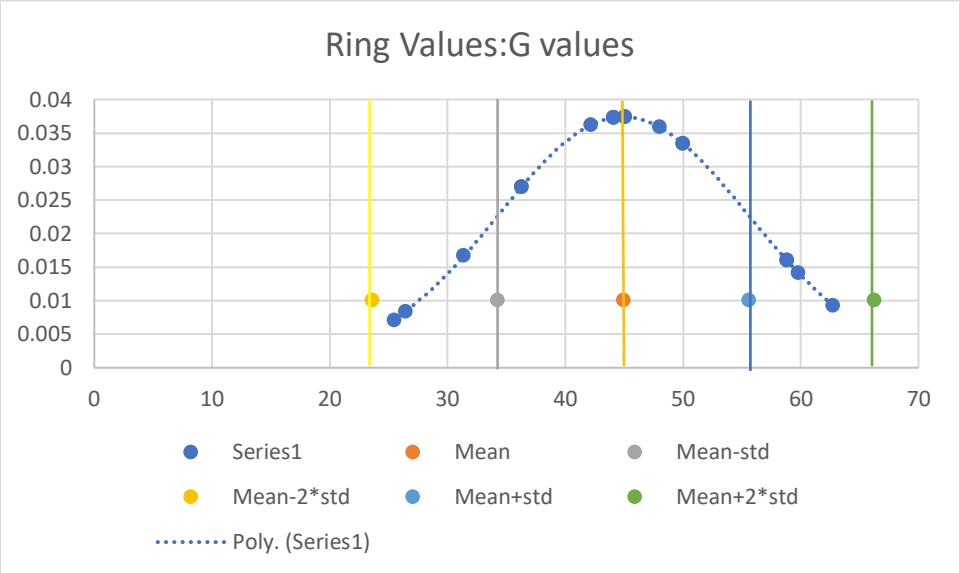

Yellow Ring : G values
0.02
0.015
0.01
0.005
0
0
20
40
60
80
100
120
140
Series1
Mean
Mean-std
Mean-2*std
Mean+std
Mean+2*std
Poly. (Series1)

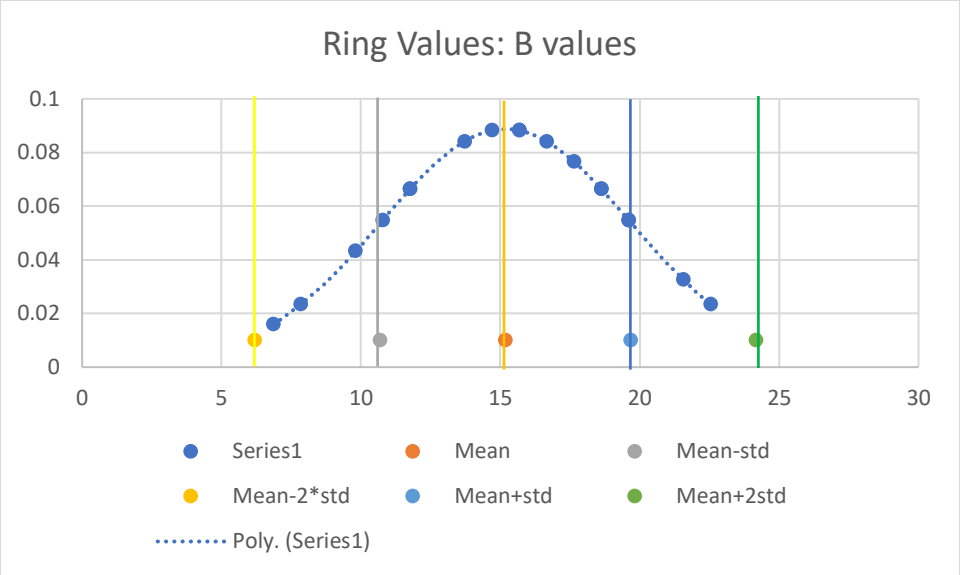

Yellow ring: R values
0.012
0.01
0.008
0.006
0.004
0.002
0
0
50
100
150
200
250
Series1
Mean
Mean-std
Mean-2*std
Mean+std
Mean+2*std
Poly. (Series1)

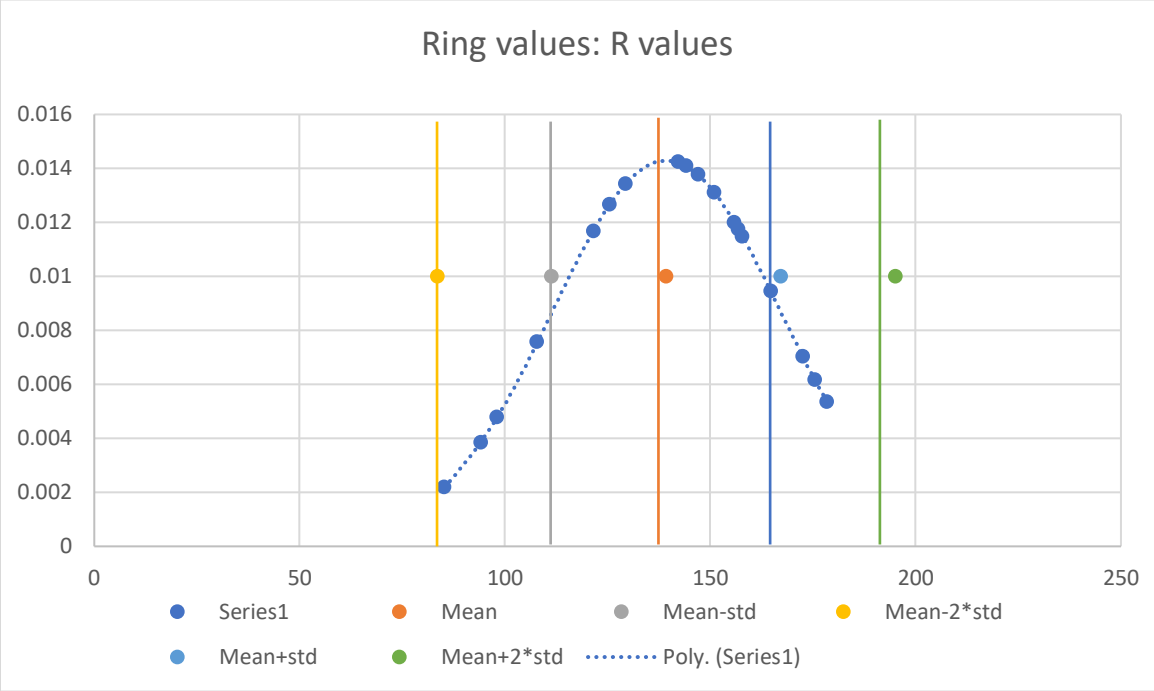

Yellow ring :B values
0.08
0.06
0.04
0.02
0
0
5
10
15
20
25
30
35
Series1
Mean
Mean-std
Mean-2std
Mean+std
Mean+2std
Poly. (Series1)

For the orange ring:

	R	G	B
1	178.4314	59.80392	18.62745
2	142.1569	45.09804	16.66667
3	155.8824	50	15.68628
4	164.7059	58.82353	19.60784
5	98.03922	31.37255	7.843138
6	121.5686	42.15686	11.76471
7	107.8431	36.27451	9.803922
8	85.29412	25.4902	6.862745
9	147.0588	50	13.72549
10	157.8431	45.09804	21.56863
11	94.11765	26.47059	11.76471
12	144.1177	44.11765	14.70588
13	156.8628	44.11765	17.64706
14	175.4902	58.82353	22.54902
15	125.4902	36.27451	15.68628
16	172.549	62.7451	19.60784
17	129.4118	44.11765	10.78431
18	150.9804	48.03922	18.62745
Mean	139.3246	44.93464	15.19608
Std.Dev	27.88884	10.66607	4.495692







Conclusion: The test results shows that we can use the RGB values to detect the color of the ring accurately.

Action: The test report will be sent to the software team to make an accurate ring detection algorithm using the results.

Distribution: Software Development, Project management