INF250: Mandatory Exercise02

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Solution starts here

Step01: cropping the extra part of the image

Select necessary part of the image → Goto Image in imageJ → Select crop

Figure-01: Cropped image

Step02: Converting the image to a 8-bit image

Goto Image in imageJ → Type → 8-bit

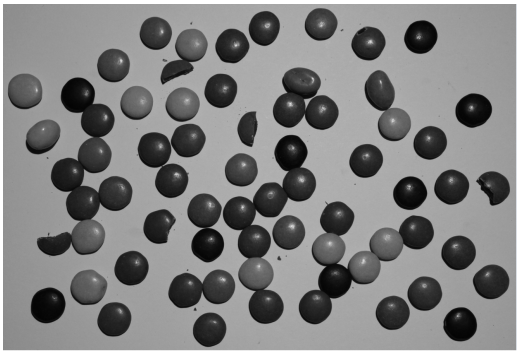


Figure-02: 8-bit image

Step03: Trying out all binarising methods

Goto image → Adjust → Auto Threshold → try all

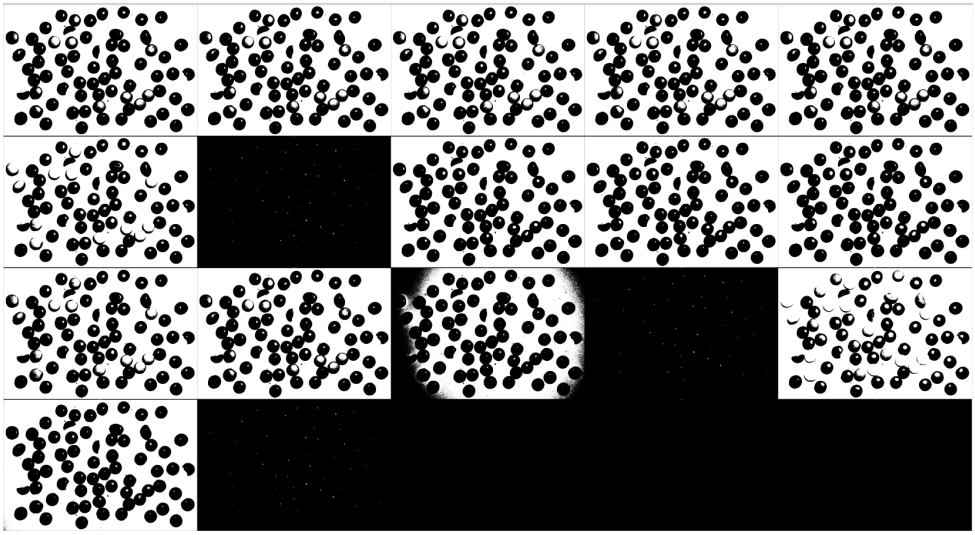


Figure-03: Trying all thresholding methods

Step04: Choosing the best threshold method for binarising the image:

From the figure-4, we can see that **Triangle** does the best job at binarising with minium holes. For this reason, I have chosen triangle threshold method.

Goto image → Adjust → Auto Threshold → Triangle

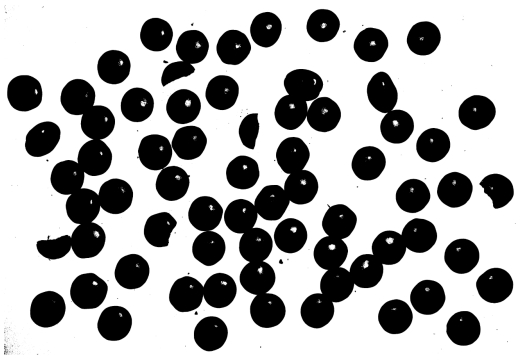


Figure-04: Binarising with Triangle thresholding

Step05: Inverting the binary image

Because usually we want the objects to be white and the background to be black.

Goto Edit → Invert

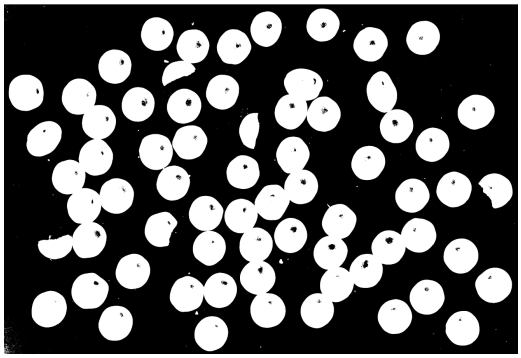


Figure-05: Inverted Binary image

Step06: Filling the holes after binarisation of image

Goto Process → Binary → Fill holes

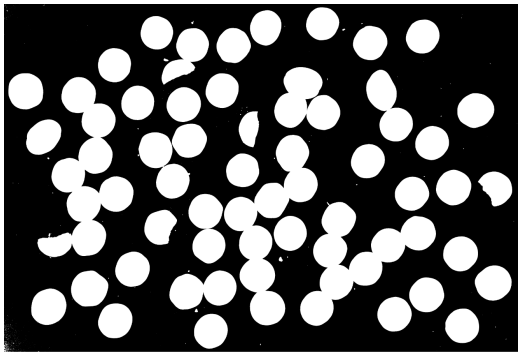


Figure-06: Filling the holes after binarisation

Step07: For analyzing setting the objects descriptors

Goto Analyze → Set Measurements → Select the Area, Center of mass, Shape descriptors, Display label → Change the decimal places from 2 to 5.</br> Since it is a binary image the max value will always be 255 and minimum value will be 0.

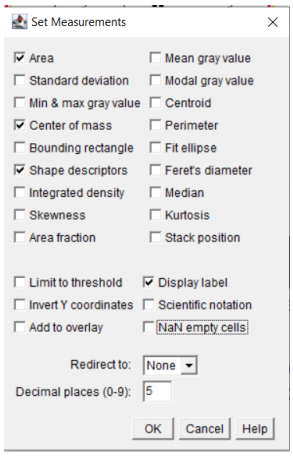


Figure-07: Set measurements

Step08: Identifying all objects present in the image

Goto Analyze → Analyze Particles → Ok (without making any changes)</br>

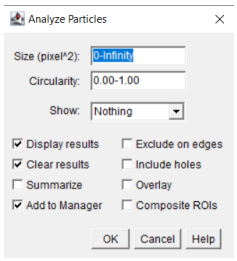


Figure-08:Analyze particles with default setting

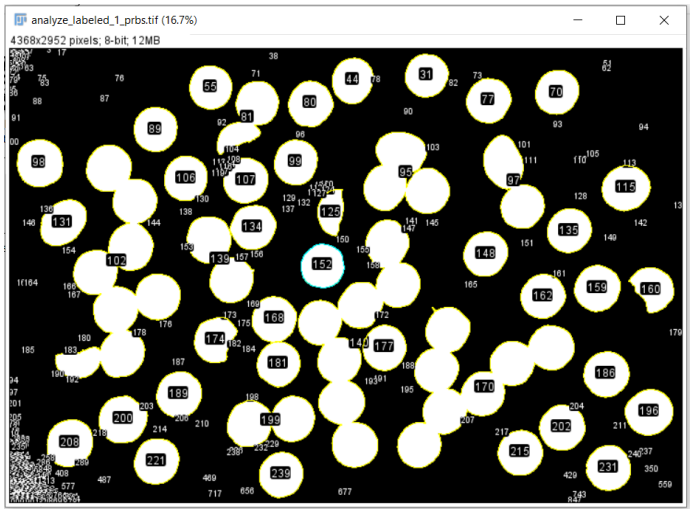


Figure-09: Object identification & analyze (1)

Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
871	ans_filledt.tif	5	81.50000	2946.30000	0.38785	2.32359	0.43037	0.47619
872	ans_filledt.tif	1	122.50000	2945.50000	1.00000	1.00000	1.00000	1.00000
873	ans_filledt.tif	4	136.25000	2946.25000	0.85737	2.00000	0.50000	0.80000
874	ans_filledt.tif	1	143.50000	2945.50000	1.00000	1.00000	1.00000	1.00000
875	ans_filledt.tif	1	147.50000	2945.50000	1.00000	1.00000	1.00000	1.00000
876	ans_filledt.tif	1	139.50000	2946.50000	1.00000	1.00000	1.00000	1.00000
877	ans_filledt.tif	7	184.78571	2948.07143	0.80011	1.66783	0.59958	0.77778
878	ans_filledt.tif	1	394.50000	2946.50000	1.00000	1.00000	1.00000	1.00000
879	ans_filledt.tif	3	12.50000	2948.50000	0.80852	3.00000	0.33333	1.00000
880	ans_filledt.tif	2	52.00000	2947.50000	1.00000	2.00000	0.50000	1.00000
881	ans_filledt.tif	2	108.00000	2948.00000	0.78540	2.64575	0.37796	0.66667
882	ans_filledt.tif	2	114.50000	2948.00000	1.00000	2.00000	0.50000	1.00000
883	ans_filledt.tif	1	141.50000	2947.50000	1.00000	1.00000	1.00000	1.00000
884	ans_filledt.tif	1	171.50000	2947.50000	1.00000	1.00000	1.00000	1.00000
885	ans_filledt.tif	16	50.93750	2950.43750	0.43269	2.44854	0.40841	0.61538
886	ans_filledt.tif	1	70.50000	2948.50000	1.00000	1.00000	1.00000	1.00000
887	ans_filledt.tif	1	168.50000	2948.50000	1.00000	1.00000	1.00000	1.00000
888	ans_filledt.tif	2	105.00000	2950.00000	0.78540	2.64575	0.37796	0.66667
889	ans_filledt.tif	4	139.00000	2950.00000	1.00000	1.00000	1.00000	1.00000
890	ans_filledt.tif	1	152.50000	2949.50000	1.00000	1.00000	1.00000	1.00000
891	ans_filledt.tif	1	157.50000	2949.50000	1.00000	1.00000	1.00000	1.00000
892	ans_filledt.tif	2	193.50000	2950.00000	1.00000	2.00000	0.50000	1.00000
893	ans_filledt.tif	1	42.50000	2950.50000	1.00000	1.00000	1.00000	1.00000
894	ans_filledt.tif	4	63.50000	2951.25000	1.00000	1.46760	0.68139	0.80000
895	ans_filledt.tif	1	68.50000	2950.50000	1.00000	1.00000	1.00000	1.00000
896	ans_filledt.tif	3	79.16667	2950.83333	1.00000	1.46365	0.68313	0.85714
897	ans_filledt.tif	2	141.50000	2951.00000	1.00000	2.00000	0.50000	1.00000
898	ans_filledt.tif	1	172.50000	2950.50000	1.00000	1.00000	1.00000	1.00000
899	ans_filledt.tif	1	18.50000	2951.50000	1.00000	1.00000	1.00000	1.00000
900	ans_filledt.tif	3	23.50000	2951.50000	0.96737	3.00000	0.33333	1.00000
901	ans_filledt.tif	1	145.50000	2951.50000	1.00000	1.00000	1.00000	1.00000

Figure-10: Object identification & analyze (2)

From figure-09 and figur-10, we can see that 901 objects have been identified. But visibly, we can see that we do not have that many objects present in the image. So for ignoring the noises present in the image, we need to change the starting size of the particles from 0 to 1000.

Step09: Identifying all objects present in the image ignoring the noises

Goto Analyze → Analyze particles → Change starting value of the size from 0 to 1000 → Ok

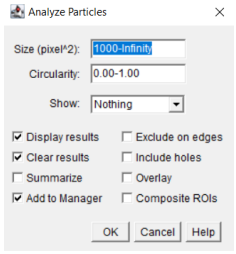


Figure-11:Analyze particles with custom size setting

Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
14	ans_filledt.tif	64048	1142.93277	842.93289	0.89088	1.05470	0.94814	0.99238
15	ans_filledt.tif	66654	1532.86826	857.70926	0.89426	1.03933	0.96216	0.99249
16	ans_filledt.tif	70797	4005.62153	906.38960	0.88571	1.09934	0.90963	0.99203
17	ans_filledt.tif	38316	2088.11721	1060.12371	0.70009	1.83890	0.54380	0.96922
18	ans_filledt.tif	67203	344.94574	1131.53460	0.85475	1.34649	0.74267	0.99070
19	ans_filledt.tif	66033	1581.16542	1161.36354	0.88423	1.05564	0.94729	0.99275
20	ans_filledt.tif	64049	3636.97784	1182.34107	0.89420	1.06606	0.93803	0.99238
21	ans_filledt.tif	134681	1365.25503	1369.42721	0.43802	2.30586	0.43368	0.84926
22	ans_filledt.tif	461974	2259.45023	1886.38531	0.18106	2.88080	0.34713	0.58069
23	ans_filledt.tif	64702	3092.50652	1335.45932	0.89200	1.07649	0.92895	0.99263
24	ans_filledt.tif	62933	2032.42711	1414.68505	0.89509	1.03409	0.96704	0.99285
25	ans_filledt.tif	68909	3819.82379	1559.40795	0.89116	1.03760	0.96376	0.99286
26	ans_filledt.tif	56140	4184.44102	1557.75622	0.77494	1.28738	0.77677	0.95100
27	ans_filledt.tif	64273	3465.73406	1611.32202	0.89238	1.05360	0.94913	0.99256
28	ans_filledt.tif	66898	1716.94605	1761.12888	0.90144	1.03046	0.97044	0.99309
29	ans_filledt.tif	450198	2998.00997	2154.77978	0.19164	1.74623	0.57266	0.64519
30	ans_filledt.tif	59513	1330.04891	1891.65718	0.79087	1.25085	0.79946	0.96237
31	ans_filledt.tif	64346	2435.07923	1946.82044	0.89412	1.06803	0.93630	0.99297
32	ans_filledt.tif	63076	1746.71785	2051.83079	0.89113	1.04845	0.95379	0.99205
33	ans_filledt.tif	67820	3878.61873	2118.60986	0.90280	1.02558	0.97505	0.99281
34	ans_filledt.tif	68020	1098.94266	2250.28868	0.89553	1.05344	0.94927	0.99254
35	ans_filledt.tif	71233	4157.09731	2366.31065	0.88969	1.06370	0.94011	0.99221
36	ans_filledt.tif	133946	1694.89077	2425.90572	0.50780	2.14178	0.46690	0.88160
37	ans_filledt.tif	74640	732.39148	2414.87256	0.88531	1.04173	0.95994	0.99205
38	ans_filledt.tif	67963	3591.50705	2466.20112	0.89515	1.03024	0.97065	0.99267
39	ans_filledt.tif	72535	388.27831	2567.25781	0.85742	1.09517	0.91310	0.98977
40	ans_filledt.tif	66210	3318.48316	2630.35905	0.89633	1.02304	0.97748	0.99274
41	ans_filledt.tif	67822	953.04782	2685.87907	0.89622	1.07423	0.93090	0.99291
42	ans_filledt.tif	66160	3892.66067	2729.38094	0.89674	1.01878	0.98157	0.99172
43	ans_filledt.tif	65409	1762.63709	2773.32519	0.89707	1.06296	0.94077	0.99268
44	ans_filledt.tif	1206	15.61940	2922.60365	0.03236	1.82662	0.54746	0.51134

Figure-12: Object identification & analyze (1)

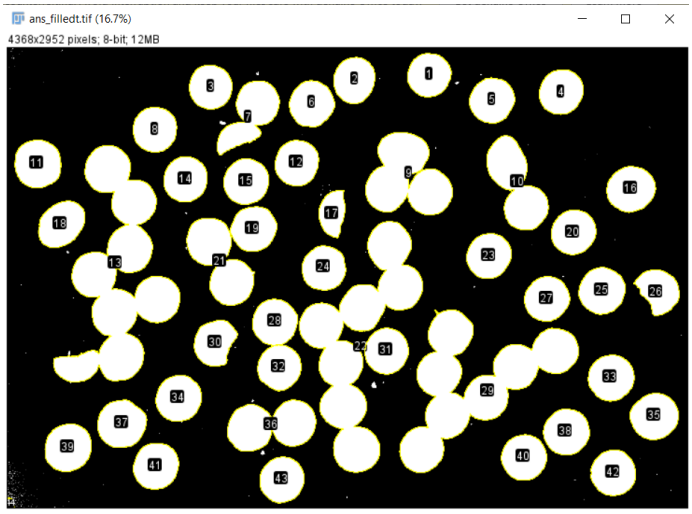


Figure-13: Object identification & analyze (2)

From figure-12 and figur-13, we can see that **44 objects** have been identified. But visibly, we can see that few of the objects have beem **merged with each other**. Hence they are considered as a single object. For solving this problem, I have used **Watershed**.

Step10: Separating the merged objects with Watershed

Goto Process → Binary → Watershed

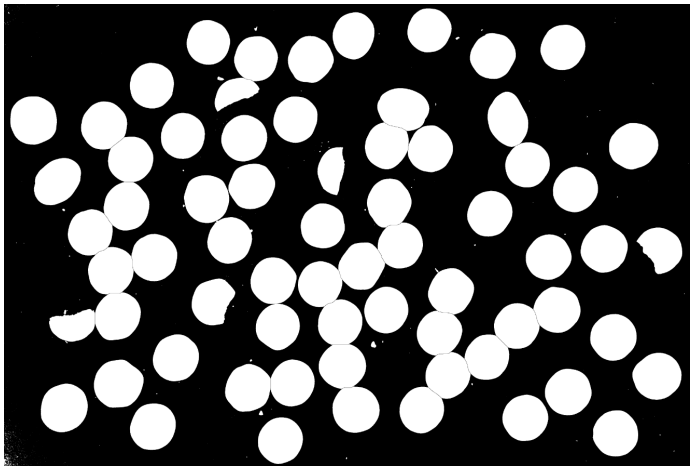


Figure-14:Separating the merged objects with Watershed

Step11: Analyzing the Watershed seprated objects

Goto Analyze → Analyze particles → Change starting value of the size from 0 to 1000 → Ok
Save the result file as a CSV.

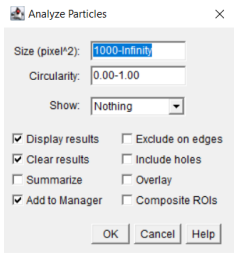
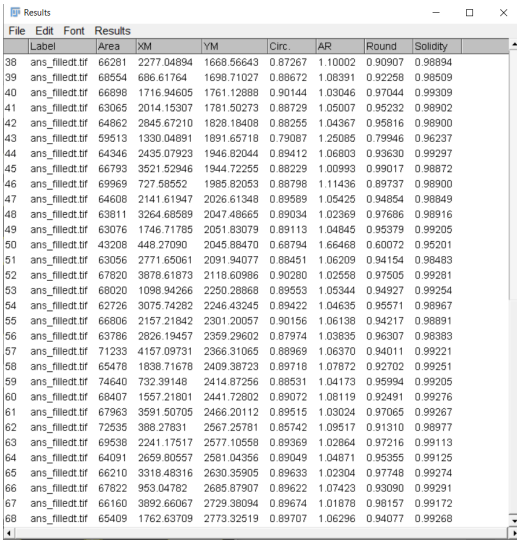


Figure-15:Analyze particles with custom size setting


Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
38	ans_filledt.tif	66281	2277.04894	1668.56643	0.87267	1.10002	0.90907	0.98894
39	ans_filledt.tif	68554	686.61764	1698.71027	0.88672	1.08391	0.92258	0.98509
40	ans_filledt.tif	66898	1716.94605	1761.12888	0.90144	1.03046	0.97044	0.99309
41	ans_filledt.tif	63065	2014.15307	1781.50273	0.88729	1.05007	0.95232	0.98902
42	ans_filledt.tif	64862	2845.67210	1828.18408	0.88255	1.04367	0.95816	0.98900
43	ans_filledt.tif	59513	1330.04891	1891.65718	0.79087	1.25085	0.79946	0.96237
44	ans_filledt.tif	64346	2435.07923	1946.82044	0.89412	1.06803	0.93630	0.99297
45	ans_filledt.tif	66793	3521.52946	1944.72255	0.88229	1.00993	0.99017	0.98872
46	ans_filledt.tif	69969	727.58552	1985.82053	0.88798	1.11436	0.89737	0.98900
47	ans_filledt.tif	64608	2141.61947	2026.61348	0.89589	1.05425	0.94854	0.98849
48	ans_filledt.tif	63811	3264.68589	2047.48665	0.89034	1.02369	0.97686	0.98916
49	ans_filledt.tif	63076	1746.71785	2051.83079	0.89113	1.04845	0.95379	0.99205
50	ans_filledt.tif	43208	448.27090	2045.88470	0.68794	1.66468	0.60072	0.95201
51	ans_filledt.tif	63056	2771.65061	2091.94077	0.88451	1.06209	0.94154	0.98483
52	ans_filledt.tif	67820	3878.61873	2118.60986	0.90280	1.02558	0.97505	0.99281
53	ans_filledt.tif	68020	1098.94266	2250.28868	0.89553	1.05344	0.94927	0.99254
54	ans_filledt.tif	62726	3075.74282	2246.43245	0.89422	1.04635	0.95571	0.98967
55	ans_filledt.tif	66806	2157.21842	2301.20057	0.90156	1.06138	0.94217	0.98891
56	ans_filledt.tif	63786	2826.19457	2359.29602	0.87974	1.03835	0.96307	0.98383
57	ans_filledt.tif	71233	4157.09731	2366.31065	0.88969	1.06370	0.94011	0.99221
58	ans_filledt.tif	65478	1838.71678	2409.38723	0.89718	1.07872	0.92702	0.99251
59	ans_filledt.tif	74640	732.39148	2414.87256	0.88531	1.04173	0.95994	0.99205
60	ans_filledt.tif	68407	1557.21801	2441.72802	0.89072	1.08119	0.92491	0.99276
61	ans_filledt.tif	67963	3591.50705	2466.20112	0.89515	1.03024	0.97065	0.99267
62	ans_filledt.tif	72535	388.27831	2567.25781	0.85742	1.09517	0.91310	0.98977
63	ans_filledt.tif	69538	2241.17517	2577.10558	0.89369	1.02864	0.97216	0.99113
64	ans_filledt.tif	64091	2659.80557	2581.04356	0.89049	1.04871	0.95355	0.99125
65	ans_filledt.tif	66210	3318.48316	2630.35905	0.89633	1.02304	0.97748	0.99274
66	ans_filledt.tif	67822	953.04782	2685.87907	0.89622	1.07423	0.93090	0.99291
67	ans_filledt.tif	66160	3892.66067	2729.38094	0.89674	1.01878	0.98157	0.99172
68	ans_filledt.tif	65409	1762.63709	2773.32519	0.89707	1.06296	0.94077	0.99268

Figure-16: Object identification & analyze (2)

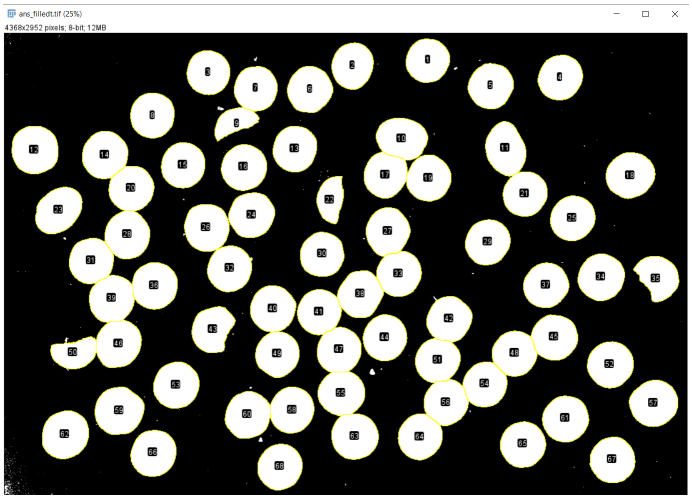


Figure-17: Object identification & analyze (3)

From figure-16 and figur-17, we can see that 68 objects have been identified which are either M&M or Nonstop.

Step12: Establishing the logic behind distinguishing Non Stops from M&Ms (Approach-01)

From the website of ImageJ we know,

```
Circ. (circularity) = (4π*area)/perimeter^2
```

A value of 1.0 indicates a perfect circle. As the value approaches 0.0, it indicates an increasingly elongated shape. Values may not be valid for very small particles.

Sources:

- https://imagej.nih.gov/ij/docs/menus/analyze.html#set
- https://imagej.nih.gov/ij/docs/guide/146-30.html#toc-Subsection-30.7

In general, we know the **Non-Stops** are **circular** and **M&M's** have a more of an **elongated shape**.

So, if the circularity is approximately 1 or over 0.855 then that the object is almost circular. So, according to this, those are Non-stops. Otherwise, those are M&Ms.

Condition for distinguishing Non-Stops from M&Ms:

```
If circularity >= 0.855:
    It is Non-stop
Else:
    It is M&M
```

Step13: Identifying Non-Stops

- Goto Analyze → Analyze particles → set Size (1000-Infinity) → set Circularity (0.855 - 1.0) → Ok

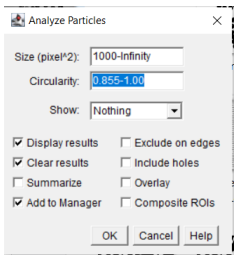


Figure-18:Analyze particles with custom Size & Circularity settings

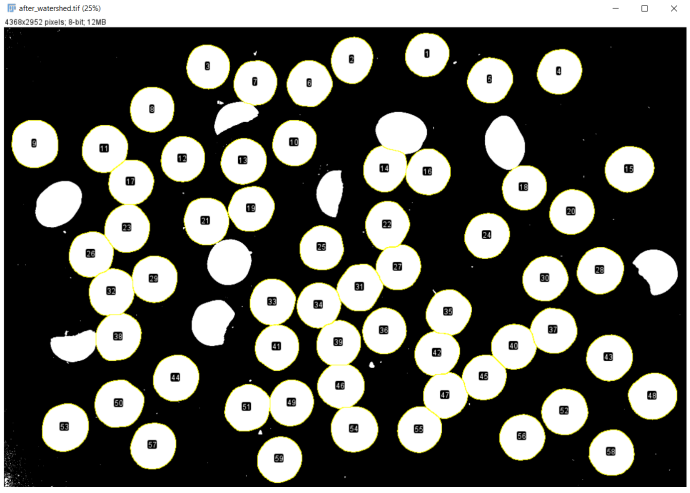
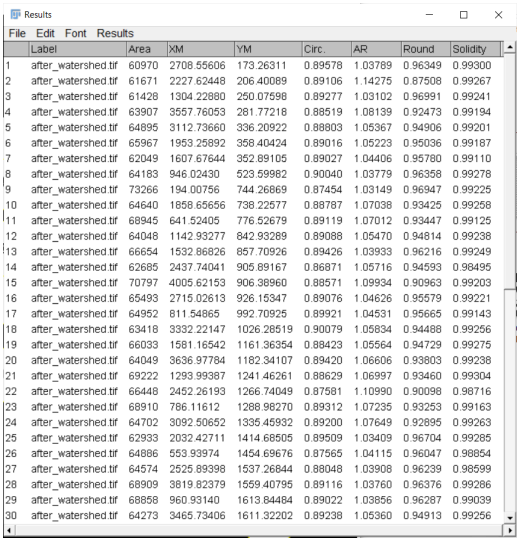


Figure-19: Non-stops identification

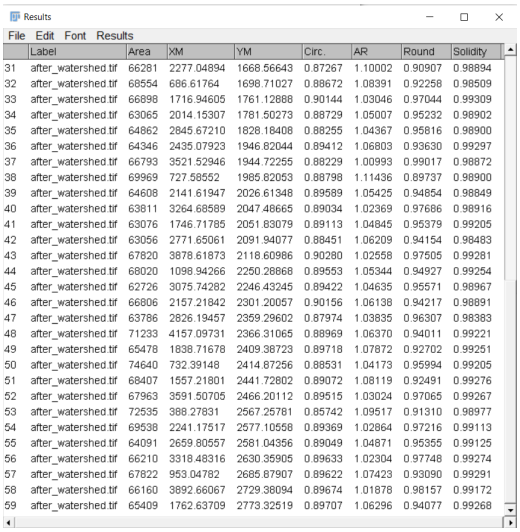


Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
1	after_watershed.tif	60970	2708.55606	173.26311	0.89578	1.03789	0.96349	0.99300
2	after_watershed.tif	61671	2227.62448	206.40089	0.89106	1.14275	0.87508	0.99267
3	after_watershed.tif	61428	1304.22880	250.07598	0.89277	1.03102	0.96991	0.99241
4	after_watershed.tif	63907	3557.76053	281.77218	0.88519	1.08139	0.92473	0.99194
5	after_watershed.tif	64895	3112.73660	336.20922	0.88803	1.05367	0.94906	0.99201
6	after_watershed.tif	65967	1953.25892	358.40424	0.89016	1.05223	0.95036	0.99187
7	after_watershed.tif	62049	1607.67644	352.89105	0.89027	1.04406	0.95780	0.99110
8	after_watershed.tif	64183	946.02430	523.59982	0.90040	1.03779	0.96358	0.99278
9	after_watershed.tif	73266	194.00756	744.26869	0.87454	1.03149	0.96947	0.99225
10	after_watershed.tif	64640	1858.65656	738.22577	0.88787	1.07038	0.93425	0.99258
11	after_watershed.tif	68945	641.52405	776.52679	0.89119	1.07012	0.93447	0.99125
12	after_watershed.tif	64048	1142.93277	842.93289	0.89088	1.05470	0.94814	0.99238
13	after_watershed.tif	66654	1532.86826	857.70926	0.89426	1.03933	0.96216	0.99249
14	after_watershed.tif	62685	2437.74041	905.89167	0.86871	1.05716	0.94593	0.98495
15	after_watershed.tif	70797	4005.62153	906.38960	0.88571	1.09934	0.90963	0.99203
16	after_watershed.tif	65493	2715.02613	926.15347	0.89076	1.04626	0.95579	0.99221
17	after_watershed.tif	64952	811.54865	992.70925	0.89921	1.04531	0.95665	0.99143
18	after_watershed.tif	63418	3332.22147	1026.28519	0.90079	1.05834	0.94488	0.99256
19	after_watershed.tif	66033	1581.16542	1161.36354	0.88423	1.05564	0.94729	0.99275
20	after_watershed.tif	64049	3636.97784	1182.34107	0.89420	1.06606	0.93803	0.99238
21	after_watershed.tif	69222	1293.99387	1241.46261	0.88629	1.06997	0.93460	0.99304
22	after_watershed.tif	66448	2452.26193	1266.74049	0.87581	1.10990	0.90098	0.98716
23	after_watershed.tif	68910	786.11612	1288.98270	0.89312	1.07235	0.93253	0.99163
24	after_watershed.tif	64702	3092.50652	1335.45932	0.89200	1.07649	0.92895	0.99263
25	after_watershed.tif	62933	2032.42711	1414.68505	0.89509	1.03409	0.96704	0.99285
26	after_watershed.tif	64886	553.93974	1454.69676	0.87565	1.04115	0.96047	0.98854
27	after_watershed.tif	64574	2525.89398	1537.26844	0.88048	1.03908	0.96239	0.98599
28	after_watershed.tif	68909	3819.82379	1559.40795	0.89116	1.03760	0.96376	0.99286
29	after_watershed.tif	68858	960.93140	1613.84484	0.89022	1.03856	0.96287	0.99039
30	after_watershed.tif	64273	3465.73406	1611.32202	0.89238	1.05360	0.94913	0.99256

Figure-20: Non-stops identification & analyze results(1)



Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
31	after_watershed.tif	66281	2277.04894	1668.56643	0.87267	1.10002	0.90907	0.98894
32	after_watershed.tif	68554	686.61764	1698.71027	0.88672	1.08391	0.92258	0.98509
33	after_watershed.tif	66898	1716.94605	1761.12888	0.90144	1.03046	0.97044	0.99309
34	after_watershed.tif	63065	2014.15307	1781.50273	0.88729	1.05007	0.95232	0.98902
35	after_watershed.tif	64862	2845.67210	1828.18408	0.88255	1.04367	0.95816	0.98900
36	after_watershed.tif	64346	2435.07923	1946.82044	0.89412	1.06803	0.93630	0.99297
37	after_watershed.tif	66793	3521.52946	1944.72255	0.88229	1.00993	0.99017	0.98872
38	after_watershed.tif	69969	727.58552	1985.82053	0.88798	1.11436	0.89737	0.98900
39	after_watershed.tif	64608	2141.61947	2026.61348	0.89589	1.05425	0.94854	0.98849
40	after_watershed.tif	63811	3264.68589	2047.48665	0.89034	1.02369	0.97686	0.98916
41	after_watershed.tif	63076	1746.71785	2051.83079	0.89113	1.04845	0.95379	0.99205
42	after_watershed.tif	63056	2771.65061	2091.94077	0.88451	1.06209	0.94154	0.98483
43	after_watershed.tif	67820	3878.61873	2118.60986	0.90280	1.02558	0.97505	0.99281
44	after_watershed.tif	68020	1098.94266	2250.28868	0.89553	1.05344	0.94927	0.99254
45	after_watershed.tif	62726	3075.74282	2246.43245	0.89422	1.04635	0.95571	0.98967
46	after_watershed.tif	66806	2157.21842	2301.20057	0.90156	1.06138	0.94217	0.98891
47	after_watershed.tif	63786	2826.19457	2359.29602	0.87974	1.03835	0.96307	0.98383
48	after_watershed.tif	71233	4157.09731	2366.31065	0.88969	1.06370	0.94011	0.99221
49	after_watershed.tif	65478	1838.71678	2409.38723	0.89718	1.07872	0.92702	0.99251
50	after_watershed.tif	74640	732.39148	2414.87256	0.88531	1.04173	0.95994	0.99205
51	after_watershed.tif	68407	1557.21801	2441.72802	0.89072	1.08119	0.92491	0.99276
52	after_watershed.tif	67963	3591.50705	2466.20112	0.89515	1.03024	0.97065	0.99267
53	after_watershed.tif	72535	388.27831	2567.25781	0.85742	1.09517	0.91310	0.98977
54	after_watershed.tif	69538	2241.17517	2577.10558	0.89369	1.02864	0.97216	0.99113
55	after_watershed.tif	64091	2659.80557	2581.04356	0.89049	1.04871	0.95355	0.99125
56	after_watershed.tif	66210	3318.48316	2630.35905	0.89633	1.02304	0.97748	0.99274
57	after_watershed.tif	67822	953.04782	2685.87907	0.89622	1.07423	0.93090	0.99291
58	after_watershed.tif	66160	3892.66067	2729.38094	0.89674	1.01878	0.98157	0.99172
59	after_watershed.tif	65409	1762.63709	2773.32519	0.89707	1.06296	0.94077	0.99268

Figure-21: Non-stops identification & analyze results(2)

From figure-19, figure-20 and figur-21, we can see that 59 Non-stops have been identified that have a circularity within the range of (0.855 to 1.0)

Step14: Identifying M&Ms

- Goto Analyze → Analyze particles → set Size (1000-Infinity) → set Circularity (0-0.855) → Ok

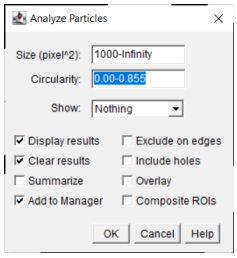


Figure-22:Analyze particles with custom Size & Circularity settings

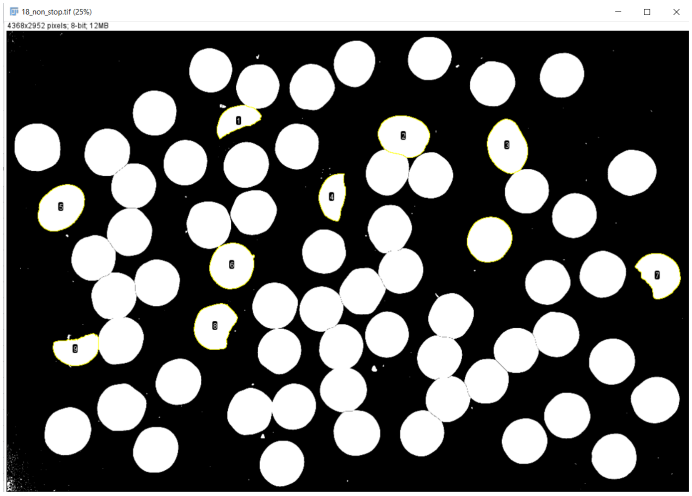


Figure-23: M&Ms identification

Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
1	18_non_stop.tif	35341	1473.41701	564.92571	0.64952	1.99074	0.50233	0.93662
2	18_non_stop.tif	68109	2544.22886	671.16350	0.85463	1.27308	0.78549	0.98524
3	18_non_stop.tif	66736	3208.26331	740.44170	0.84640	1.39686	0.71589	0.99116
4	18_non_stop.tif	38316	2088.11721	1060.12371	0.70009	1.83890	0.54380	0.96922
5	18_non_stop.tif	67203	344.94574	1131.53460	0.85475	1.34649	0.74267	0.99070
6	18_non_stop.tif	65447	1440.62795	1504.77088	0.83765	1.06413	0.93974	0.98447
7	18_non_stop.tif	56140	4184.44102	1557.75622	0.77494	1.28738	0.77677	0.95100
8	18_non_stop.tif	59513	1330.04891	1891.65718	0.79087	1.25085	0.79946	0.96237
9	18_non_stop.tif	43208	448.27090	2045.88470	0.68794	1.66468	0.60072	0.95201

Figure-24: M&Ms identification & analyze results

From figure-23 and figur-24, we can see that 9 M&Ms have been identified that have a circularity within the range of (0 to 0.855)

The total number of identified M&Ms & Non-stops sums up to the total number of object identified in the image.

= 9(M&Ms)+ 59(Non-stops) = 68(Total object)

Problem associated with the solution of Step-14 (Approach-01):

From the figure-23, we can see that few of the M&M detected chocolates are not M&Ms. Rather they are half-eaten Non-stops. So, the area/half-eaten characteristic has to be considered while determining the chocolates.

Step15: Establishing the logic behind distinguishing Non Stops from M&Ms (Approach-02)

If a chocolate has been eaten its area will be less than a full-sized M&M and Non-stop. From the data, I have identified the area of the smallest full non-stop is 60970 and area of the smallest full M&M is 66448.

So, for determining half-eaten chocolates, I have considered the threhold value of 60000. Any chocolate which has a area less then 60000 is considered half-eaten.

Non-Stops have cicularity which is close to 1.0. Since it is half eaten, it will have a circularity greater than or equal to 0.5. Any half eaten chocolate with a circularity less than 0.5 will be considered as M&M.

Updated conditions for distinguishing Non-Stops from M&Ms:

```
If area >= 60000: #full chocolate
    If circularity >= 0.855:
        It is Non-stop
    Else:
        It is M&M
Else: #Half-eaten chocolate
    If circularity >= 0.5:
        It is Non-stop
    Else:
        It is M&M
```

Step16: Identifying half-eaten Non-Stops

- Goto Analyze → Analyze particles → set Size (1000-59999) → set size Circularity (0.5-1.0) → Ok

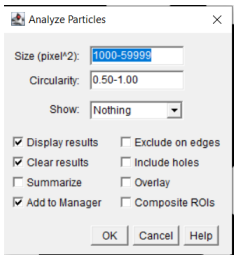


Figure-25:Analyze particles with custom Size & Circularity settings

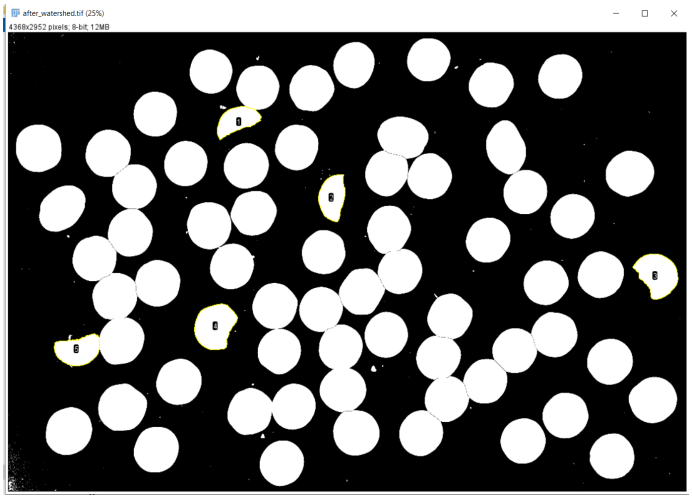
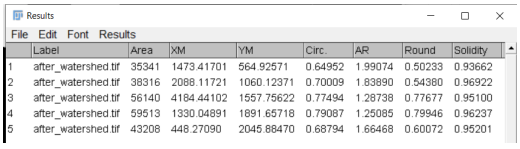


Figure-26: half-eaten Non-Stops identification



Results

File Edit Font Results

	Label	Area	XM	YM	Circ.	AR	Round	Solidity
1	after_watershed.tif	35341	1473.41701	564.92571	0.64952	1.99074	0.50233	0.93662
2	after_watershed.tif	38316	2088.11721	1060.12371	0.70009	1.83890	0.54380	0.96922
3	after_watershed.tif	56140	4184.44102	1557.75622	0.77494	1.28738	0.77677	0.95100
4	after_watershed.tif	59513	1330.04891	1891.65718	0.79087	1.25085	0.79946	0.96237
5	after_watershed.tif	43208	448.27090	2045.88470	0.68794	1.66468	0.60072	0.95201

Figure-27: half-eaten Non-Stops identification & analyze results

From figure-26 and figur-27, we can see that **5 half-eaten Non-Stops** have been identified.

Step17: Identifying half-eaten M&Ms

- Goto Analyze → Analyze particles → set Size (1000-59999) → set size Circularity (0-0.5) → Ok

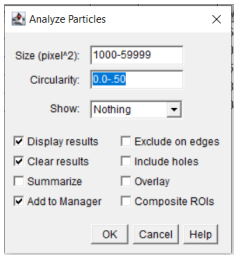


Figure-28:Analyze particles with custom Size & Circularity settings

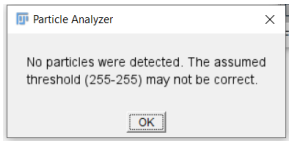


Figure-29: half-eaten M&Ms identification

From figure-28 and figur-29, we can see that **No half-eaten M&Ms** has been identified.

Step18: Identifying full-size Non-Stops

- Goto Analyze → Analyze particles → set Size (1000-59999) → set size Circularity (0.5-1.0) → Ok

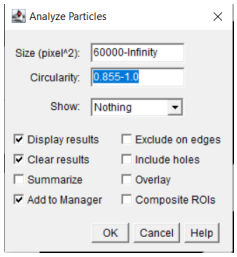


Figure-30:Analyze particles with custom Size & Circularity settings

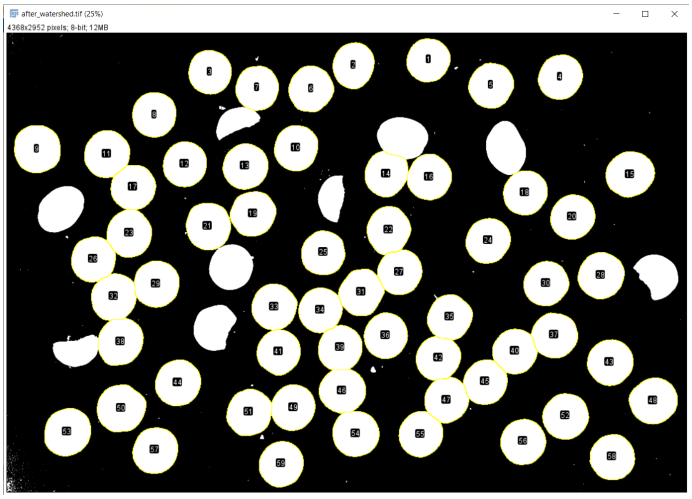
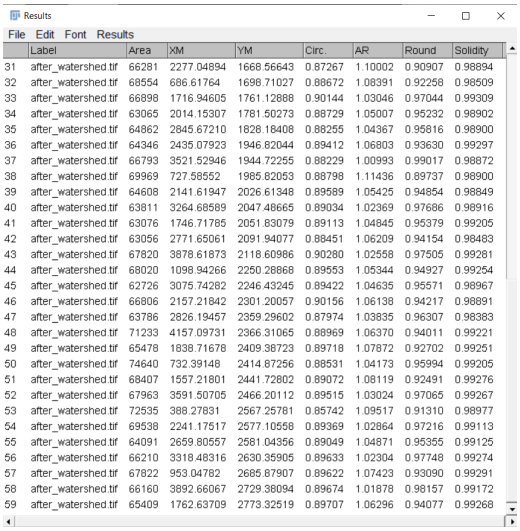


Figure-31: full-size Non-Stops identification



	Label	Area	XM	YM	Circ.	AR	Round	Solidity
31	after_watershed.tif	66281	2277.04894	1668.56643	0.87267	1.10002	0.90907	0.98894
32	after_watershed.tif	68554	686.61764	1698.71027	0.88672	1.08391	0.92258	0.98509
33	after_watershed.tif	66898	1716.94605	1761.12888	0.90144	1.03046	0.97044	0.99309
34	after_watershed.tif	63065	2014.15307	1781.50273	0.88729	1.05007	0.95232	0.98902
35	after_watershed.tif	64862	2845.67210	1828.18408	0.88255	1.04367	0.95816	0.98900
36	after_watershed.tif	64346	2435.07923	1946.82044	0.89412	1.06803	0.93630	0.99297
37	after_watershed.tif	66793	3521.52946	1944.72255	0.88229	1.00993	0.99017	0.98872
38	after_watershed.tif	69969	727.58552	1985.82053	0.88798	1.11436	0.89737	0.98900
39	after_watershed.tif	64608	2141.61947	2026.61348	0.89589	1.05425	0.94854	0.98849
40	after_watershed.tif	63811	3264.68589	2047.48665	0.89034	1.02369	0.97686	0.98916
41	after_watershed.tif	63076	1746.71785	2051.83079	0.89113	1.04845	0.95379	0.99205
42	after_watershed.tif	63056	2771.65061	2091.94077	0.88451	1.06209	0.94154	0.98483
43	after_watershed.tif	67820	3878.61873	2118.60986	0.90280	1.02558	0.97505	0.99281
44	after_watershed.tif	68020	1098.94266	2250.28868	0.89553	1.05344	0.94927	0.99254
45	after_watershed.tif	62726	3075.74282	2246.43245	0.89422	1.04635	0.95571	0.98967
46	after_watershed.tif	66806	2157.21842	2301.20057	0.90156	1.06138	0.94217	0.98891
47	after_watershed.tif	63786	2826.19457	2359.29602	0.87974	1.03835	0.96307	0.98383
48	after_watershed.tif	71233	4157.09731	2366.31065	0.88969	1.06370	0.94011	0.99221
49	after_watershed.tif	65478	1838.71678	2409.38723	0.89718	1.07872	0.92702	0.99251
50	after_watershed.tif	74640	732.39148	2414.87256	0.88531	1.04173	0.95994	0.99205
51	after_watershed.tif	68407	1557.21801	2441.72802	0.89072	1.08119	0.92491	0.99276
52	after_watershed.tif	67963	3591.50705	2466.20112	0.89515	1.03024	0.97065	0.99267
53	after_watershed.tif	72535	388.27831	2567.25781	0.85742	1.09517	0.91310	0.98977
54	after_watershed.tif	69538	2241.17517	2577.10558	0.89369	1.02864	0.97216	0.99113
55	after_watershed.tif	64091	2659.80557	2581.04356	0.89049	1.04871	0.95355	0.99125
56	after_watershed.tif	66210	3318.48316	2630.35905	0.89633	1.02304	0.97748	0.99274
57	after_watershed.tif	67822	953.04782	2685.87907	0.89622	1.07423	0.93090	0.99291
58	after_watershed.tif	66160	3892.66067	2729.38094	0.89674	1.01878	0.98157	0.99172
59	after_watershed.tif	65409	1762.63709	2773.32519	0.89707	1.06296	0.94077	0.99268

Figure-32: full-size Non-Stops identification & analyze results

From figure-31 and figur-32, we can see that **59 full-size Non-Stops** have been identified.

Step19: Identifying full-size M&Ms

- Goto Analyze → Analyze particles → set Size (1000-59999) → set size Circularity (0-0.5) → Ok

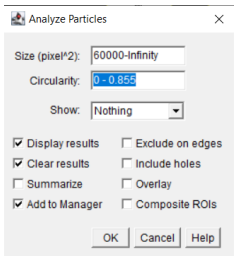


Figure-33:Analyze particles with custom Size & Circularity settings

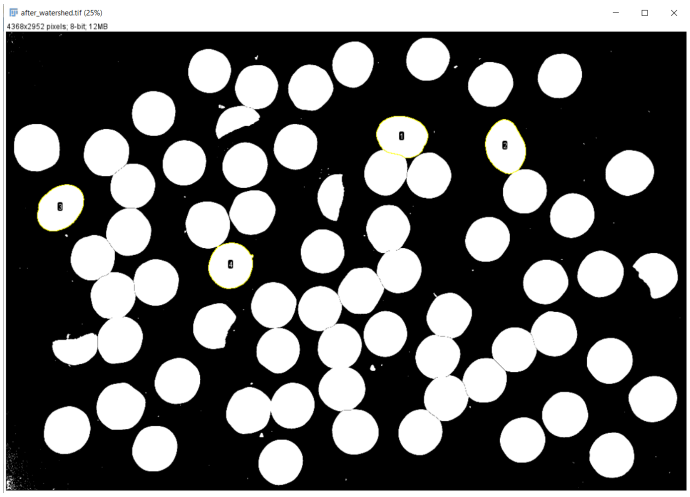
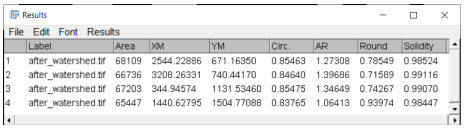


Figure-34: full-size M&Ms identification



	Label	Area	XM	YM	Circ.	AR	Round	Solidity
1	after_watershed.tif	68109	2544.22886	671.16350	0.85463	1.27308	0.78549	0.98524
2	after_watershed.tif	66736	3208.26331	740.44170	0.84640	1.39686	0.71589	0.99116
3	after_watershed.tif	67203	344.94574	1131.53460	0.85475	1.34649	0.74267	0.99070
4	after_watershed.tif	65447	1440.62795	1504.77088	0.83765	1.06413	0.93974	0.98447

Figure-35: full-size M&Ms identification & analyze results

From figure-28 and figur-29, we can see that **4 full-size M&Ms** has been identified.

The total number of identified M&Ms & Non-stops sums up to the total number of object identified in the image.

= 4(full-size M&Ms)+ 59(full-size Non-stops) + 0(half-eaten M&Ms)+ 5(half-eaten Non-stops)= 68(Total object)

Using the approach-02, I was able to sucessfully identify Non-stops and M&M despite few of the chocolates being half eaten.

In [ ]: