Image Segmentation

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>
> > github: KhadgaA/Spectral-Clustering (github.com)

Ratio Cut Segmentaion

Steps:

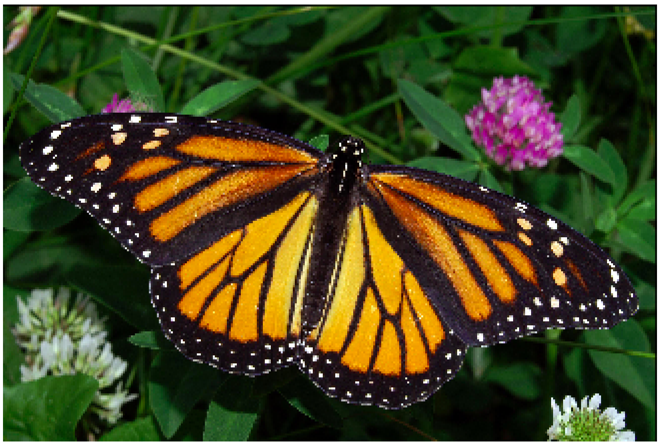
1. Convert the image into a Graph. This can be done by simply reshaping the image into a vector of `N = height*width` nodes.

2. Compute the affinity of each node of the graph/image w.r.to all other nodes/pixels. Therefore `Affinity (A) = (N , N)` matrix. We can either use the euclidean based affinity : $e^{||I(i)-I(j)||_2^2}$ or we can use the Cosine Similarity: $A_{i,j} = \frac{I(i) \cdot I(j)}{||I(i)|| \cdot ||I(j)||}$.
3. Refine Affinity Matrix
4. Compute the Degree Matrix. $D_i = \sum_{j=1}^{N} A_{ij}$
5. Compute the Laplacian of the graph. `L = D - A`. Normalize Laplacian Matrix.
6. Compute the eigenvalues and eigenvectors of the Laplacian matrix.
7. Take eigenvectors corresponding to K^{th} smallest eigenvalue.
8. Perform Clustering on K.

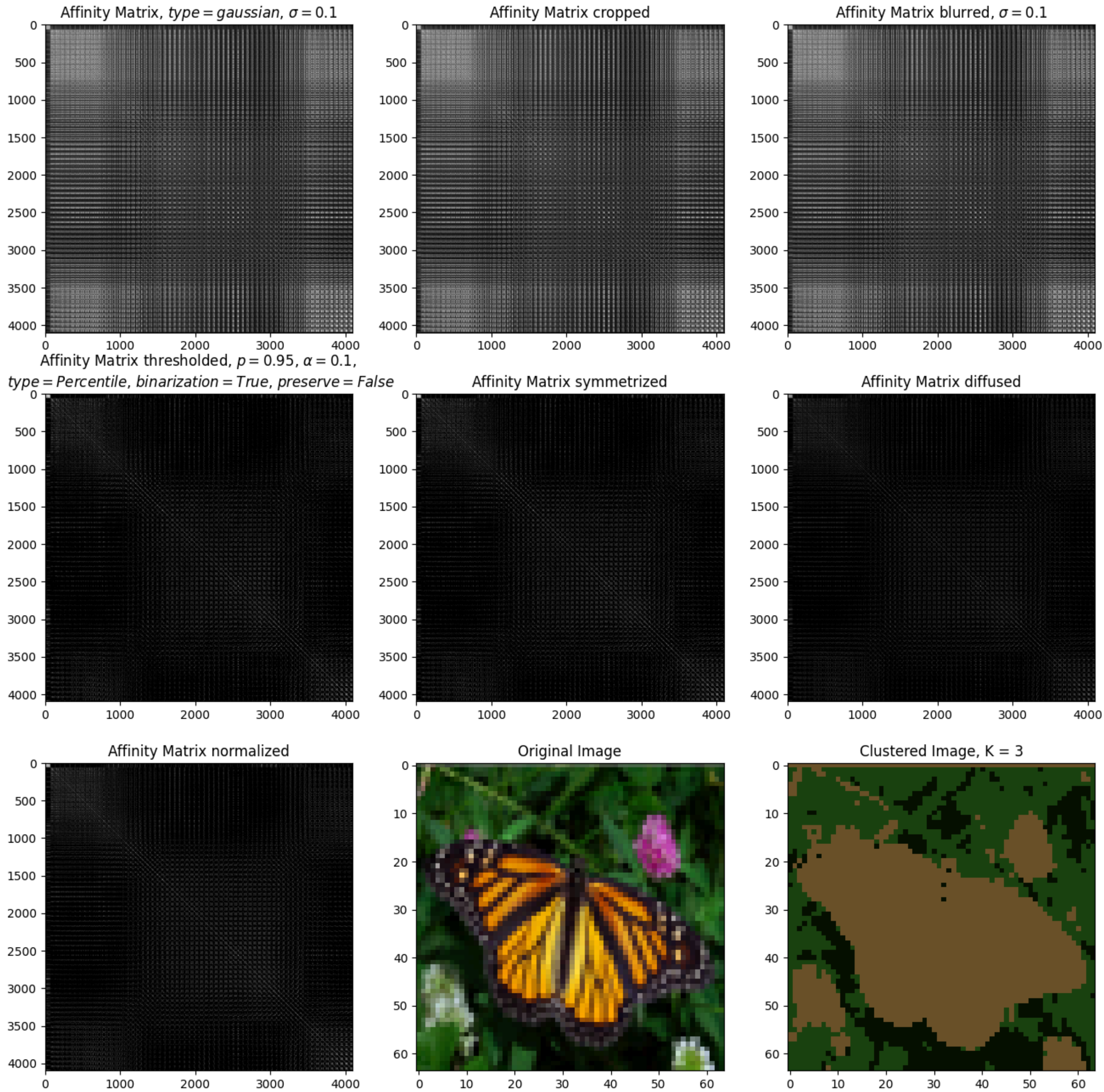
> Please See Appendix Section for exact details.

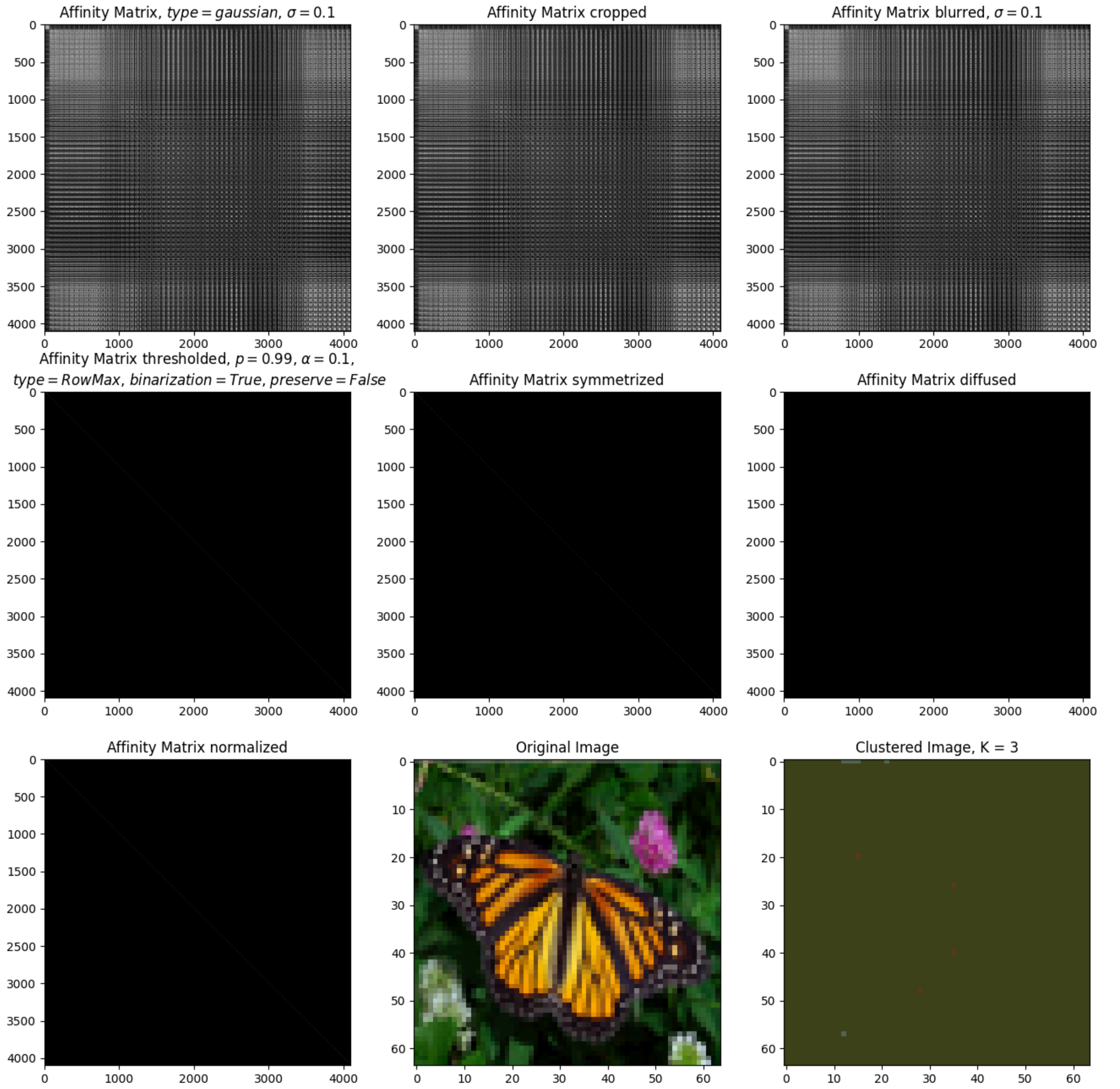
Segmentation Results - 3 Clusters

Image 1:



Ratio Cut


Affinity Matrix, $type = gaussian$, $\sigma = 0.1$
Affinity Matrix cropped
Affinity Matrix blurred, $\sigma = 0.1$
Affinity Matrix thresholded, $p = 0.95$, $\alpha = 0.1$,
$type = Percentile$, $binarization = True$, $preserve = False$
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 3


Affinity Matrix, $type = gaussian$, $\sigma = 0.1$
Affinity Matrix cropped
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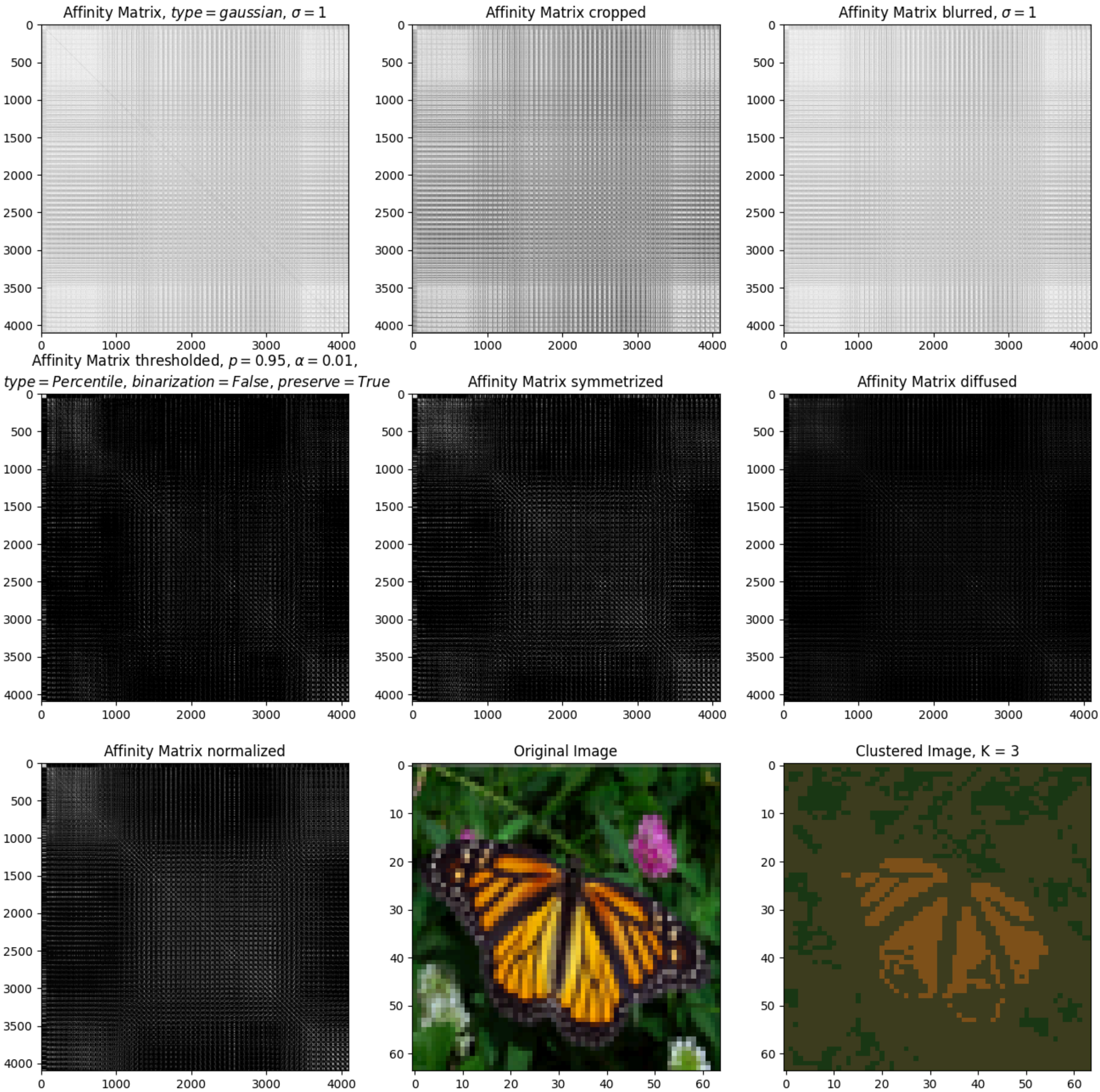
Affinity Matrix thresholded, $p = 0.99$, $\alpha = 0.1$,
$type = RowMax$, $binarization = True$, $preserve = False$
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 3



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Affinity Matrix cropped
Affinity Matrix blurred, $\sigma = 1$
Affinity Matrix thresholded, $p = 0.95$, $\alpha = 0.01$,
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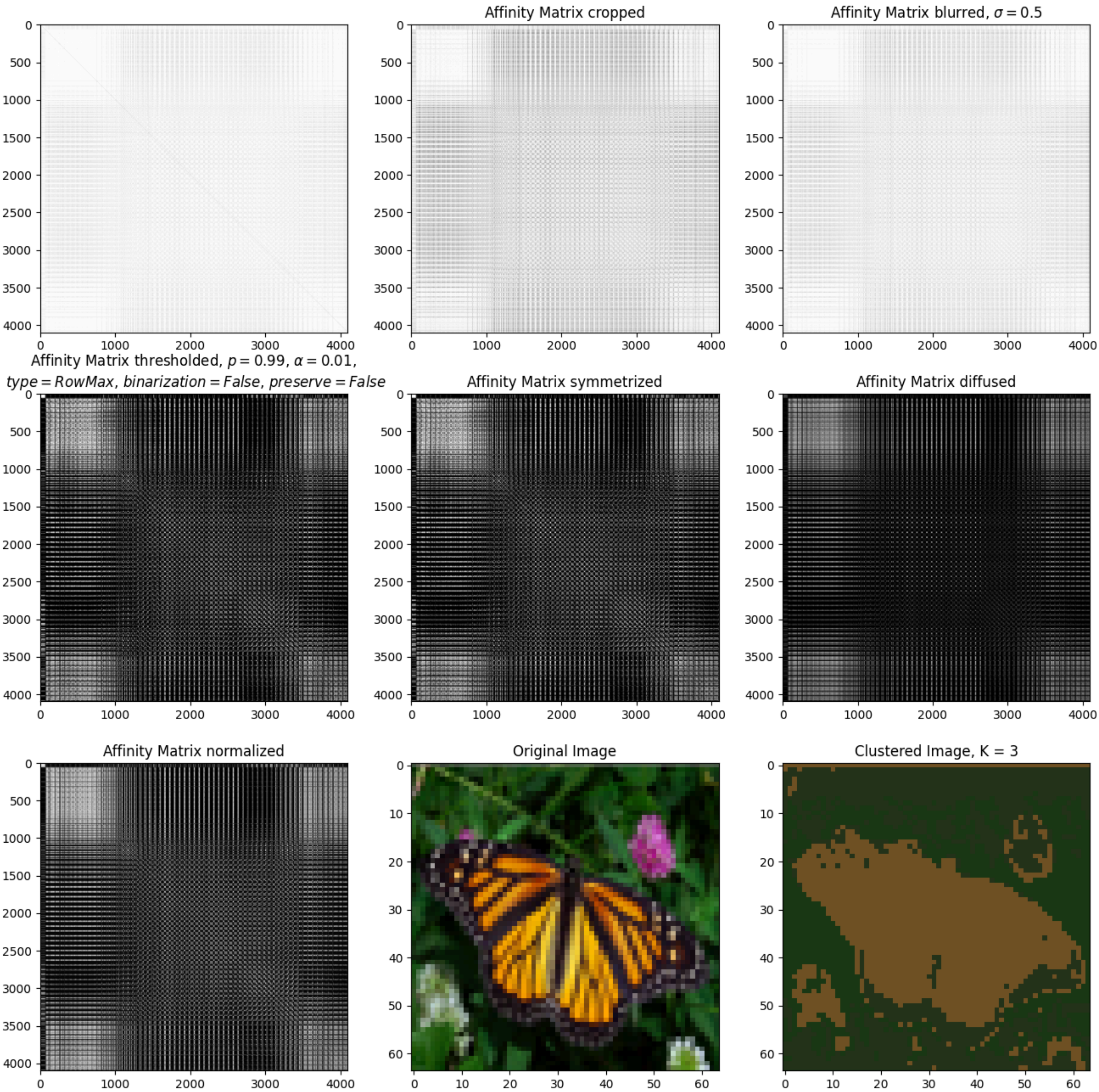
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 3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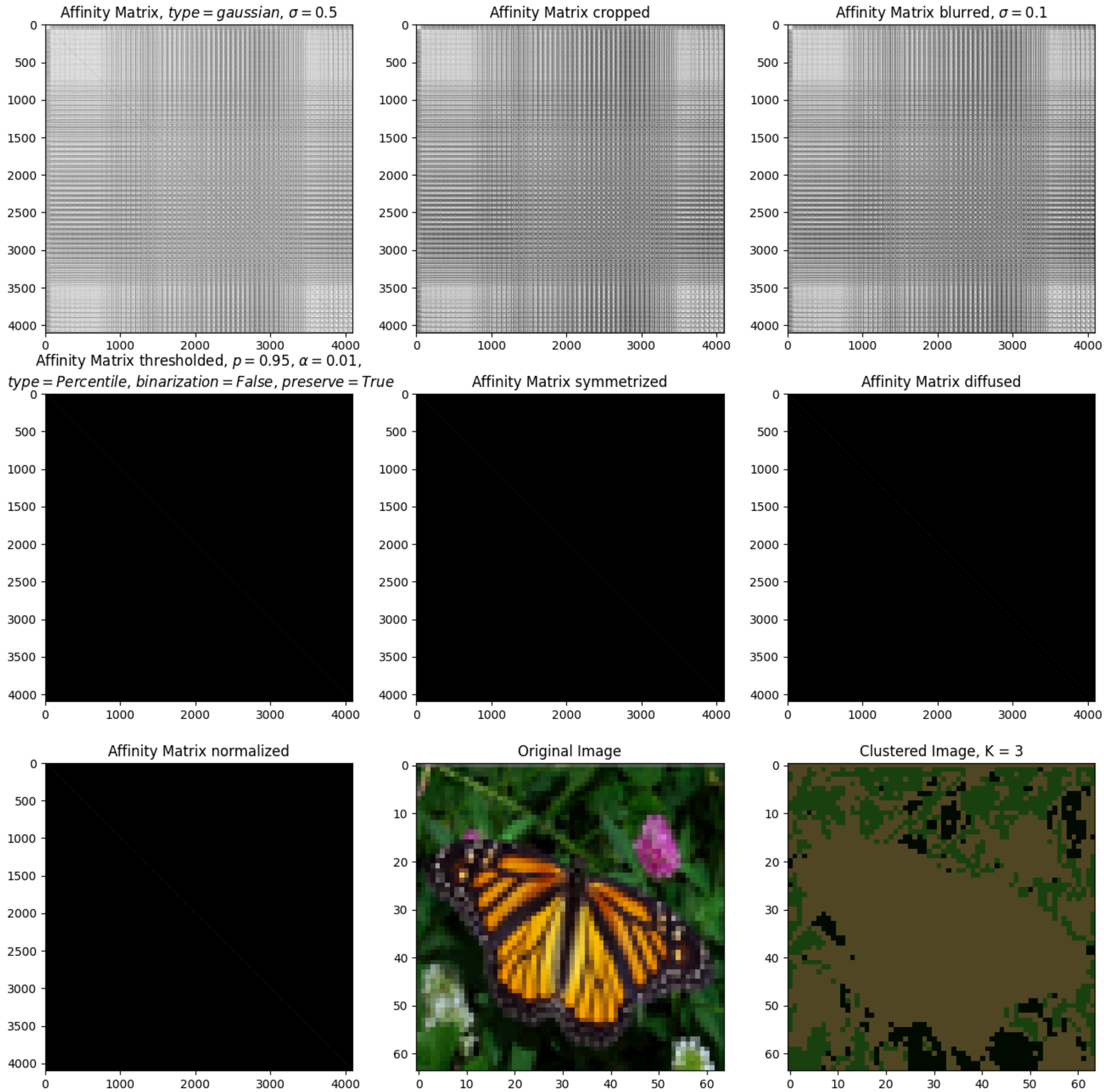
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 3



KMeans Clustering:

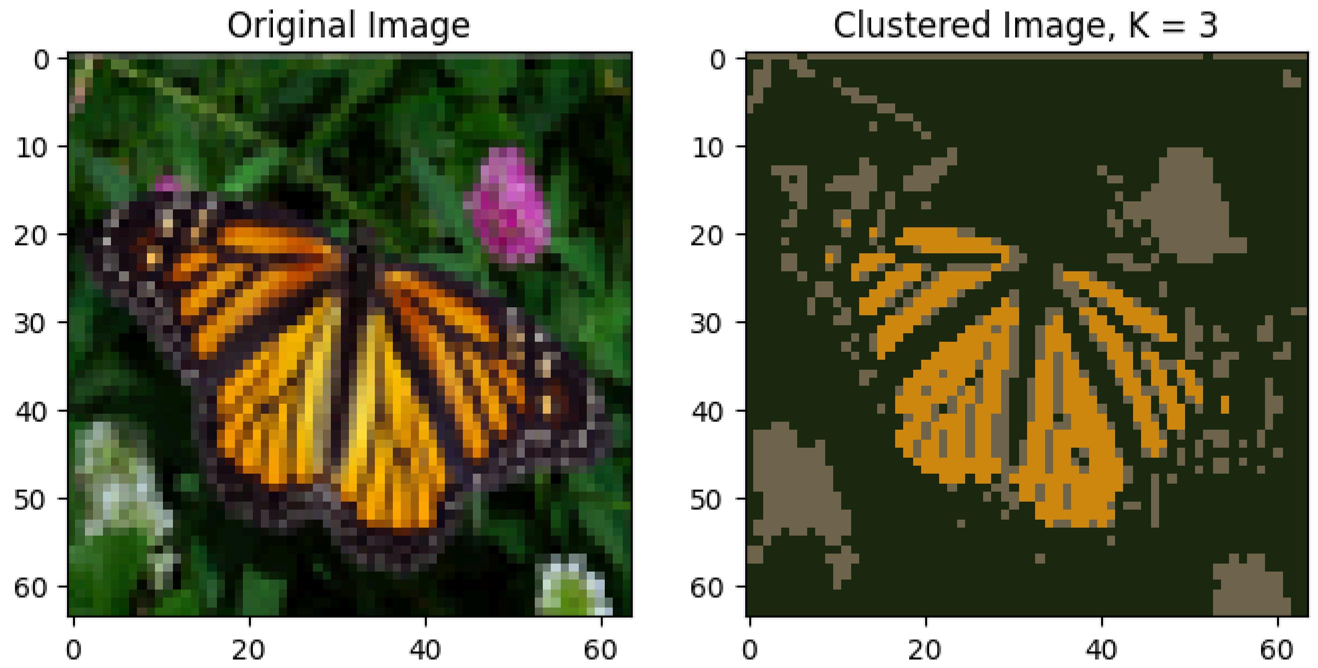
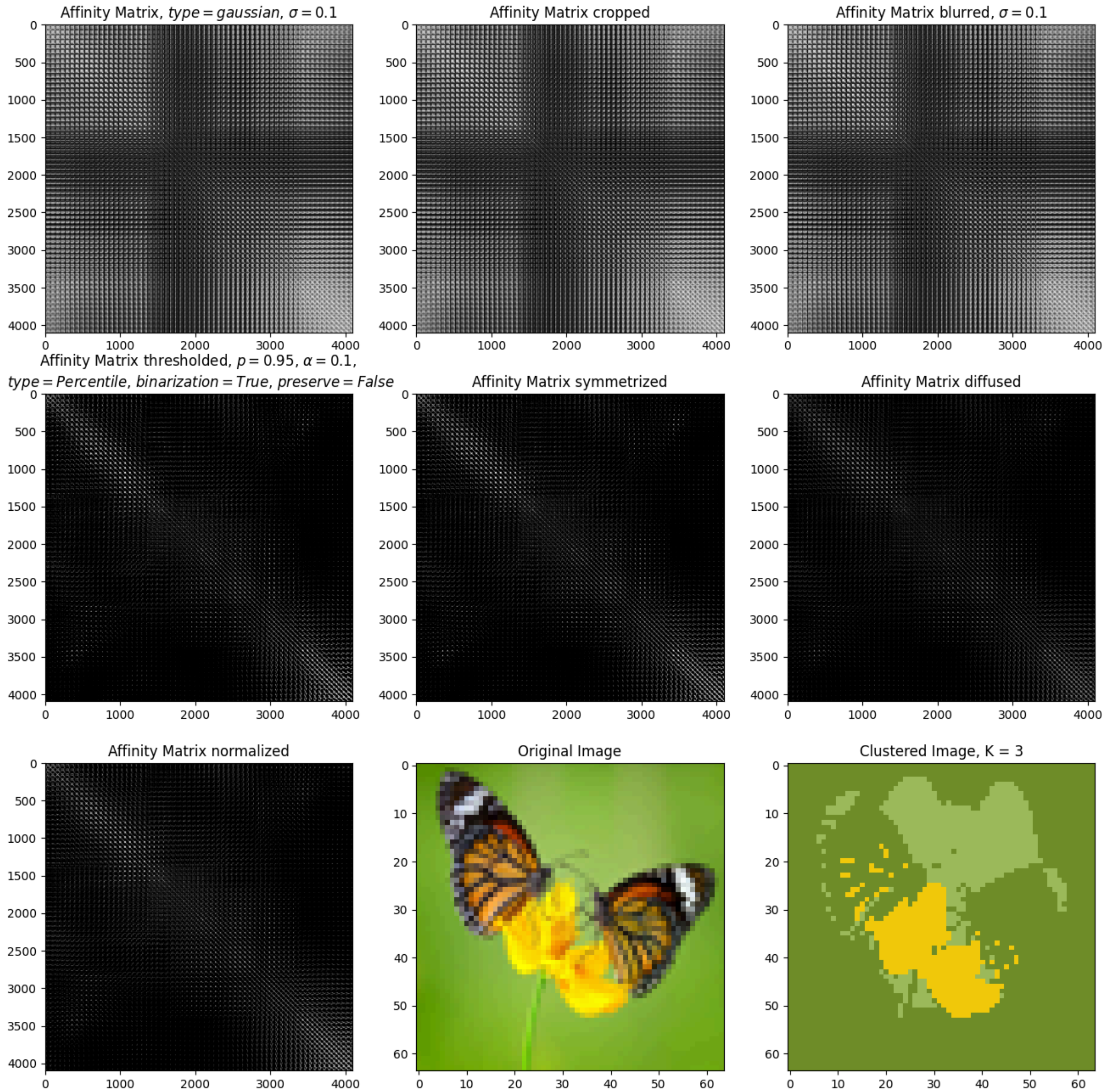


Image 2:

Ratio Cut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Affinity Matrix cropped
Affinity Matrix blurred, σ = 0.1
Affinity Matrix thresholded, p = 0.95, α = 0.1,
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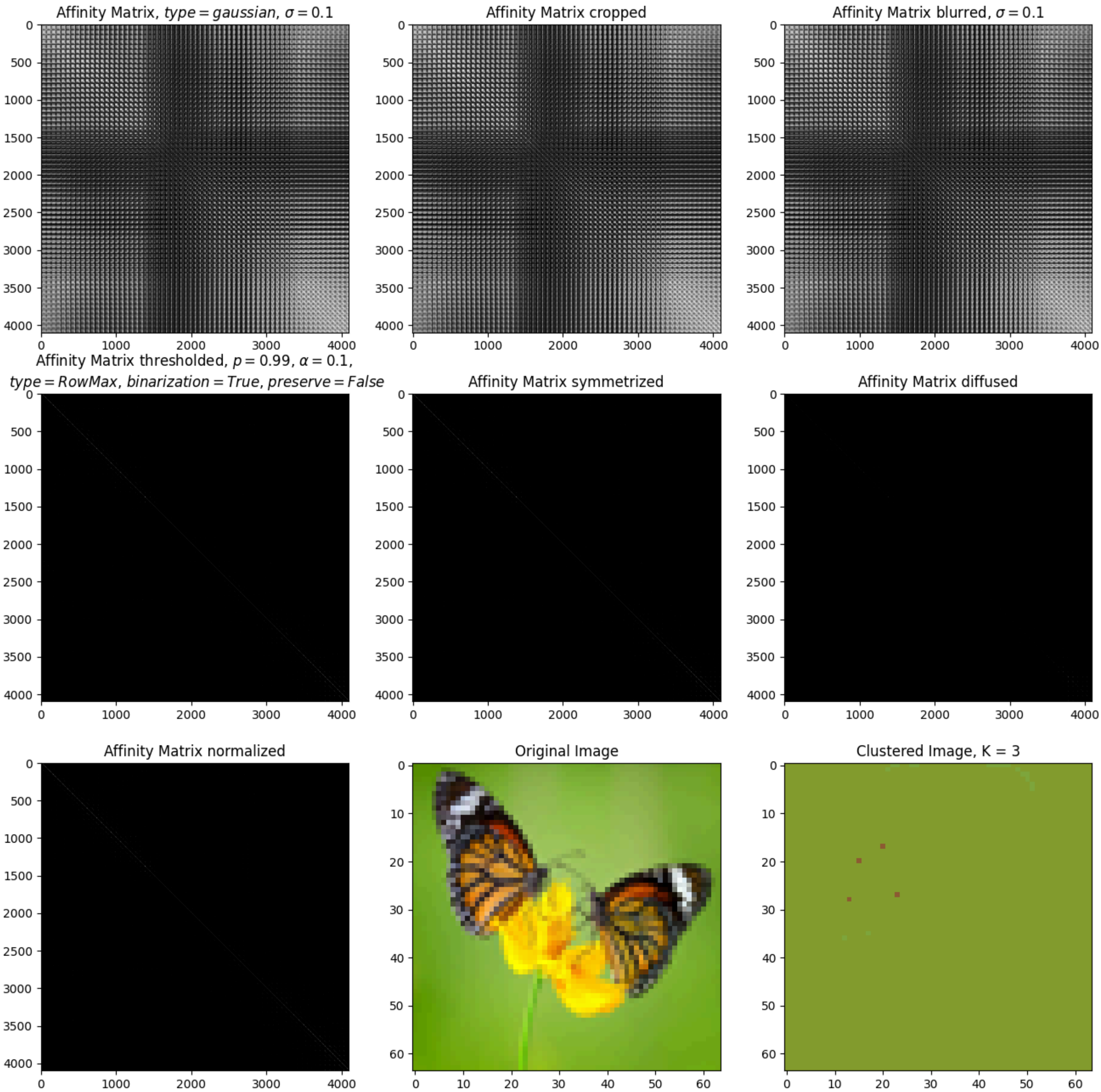
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 3



Affinity Matrix, $type = gaussian$, $\sigma = 0.1$
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Affinity Matrix symmetrized
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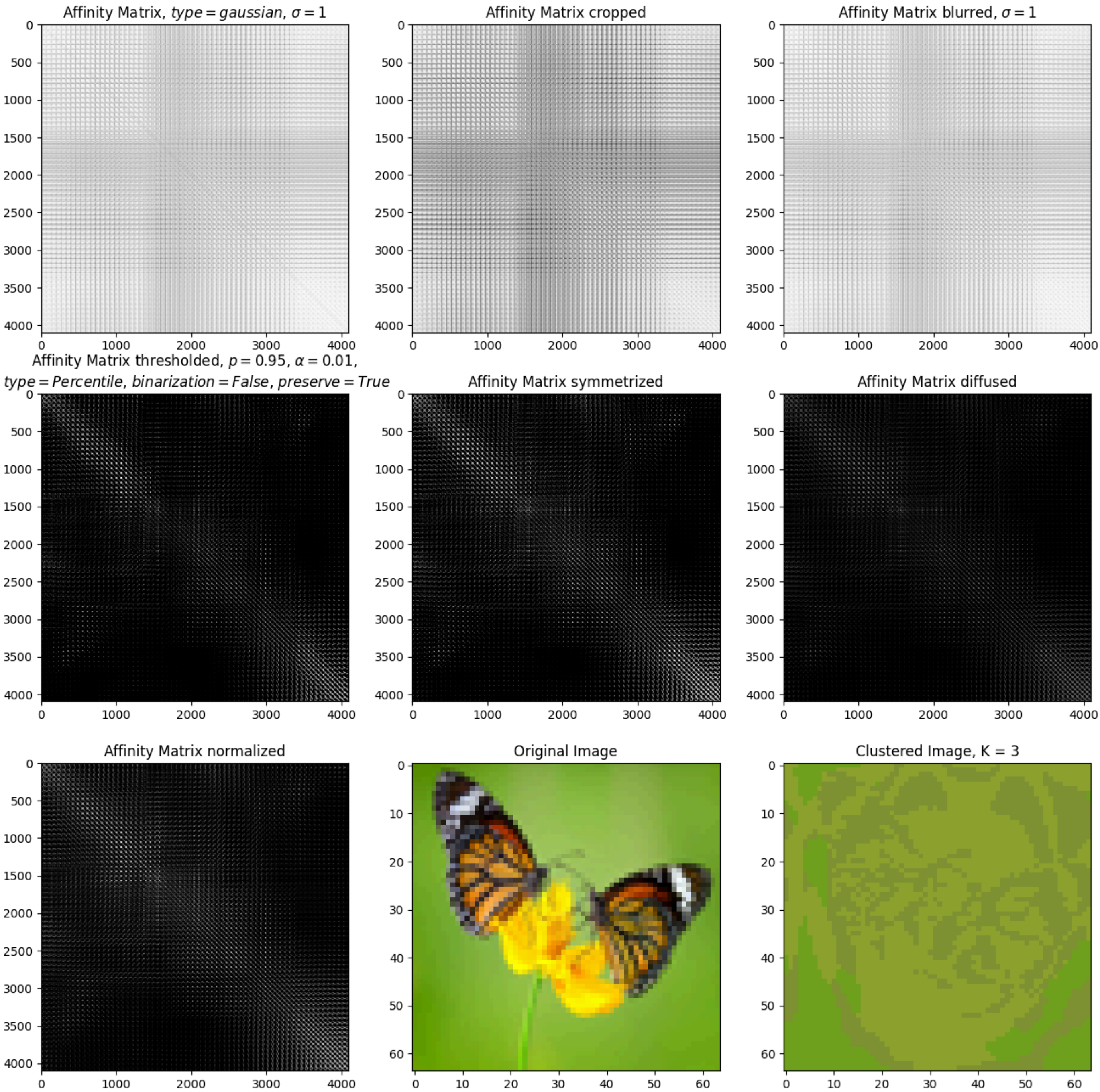
Original Image
Clustered Image, K = 3


Affinity Matrix, $type = gaussian$, $\sigma = 1$
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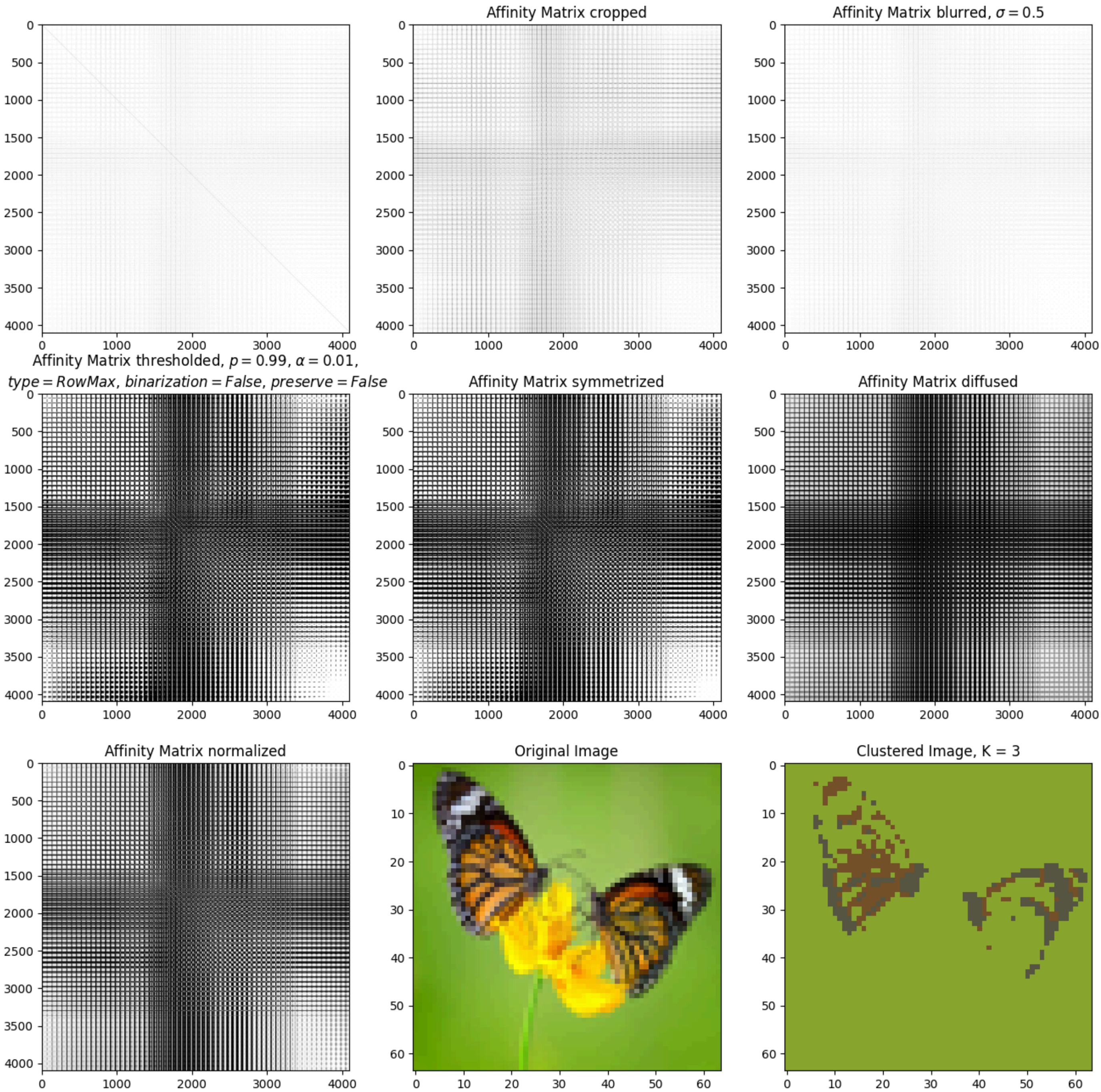
Original Image
Clustered Image, K = 3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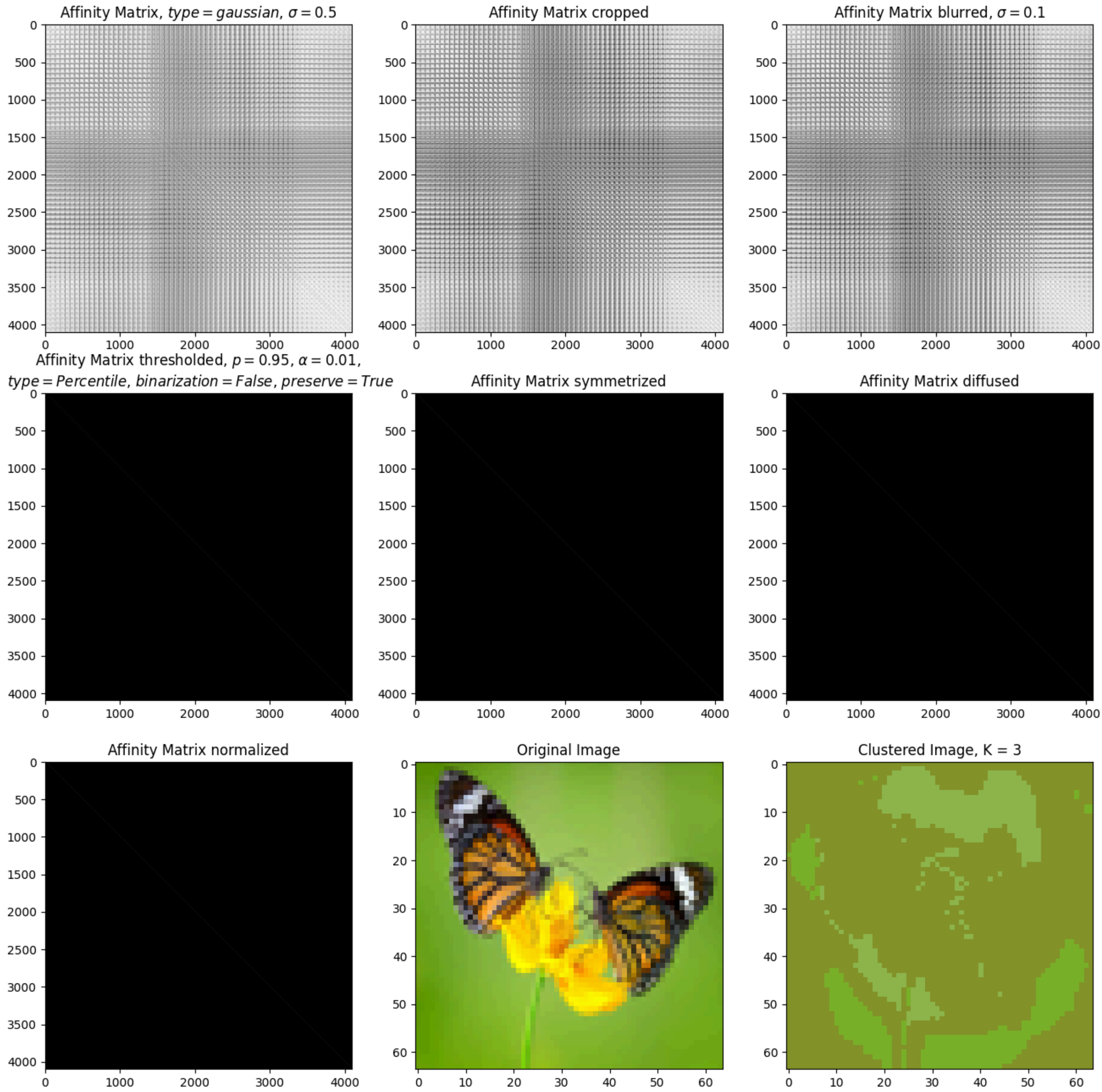
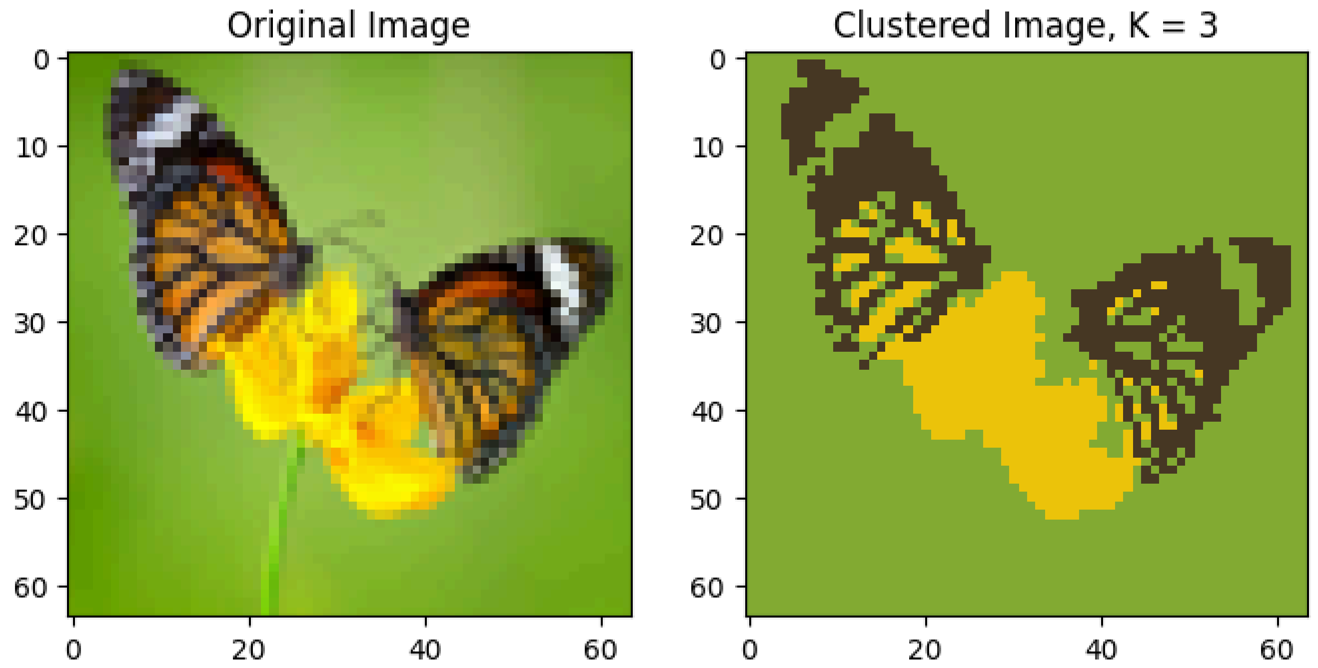


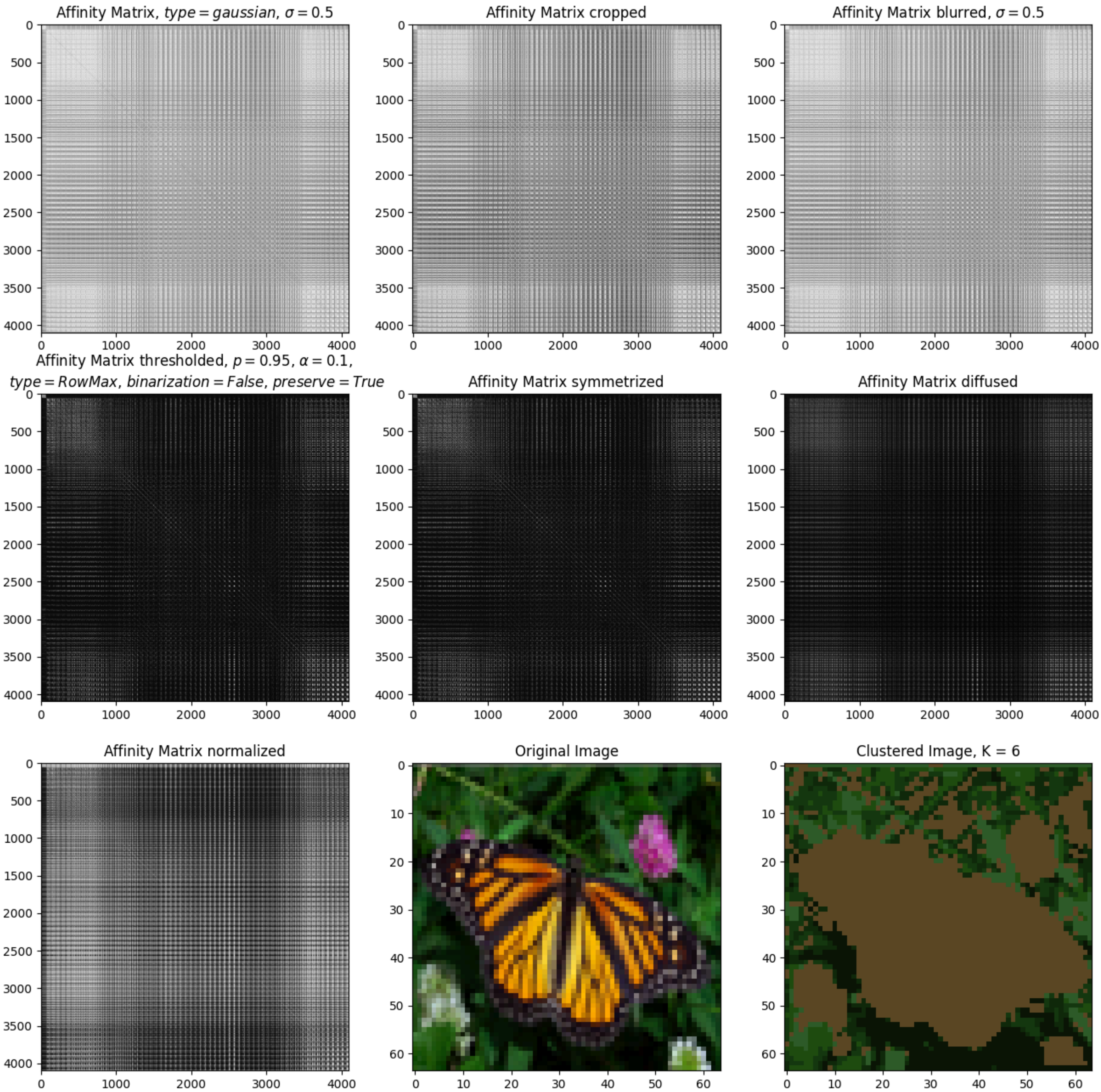
KMeans Clustering:



Segmentation Results - 6 Clusters

Image 1

Ratio Cut



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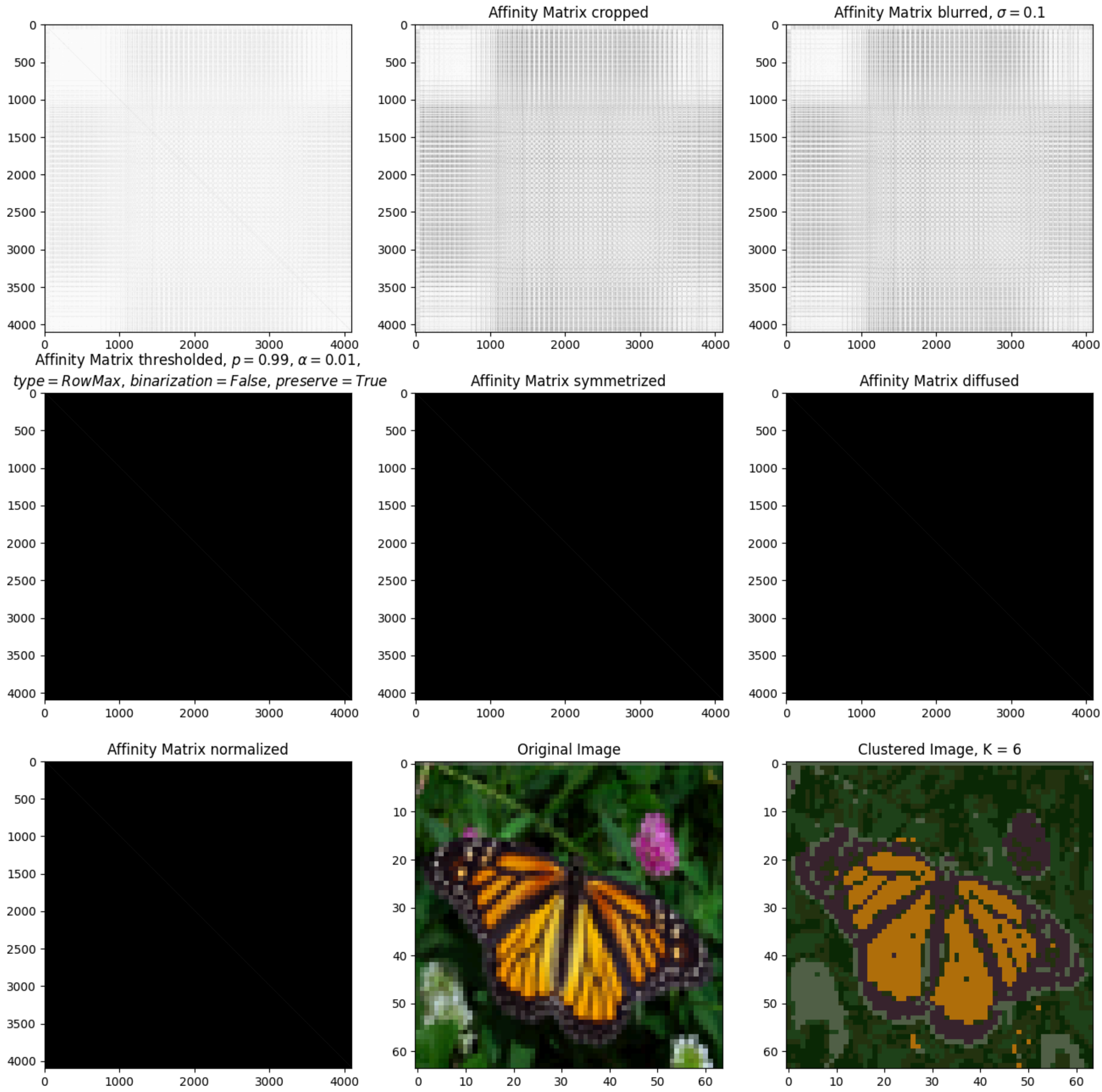
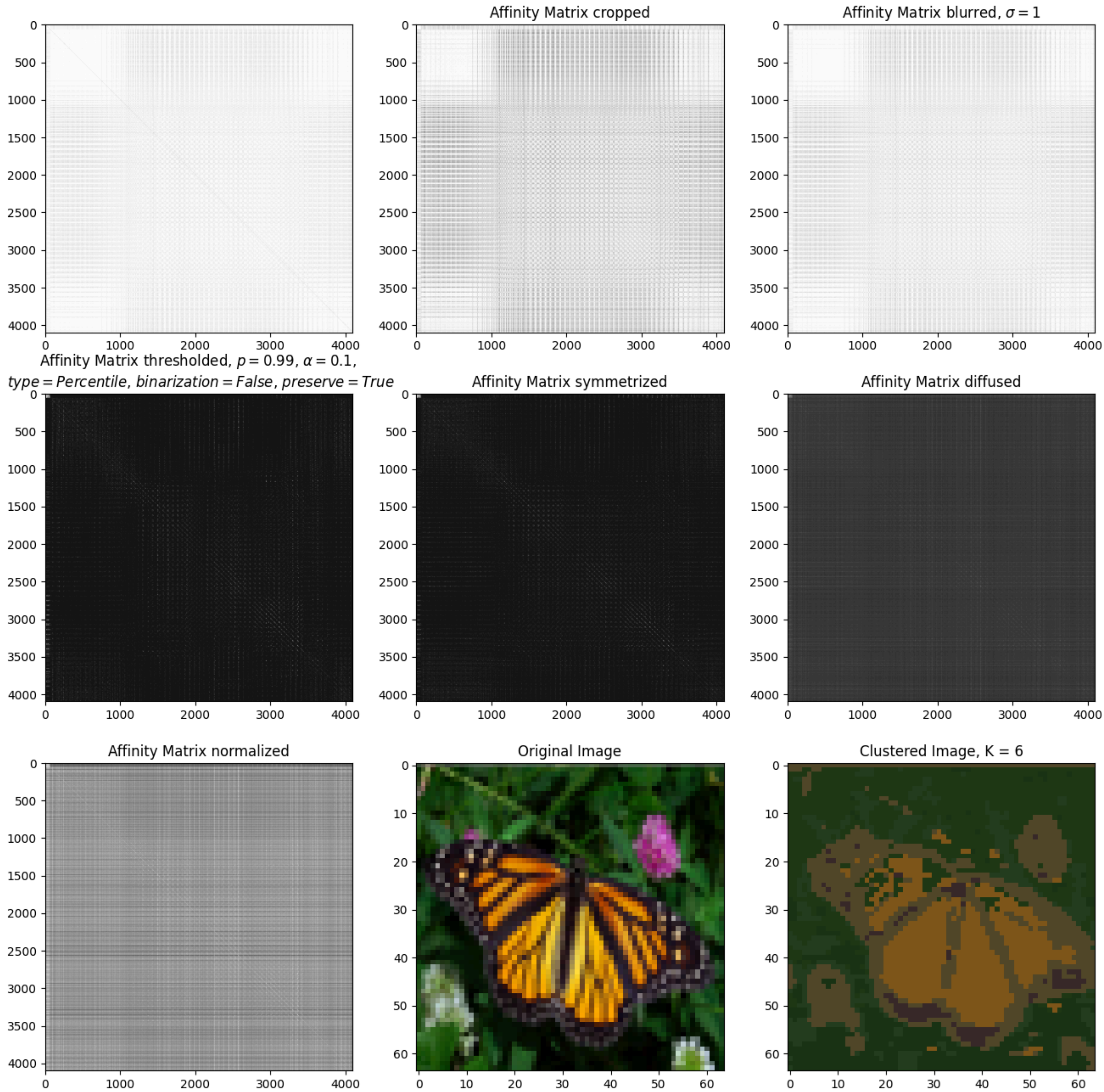
Affinity Matrix thresholded, $p = 0.95$, $\alpha = 0.1$, $type = RowMax$, $binarization = False$, $preserve = True$
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 6



Affinity Matrix cropped
Affinity Matrix blurred, $\sigma = 0.1$
Affinity Matrix thresholded, $p = 0.99$, $\alpha = 0.01$,
$type = RowMax$, $binarization = False$, $preserve = True$
Affinity Matrix symmetrized
Affinity Matrix diffused
Affinity Matrix normalized
Original Image
Clustered Image, K = 6
0
500
1000
1500
2000
2500
3000
3500
4000
0
10
20
30
40
50
60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Affinity Matrix blurred, $\sigma = 1$
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$type = Percentile$, $binarization = False$, $preserve = True$
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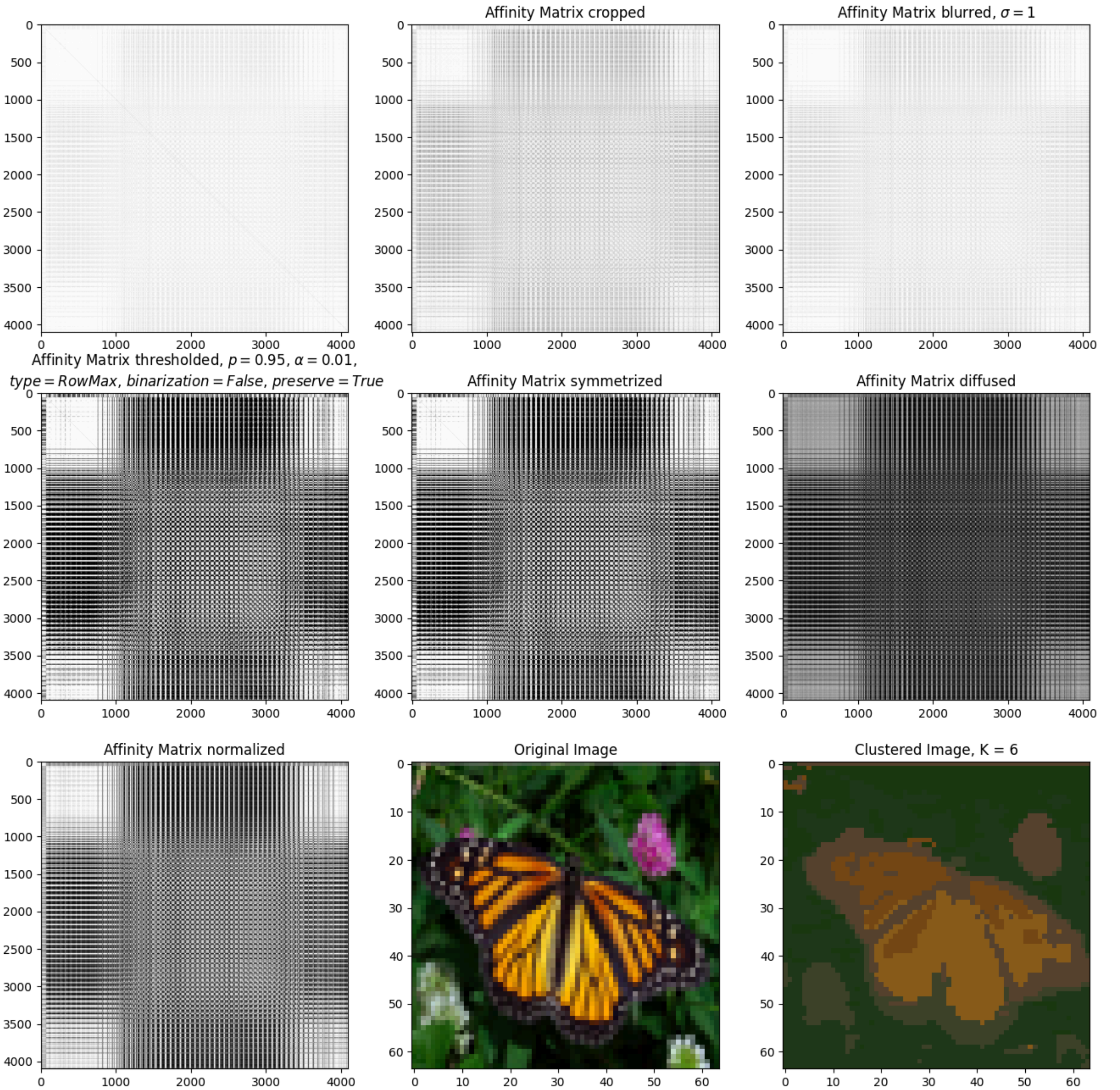
Original Image
Clustered Image, K = 6



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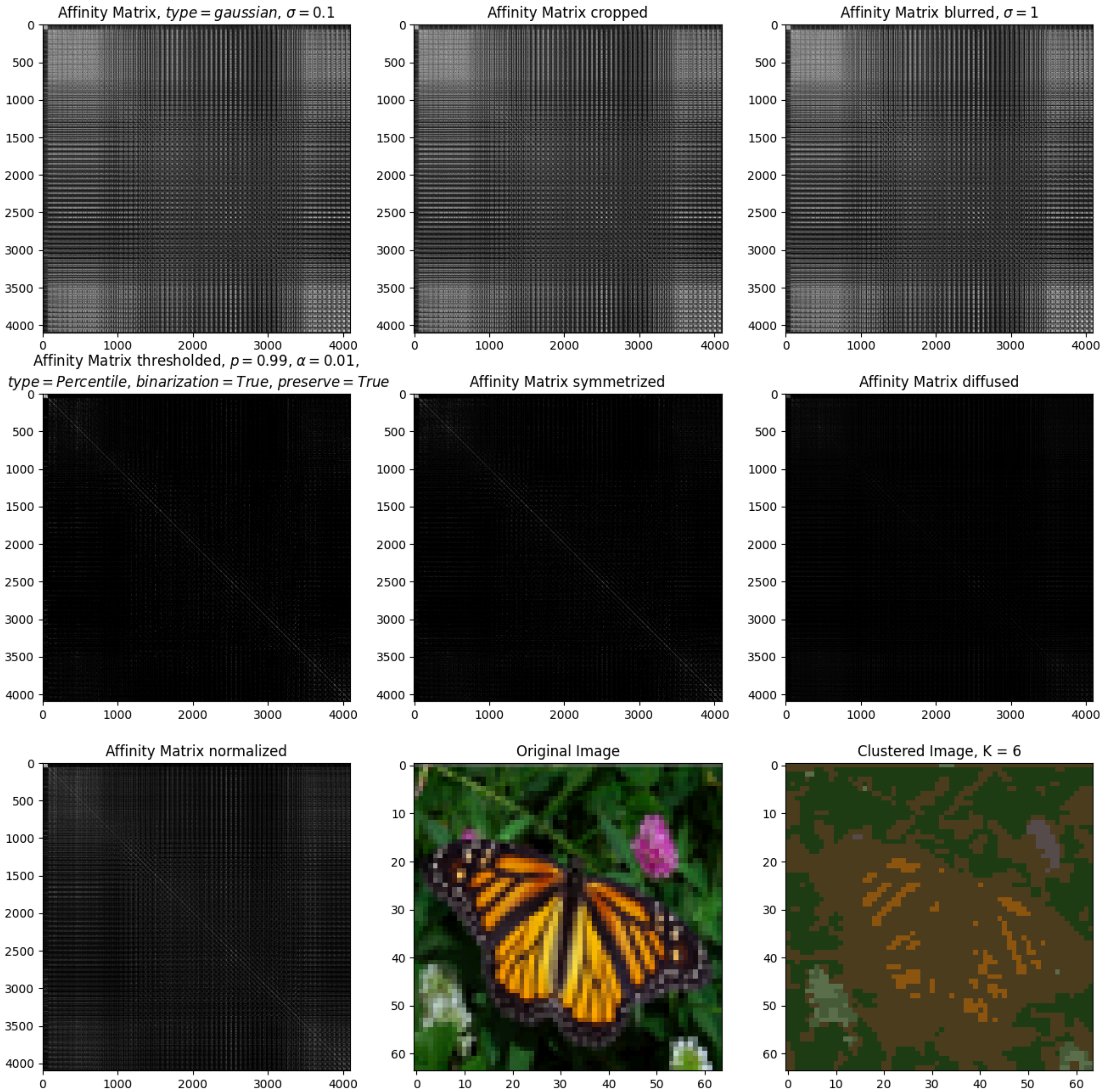


KMeans Clustering:

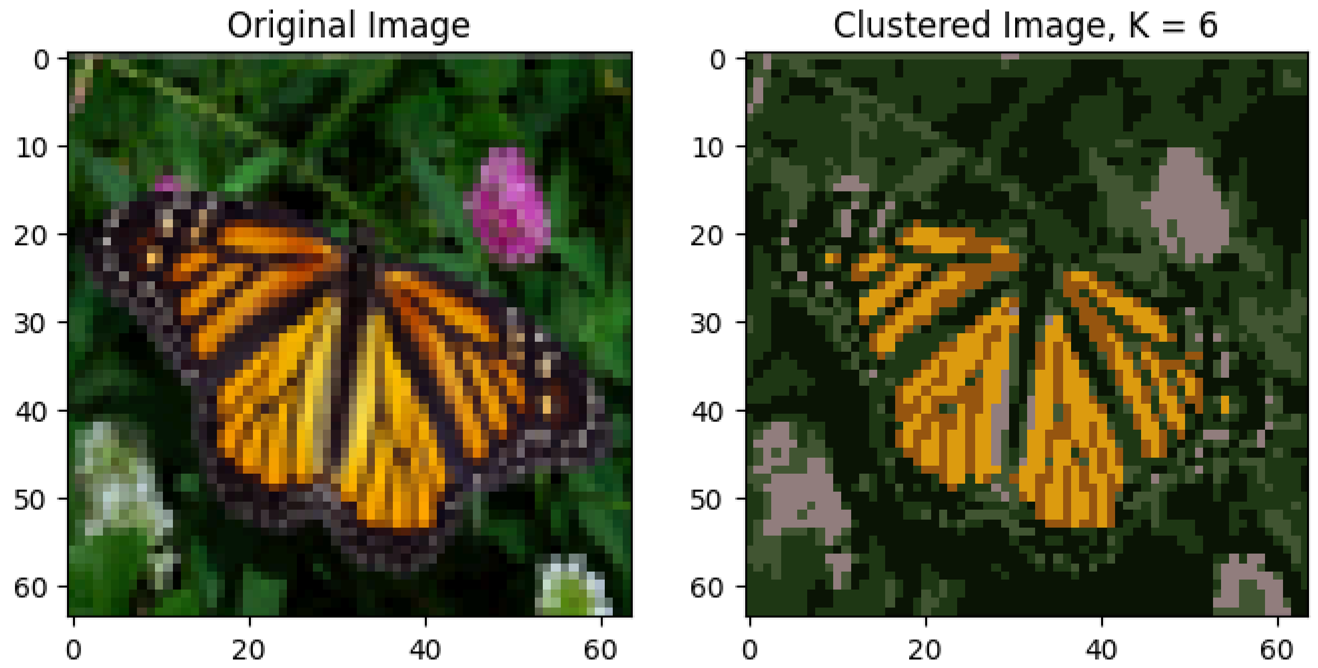
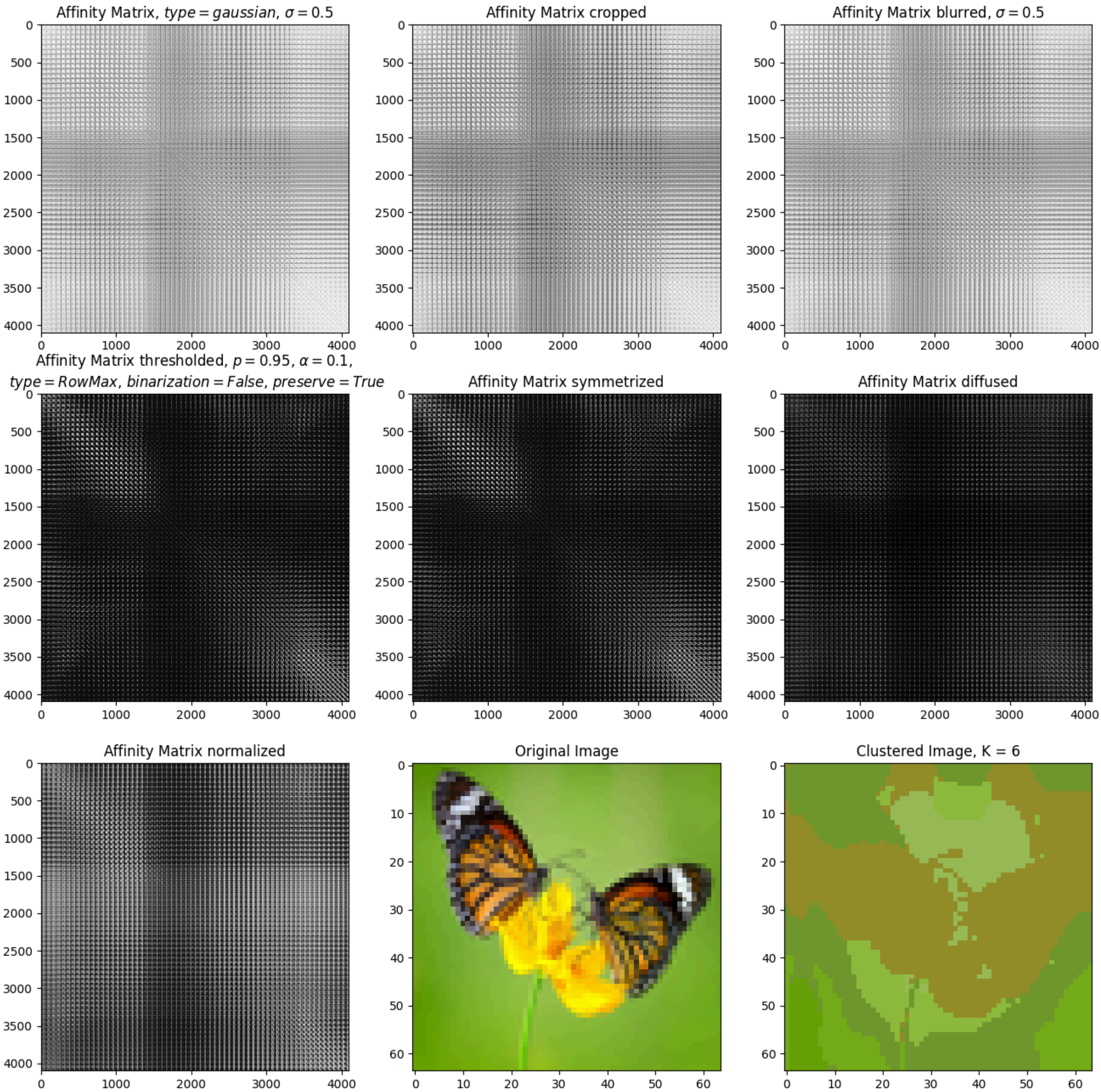


Image 2:

Ratio Cut



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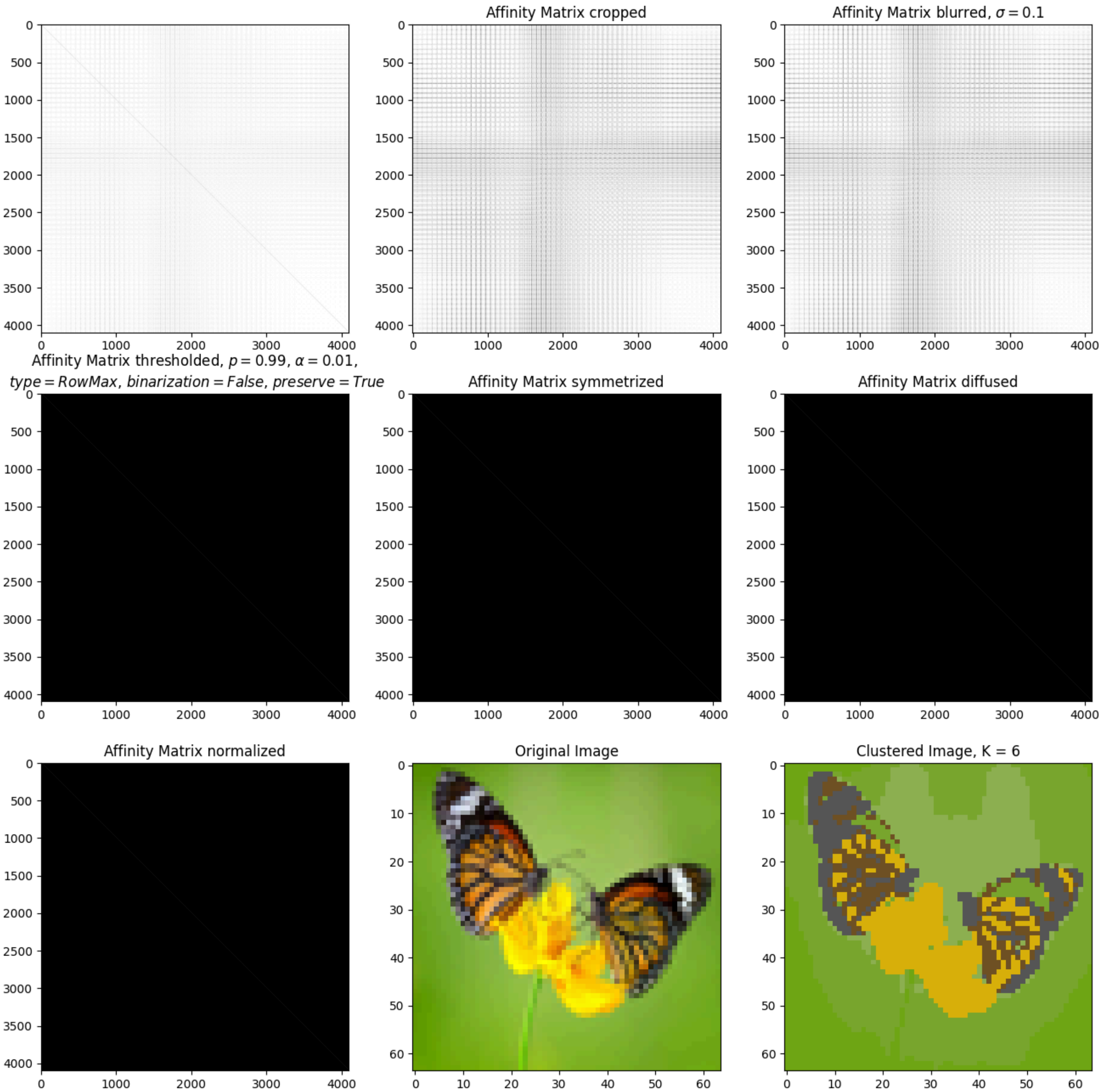
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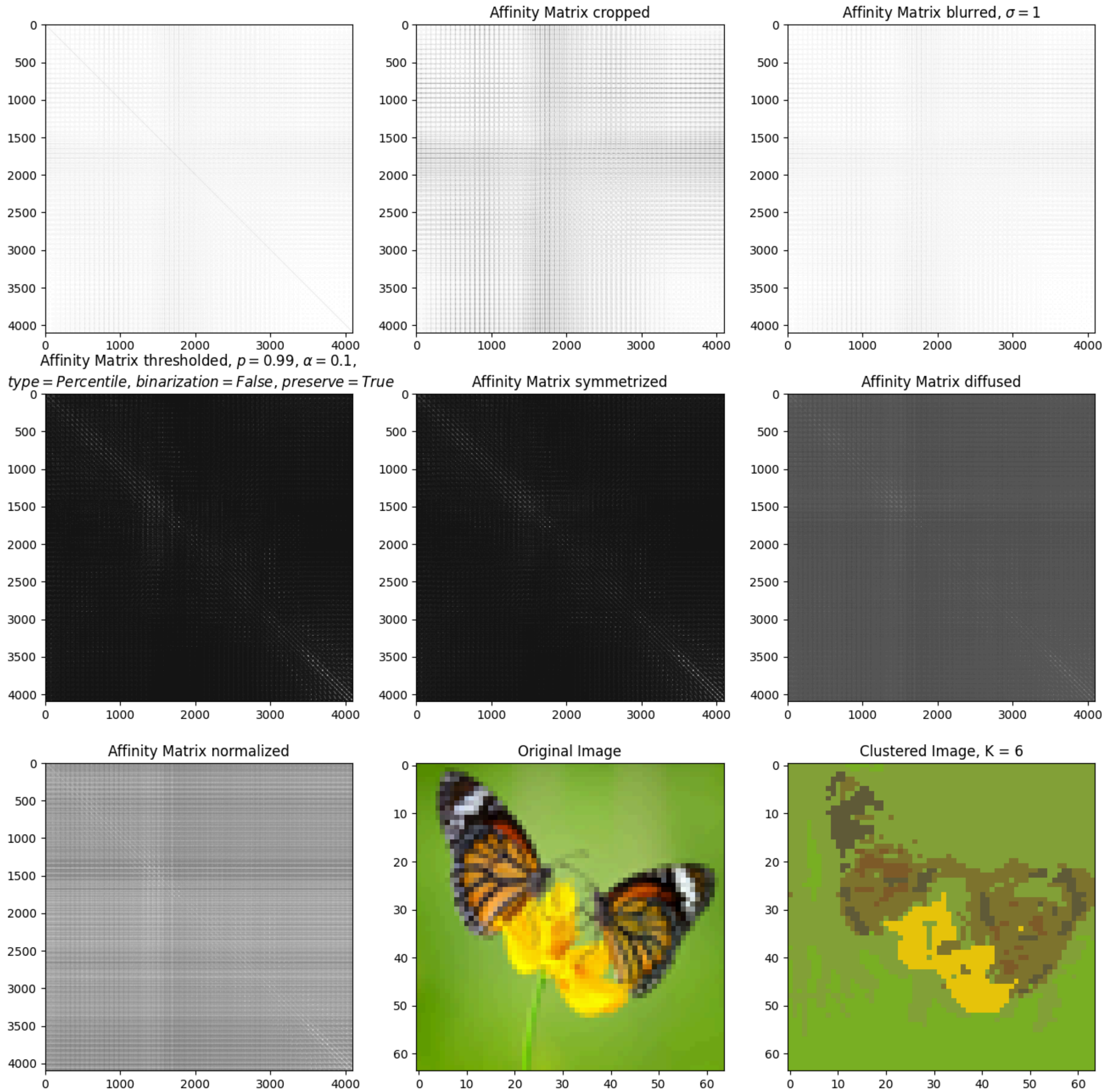
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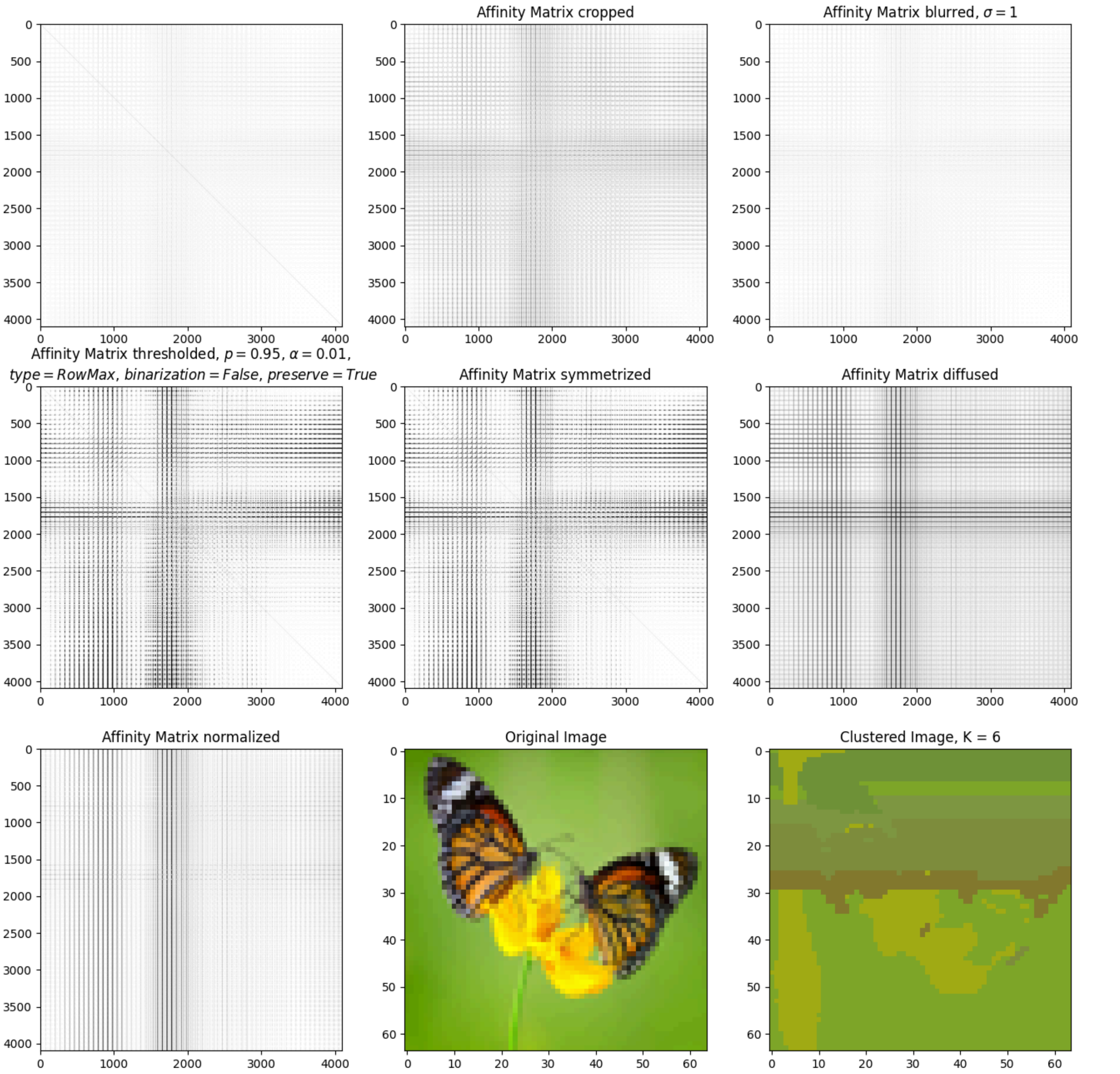

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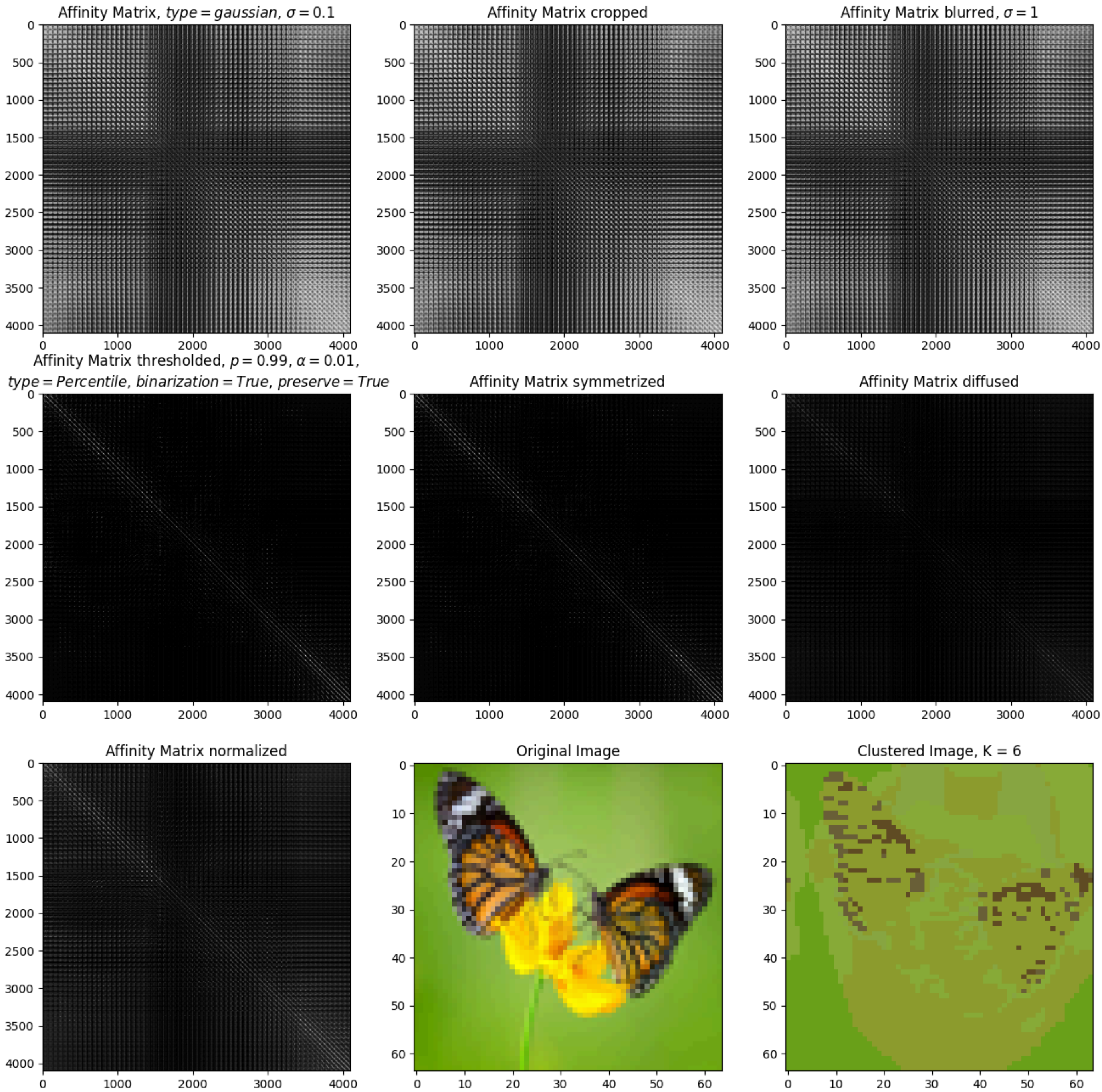
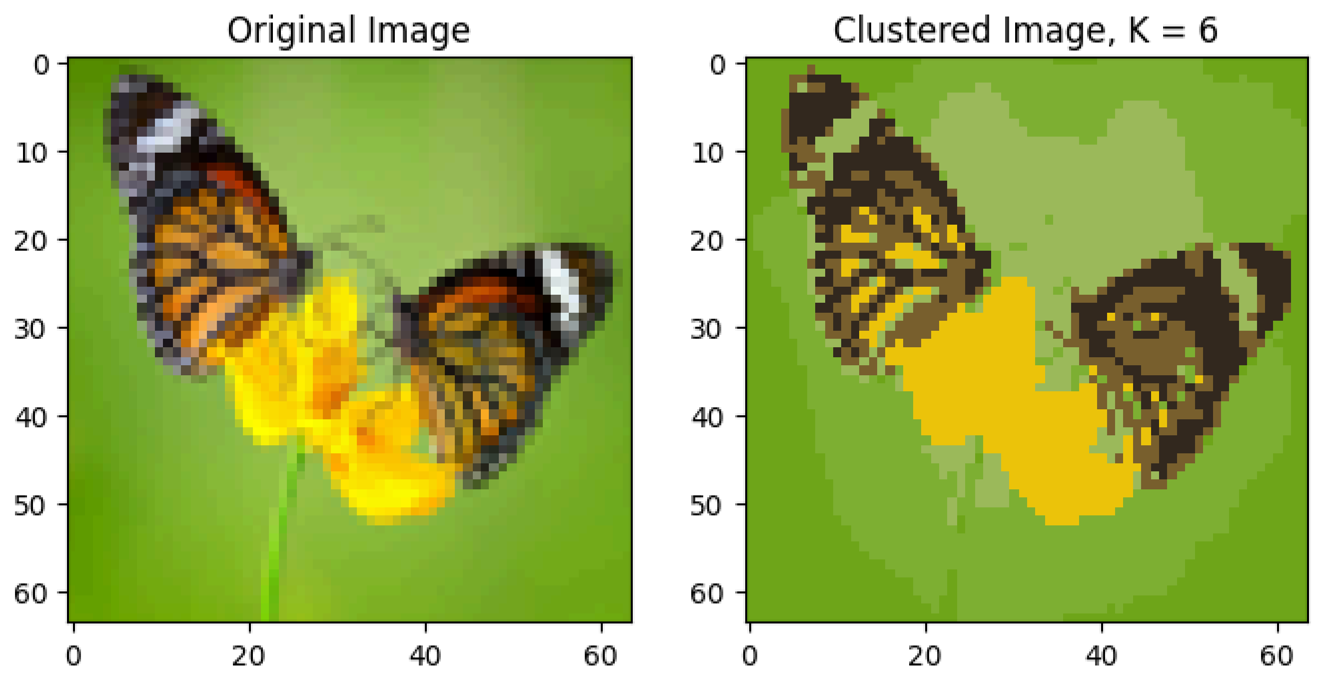


KMeans Clustering:

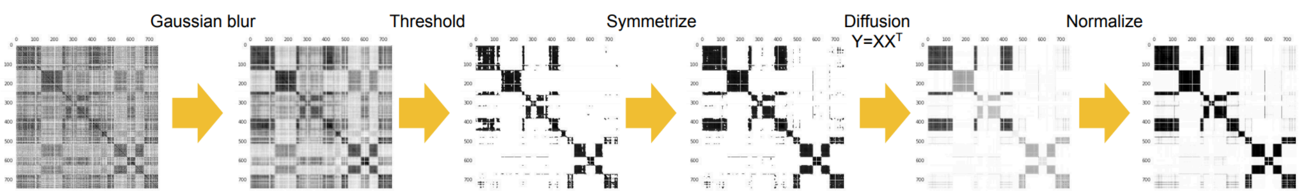


Appendix

Affine Matrix Refinement

Steps:

1. Blurring : Perform Gaussian Blurring on Affinity Matrix to smoothout the Affinities
2. Thresholding: Perform thresholding on the matrix to remove outliers, and constraint the Laplacian Matrix Range
3. Symmetrize: Since Blurring followed by Thresholding is non linear operation and non-symmetric. It will messup the symmetric property of Laplacian Matrix. Therefore we Re-Symmetrize the Laplacian.
4. Diffussion: Its done as XX^T
5. Normalization: Normalize each row of Laplacian, since each row of Laplacian is a different Vertex of the Graph.



The Parameters for each of the operations is dependent on the problem at hand.

References


```
@misc{wang2022speaker,
    title={Speaker Diarization with LSTM},
      author={Quan Wang and Carlton Downey and Li Wan and Philip Andrew Mansfield and Ignacio Lopez Moreno},
      year={2022},
      eprint={1710.10468},
      archivePrefix={arXiv},
      primaryClass={eess.AS},
      url = {https://arxiv.org/abs/1710.10468},
      github = {https://github.com/wq2012/SpectralCluster}
}
```