APPLIED PHYSICS 157

FEATURE EXTRACTION FROM IMAGES

MANALANG, JOHNENN R.

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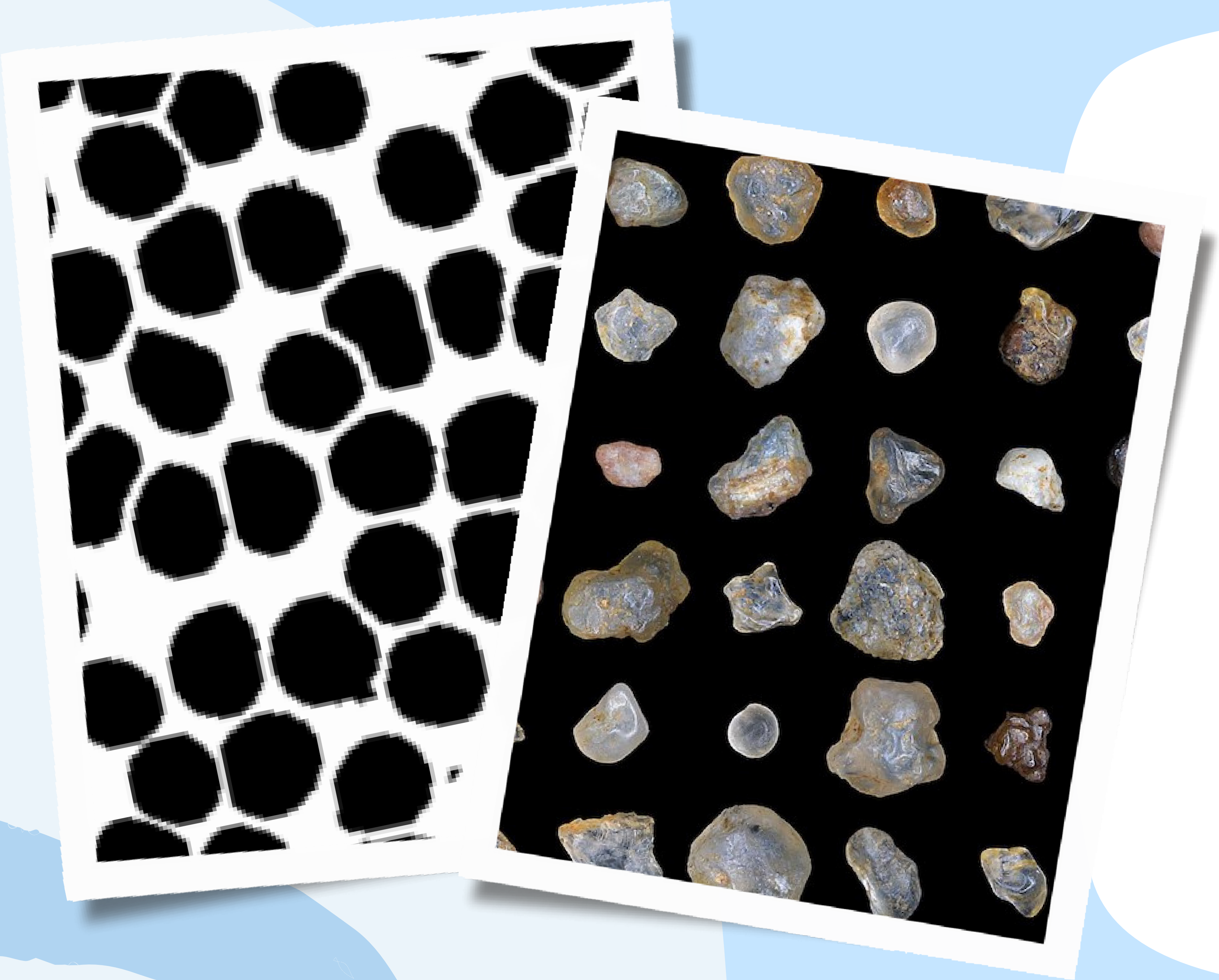

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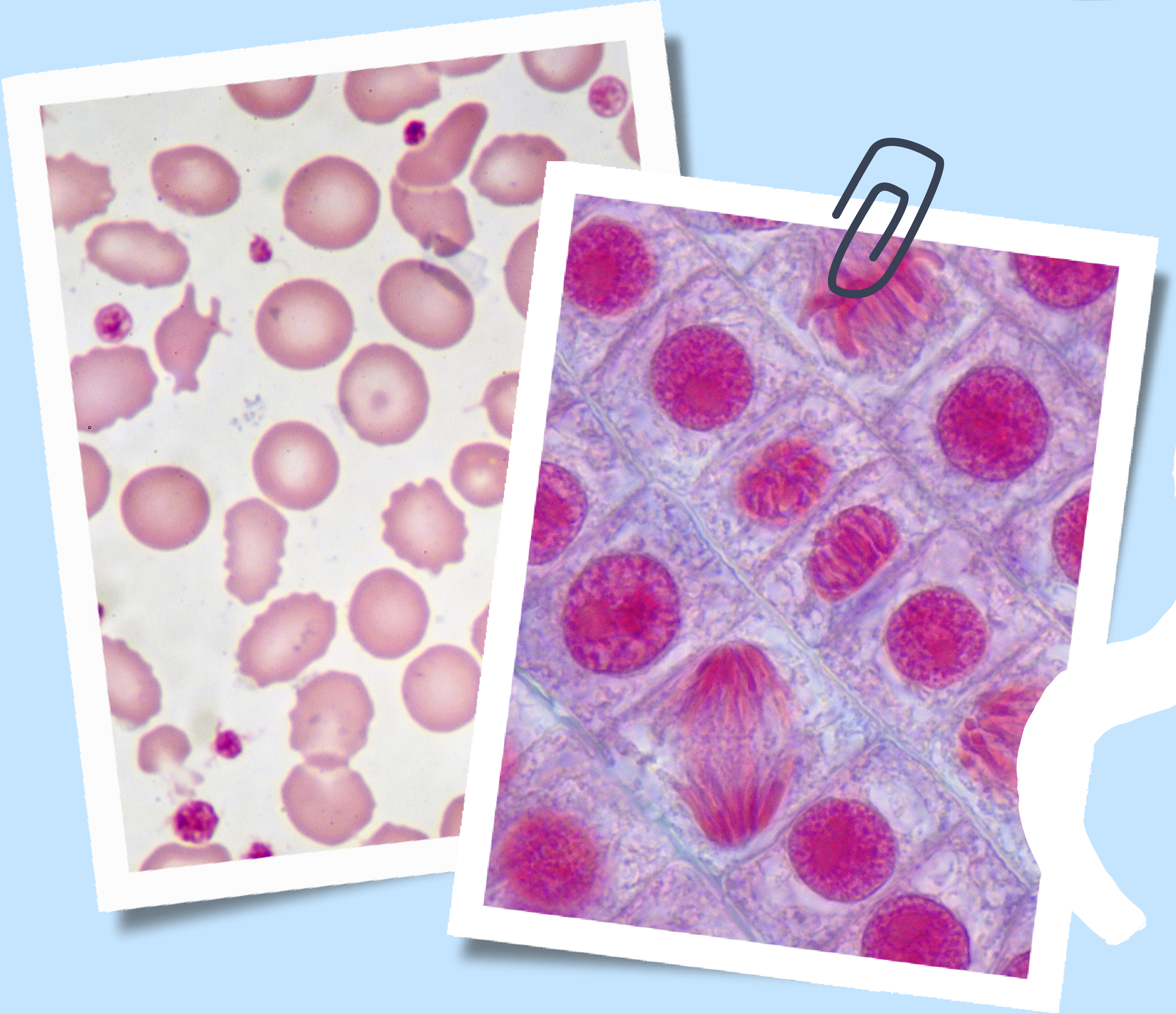
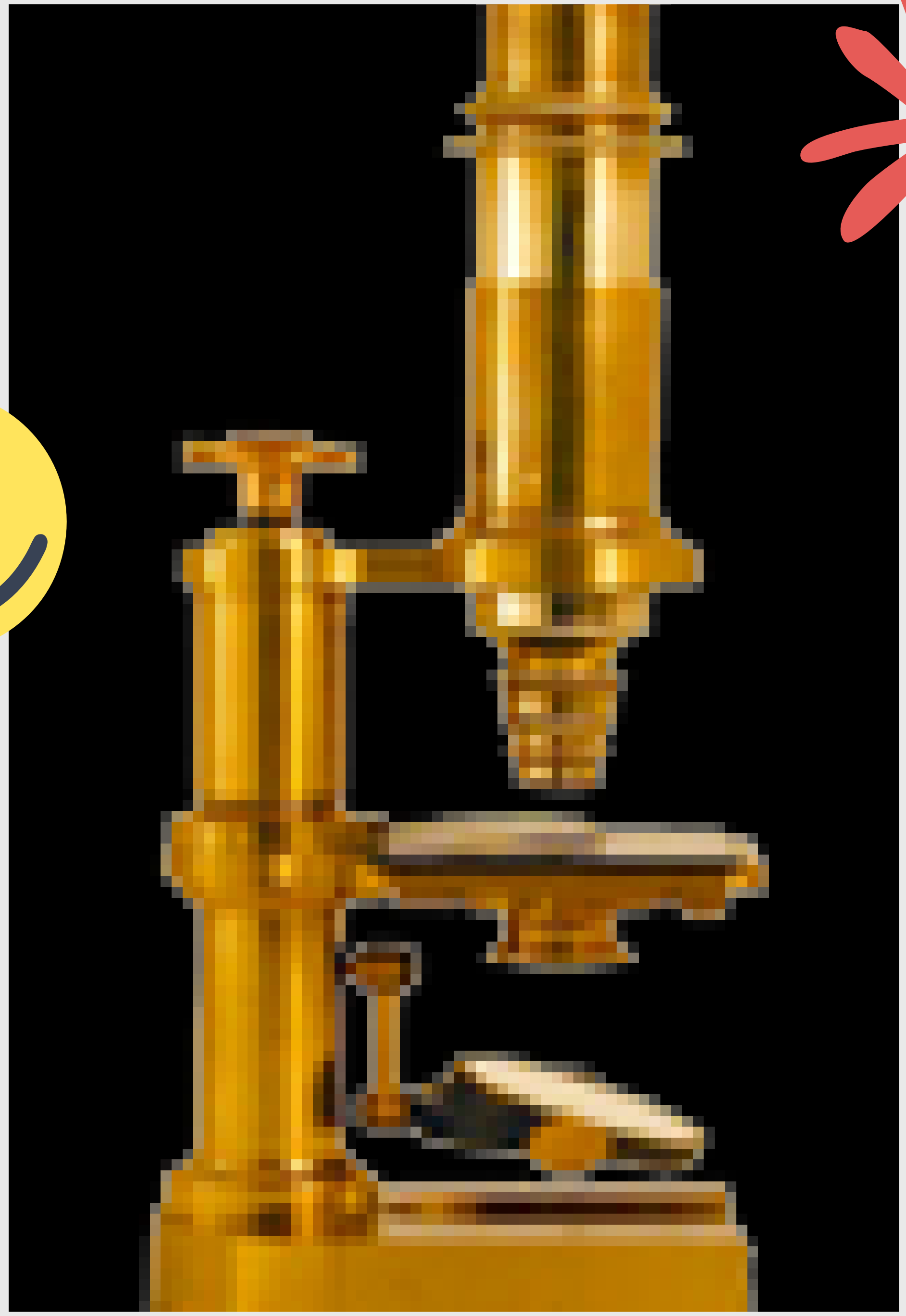
OBJECTIVES

- AUTOMATICALLY MEASURE THE PROPERTIES OF IMAGES USING IMAGEJ

- EXTRACT THE PROPERTIES OF OBJECTS OF DIFFERENT SHAPES AND TEXTURE USING IMAGEJ





BACKGROUND

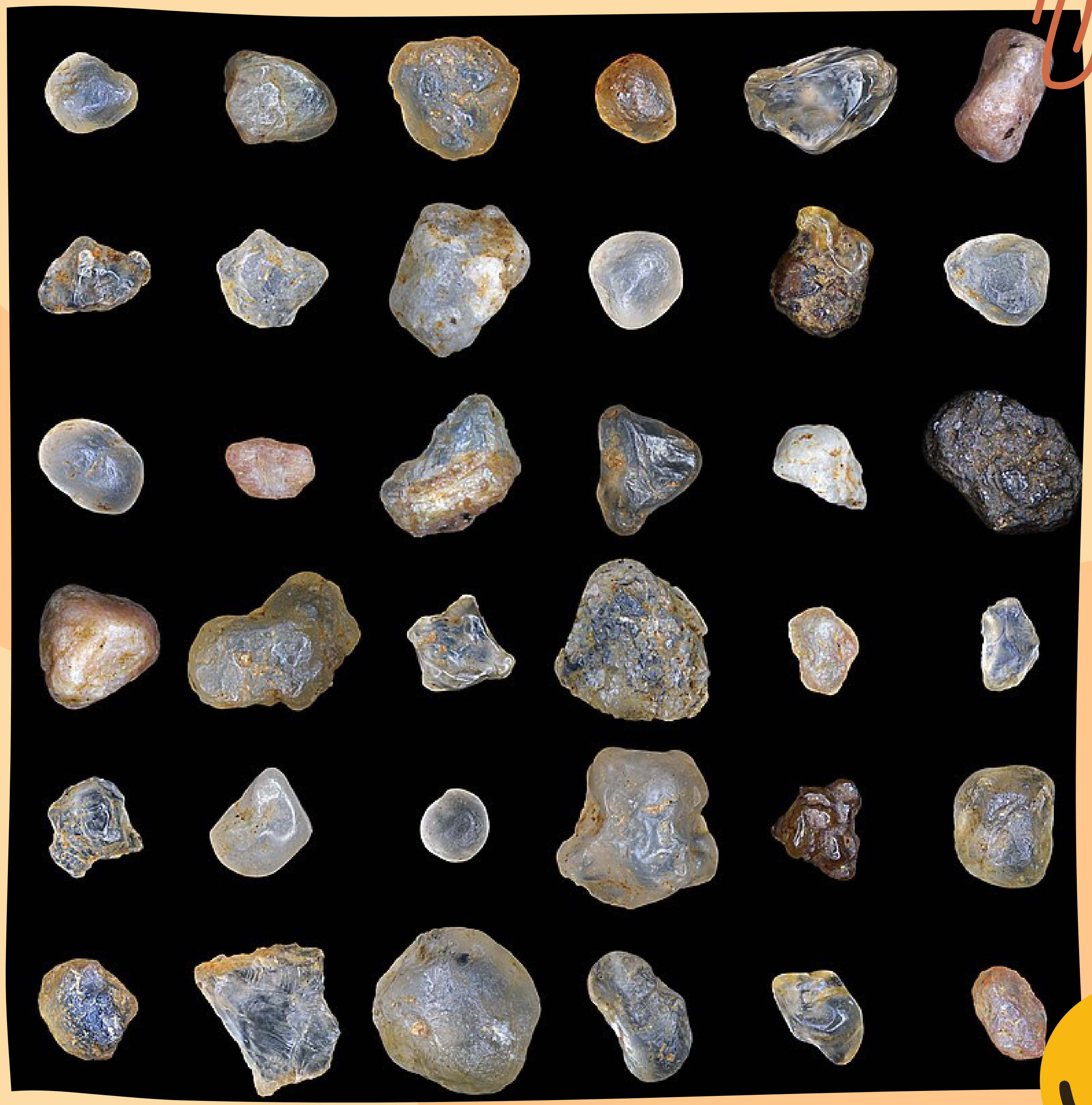
Image segmentation has numerous applications in different fields such as image analysis, face recognition, video surveillance, and satellite image analysis. It enables analysis and processing of images by dividing images into segments, reducing their complexity.

The simplest method of image segmentation is thresholding. It is done by dividing the pixels of an image based on their intensity relative to a threshold. It is best for segmenting objects with higher intensity than other objects or the background. A prerequisite of image segmentation is feature extraction. It is a reduction process that ensures that the raw data is reduced to more manageable groups.

In this activity, we will use ImageJ for extraction of features from images with different objects.

SAND IMAGE

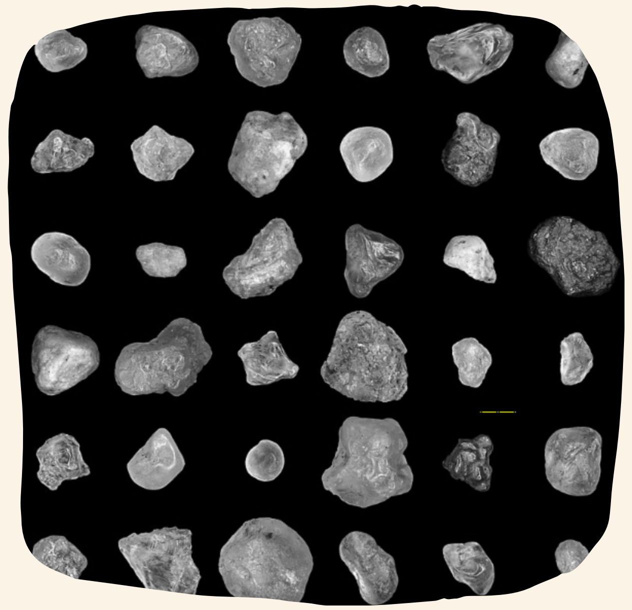
FOLLOWING THE STEPS DONE IN THE MODULE, WE WILL TRY TO EXTRACT THE FEATURES OF THE DIFFERENT SAND GRAINS IN THIS IMAGE. AS WE CAN SEE, THE BACKGROUND IS CLEAN (NO NOISE OR OTHER OBJECTS INCLUDED) AND THE SAND GRAINS ARE EQUALLY SPACED. USING IMAGEJ, WE WILL TRY TO GET SOME INFORMATION (E.G. AREA, AND PERIMETER) THAT DESCRIBES EACH OF THE SAND GRAINS.



STEP-BY-STEP PROCESS

ORIGINAL

Since there is no scale bar, I used an arbitrary scale bar and set the measurement to 50 pixels/mm.

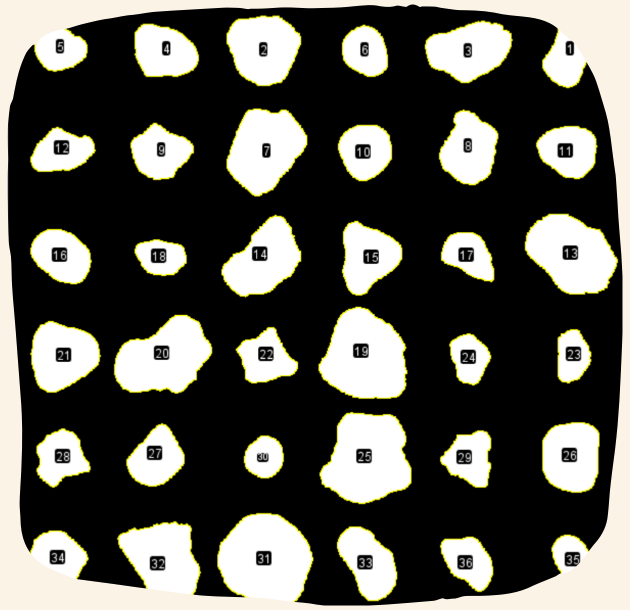


GRAYSCALE

Set the image to grayscale (8-bit). This will enable us to use the thresholding in the next step.

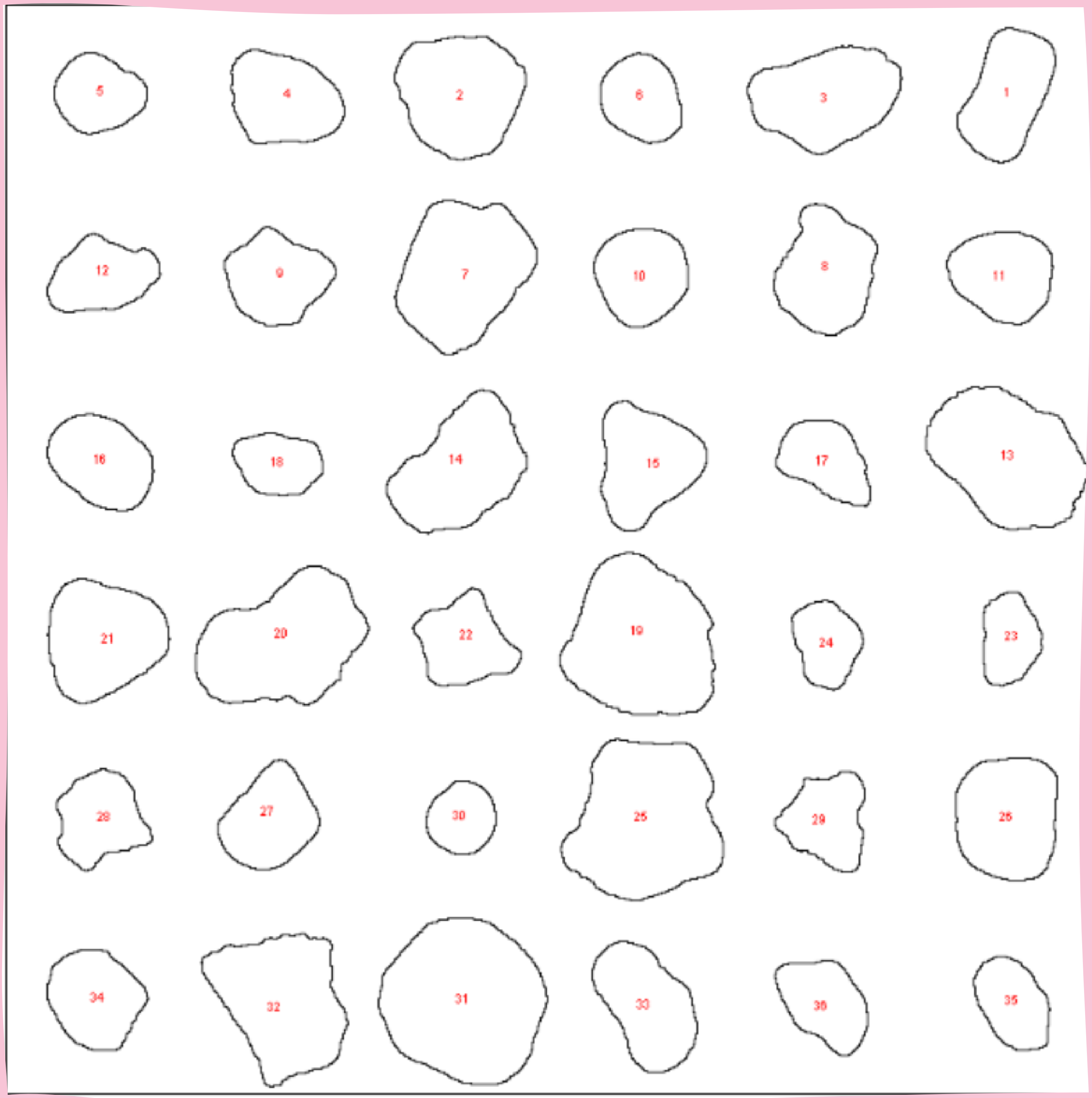
THRESHOLDING

Using the thresholding, the grains are separated from the background.



BINARIZED

Binarize the image. The region of interest is the white parts.



Slice	Count	Total Area	Average Size	%Area	Perim.	Circ.	Solidity
sand.jpg	36	72.318	2.009	28.249	5.470	0.805	0.952

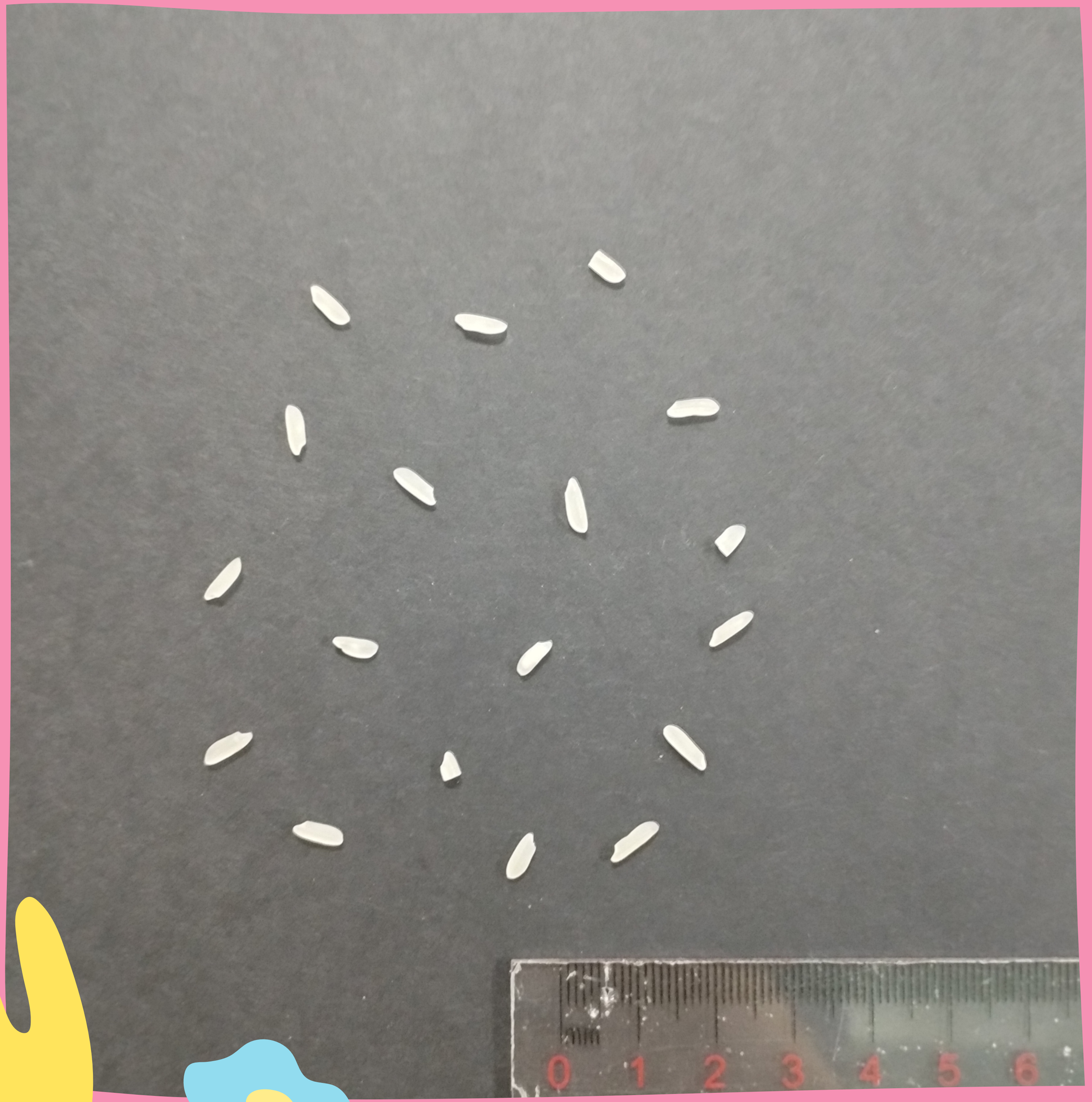
FINAL IMAGE

In order to get smoother boundaries, I added few more steps after thresholding. This is because in the first try, there are several small dots (or particles) that the software defines as a region. To address the problem, I also used **fill holes, dilate,** and **erode**. Moreover, I adjusted the **particle size to 100-infinity** so that the few small particles will not be considered as separate regions.

Tada! The final image contains regions with smoother boundaries.

The measurements that I chose are **area, perimeter, centroid,** and **shape descriptors.** These are the resulting measurements for each of the regions. In total, there are 36 sand grains of different shapes and sizes. As we can see, the software automatically extracted these information for each of the grains. All you need to do is to properly threshold and get smoother boundaries.

	Label	Area	X	Y	Perim.	Circ.	AR	Round	Solidity
1	sand.jpg	1.825	14.675	1.295	5.610	0.729	1.881	0.532	0.942
2	sand.jpg	2.624	6.643	1.286	6.220	0.852	1.048	0.954	0.971
3	sand.jpg	2.474	12.011	1.330	6.418	0.755	1.596	0.627	0.954
4	sand.jpg	1.768	4.052	1.365	5.192	0.824	1.340	0.746	0.969
5	sand.jpg	1.170	1.328	1.291	4.124	0.865	1.190	0.840	0.964
6	sand.jpg	1.190	9.305	1.360	4.114	0.883	1.202	0.832	0.974
7	sand.jpg	3.204	6.682	3.915	7.047	0.811	1.301	0.769	0.965
8	sand.jpg	2.033	12.017	3.913	5.728	0.779	1.326	0.754	0.939
9	sand.jpg	1.576	3.949	4.000	4.935	0.813	1.147	0.872	0.944
10	sand.jpg	1.533	9.305	3.960	4.644	0.893	1.057	0.946	0.977
11	sand.jpg	1.600	14.608	3.954	4.797	0.873	1.179	0.848	0.972
12	sand.jpg	1.317	1.375	3.974	4.699	0.750	1.585	0.631	0.935
13	sand.jpg	3.471	14.684	6.645	7.363	0.805	1.440	0.695	0.959
14	sand.jpg	2.617	6.649	6.798	6.631	0.748	1.584	0.631	0.939
15	sand.jpg	1.999	9.369	6.724	5.768	0.755	1.179	0.848	0.942
16	sand.jpg	1.606	1.375	6.701	4.812	0.872	1.368	0.731	0.972
17	sand.jpg	1.172	12.004	6.685	4.418	0.755	1.549	0.646	0.948
18	sand.jpg	0.936	3.969	6.729	3.754	0.835	1.466	0.682	0.963
19	sand.jpg	4.008	9.296	9.341	7.906	0.806	1.136	0.880	0.963
20	sand.jpg	3.481	4.041	9.358	7.704	0.737	1.574	0.635	0.921
21	sand.jpg	2.403	1.398	9.307	6.015	0.835	1.070	0.935	0.972
22	sand.jpg	1.408	6.704	9.363	4.944	0.724	1.112	0.899	0.893
23	sand.jpg	0.916	14.705	9.314	3.850	0.776	1.607	0.622	0.959
24	sand.jpg	0.966	12.018	9.371	3.858	0.816	1.362	0.734	0.950
25	sand.jpg	4.128	9.363	11.990	8.218	0.768	1.124	0.890	0.937
26	sand.jpg	2.290	14.680	11.936	5.738	0.874	1.208	0.827	0.981
27	sand.jpg	1.570	3.846	11.972	4.858	0.836	1.264	0.791	0.968
28	sand.jpg	1.374	1.353	11.956	4.784	0.754	1.087	0.920	0.905
29	sand.jpg	1.315	12.027	11.980	4.802	0.716	1.131	0.884	0.908
30	sand.jpg	0.844	6.665	11.950	3.403	0.916	1.086	0.921	0.971
31	sand.jpg	4.528	6.699	14.643	8.036	0.881	1.068	0.936	0.980
32	sand.jpg	3.117	4.023	14.654	7.555	0.686	1.302	0.768	0.910
33	sand.jpg	1.900	9.378	14.705	5.584	0.765	1.803	0.555	0.942
34	sand.jpg	1.575	1.282	14.606	4.772	0.869	1.153	0.867	0.969
35	sand.jpg	1.104	14.754	14.673	4.121	0.816	1.618	0.618	0.963
36	sand.jpg	1.278	11.990	14.669	4.501	0.793	1.560	0.641	0.954



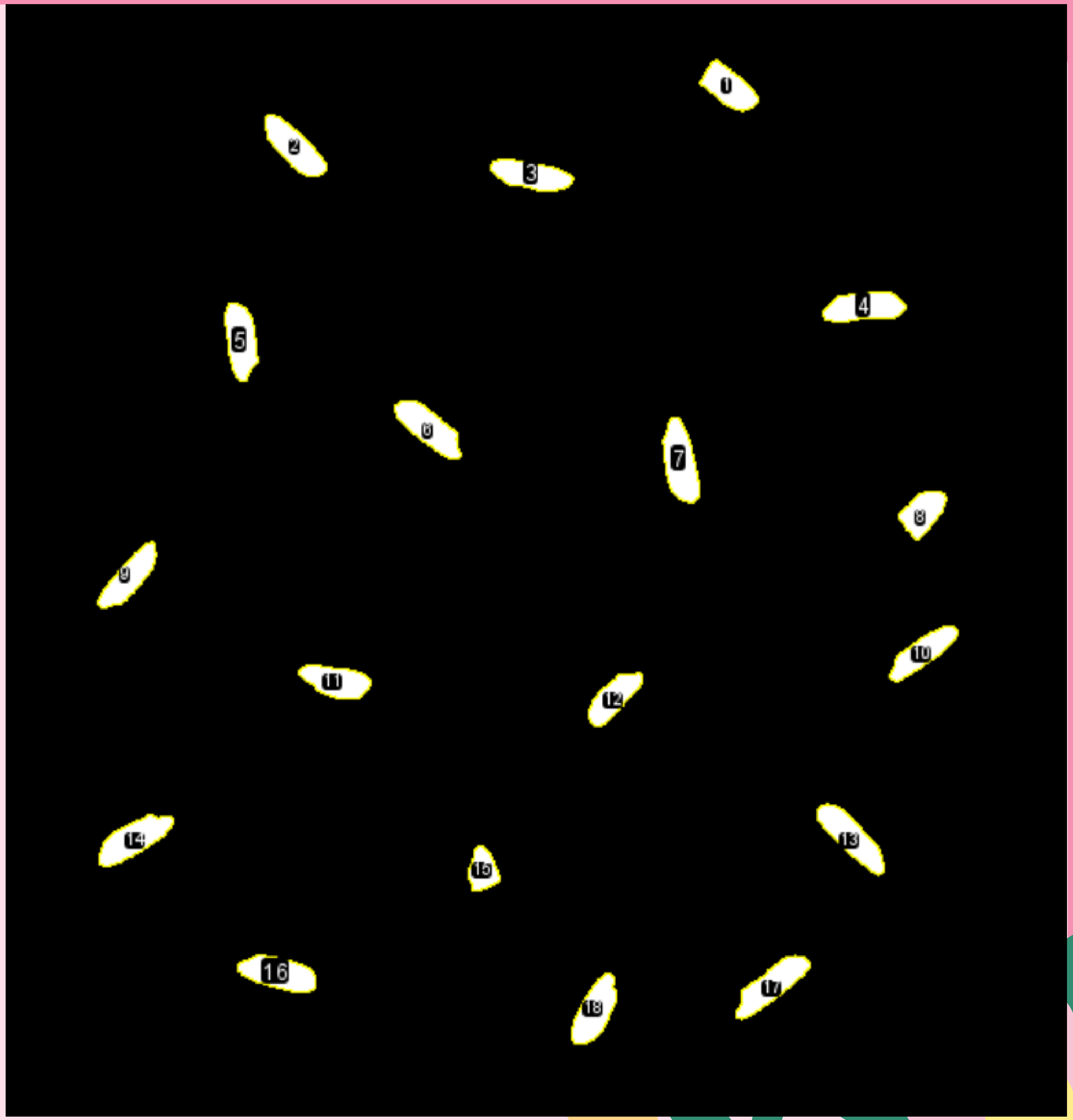
EXTRA CHALLENGE

RICE GRAINS

I tried capturing my own images this time. In this example, these are rice grains of different shapes and sizes. Compared to the image of sand grains, the rice grains here are not equally spaced. I placed them in a black background so that it can be easy for thresholding. I also used a ruler (the centimeter part) for the scale.

RICE GRAINS

Shown below is the processed image of the rice grains. After thresholding and some adjustments, the software was able to detect 18 regions corresponding to the 18 rice grains present in the image. I also cropped out the ruler after scaling so that it will not affect the results of the thresholding process.



Moreover, I adjusted the detected size particles to 10-infinity to ensure that there are no small particles that will be included in the extraction.

RICE GRAINS

Slice	Count	Total Area	Average Size	%Area	Perim.	Circ.	Solidity
rice.jpg	18	189.958	10.553	2.559	14.616	0.624	0.961

	Label	Area	X	Y	Perim.	Circ.	AR	Round	Solidity
1	rice.jpg	9.638	56.870	7.013	12.922	0.725	2.001	0.500	0.964
2	rice.jpg	11.228	22.848	11.704	14.869	0.638	2.807	0.356	0.967
3	rice.jpg	10.601	41.382	13.885	15.253	0.573	3.222	0.310	0.964
4	rice.jpg	11.225	67.482	24.212	15.304	0.602	3.020	0.331	0.952
5	rice.jpg	11.073	18.661	26.809	14.917	0.625	2.690	0.372	0.962
6	rice.jpg	11.561	33.359	33.680	15.483	0.606	2.810	0.356	0.955
7	rice.jpg	12.662	53.070	36.364	16.301	0.599	2.876	0.348	0.972
8	rice.jpg	8.268	72.046	40.292	11.630	0.768	1.637	0.611	0.964
9	rice.jpg	10.153	9.933	45.337	14.993	0.568	3.219	0.311	0.964
10	rice.jpg	9.736	72.062	51.215	15.172	0.531	3.450	0.290	0.960
11	rice.jpg	9.934	26.147	53.511	13.747	0.661	2.421	0.413	0.966
12	rice.jpg	8.807	47.833	54.791	13.153	0.640	2.702	0.370	0.961
13	rice.jpg	12.119	66.444	65.705	16.378	0.568	3.425	0.292	0.966
14	rice.jpg	12.071	10.277	65.847	16.022	0.591	2.816	0.355	0.961
15	rice.jpg	5.808	37.606	68.282	10.035	0.725	1.499	0.667	0.950
16	rice.jpg	11.759	21.624	76.374	15.372	0.625	2.683	0.373	0.968
17	rice.jpg	12.102	60.226	77.268	16.749	0.542	3.364	0.297	0.945
18	rice.jpg	11.215	46.375	79.310	14.792	0.644	2.511	0.398	0.965

I chose the measurements for **area, perimeter, centroid,** and **shape detectors**.

These are the outlines of the rice grains. As we can see, the outlines are not that smooth (there are some broken lines). This may be due to the image quality that affected the thresholding process.

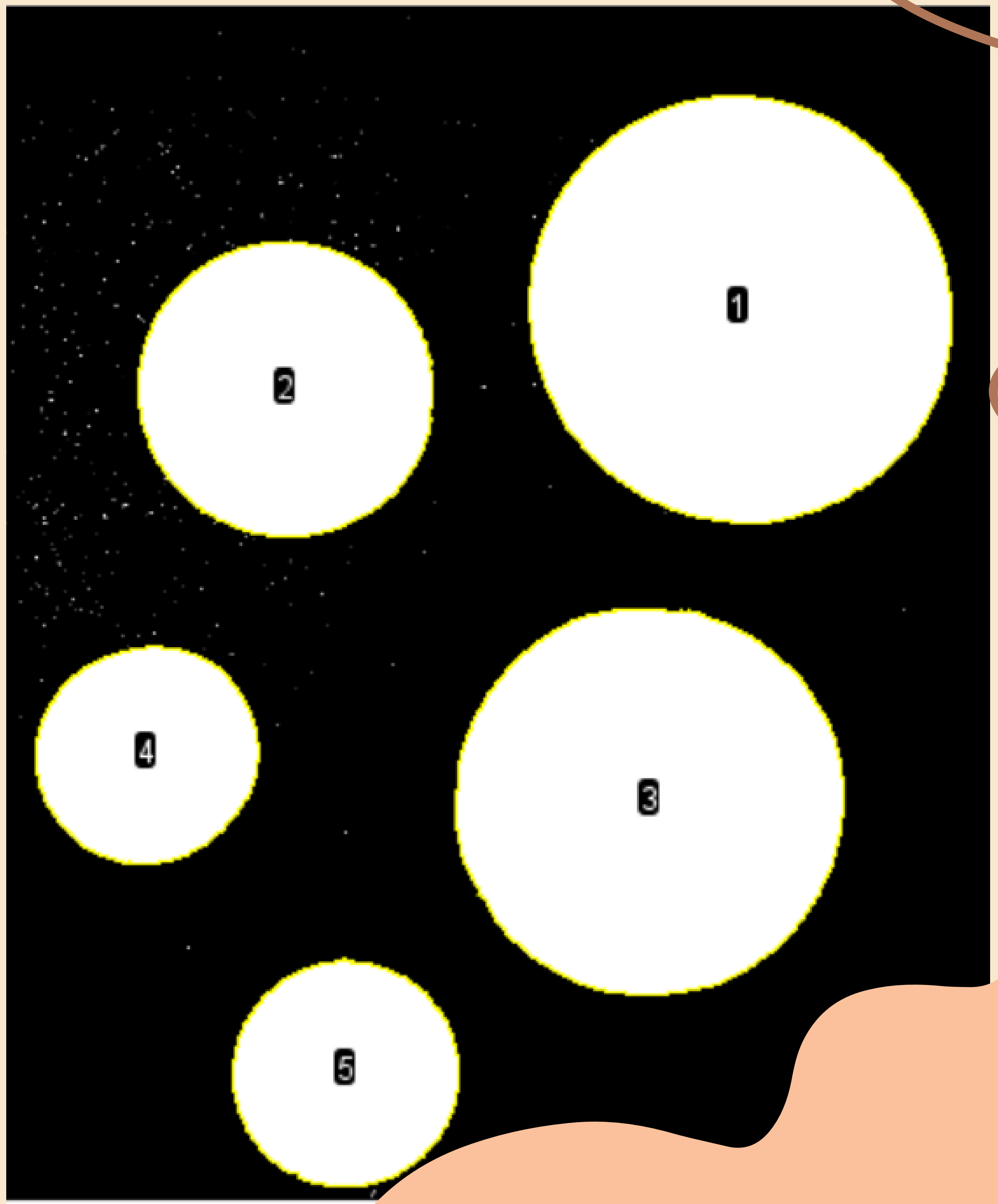
EXTRA CHALLENGE

CIRCULAR OBJECTS

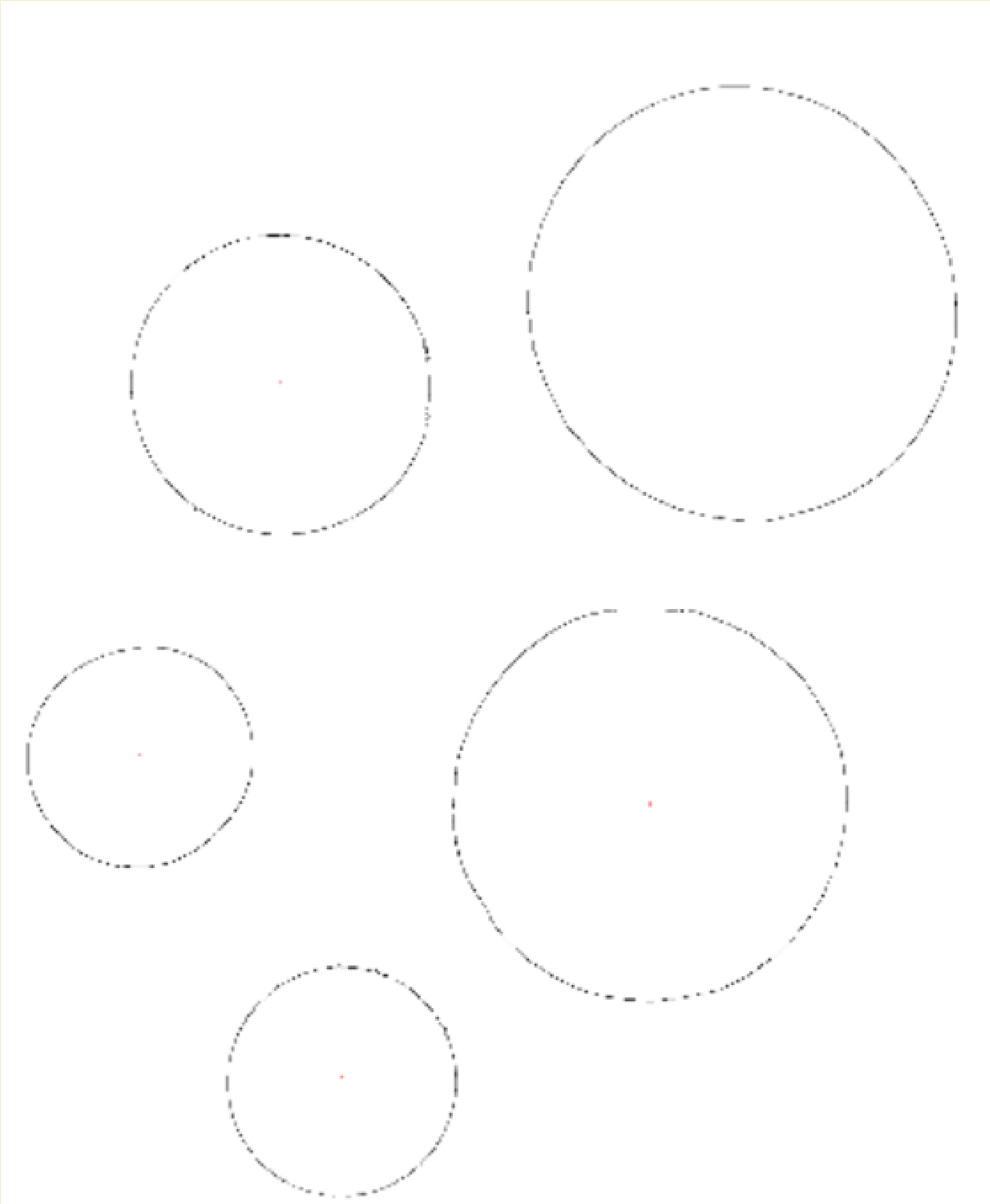
FOR THIS PART, I TRIED TO USE DIFFERENT KINDS OF TAPE. I USED THE MEASUREMENTS FOR AREA, CENTROID, FIT ELLIPSE, AND SHAPE DETECTORS.

CIRCULAR OBJECTS

I cropped out the ruler after making the scale of **80 pixels/cm**. Then, after thresholding and making some adjustments (e.g. **fill holes, dilate, and erode**), this is the final image. Notice that the image still has little dots on the background. This may be due to poor image quality. To make sure that the software disregard the small dots, I set the particle size detected to **50-infinity**. In total, there are **5 regions** corresponding to the 5 tapes that I used.



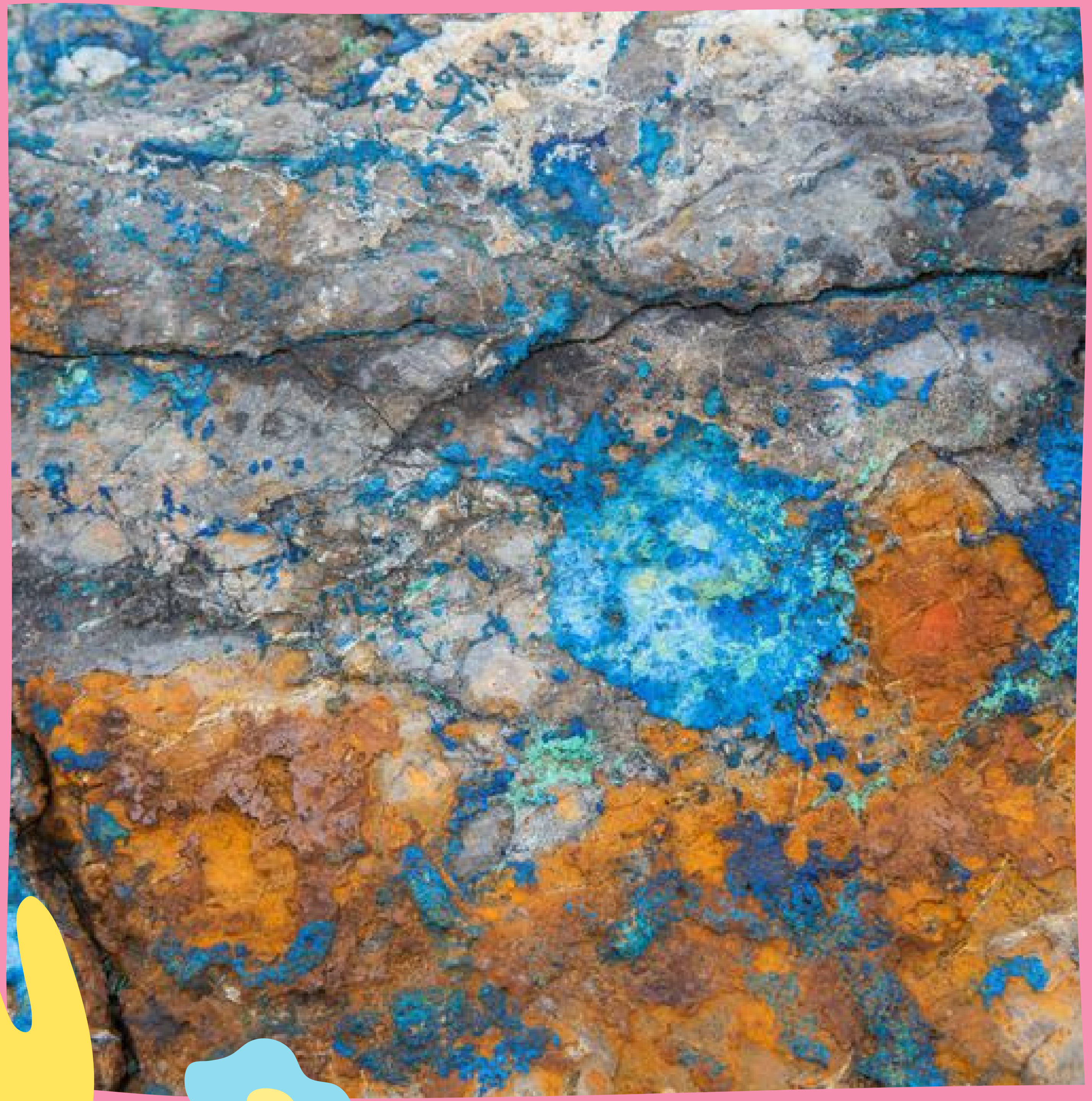
CIRCULAR OBJECTS



Slice	Count	Total Area	Average Size	%Area	Perim.	Major	Minor	Angle	Circ.	Solidity
IMG_20230425_100709.jpg	5	147.128	29.426	34.255	19.852	5.971	5.853	72.055	0.874	0.993

	Label	Area	X	Y	Perim.	Major	Minor	Angle	Circ.	AR	Round	Solidity
1	IMG_20230425_100709.jpg	51.240	14.051	5.752	26.895	8.214	7.943	125.407	0.890	1.034	0.967	0.996
2	IMG_20230425_100709.jpg	24.836	5.381	7.272	19.105	5.665	5.582	136.244	0.855	1.015	0.985	0.993
3	IMG_20230425_100709.jpg	42.880	12.312	15.131	24.771	7.396	7.382	29.511	0.878	1.002	0.998	0.994
4	IMG_20230425_100709.jpg	13.665	2.733	14.244	13.814	4.272	4.073	28.473	0.900	1.049	0.953	0.993
5	IMG_20230425_100709.jpg	14.506	6.523	20.335	14.675	4.310	4.285	40.639	0.846	1.006	0.994	0.988

These are the resulting measurements after the analysis. As we can see, the lines are still not smooth. Similar to the previous image, this may also be due to poor quality image or poor lighting.



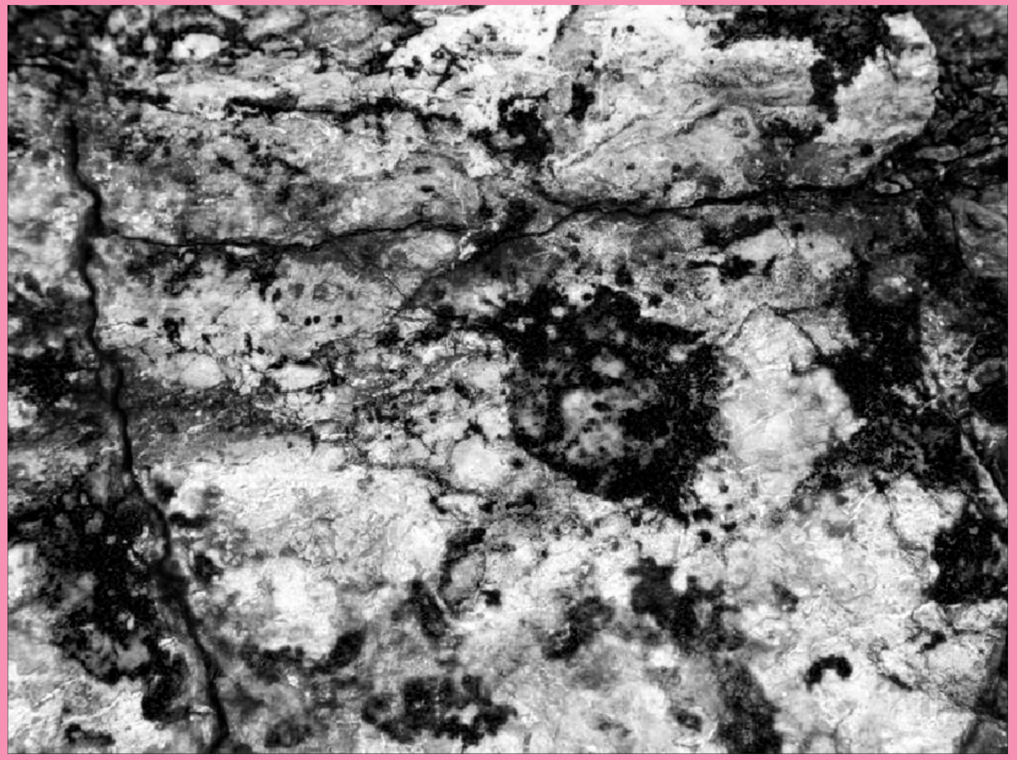
ADDITIONAL WORK

MINERALS

Feature extraction is one of the methods used in mineral segmentation. Mineral Segmentation is an important technique in geology which identifies and characterizes minerals in a certain sample.
Here is a picture of a mineral deposit that I saw online. Notice that there are red and blue deposits in the rock sample. Suppose we want to extract the feature of the blue and red mineral present in the picture. We can also use thresholding; and to do this efficiently, we can split the image into its RGB channels.

RGB CHANNELS

RED CHANNEL



BLUE CHANNEL

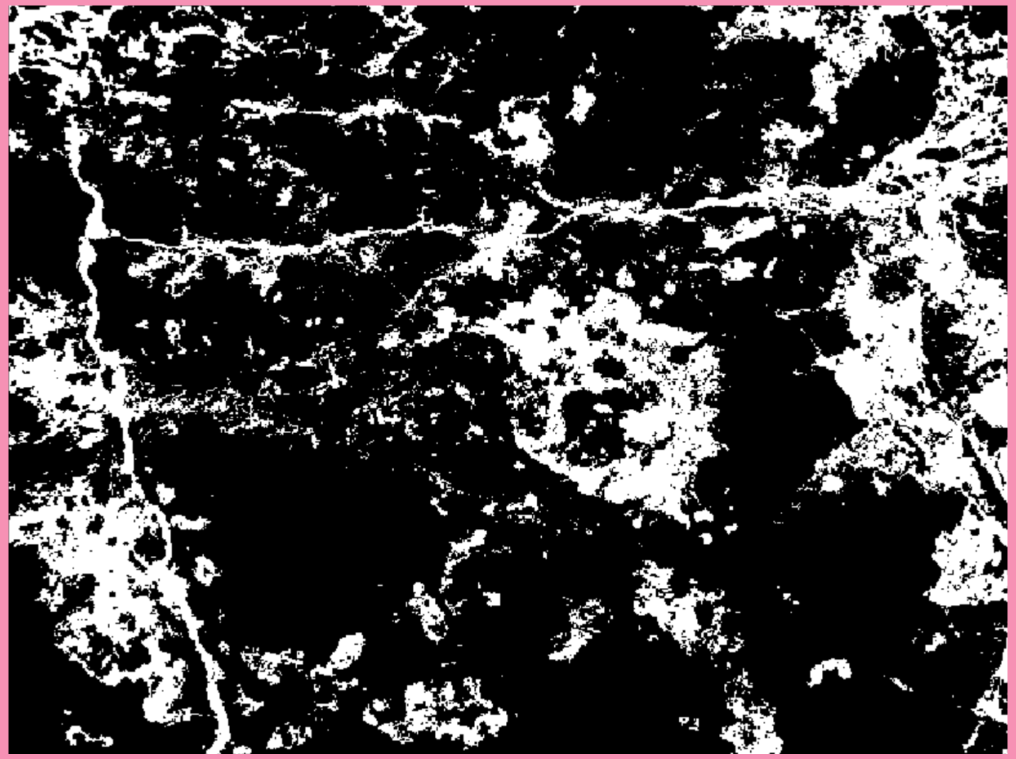
GREEN CHANNEL

Notice that there are darker and lighter spots present in the different channels. **The higher the RGB values, the lighter the spots are in the image.** For instance, in the red channel, the lighter regions have higher red values.

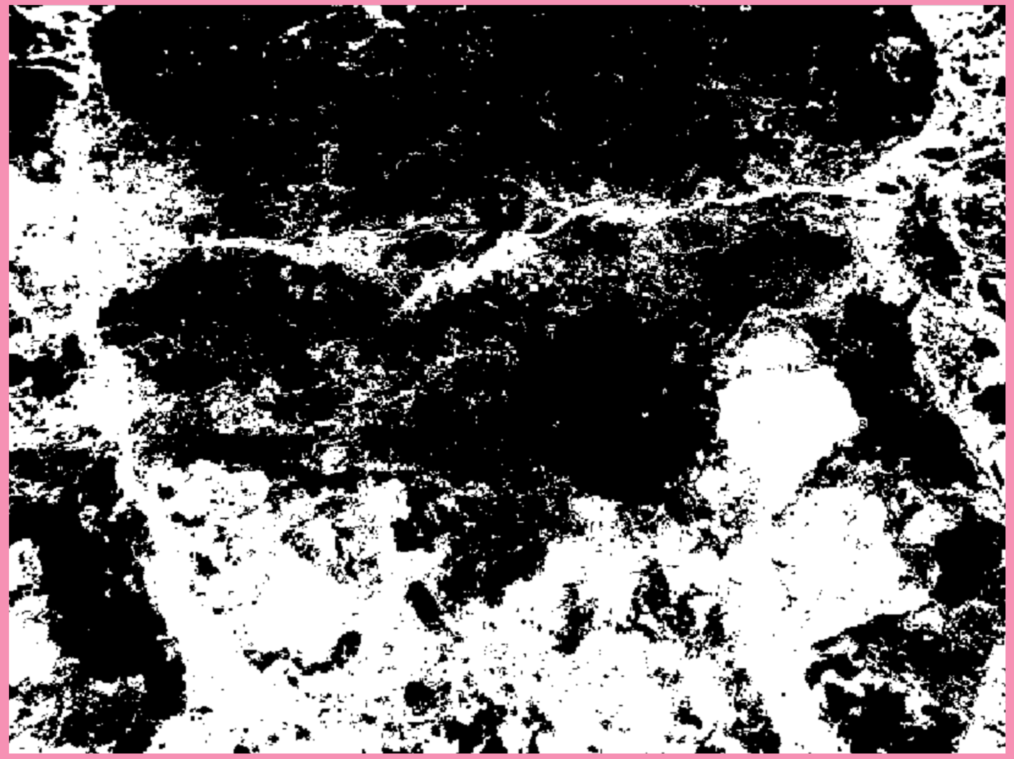
FEATURE EXTRACTION

ORIGINAL

BLUE MINERALS



RED MINERALS

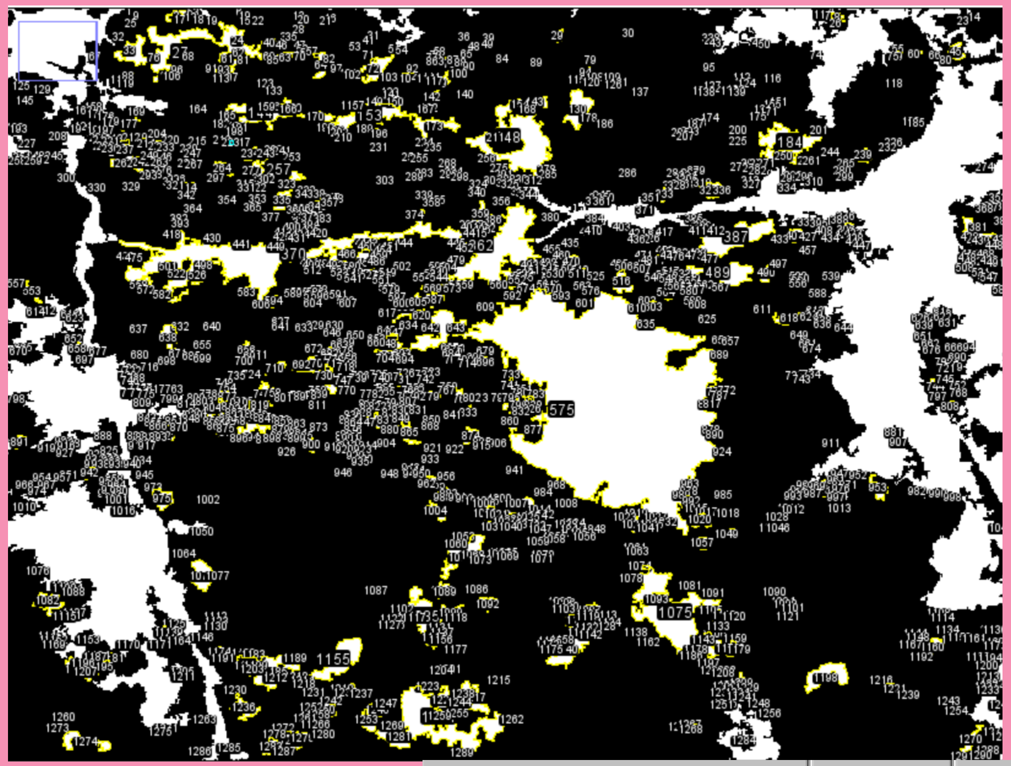


After thresholding, we get the white regions which corresponds to the red and blue minerals. For the blue minerals, I used the red channel. And for the red minerals, I used the blue channel. This is because it is easier for me to separate the darker regions than the lighter ones. This is not a perfect thresholding I know, since it also depends on the quality of the image. But with more applied techniques, we will be able to get a more defined extraction. This is just the first part.

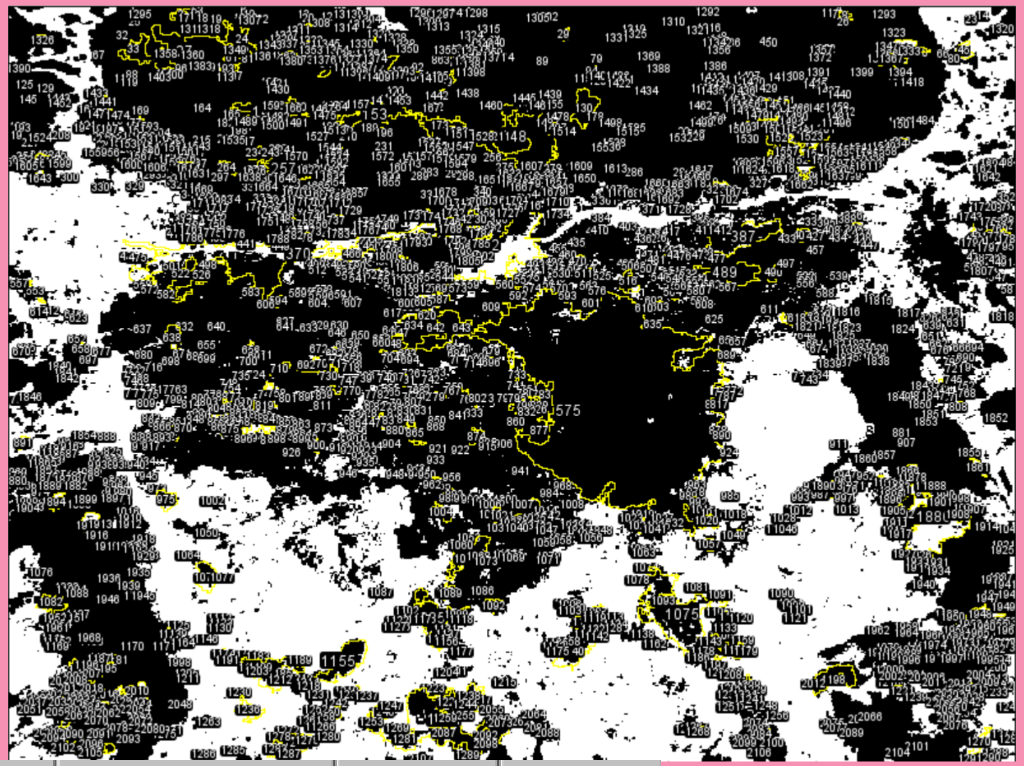
FEATURE EXTRACTION

ORIGINAL

BLUE MINERALS



RED MINERALS



Slice	Count	Total Area	Average Size	%Area	Perim.
minerals1.jpg (red)	1291	42371	32.820	11.935	15.149
minerals1.jpg (blue)	816	6110	7.488	1.721	8.732

I only set the measurements for area and perimeter. We can see that it did work for feature extraction.

REFERENCES

1. https://datagen.tech/guides/image-annotation/image-segmentation/#:~:text=Image%20segmentation%20is%20a%20method,analysis%20of%20each%20image%20segment.
2. https://www.mathworks.com/discovery/feature-extraction.html#:~:text=Feature%20extraction%20refers%20to%20the,in%20the%20original%20data%20set.
3. http://www.uoxray.uoregon.edu/local/manuals/GUM/channels.html
4. https://www.sciencedirect.com/science/article/pii/S0892687512000106

REFLECTION

Working with ImageJ at first frustrated me. I followed the steps religiously when I first tried it using the minerals image. However, I always get an error message when I try to analyze the particles. It happened for a few more times so I asked for help from my labmates on how to properly do it. Turns out the version of the ImageJ that I am using is a different version from the one in the manual. I needed to check the box with the "don't reset range" in thresholding so that the threshold values of the image would not go back to the extreme values. After a few more practice and doing it on my own, I was able to learn how to use it and obtained the results that I want.

In doing the activity, I also learned the value of a good quality image. It really affects the result of the feature extraction. Shadows can affect the thresholding and a bad contrast of the objects from the background will make it harder to separate the two.

The idea of the mineral segmentation came from Ate Grass, one of the students under Ma'am Soriano. I saw the work that she's doing with the minerals and tried if I can also replicate what she's doing using ImageJ. Turns out there's a lot more techniques to apply in order to get better results. The point here is that, ImageJ can also be applied in mineral segmentation.

Overall, I enjoyed doing the activity as it did not take much of my time. I learned how powerful ImageJ is as a tool for image processing and mastering how to use it will be a useful skill in the future.

REPORT GRADE

Criteria	Score
Technical Correctness	35
Quality of Presentation	35
Self Reflection	30
Initiative	10
TOTAL	100 (+10)

EVALUATION

Overall, I know that I have accomplished all the tasks included in this activity. Moreover, I did some extra experiments and made some comparisons in the resulting images. I also put a lot of effort in creating this presentation and cited a lot of sources for additional information in the report.