PerLeaf

Image Classification Application for Plants Leaf and its diseases

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5. Conclusion & Future work
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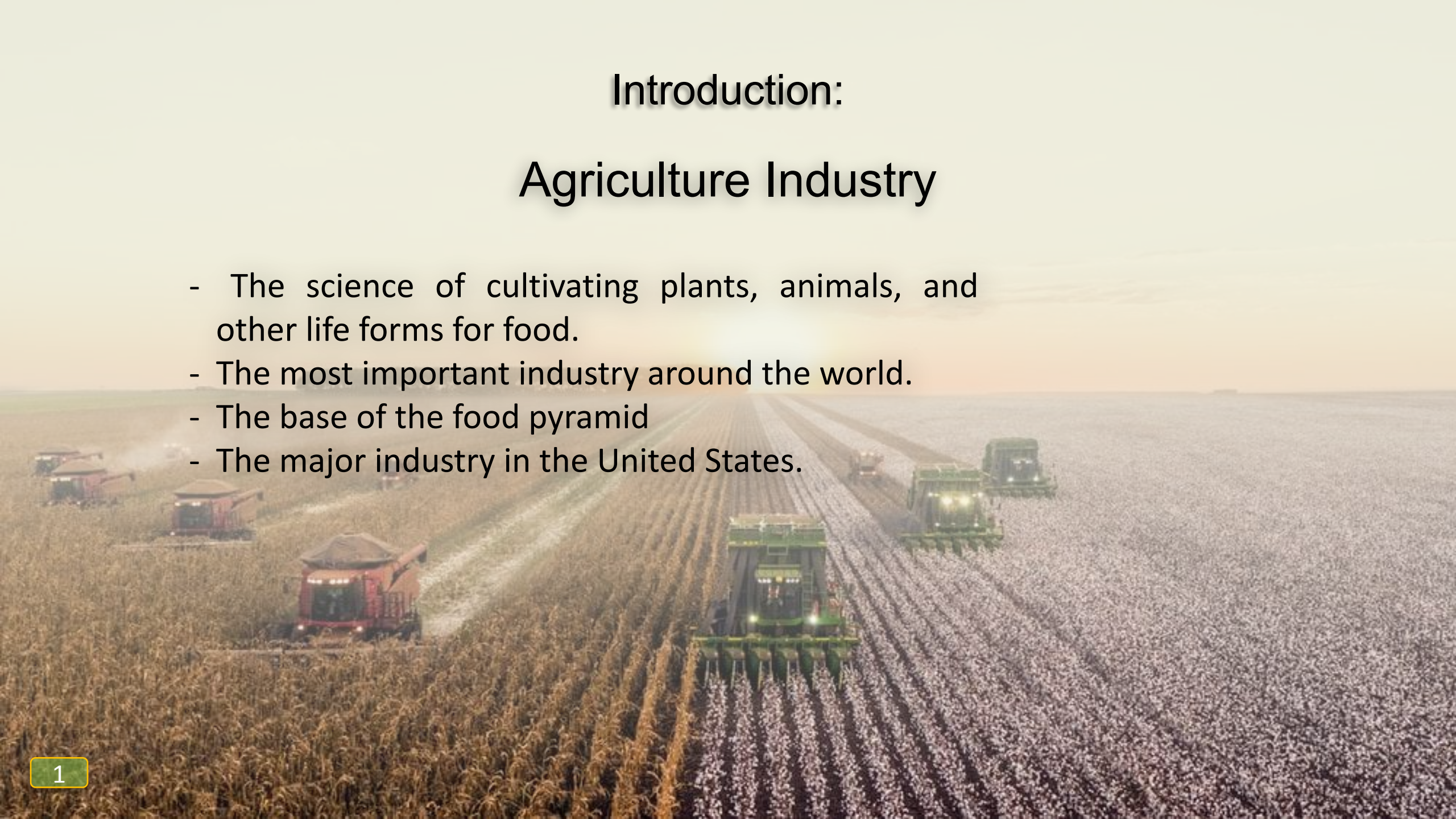
Introduction:

Agriculture Industry

- The science of cultivating plants, animals, and other life forms for food.
- The most important industry around the world.
- The base of the food pyramid
- The major industry in the United States.



Introduction:

Green Revolution

- Better Quality
- More Quantity
- Better Income
- Better Life

Problem Statement:

1. Economic losses caused by plant viruses[1]
2. Reduces global agriculture productivity by 20%-40%
3. Non-experts don't know how to deal with a plant disease
4. Asylum to experts costly on small farmer industry

[1] Purification and Phytotoxic Analysis of *Botrytis cinerea* Virulence

Plants Diseases:

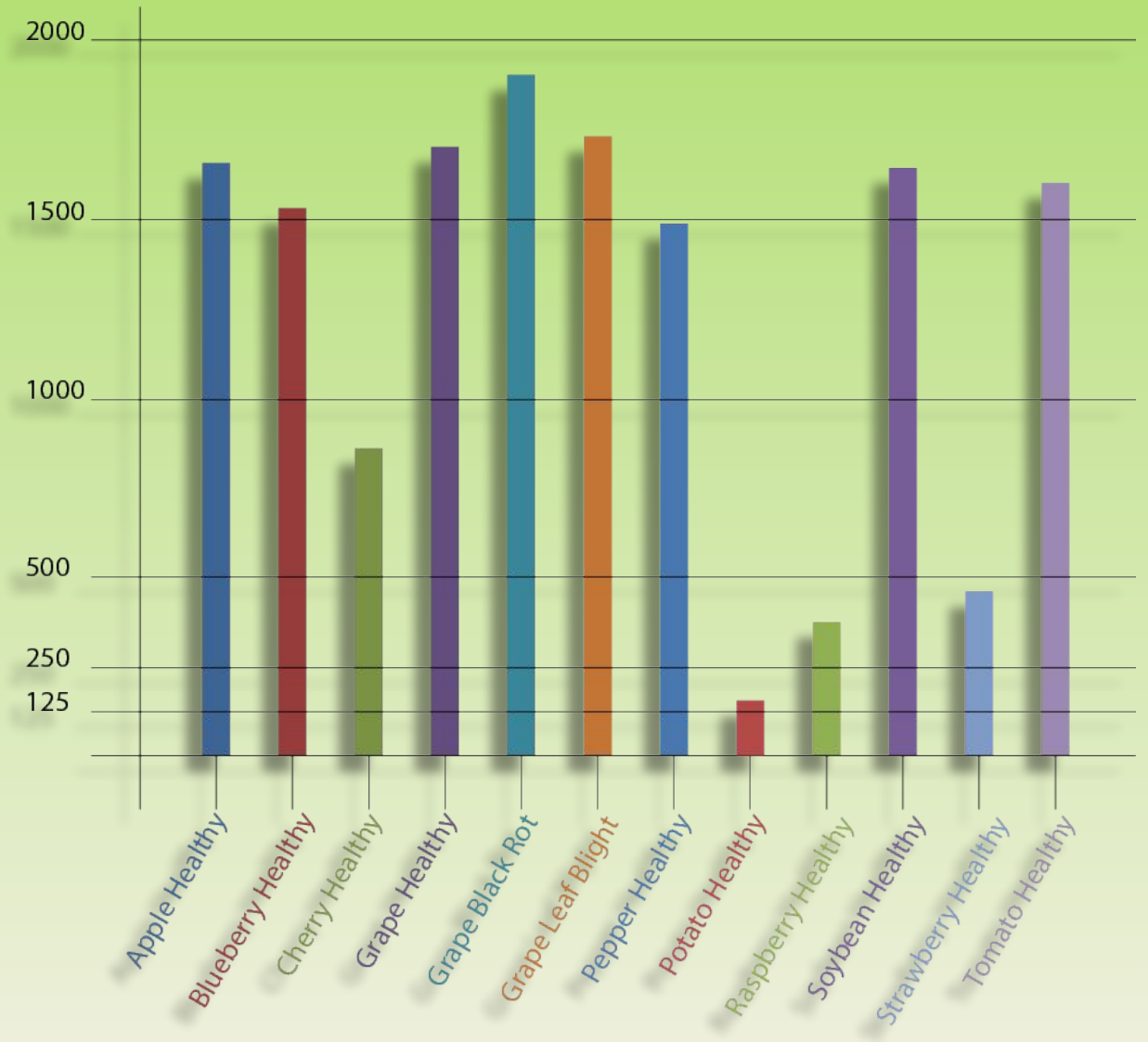
1- Grape Black rot




2- Grape Leaf blight




Image Acquisition:



Dataset Samples:


Apple


Blueberry


Cherry


Grape healthy


Grape Black rot


Grape leaf blight


Pepper


Potato


Raspberry


Soybean


Strawberry


tomato

Image Processing:

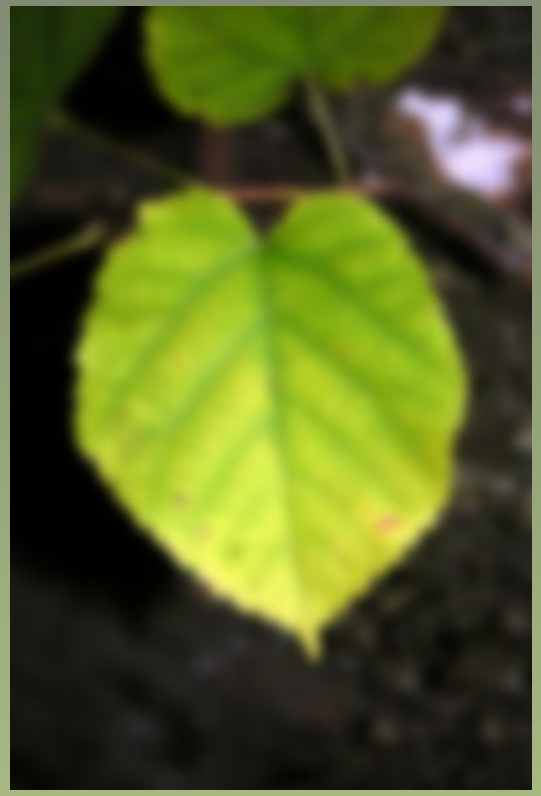
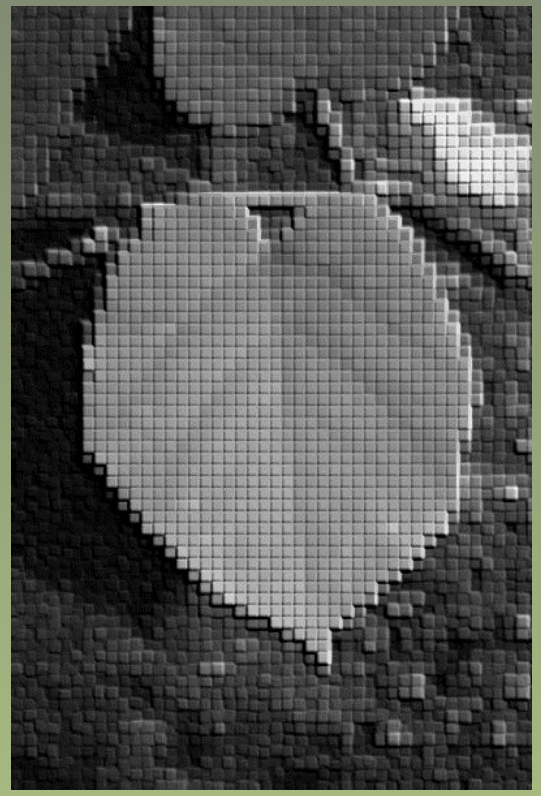





Image Processing:

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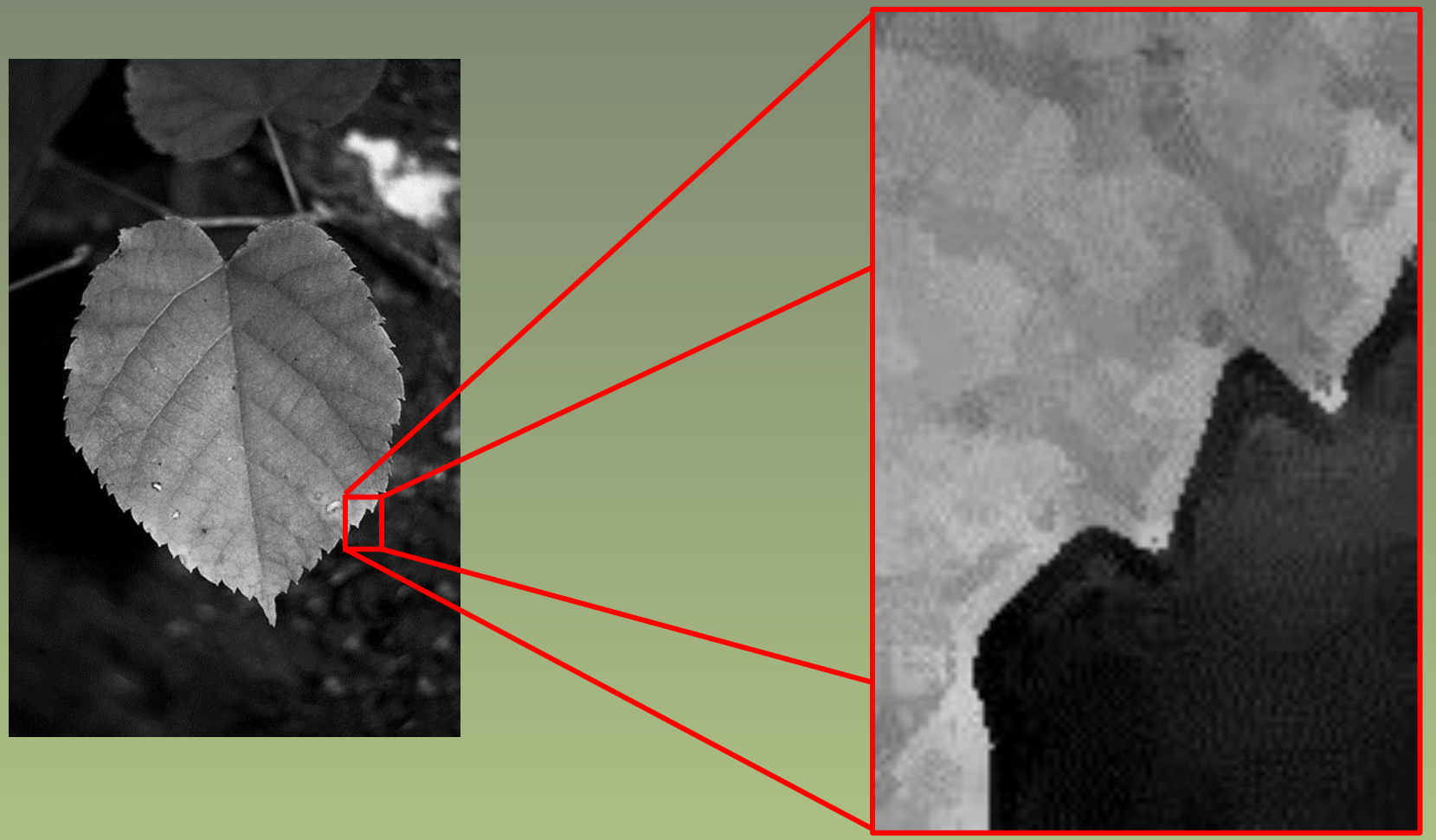


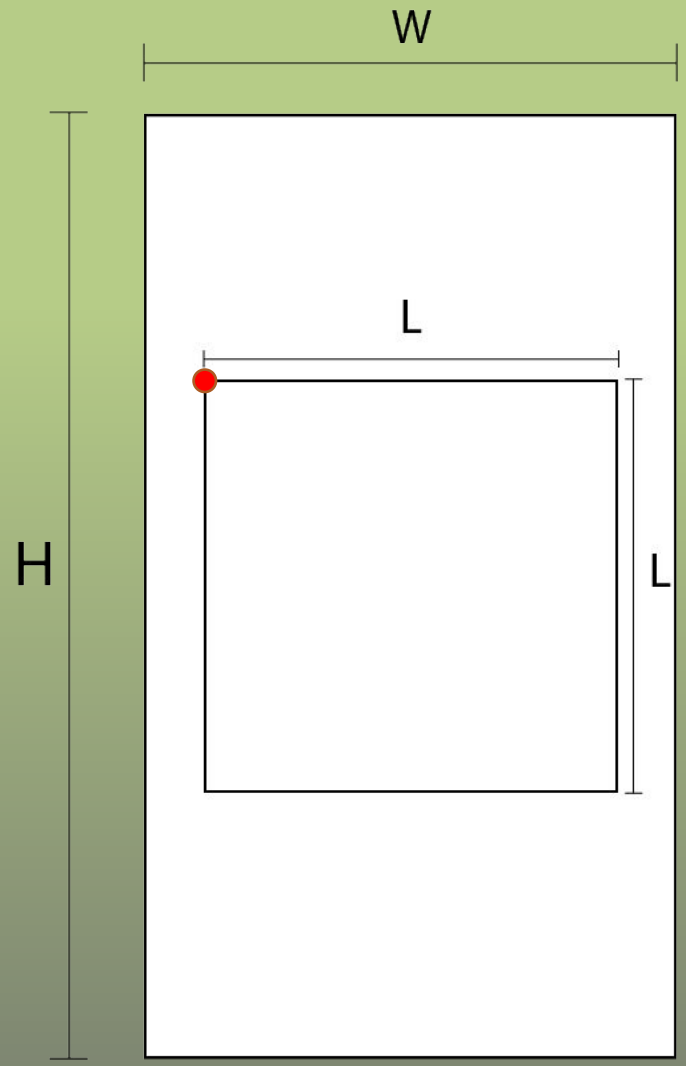
1- Image Cropping & Resizing

H: Hight, **W**: Width, **R**: aspect ratio, **C**: constant length,
L: square length, (**Px, Py**): pivot coordinates

R = W/H
C = 600
W_new = C
H_new = W_new/R
resized_image = (original_image, (W_new, H_new)

L = $W\_new \times 0.8$
Px = $(W\_new - L)/2$
Px = $(H\_new - L)/2$

cropped_resized_image = (resized_image , (Px,Py), (L, L))



2- Leaf Segmentation:

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- Shape Segmentation
- Texture Segmentation
- Color Segmentation

2- Leaf Segmentation:

- Color Segmentation:

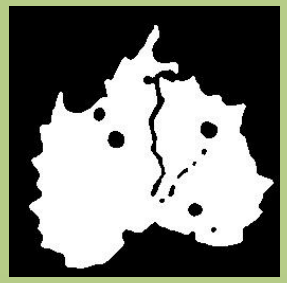
R G B
[47, 65, 23]

2- Leaf Segmentation:

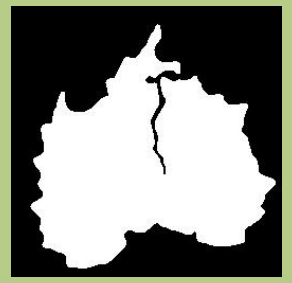
$$\text{new\_pixel\_value} = 2 \times G - R - B$$

```
If new_pixel_value > 0:
        write(new_pixel_value, seg_img);
else
        write(0, seg_img);
```

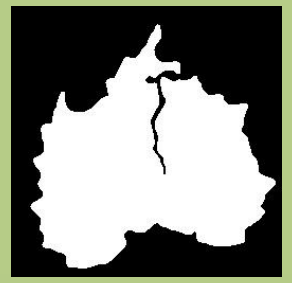
2- Leaf Segmentation:



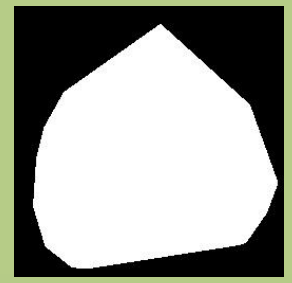
Init_mask



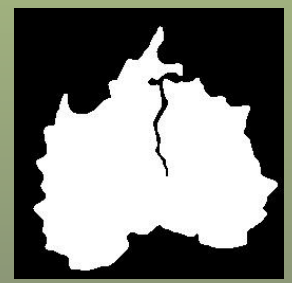
IC_mask



IC_mask_or



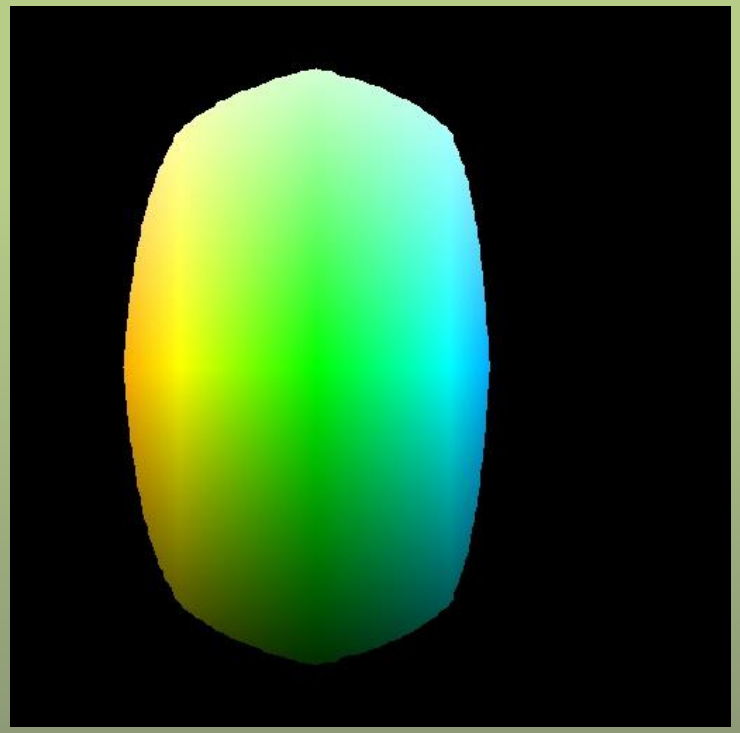
ICx_mask



ICx_mask_and

Final_mask_closing

2- Leaf Segmentation:



Feature Extraction

Objects Descriptors

How to describe our input?

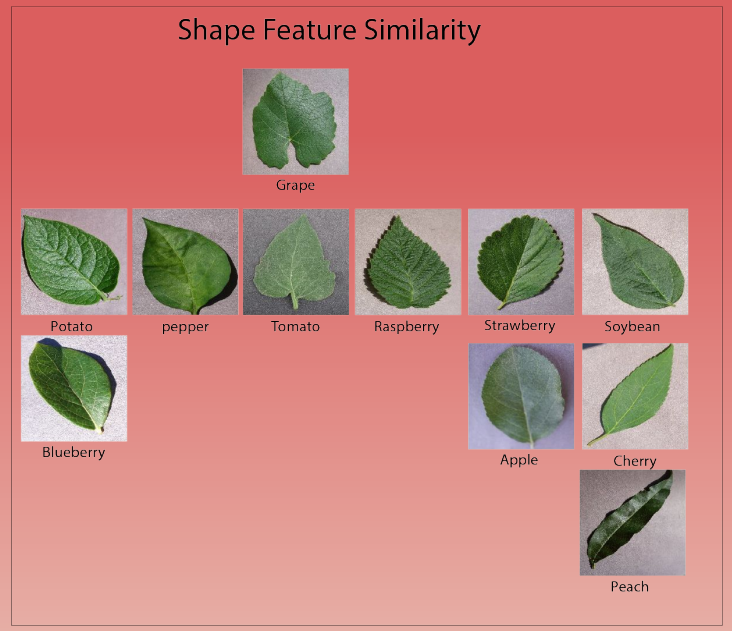
It’s a Leaf
Grape Leaf
Not Healthy
Disease Name: Black rot

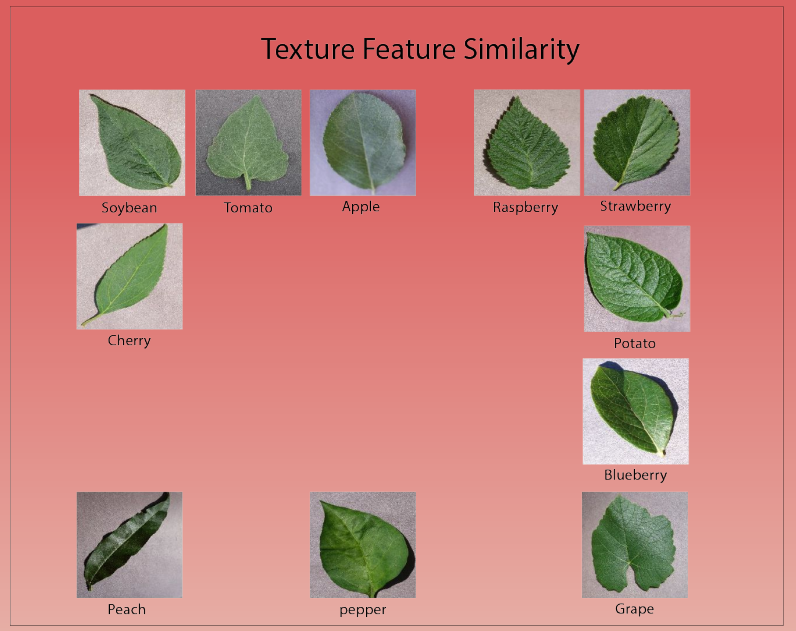
Feature Extraction

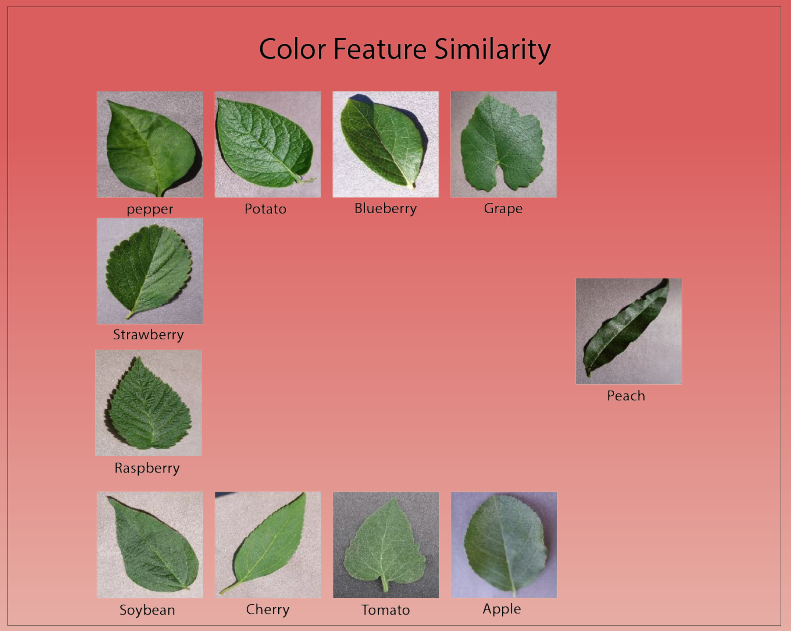
How to “Numeric” these “Descriptors?

Feature Extraction

Manual grouping







Random mess!!

Feature Extraction

Manual grouping

More Elegant!

Feature Extraction

Main Descriptors

1- Color Features

2- Texture Features

3- Shape Features

Feature Extraction

1- Color Features:

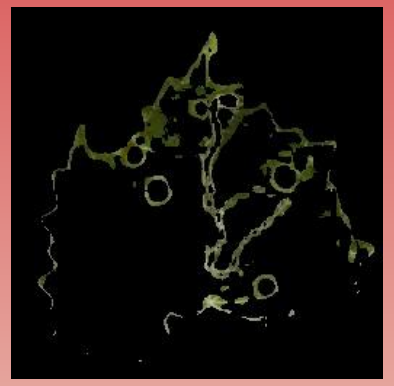
Green range:
[(35, 0, 0), (75, 255, 255)]

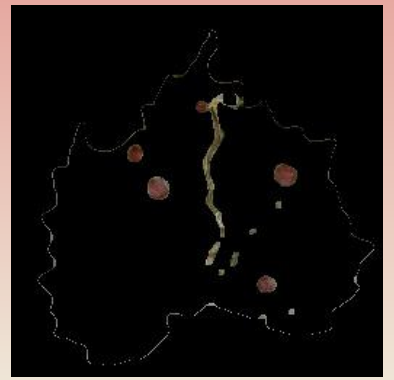
Yellow range:
[(25, 0, 0), (40, 255, 255)]

[LowerColorBoundary, UpperColorBoundary],

Feature Extraction

1- Color Features:





Feature Extraction

1- Color Features:

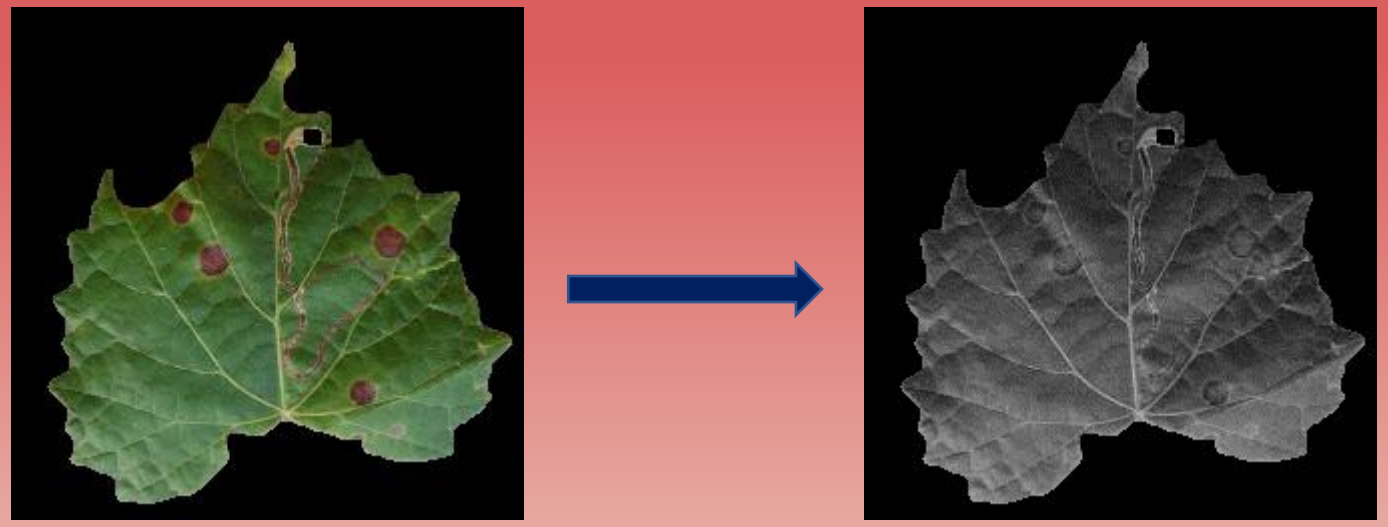
Final Output:

[green_percentage,
yellow_percentage,
nonGreen_percentage,
Mean,
variance,
standardDeviation,
skewness]

= 7 color features

Feature Extraction

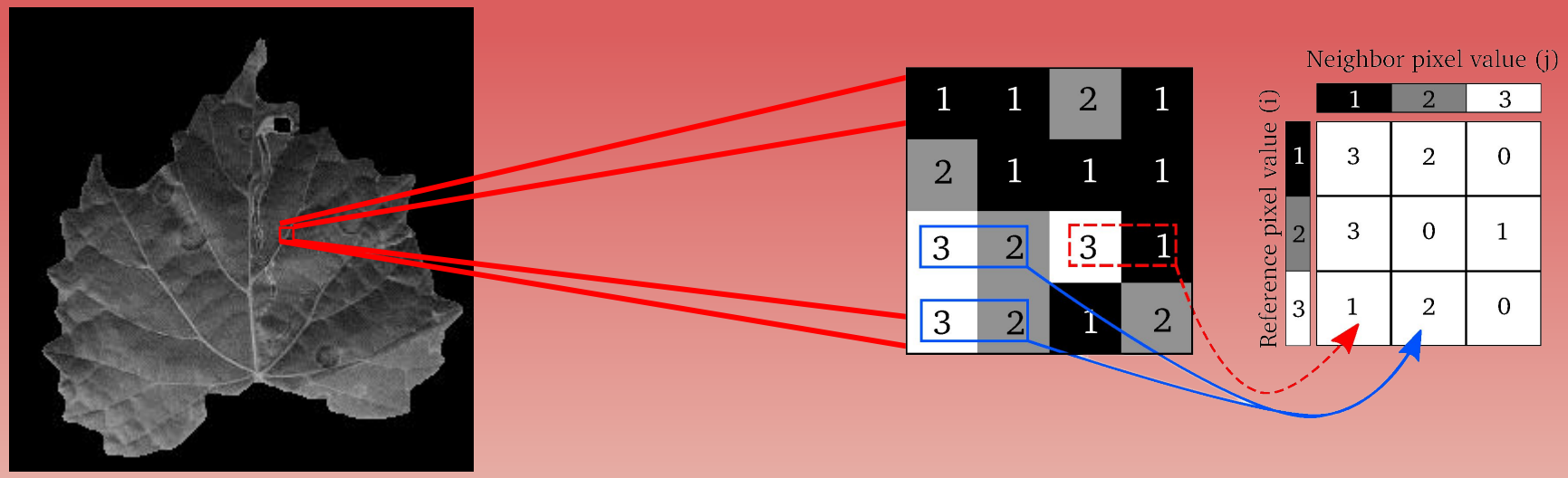
2- Texture Features:



Feature Extraction

2- Texture Features:

GLCM (Gray Level Co-occurrence Matrix)



Feature Extraction

2- Texture Features:

GLCM -> Haralick Texture Algorithm -> [0:12] Features

+

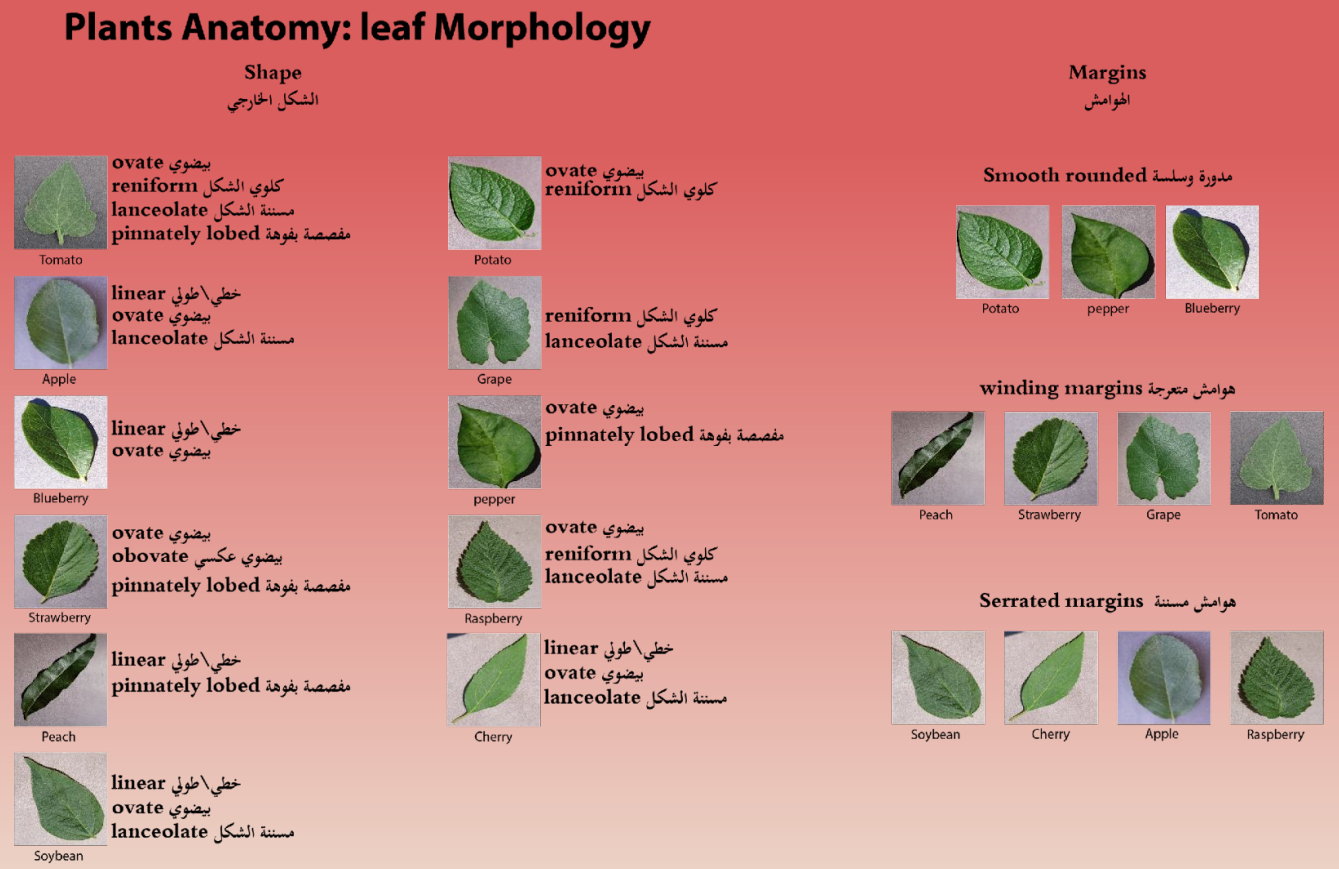
Correlation & Standard Deviation

=

[(0:12), correlation, standard_deviation] = 15 Texture feature

Feature Extraction

3- Shape Features:

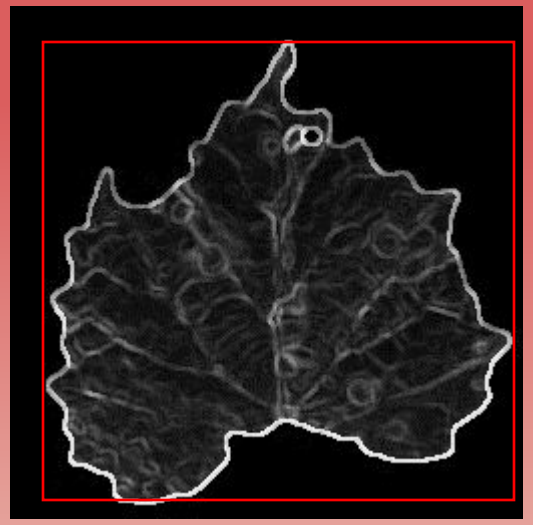


Feature Extraction

3- Shape Features:

3.1 – Eccentricity

$$E = W_{max} / H_{max}$$

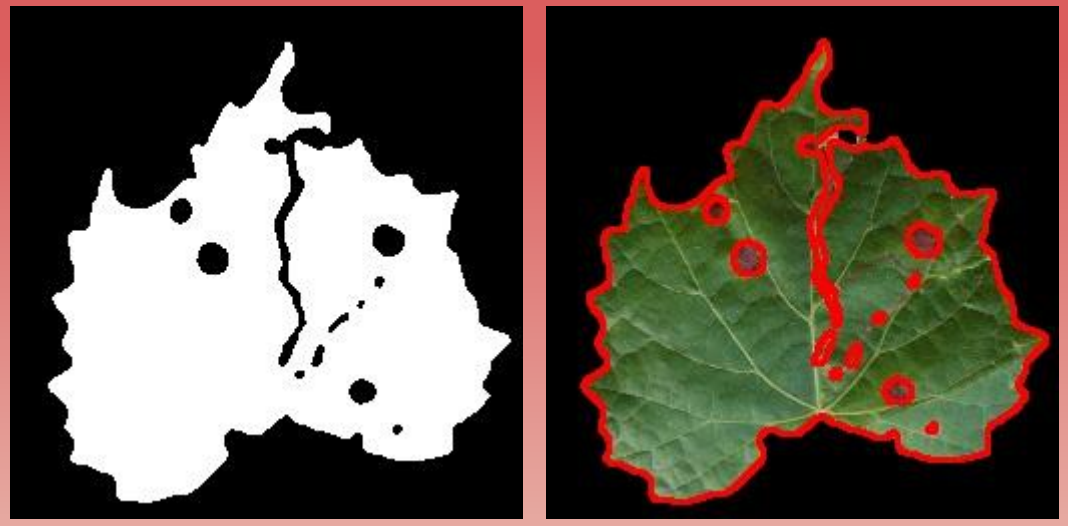


Feature Extraction

3- Shape Features:

3.1 – Eccentricity
3.2 – Euler Number

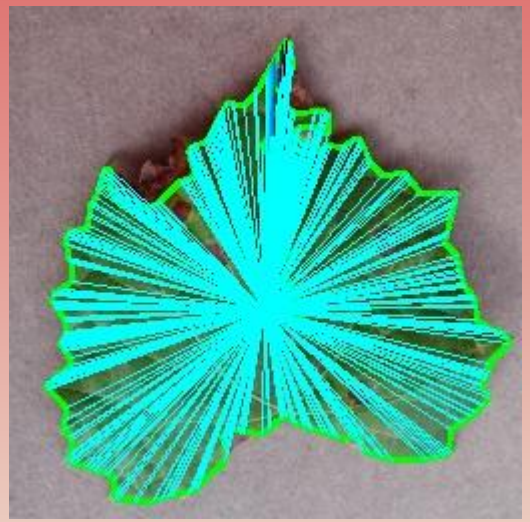
- Euler = 1 - #H
- avg_areas
- avg_areas/leaf_area

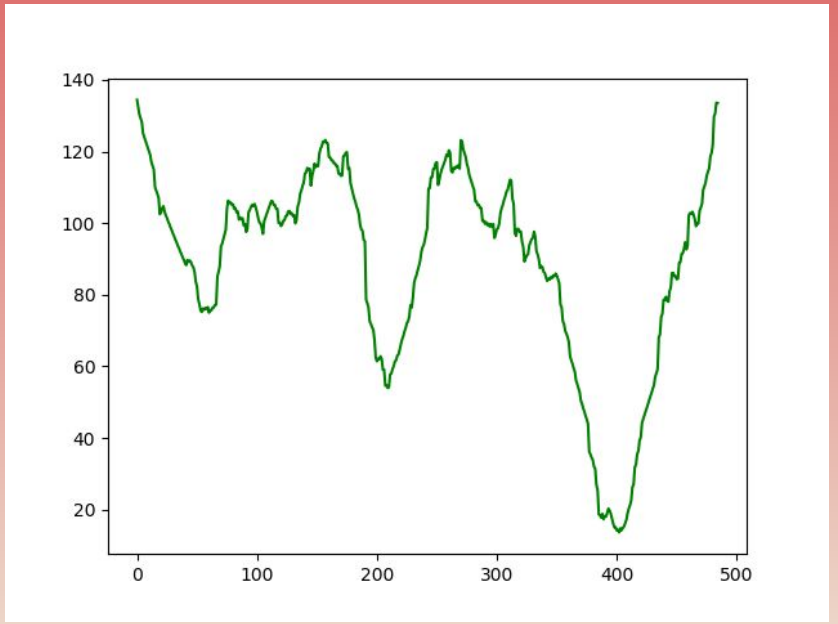


Feature Extraction

3- Shape Features:

3.1 – Eccentricity
3.2 – Euler Number
3.3 – Signature



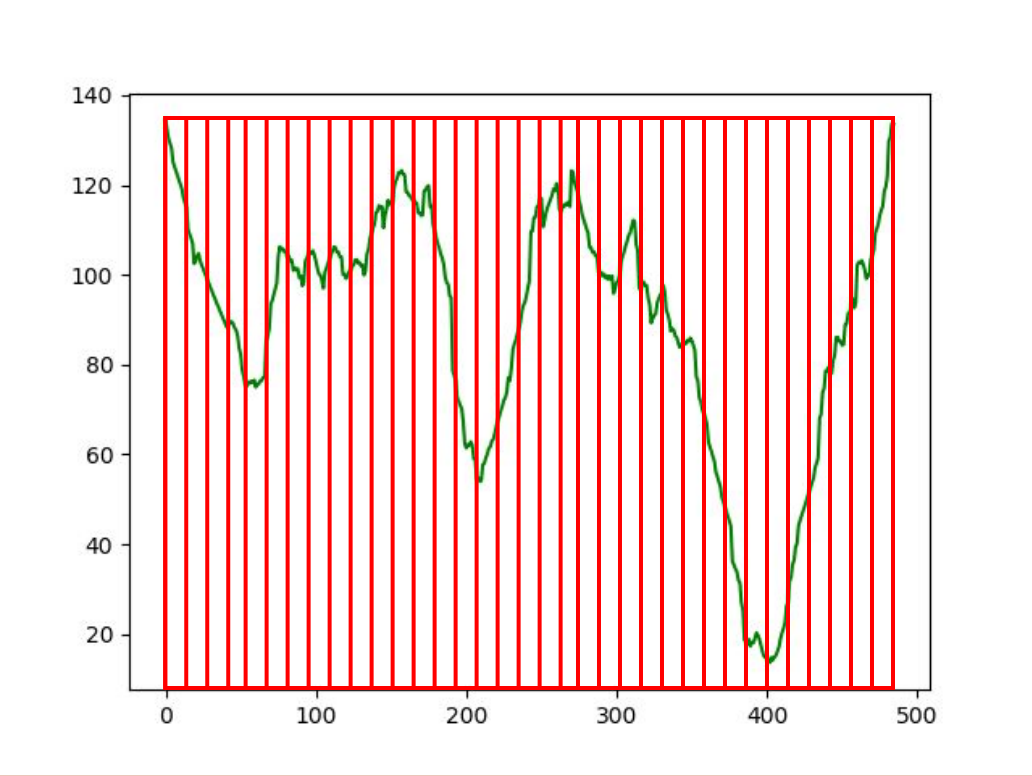


Feature Extraction

3.3 – Signature

3.3.1 – Signature Variance

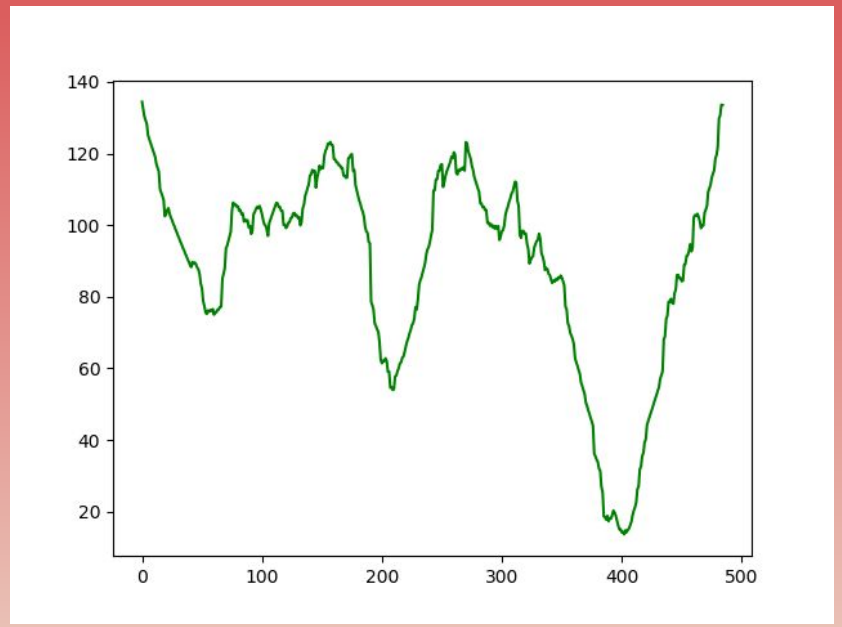
$$S\_variance = \frac{\sum segment\_variance}{\#segments}$$



Feature Extraction

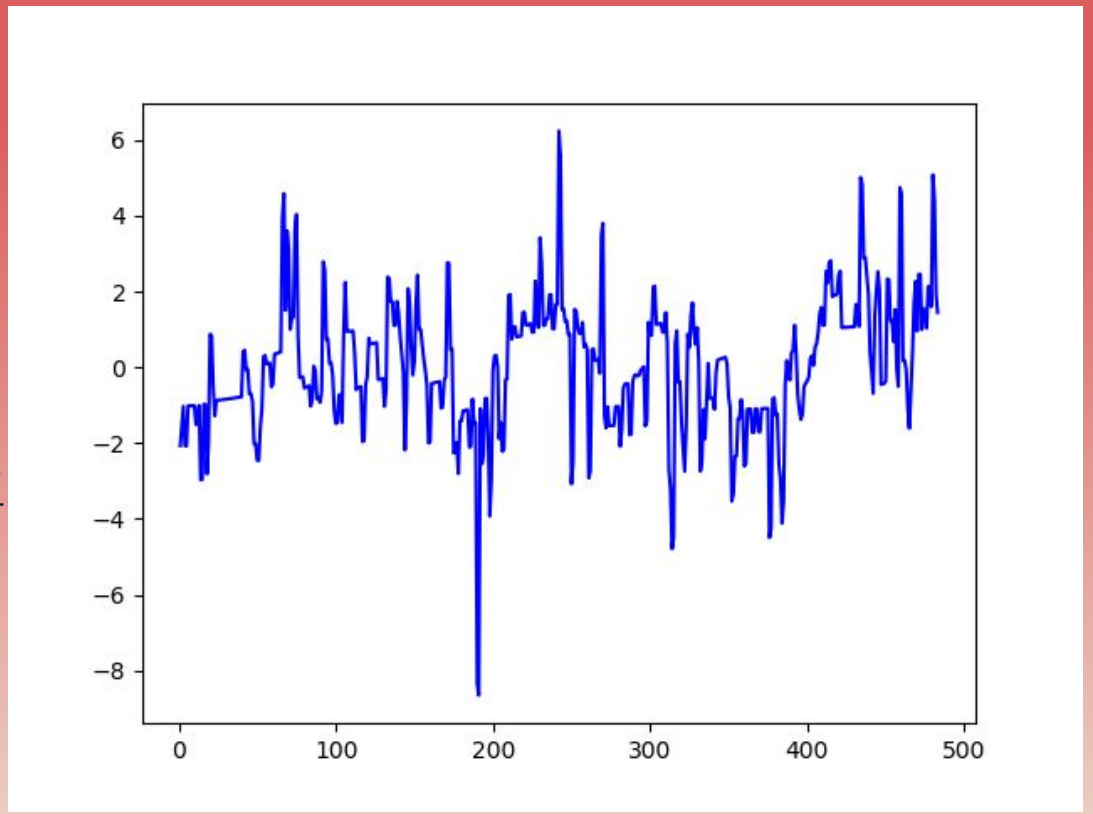
3.3 – Signature

3.3.2 – 1st Derivative



1st Derivative

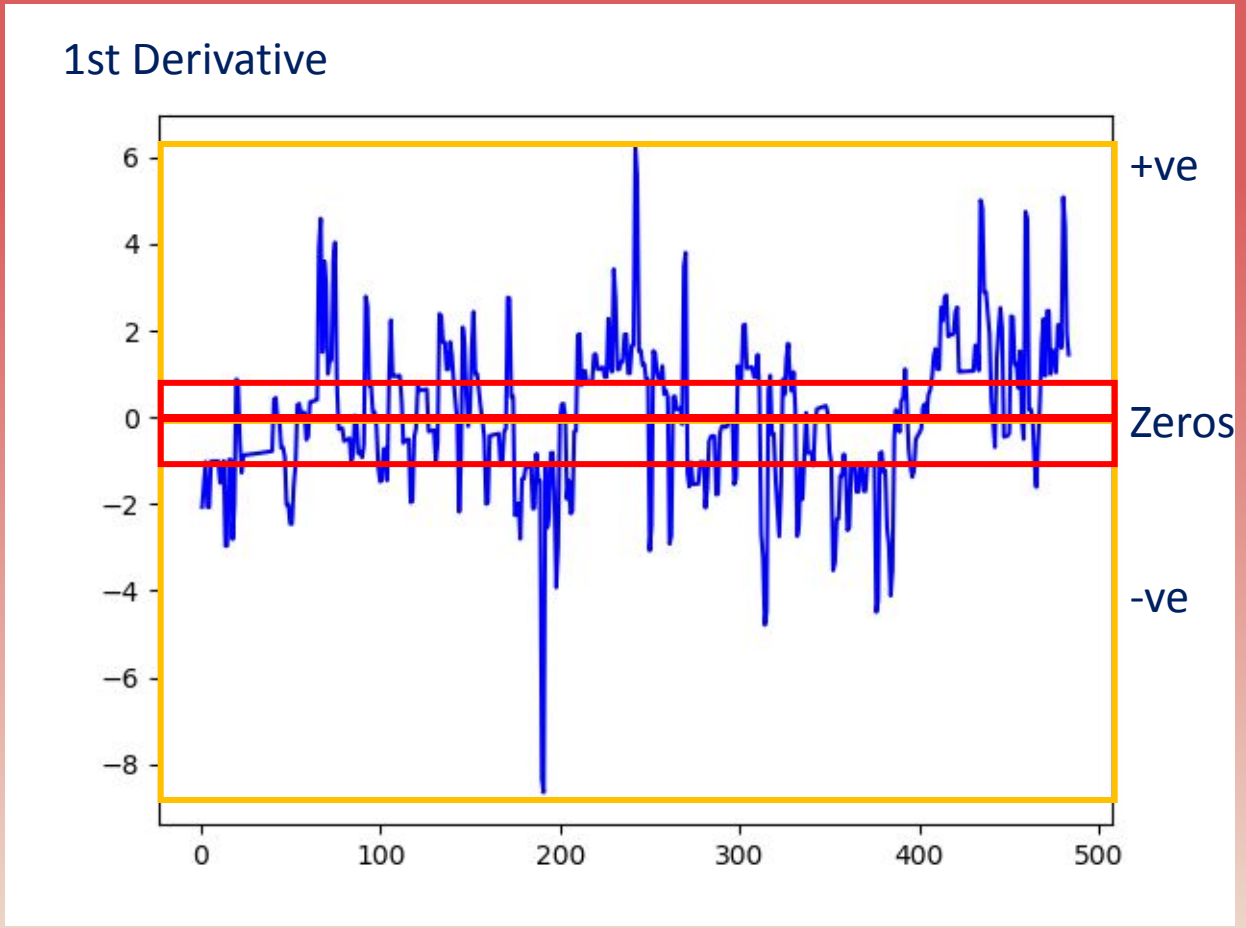
$$f1 = \frac{f(x+h) - f(x-h)}{2h}$$



Feature Extraction

3.3 – Signature

3.3.2 – 1st Derivative



Feature Extraction

3.3 – Signature

3.3.2 – 1st Derivative

- **# of corners** = # of zero values (include the margin of threshold)
- **Corners_percentage** = # of corners / # of points
- **Curvature** = (∑nonZerosV alues) / (∑signatureV alues)

Feature Extraction

3- Shape Features:

3.1 – Eccentricity
3.2 – Euler Number
3.3 – Signature
3.4 – other shape equations:

AspectRation(Aspect), Compactness(C), Roundness(R), Roughness(G), Elongation(E), Solidity(S)

$$Aspect = rotated\_rectangle\_width / rotated\_rectangle\_lenght$$

$$C = A^2 / (2\pi \times \sqrt{minRectLenght^2 + minRectWidth^2})$$

$$R = 4 \times \pi \times A / HP^2$$

$$G = HP / P$$

$$E = minRectLength / P$$

$$S = A / HA$$

Feature Extraction

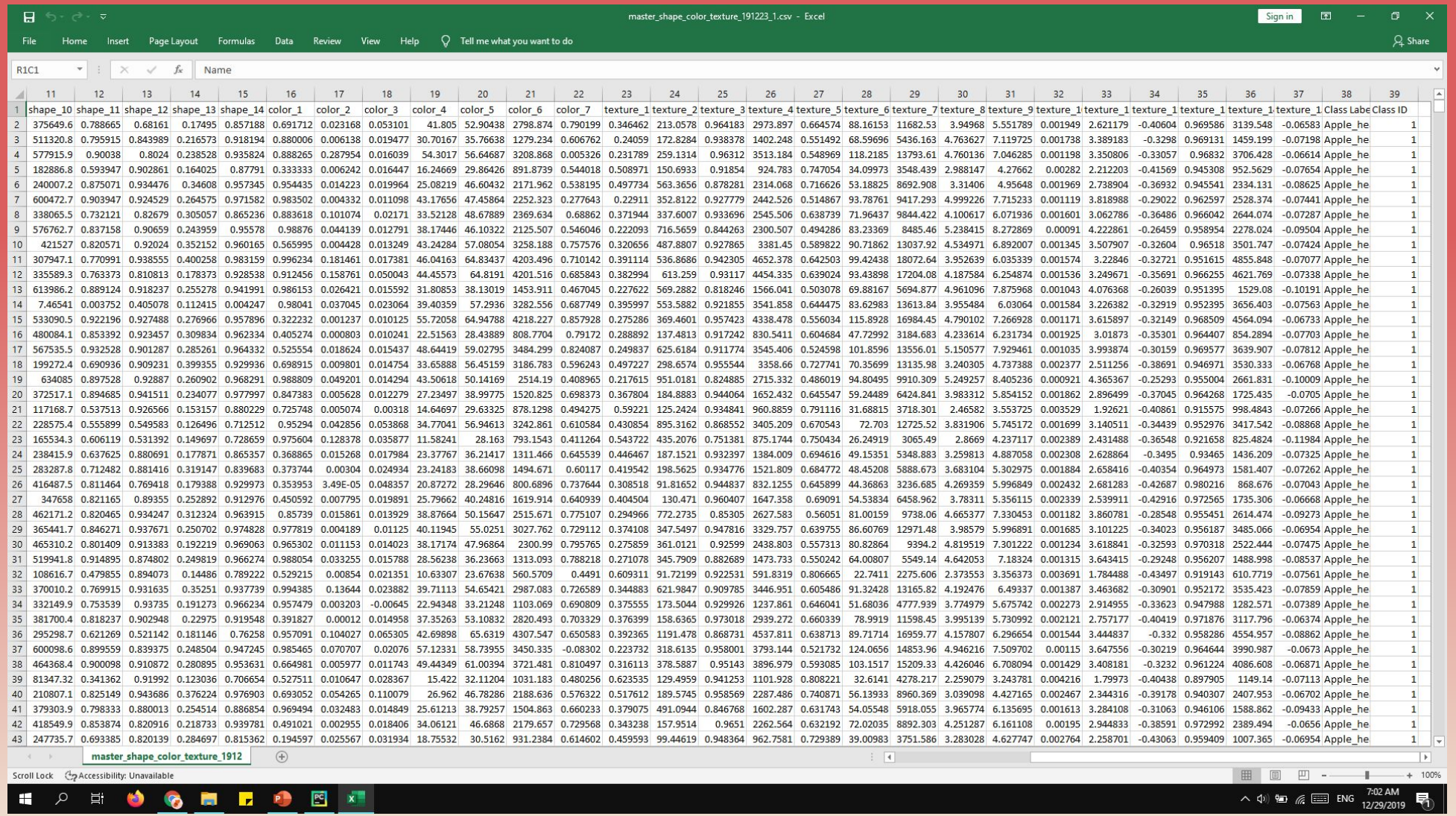
3- Shape Features:

Final Output:

[holes_number, holes_meanArea, cntHoles_Area, Eccentricity, Signature_variances_mean, Signature_corners_percent, Signature_Curvature, num_corners, Aspect, C, R, G, E, S]

= 14 shape features

Feature Extraction

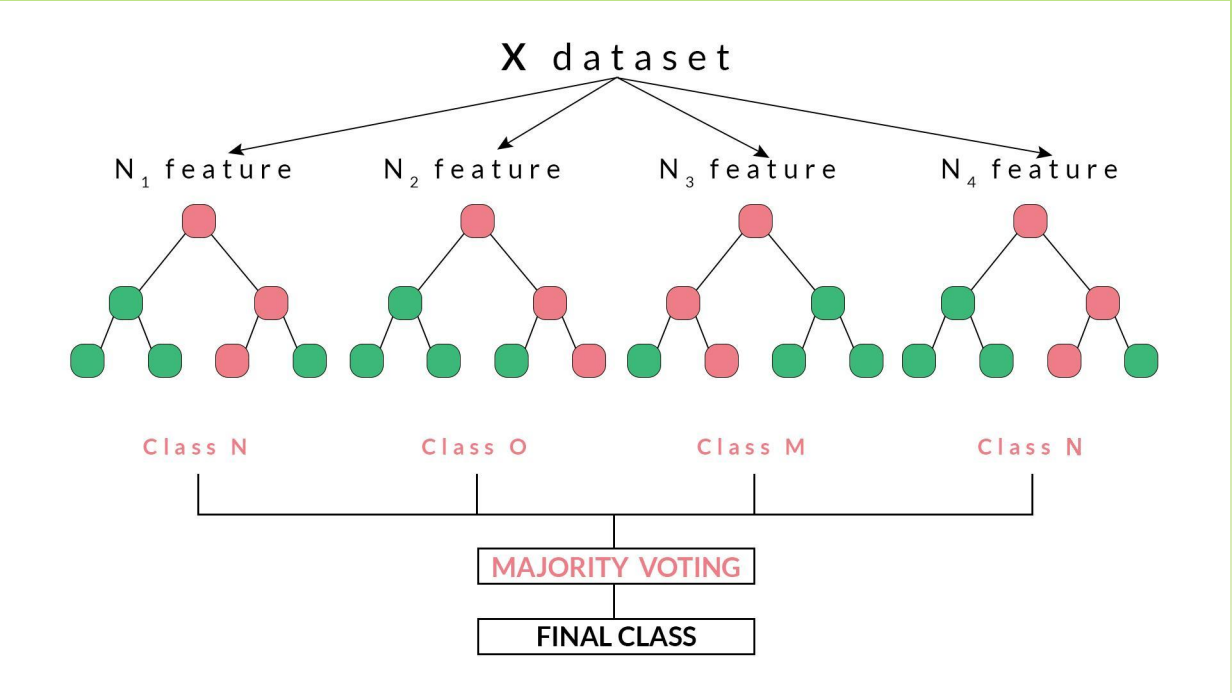


master_shape_color_texture_191223_1.csv - Excel

	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1	shape_10	shape_11	shape_12	shape_13	shape_14	color_1	color_2	color_3	color_4	color_5	color_6	color_7	texture_1	texture_2	texture_3	texture_4	texture_5	texture_6	texture_7	texture_8	texture_9	texture_1	texture_1	texture_1	texture_1	texture_1	texture_1	Class Labe	Class ID
2	375649.6	0.788665	0.68161	0.17495	0.857188	0.691712	0.023168	0.053101	41.805	52.90438	2798.874	0.790199	0.346462	213.0578	0.964183	2973.897	0.664574	88.16153	11682.53	3.94968	5.551789	0.001949	2.621179	-0.40604	0.969586	3139.548	-0.06583	Apple_he	1
3	511320.8	0.795915	0.843989	0.216573	0.918194	0.880006	0.006138	0.019477	30.70167	35.76638	1279.234	0.606762	0.24059	172.8284	0.938378	1402.248	0.551492	68.59696	5436.163	4.763627	7.119725	0.001738	3.389183	-0.3298	0.969131	1459.199	-0.07198	Apple_he	1
4	577915.9	0.90038	0.8024	0.238528	0.935824	0.888265	0.287954	0.016039	54.3017	56.64687	3208.868	0.005326	0.231789	259.1314	0.96312	3513.184	0.548969	118.2185	13793.61	4.760136	7.046285	0.001198	3.350806	-0.33057	0.96832	3706.428	-0.06614	Apple_he	1
5	182886.8	0.593947	0.902861	0.164025	0.87791	0.333333	0.006242	0.016447	16.24669	29.86426	891.8739	0.544018	0.508971	150.6933	0.91854	924.783	0.747054	34.09973	3548.439	2.988147	4.27662	0.00282	2.212203	-0.41569	0.945308	952.5629	-0.07654	Apple_he	1
6	240007.2	0.875071	0.934476	0.34608	0.957345	0.954435	0.014223	0.019964	25.08219	46.60432	2171.962	0.538195	0.497734	563.3656	0.878281	2314.068	0.716626	53.18825	8692.908	3.31406	4.95648	0.001969	2.738904	-0.36932	0.945541	2334.131	-0.08625	Apple_he	1
7	600472.7	0.903947	0.924529	0.264575	0.971582	0.983502	0.004332	0.011098	43.17656	47.45864	2252.323	0.277643	0.22911	352.8122	0.927779	2442.526	0.514867	93.78761	9417.293	4.999226	7.715233	0.001119	3.818988	-0.29022	0.962597	2528.374	-0.07441	Apple_he	1
8	338065.5	0.732121	0.82679	0.305057	0.865236	0.883618	0.101074	0.02171	33.52128	48.67889	2369.634	0.68862	0.371944	337.6007	0.933696	2545.506	0.638739	71.96437	9844.422	4.100617	6.071936	0.001601	3.062786	-0.36486	0.966042	2644.074	-0.07287	Apple_he	1
9	576762.7	0.837158	0.90659	0.243959	0.95578	0.98876	0.044139	0.012791	38.17446	46.10322	2125.507	0.546046	0.222093	716.5659	0.844263	2300.507	0.494286	83.23369	8485.46	5.238415	8.272869	0.00091	4.222861	-0.26459	0.958954	2278.024	-0.09504	Apple_he	1
10	421527	0.820571	0.92024	0.352152	0.960165	0.565995	0.004428	0.013249	43.24284	57.08054	3258.188	0.757576	0.320656	487.8807	0.927865	3381.45	0.589822	90.71862	13037.92	4.534971	6.892007	0.001345	3.507907	-0.32604	0.96518	3501.747	-0.07424	Apple_he	1
11	307947.1	0.770991	0.938555	0.400258	0.983159	0.996234	0.181461	0.017381	46.04163	64.83437	4203.496	0.710142	0.391114	536.8686	0.942305	4652.378	0.642503	99.42438	18072.64	3.952639	6.035339	0.001574	3.22846	-0.32721	0.951615	4855.848	-0.07077	Apple_he	1
12	335589.3	0.763373	0.810813	0.178373	0.928538	0.912456	0.158761	0.050043	44.45573	64.8191	4201.516	0.685843	0.382994	613.259	0.93117	4454.335	0.639024	93.43898	17204.08	4.187584	6.254874	0.001536	3.249671	-0.35691	0.966255	4621.769	-0.07338	Apple_he	1
13	613986.2	0.889124	0.918237	0.255278	0.941991	0.986153	0.026421	0.015592	31.80853	38.13019	1453.911	0.467045	0.227622	569.2882	0.818246	1566.041	0.503078	69.88167	5694.877	4.961096	7.875968	0.001043	4.076368	-0.26039	0.951395	1529.08	-0.10191	Apple_he	1
14	7.46541	0.003752	0.405078	0.112415	0.004247	0.98041	0.037045	0.023064	39.40359	57.2936	3282.556	0.687749	0.395997	553.5882	0.921855	3541.858	0.644475	83.62983	13613.84	3.955484	6.03064	0.001584	3.226382	-0.32919	0.952395	3656.403	-0.07563	Apple_he	1
15	533090.5	0.922196	0.927488	0.276966	0.957896	0.322232	0.001237	0.010125	55.72058	64.94788	4218.227	0.857928	0.275286	369.4601	0.957423	4338.478	0.556034	115.8928	16984.45	4.790102	7.266928	0.001171	3.615897	-0.32149	0.968509	4564.094	-0.06733	Apple_he	1
16	480084.1	0.853392	0.923457	0.309834	0.962334	0.405274	0.000803	0.010241	22.51563	28.43889	808.7704	0.79172	0.288892	137.4813	0.917242	830.5411	0.604684	47.72992	3184.683	4.233614	6.231734	0.001925	3.01873	-0.35301	0.964407	854.2894	-0.07703	Apple_he	1
17	567535.5	0.932528	0.901287	0.285261	0.964332	0.525554	0.018624	0.015437	48.64419	59.02795	3484.299	0.824087	0.249837	625.6184	0.911774	3545.406	0.524598	101.8596	13556.01	5.150577	7.929461	0.001035	3.993874	-0.30159	0.969577	3639.907	-0.07812	Apple_he	1
18	199272.4	0.690936	0.909231	0.399355	0.929936	0.698915	0.009801	0.014754	33.65888	56.45159	3186.783	0.596243	0.497227	298.6574	0.955544	3358.66	0.727741	70.35699	13135.98	3.240305	4.737388	0.002377	2.511256	-0.38691	0.946971	3530.333	-0.06768	Apple_he	1
19	634085	0.897528	0.92887	0.260902	0.968291	0.988809	0.049201	0.014294	43.50618	50.14169	2514.19	0.408965	0.217615	951.0181	0.824885	2715.332	0.486019	94.80495	9910.309	5.249257	8.405236	0.000921	4.365367	-0.25293	0.955004	2661.831	-0.10009	Apple_he	1
20	372517.1	0.894685	0.941511	0.234077	0.977997	0.847383	0.005628	0.012279	27.23497	38.99775	1520.825	0.698373	0.367804	184.8883	0.944064	1652.432	0.645547	59.24489	6424.841	3.983312	5.854152	0.001862	2.896499	-0.37045	0.964268	1725.435	-0.0705	Apple_he	1
21	117168.7	0.537513	0.926566	0.153157	0.880229	0.725748	0.005074	0.00318	14.64697	29.63325	878.1298	0.494275	0.59221	125.2424	0.934841	960.8859	0.791116	31.68815	3718.301	2.46582	3.553725	0.003529	1.92621	-0.40861	0.915575	998.4843	-0.07266	Apple_he	1
22	228575.4	0.555899	0.549583	0.126496	0.712512	0.95294	0.042856	0.053868	34.77041	56.94613	3242.861	0.610584	0.430854	895.3162	0.868552	3405.209	0.670543	72.703	12725.52	3.831906	5.745172	0.001699	3.140511	-0.34439	0.952976	3417.542	-0.08868	Apple_he	1
23	165534.3	0.606119	0.531392	0.149697	0.728659	0.975604	0.128378	0.035877	11.58241	28.163	793.1543	0.411264	0.543722	435.2076	0.751381	875.1744	0.750434	26.24919	3065.49	2.8669	4.237117	0.002389	2.431488	-0.36548	0.921658	825.4824	-0.11984	Apple_he	1
24	238415.9	0.637625	0.880691	0.177871	0.865357	0.368865	0.015268	0.017984	23.37767	36.21417	1311.466	0.645539	0.446467	187.1521	0.932397	1384.009	0.694616	49.15351	5348.883	3.259813	4.887058	0.002308	2.628864	-0.3495	0.93465	1436.209	-0.07325	Apple_he	1
25	283287.8	0.712482	0.881416	0.319147	0.839683	0.373744	0.00304	0.024934	23.24183	38.66098	1494.671	0.60117	0.419542	198.5625	0.934776	1521.809	0.684772	48.45208	5888.673	3.683104	5.302975	0.001884	2.658416	-0.40354	0.964973	1581.407	-0.07262	Apple_he	1
26	416487.5	0.811464	0.769418	0.179388	0.929973	0.353953	3.49E-05	0.048357	20.87272	28.29646	800.6896	0.737644	0.308518	91.81652	0.944837	832.1255	0.645899	44.36863	3236.685	4.269359	5.996849	0.002432	2.681283	-0.42687	0.980216	868.676	-0.07043	Apple_he	1
27	347658	0.821165	0.89355	0.252892	0.912976	0.450592	0.007795	0.019891	25.79662	40.24816	1619.914	0.640939	0.404504	130.471	0.960407	1647.358	0.69091	54.53834	6458.962	3.78311	5.356115	0.002339	2.539911	-0.42916	0.972565	1735.306	-0.06668	Apple_he	1
28	462171.2	0.820465	0.934247	0.312324	0.963915	0.85739	0.015861	0.013929	38.87664	50.15647	2515.671	0.775107	0.294966	772.2735	0.85305	2627.583	0.56051	81.00159	9738.06	4.665377	7.330453	0.001182	3.860781	-0.28548	0.955451	2614.474	-0.09273	Apple_he	1
29	365441.7	0.846271	0.937671	0.250702	0.974828	0.977819	0.004189	0.01125	40.11945	55.0251	3027.762	0.729112	0.374108	347.5497	0.947816	3329.757	0.639755	86.60769	12971.48	3.98579	5.996891	0.001685	3.101225	-0.34023	0.956187	3485.066	-0.06954	Apple_he	1
30	465310.2	0.801409	0.913383	0.192219	0.969063	0.965302	0.011153	0.014023	38.17174	47.96864	2300.99	0.795765	0.275859	361.0121	0.92599	2438.803	0.557313	80.82864	9394.2	4.819519	7.301222	0.001234	3.618841	-0.32593	0.970318	2522.444	-0.07475	Apple_he	1
31	519941.8	0.914895	0.874802	0.249819	0.966274	0.988054	0.033255	0.015788	28.56238	36.23663	1313.093	0.788218	0.271078	345.7909	0.882689	1473.733	0.550242	64.00807	5549.14	4.642053	7.18324	0.001315	3.643415	-0.29248	0.956207	1488.998	-0.08537	Apple_he	1
32	108616.7	0.479855	0.894073	0.14486	0.789222	0.529215	0.00854	0.021351	10.63307	23.67638	560.5709	0.4491	0.609311	91.72199	0.922531	591.8319	0.806665	22.7411	2275.606	2.373553	3.356373	0.003691	1.784488	-0.43497	0.919143	610.7719	-0.07561	Apple_he	1
33	370010.2	0.769915	0.931635	0.35251	0.937739	0.994385	0.13644	0.023882	39.71113	54.65421	2987.083	0.726589	0.344883	621.9847	0.909785	3446.951	0.605486	91.32428	13165.82	4.192476	6.49337	0.001387	3.463682	-0.30901	0.952172	3535.423	-0.07859	Apple_he	1
34	332149.9	0.753539	0.93735	0.191273	0.966234	0.957479	0.003203	-0.00645	22.94348	33.21248	1103.069	0.690809	0.375555	173.5044	0.929926	1237.861	0.646041	51.68036	4777.939	3.774979	5.675742	0.002273	2.914955	-0.33623	0.947988	1282.571	-0.07389	Apple_he	1
35	381700.4	0.818237	0.902948	0.22975	0.919548	0.391827	0.00012	0.014958	37.35263	53.10832	2820.493	0.703329	0.376399	158.6365	0.973018	2939.272	0.660339	78.9919	11598.45	3.995139	5.730992	0.002121	2.757177	-0.40419	0.971876	3117.796	-0.06374	Apple_he	1
36	295298.7	0.621269	0.521142	0.181146	0.76258	0.957091	0.104027	0.065305	42.69898	65.6319	4307.547	0.650583	0.392365	1191.478	0.868731	4537.811	0.638713	89.71714	16959.77	4.157807	6.296654	0.001544	3.444837	-0.332	0.958286	4554.957	-0.08862	Apple_he	1
37	600098.6	0.899559	0.839375	0.248504	0.947245	0.985465	0.070707	0.02076	57.12331	58.73955	3450.335	-0.08302	0.223732	318.6135	0.958001	3793.144	0.521732	124.0656	14853.96	4.946216	7.509702	0.00115	3.647556	-0.30219	0.964644	3990.987	-0.0673	Apple_he	1
38	464368.4	0.900098	0.910872	0.280895	0.953631	0.664981	0.005977	0.011743	49.44349	61.00394	3721.481	0.810497	0.316113	378.5887	0.95143	3896.979	0.593085	103.1517	15209.33	4.426046	6.708094	0.001429	3.408181	-0.3232	0.961224	4086.608	-0.06871	Apple_he	1
39	81347.32	0.341362	0.91992	0.123036	0.706654	0.527511	0.010647	0.028367	15.422	32.11204	1031.183	0.480256	0.623535	129.4959	0.941253	1101.928	0.808221	32.6141	4278.217	2.259079	3.243781	0.004216	1.79973	-0.40438	0.897905	1149.14	-0.07113	Apple_he	1
40	210807.1	0.825149	0.943686	0.376224	0.976903	0.693052	0.054265	0.110079	26.962	46.78286	2188.636	0.576322	0.517612	189.5745	0.958569	2287.486	0.740871	56.13933	8960.369	3.039098	4.427165	0.002467	2.344316	-0.39178	0.940307	2407.953	-0.06702	Apple_he	1
41	379303.9	0.798333	0.880013	0.254514	0.886854	0.969494	0.032483	0.014849	25.61213	38.79257	1504.863	0.660233	0.379075	491.0944	0.846768	1602.287	0.631743	54.05548	5918.055	3.965774	6.135695	0.001613	3.284108	-0.31063	0.946106	1588.862	-0.09433	Apple_he	1
42	418549.9	0.853874	0.820916	0.218733	0.939781	0.491021	0.002955	0.018406	34.06121	46.6868	2179.657	0.729568	0.343238	157.9514	0.9651	2262.564	0.632192	72.02035	8892.303	4.251287	6.161108	0.00195	2.944833	-0.38591	0.972992	2389.494	-0.0656	Apple_he	1
43	247735.7	0.693385	0.820139	0.284697	0.815362	0.194597	0.025567	0.031934	18.75532	30.5162	931.2384	0.614602	0.459593	99.44619	0.948364	962.7581	0.729389	39.00983	3751.586	3.283028	4.627747	0.002764	2.258701	-0.43063	0.959409	1007.365	-0.06954	Apple_he	1

Model Training:

Random Forest Classifier



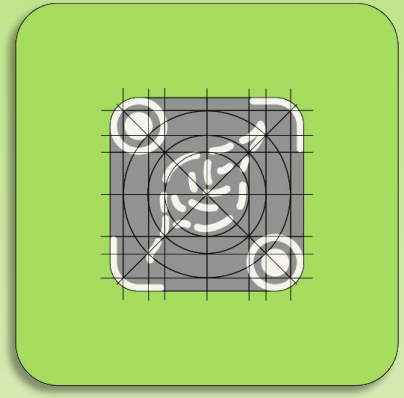
Accuracies:

- First Accuracy: **~56%** (general shape features)
- Second Accuracy: **~83%** (shape/color)
- Third Accuracy:
  - Master Dataset: **~89.942%** (Shape/Color/Texture)
  - Grape Dataset: **~98.174%** (Shape/Color/Texture)

Model Training & Accuracies

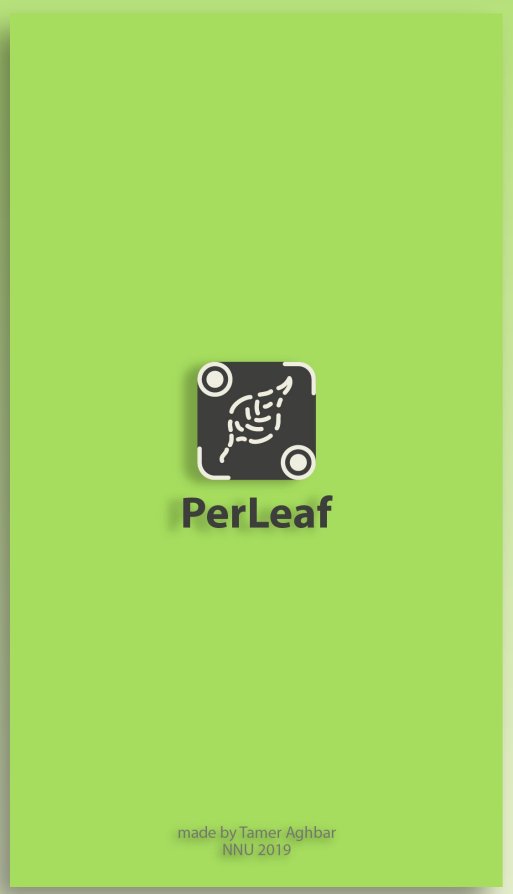
It’s a Leaf
Grape Leaf
Not Healthy
Disease: Black rot

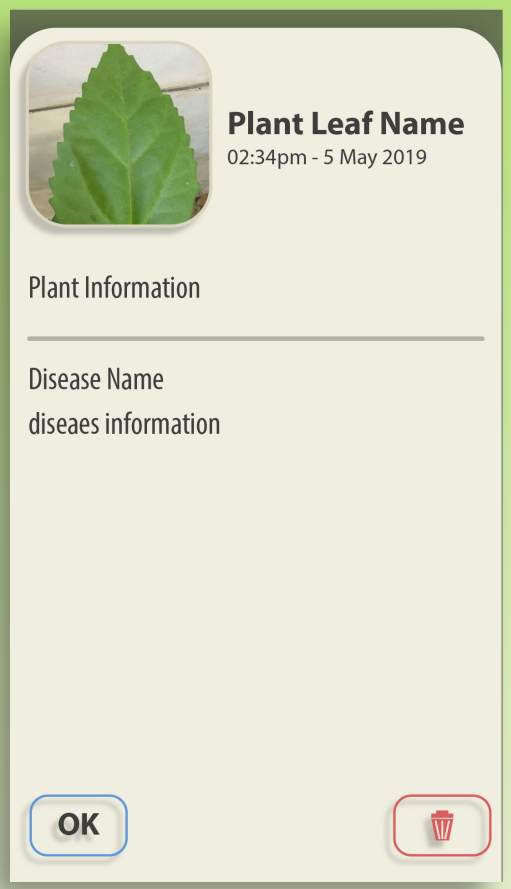
Design & Implementation:



Design & Implementation:

Design & Implementation:





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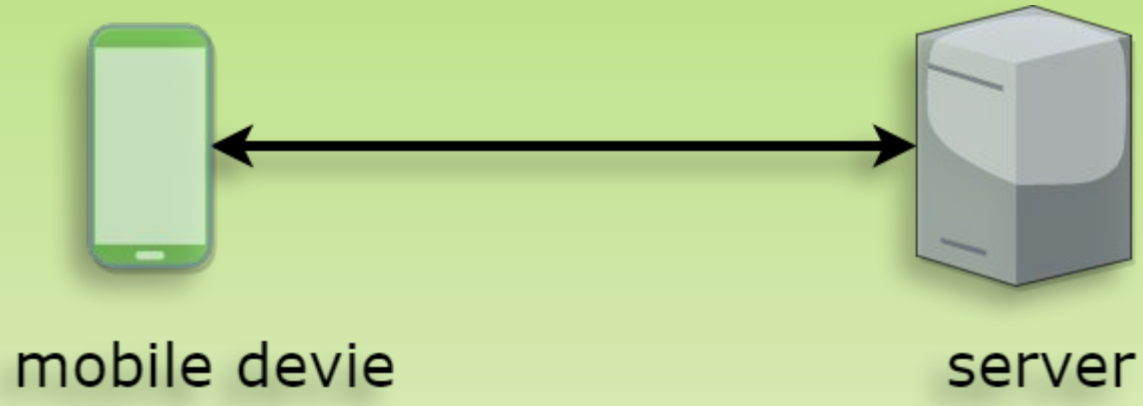
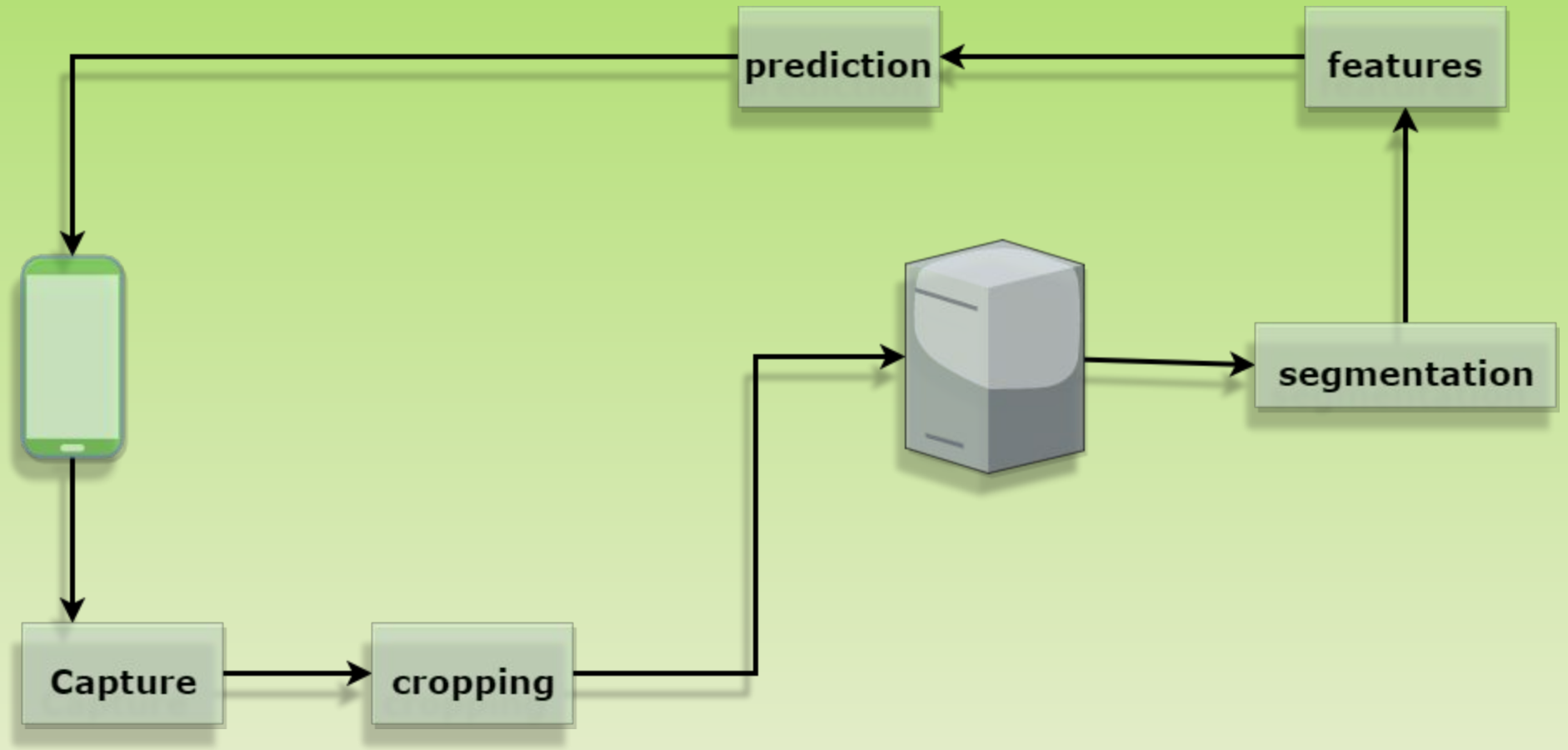


Design & Implementation:



Conclusion & Future work:

1) Dataset
    1) Build our own dataset
    2) study more disease can be used in our model
2) Features & Machine Learning
    1) Make more accurate features
    2) Compline similar features by doing some feature analysis, In order to minimize the processing time

Conclusion & Future work:

3) Mobile Application:

    1) Cross platform application
    2) Build a website
    3) Add dashboard screen
    4) Users accounts for non-expert people and experts
    5) Involve GPS & maps

Demo

PerLeaf

Presented by:
Tamer Aghbar

Thank you!

Supervised by:
Dr. Mohammad Sharaf
Dr. Anas Toma