

# Appendix

## Density Ascend Algorithm Versions's Specks

The following section defines the parameters that run each version used for testing: (1) Brute DA Algorithm; (2) Optimized DA Algorithm; (3) Dynamic DA Algorithm.

### Brute Density Ascend Algorithm

- Early Stop: 200 iterations
- Radius: 100 pixels
- Tolerance: 0 pixels
- Stored Start: False
- Reducing Circles: False

### Optimized Density Ascend Algorithm

- Early Stop: 200 iterations
- Radius: 100 pixels
- Tolerance: 1 pixel
- Stored Start: True
- Reducing Circles: False

### Dynamic Density Ascend Algorithm

- Early Stop: 200 iterations
- Starting Radius: 600 pixels
- Ending Radius: 100 pixels
- Reducing Iterations: 20 iterations
- Tolerance: 1 pixel
- Stored Start: True
- Reducing Circles: True

These models were tested in different scenarios. The final version of the Density Ascend Algorithm is the Dynamic Version, as this one provided better results.

## Testing Scenarios

To evaluate each model we subjected each one to three different scenarios where the starting position changed quality: (1) Horrible Start; (2) Medium Start; (3) Perfect Start. Each matrix represents two starting circles. The first row is the x and y coordinates for the circle that will search for the lower aggregate. The second row is for the higher aggregate.

### Horrible Start

$$\begin{bmatrix} 1000 & 2000 \\ 900 & 0 \end{bmatrix}$$

### Medium Start

$$\begin{bmatrix} 1000 & 1000 \\ 900 & 400 \end{bmatrix}$$

### Perfect Start

$$\begin{bmatrix} 1000 & 1200 \\ 900 & 600 \end{bmatrix}$$

## Obtained Data

To evaluate the models in these different scenarios we run the code 5 times for each condition, registering the following variables:

### Observed Variables

- Search Time: Time it took the algorithm to search all 28 images in the dataset;
- N° Early Stops: Number of times the search was terminated not because it found a resting position, but because it reached a limited number of iterations;
- N° Deviation to Other Aggregates: Number of times the circle moved and stopped at the wrong aggregate;
- N° Failed Searches: Number of times the circle didn't find the aggregate (these include the N° Deviation to Other Aggregates);
- Accuracy: Indirect variable calculated from the successful searches divided by the number of total searches (56 for this dataset);
- Otsu Time: Time it took the algorithm to run the otsu code (used as a comparison validation metric)

### Obtained Data - Brute Density Ascend Algorithm Version

Situation 1.1							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	161.73	159.43	156.51	157.59	160.24	159.10	2.08
N° Early Stops	34.00	34.00	34.00	34.00	34.00	34.00	0.00
N° Deviation to Other Aggregates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N° Failed Search	56.00	56.00	56.00	56.00	56.00	56.00	0.00
Accuracy (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Otsu Time (sec)	3.80	3.42	3.34	3.09	3.00	3.33	0.31

Figure 1: Data from Horrible Start

Situation 1.2							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	74.23	74.59	74.84	71.57	71.30	73.31	1.72
N° Early Stops	7.00	7.00	7.00	7.00	7.00	7.00	0.00
N° Deviation to Other Aggregates	4.00	4.00	4.00	4.00	4.00	4.00	0.00
N° Failed Search	14.00	14.00	14.00	14.00	14.00	14.00	0.00
Accuracy (%)	75.00	75.00	75.00	75.00	75.00	75.00	0.00
Otsu Time (sec)	4.02	4.06	3.61	3.51	3.12	3.66	0.39

Figure 2: Data from Medium Start

Situation 1.3							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	38.32	39.09	34.84	34.16	34.84	36.25	2.27
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	4.81	3.33	3.44	3.06	3.12	3.55	0.72

Figure 3: Data from Perfect Start

### Obtained Data - Optimized Density Ascend Algorithm Version

Situation 2.1							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	16.52	18.64	18.62	14.26	11.70	15.95	2.98
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	56.00	56.00	56.00	56.00	56.00	56.00	0.00
Accuracy (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Otsu Time (sec)	3.56	4.38	4.10	3.66	3.05	3.75	0.51

Figure 4: Data from Horrible Start

Situation 2.2							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	16.23	17.19	12.82	11.36	11.49	13.82	2.72
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	3.76	3.83	3.43	4.15	3.87	3.81	0.26

Figure 5: Data from Medium Start

Situation 2.3							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	10.31	9.58	9.14	9.72	10.03	9.76	0.45
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	3.31	3.54	3.64	3.35	3.31	3.43	0.15

Figure 6: Data from Perfect Start

## Obtained Data - Dynamic Density Ascend Algorithm Version

Situation 3.1							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	18.53	14.72	13.76	16.10	14.06	15.43	1.95
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	3.97	3.94	3.90	3.23	3.10	3.63	0.43

Figure 7: Data from Horrible Start

Situation 3.2							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	13.96	15.42	12.04	12.22	11.07	12.94	1.73
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	4.03	3.90	3.65	3.86	3.07	3.70	0.38

Figure 8: Data from Medium Start

Situation 3.3							
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Error
Search Time (sec)	14.36	11.50	12.67	16.16	15.93	14.12	2.03
Nº Early Stops	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Deviation to Other Agreggates	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nº Failed Search	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Accuracy (%)	100.00	100.00	100.00	100.00	100.00	100.00	0.00
Otsu Time (sec)	3.38	3.96	3.79	3.68	3.68	3.70	0.21

Figure 9: Data from Perfect Start