

ADVANCED DIGITAL IMAGE PROCESSING

ECE 7680

COURSE TERM PROJECT

WINTER 2018

BY

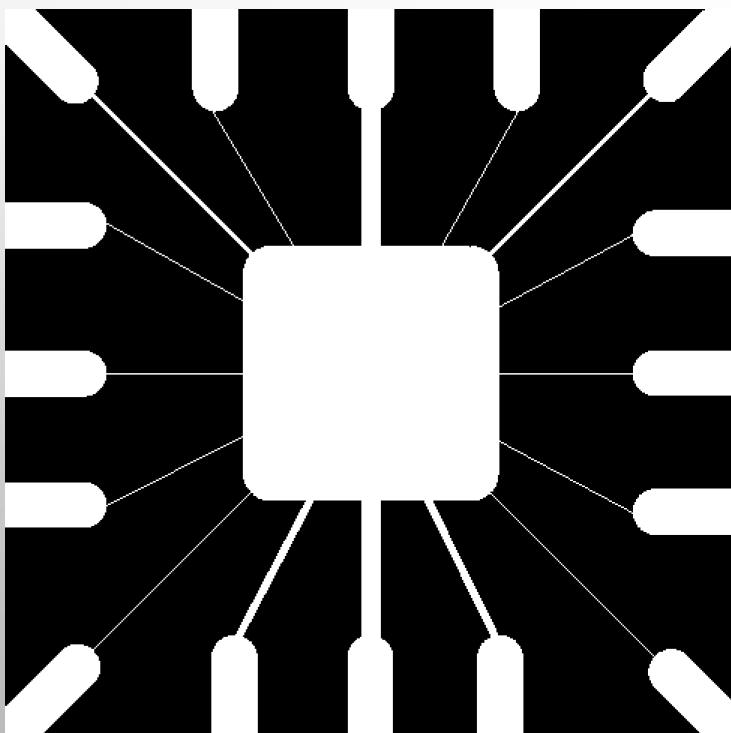
ROHIT RAIBAGKAR

GD4139

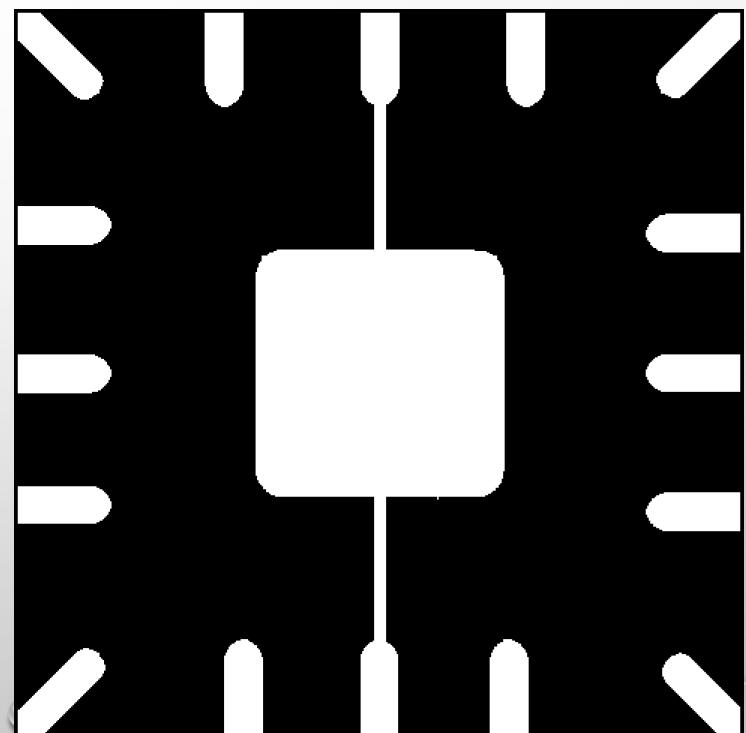
MORPHOLOGICAL IMAGE PROCESSING

EROSION - BINARY

486 X 486 WIRE BOND MASK
(BINARY)

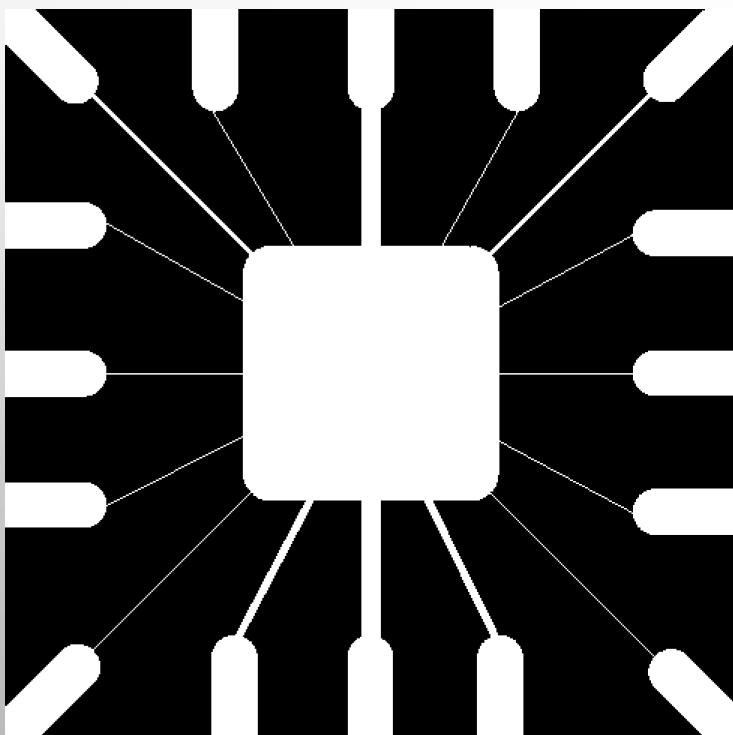


EROSION BY 11 X 11 SE

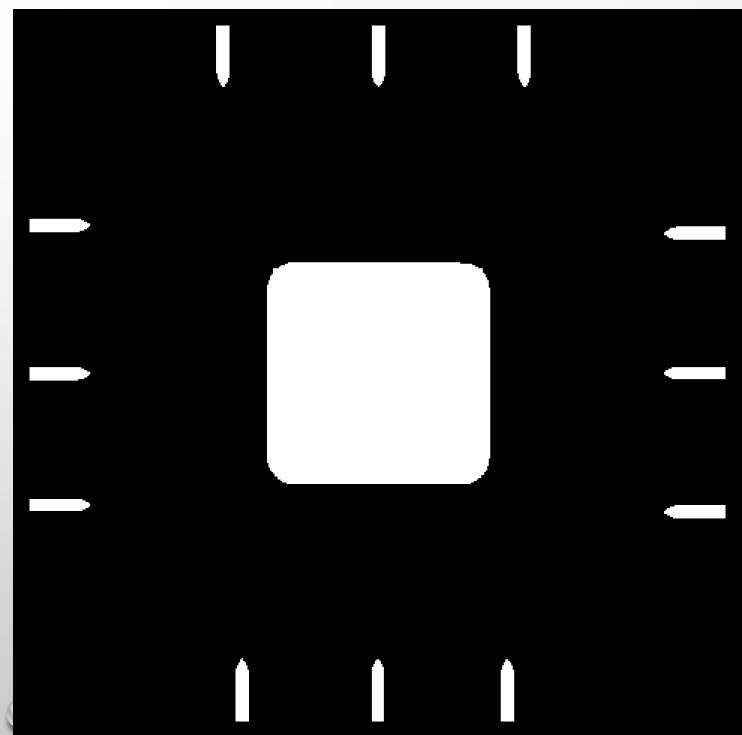


EROSION - BINARY

486 X 486 WIRE BOND MASK
(BINARY)

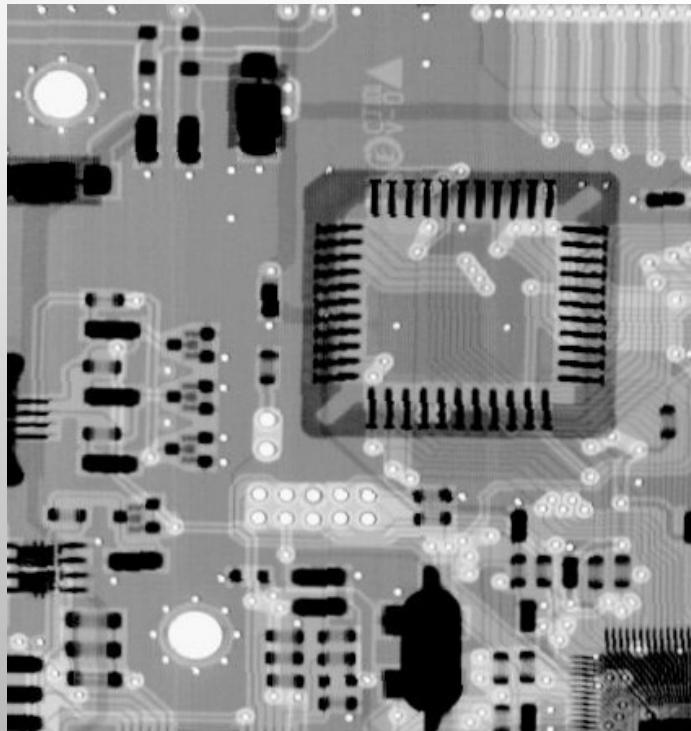


EROSION BY 45 X 45 SE

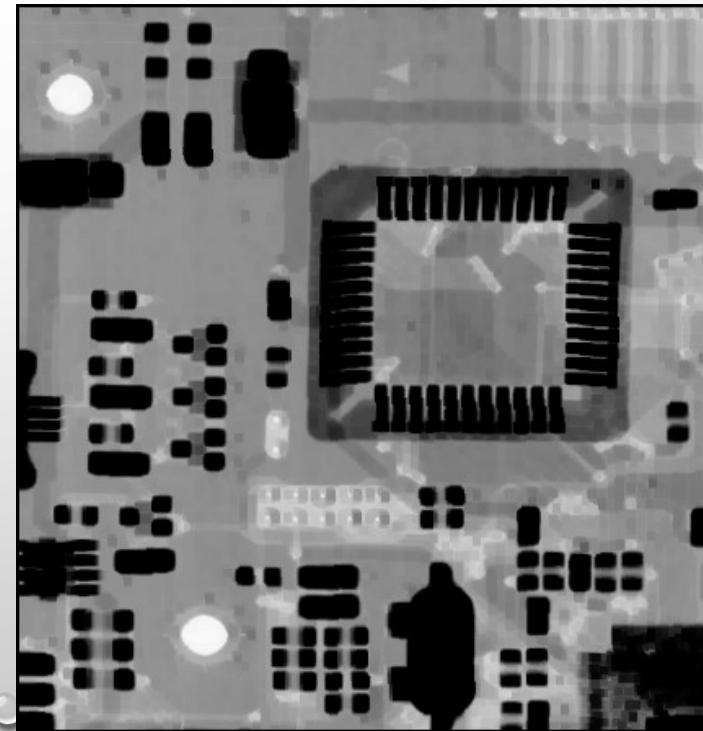


EROSION - GRayscale

448 X 425 GRAY-SCALE X-RAY OF CIRCUIT BOARD



EROSION BY 5 X 5 SE



DILATION - BINARY

- BROKEN TEXT 1019 X 889 PIXELS
BINARY IMAGE

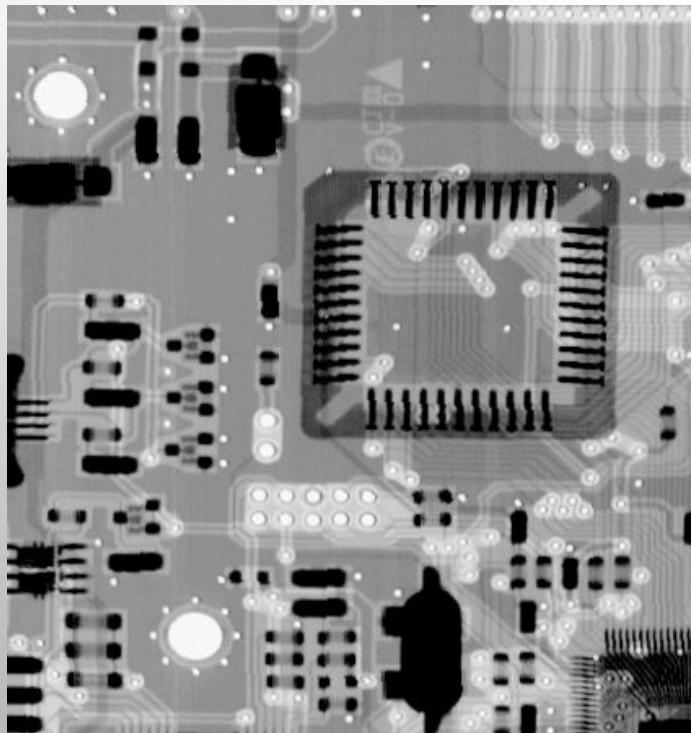
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

DILATION BY 3 X 3 SE

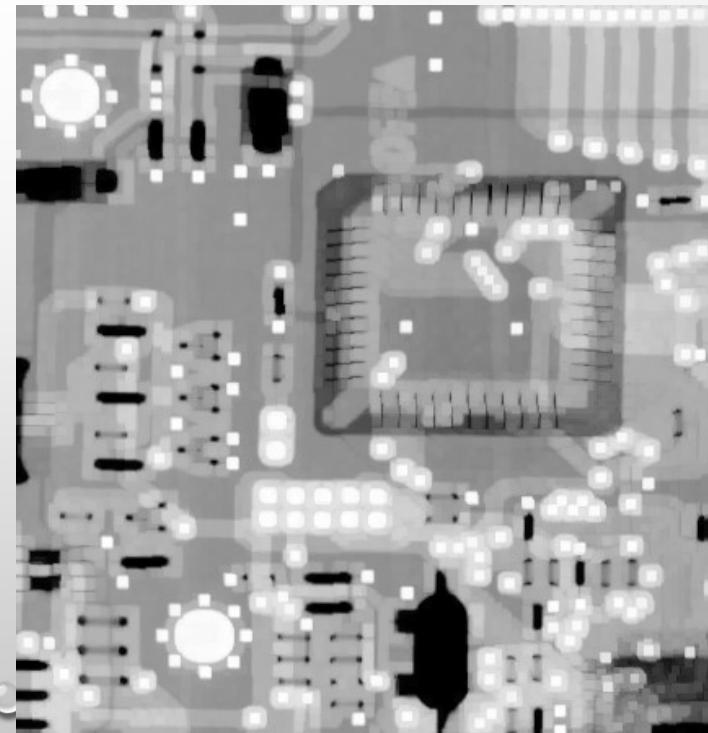
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

DILATION - GRayscale

448 X 425 GRAY-SCALE X-RAY OF CIRCUIT BOARD

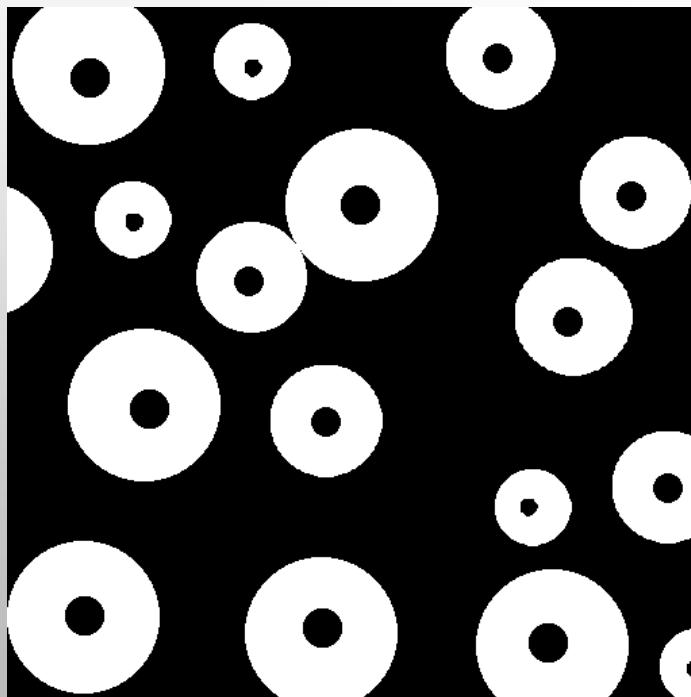


DILATION BY 5 X 5 SE

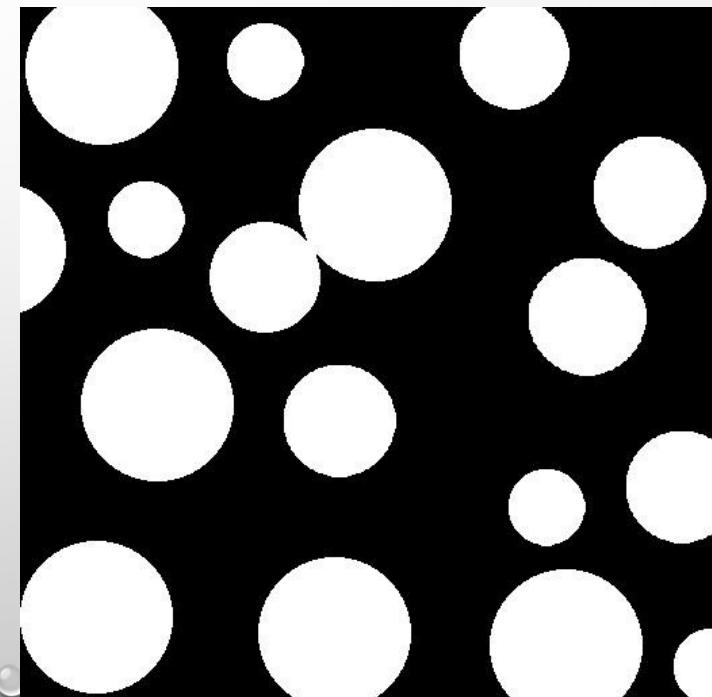


HOLE FILLING - BINARY

512 X 512 BALLS WITH
REFLECTIONS

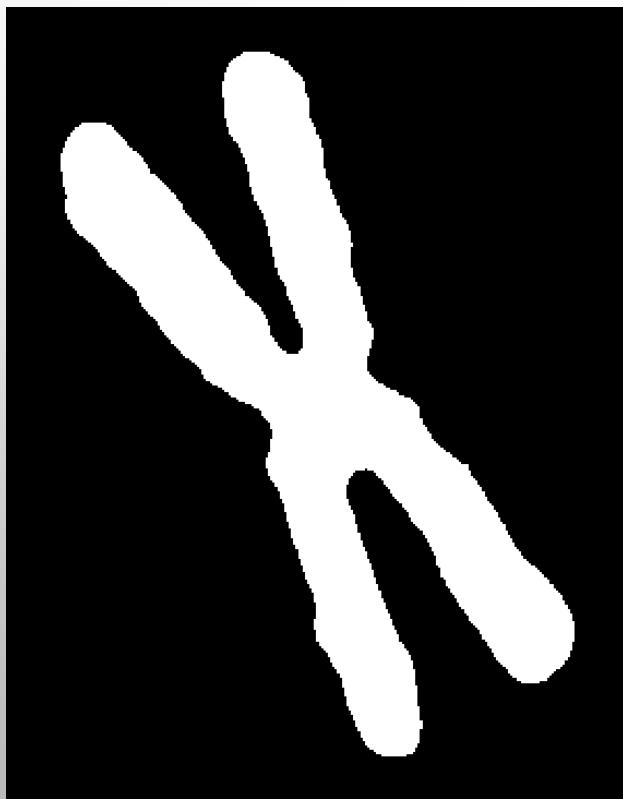


HOLE FILLING

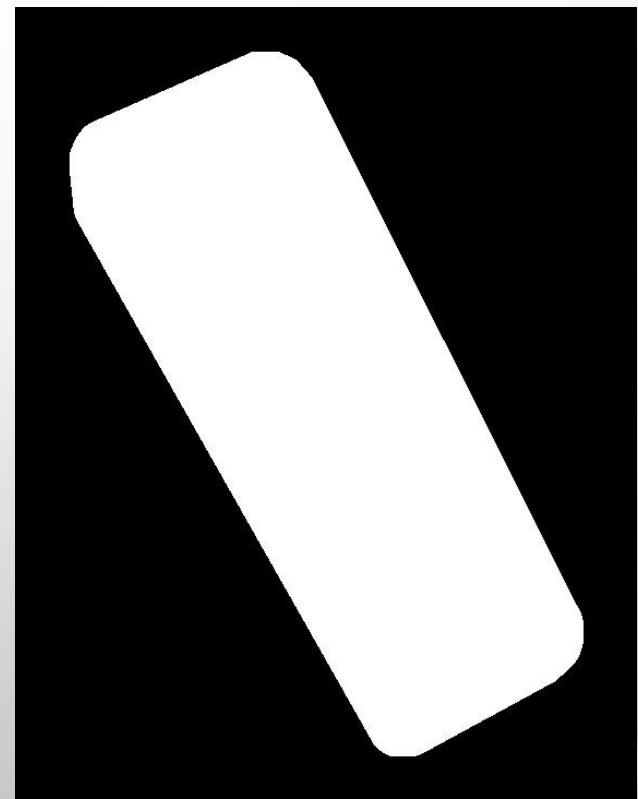


CONVEX HULL - BINARY

570 X 727 CHROMOSOME

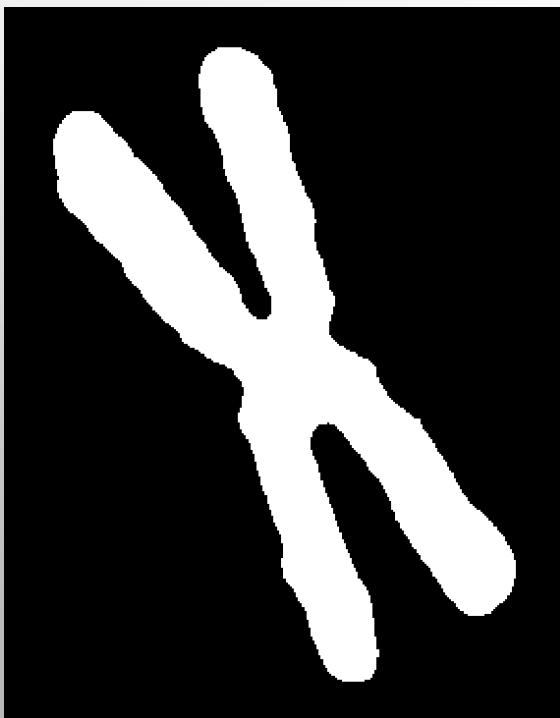


CONVEX HULL

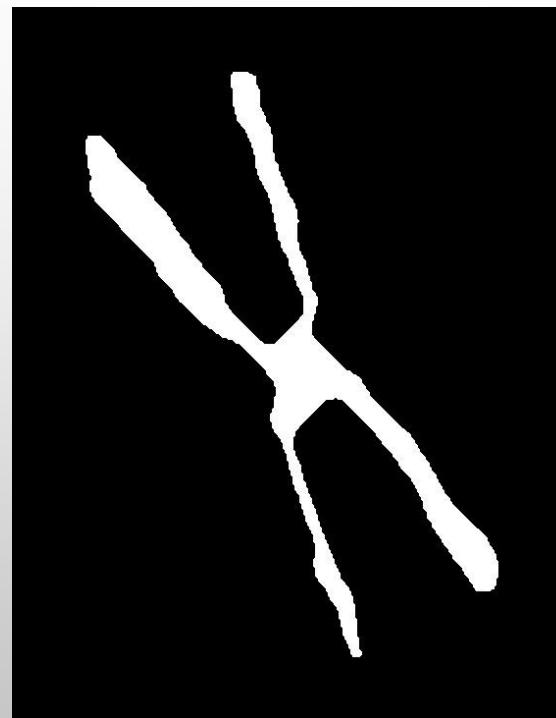


THINNING – BINARY IMAGE

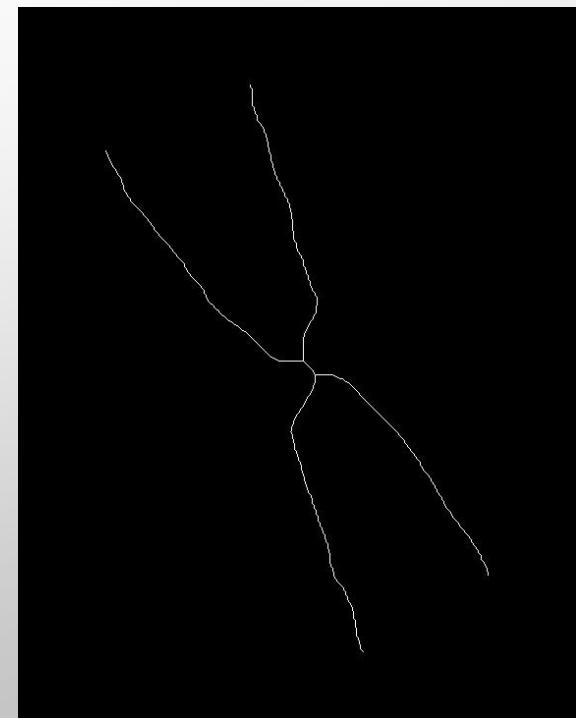
570 X 727
CHROMOSOME



THINNING AFTER 25
ITERATION

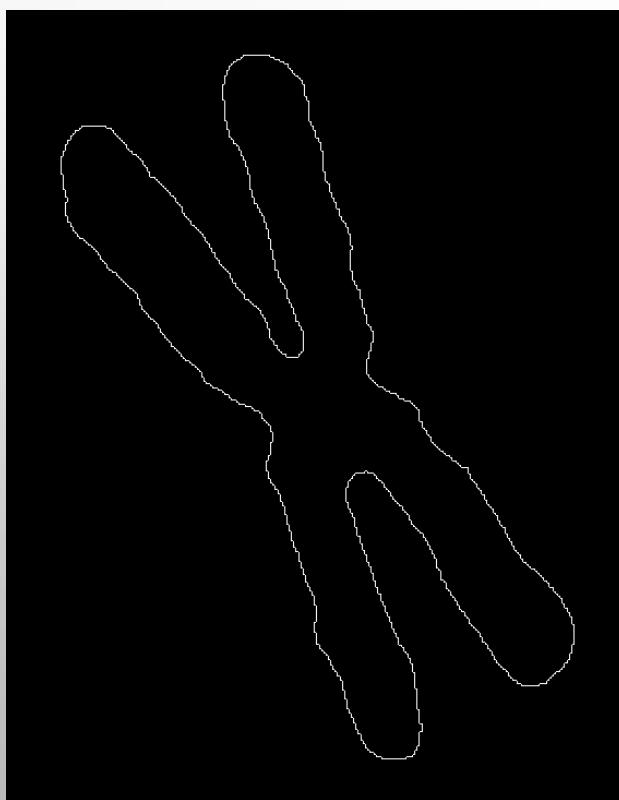


THINNING AFTER
INFINITE ITERATION

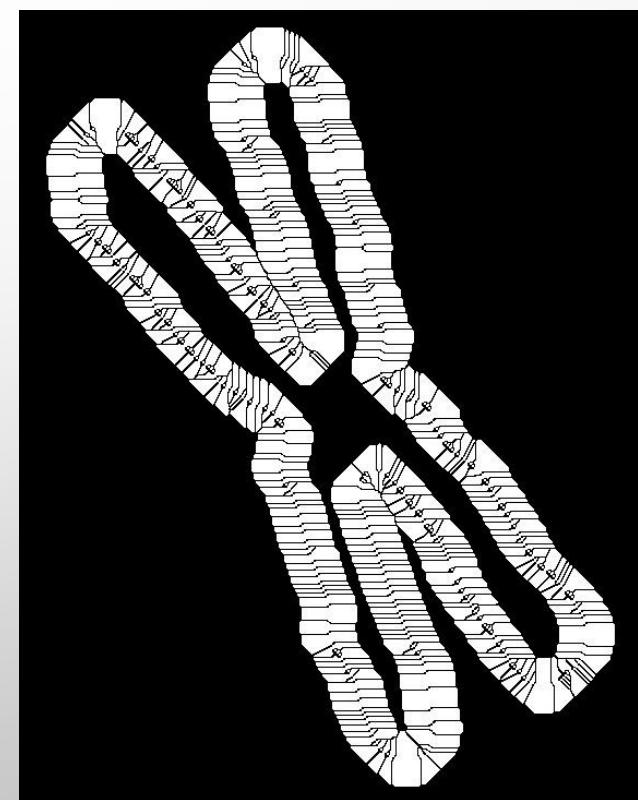


THICKENING - BINARY

570 X 727 CHROMOSOME EDGE

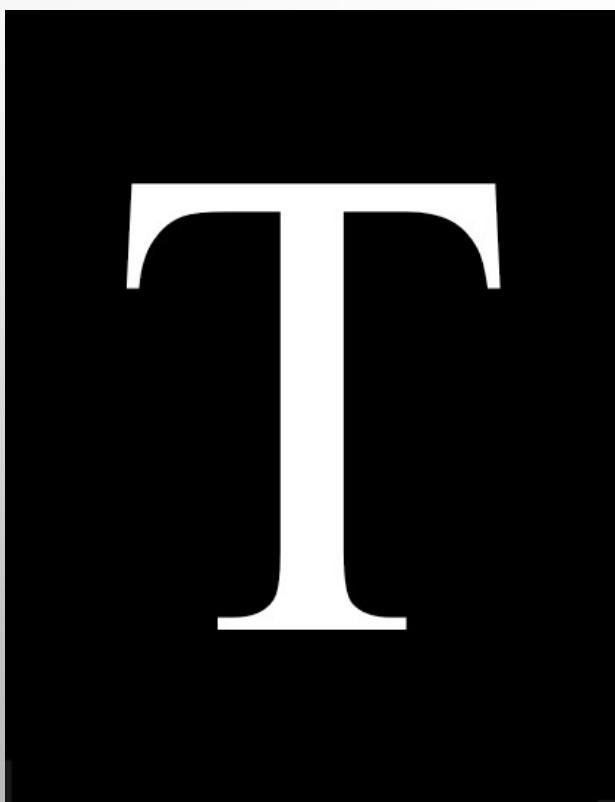


THICKENING AFTER 25
ITERATIONS

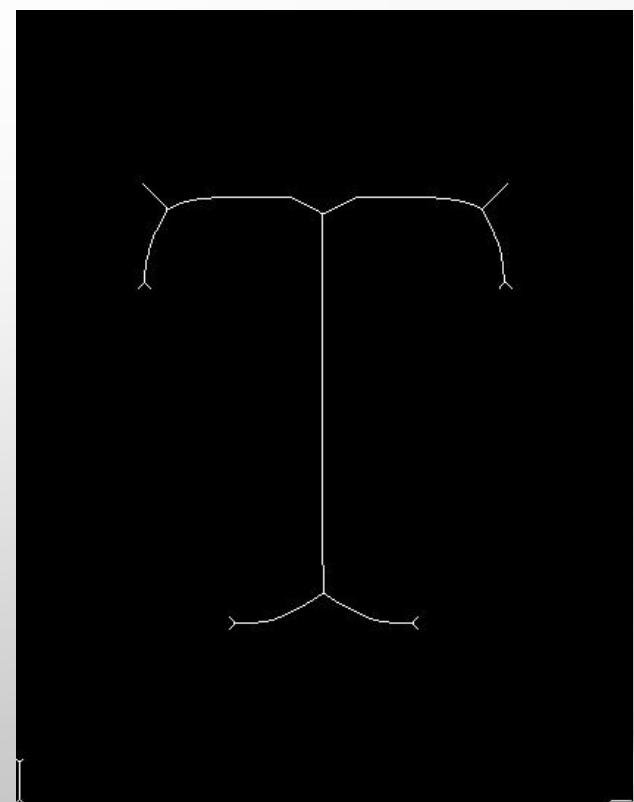


SKELETONS - BINARY

420 X 540 LETTER T



SKELETON AFTER INFINITE
ITERATIONS

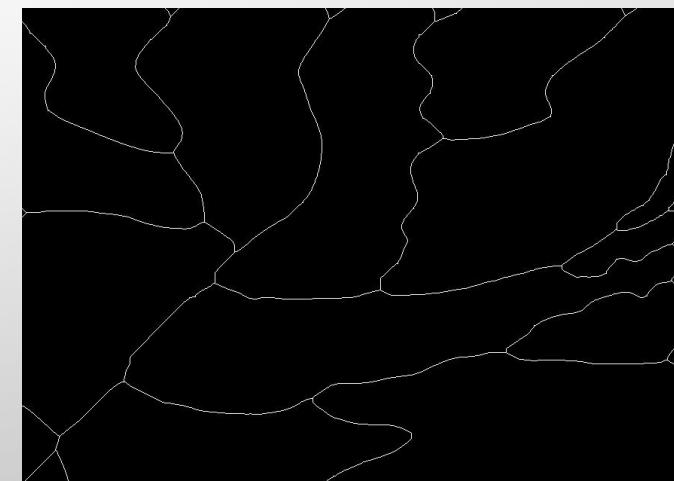
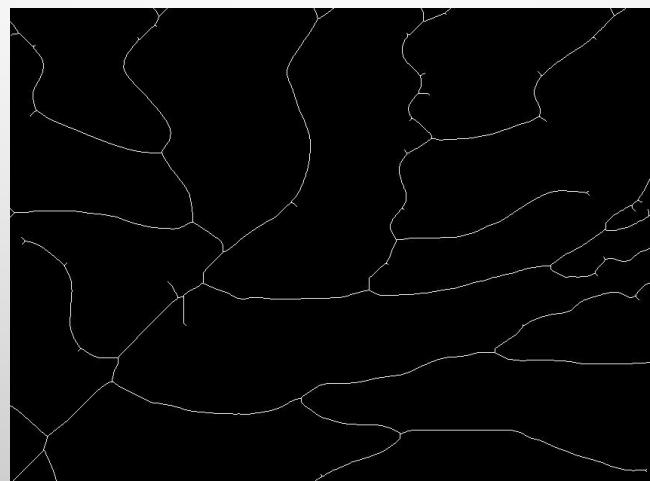


PRUNING – BINARY IMAGE

869 X 632
BLOOD VESSELS

SKELETON AFTER INFINITE
ITERATIONS

PRUNING AFTER INFINITE
ITERATION



OPENING - BINARY

NOISY FINGERPRINT 315 X 228
PIXELS, BINARY

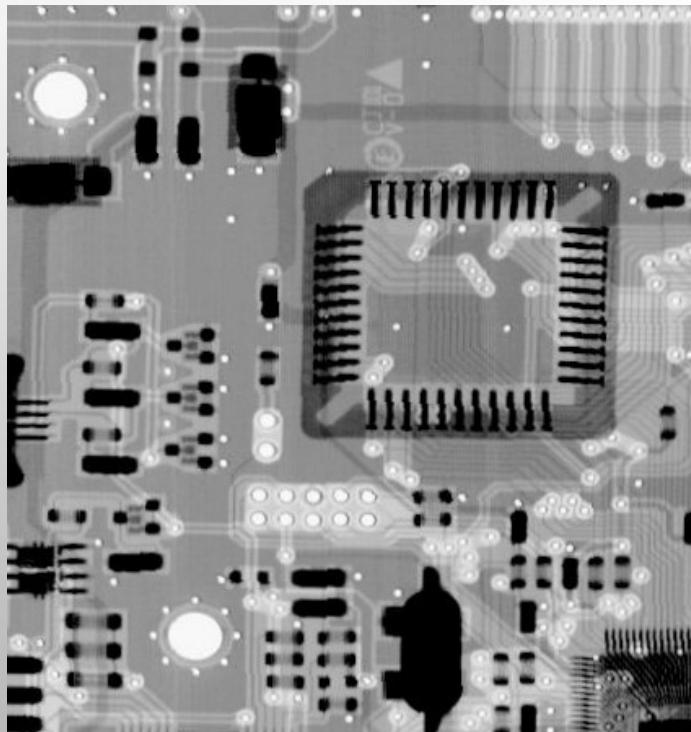


OPENING BY 3 X 3 SE

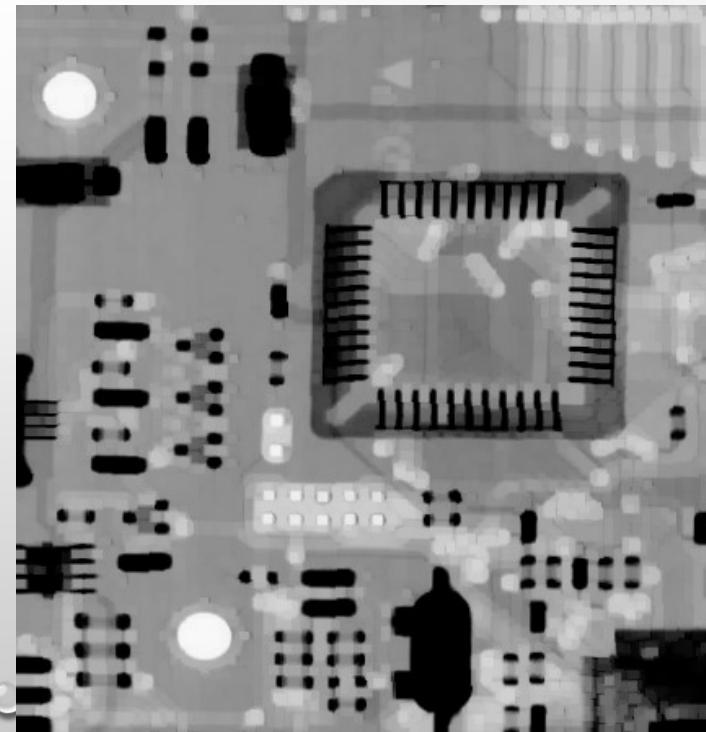


OPENING - GRayscale

448 X 425 GRAY-SCALE X-RAY OF CIRCUIT BOARD



OPENING BY 5 X 5 SE



CLOSING - BINARY

- BROKEN TEXT 1019 X 889 PIXELS
BINARY IMAGE

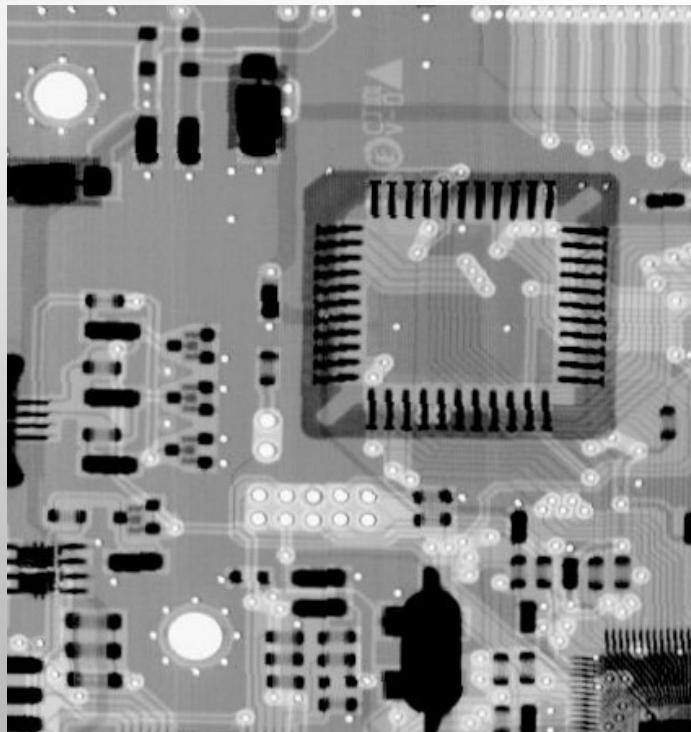
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

- CLOSING BY 5 X 5 SE

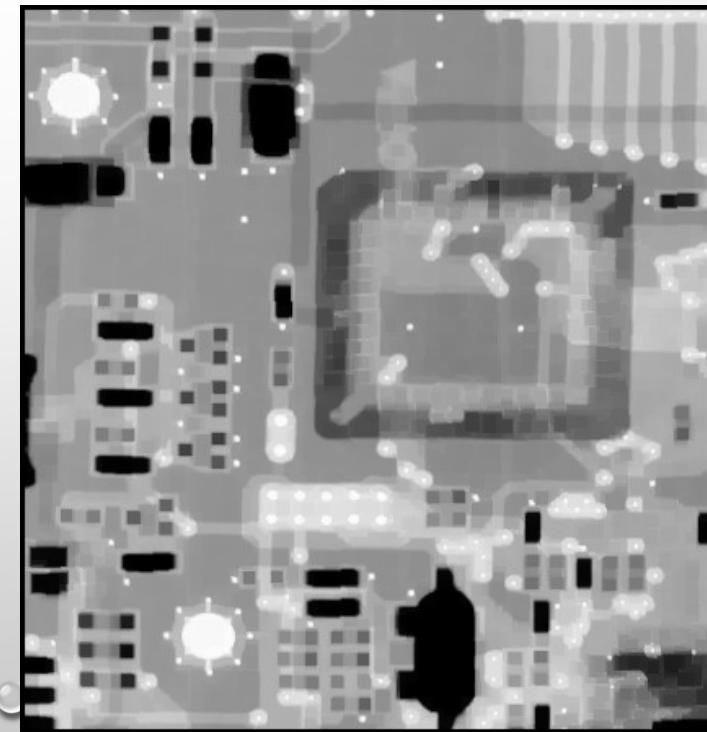
Historically, certain computer programs were written using only two digits rather than four to define the applicable year. Accordingly, the company's software may recognize a date using "00" as 1900 rather than the year 2000.

CLOSING - GRayscale

448 X 425 GRAY-SCALE X-RAY OF CIRCUIT BOARD



CLOSING BY 7 X 7 SE



BOUNDARY EXTRACTION – BINARY IMAGE

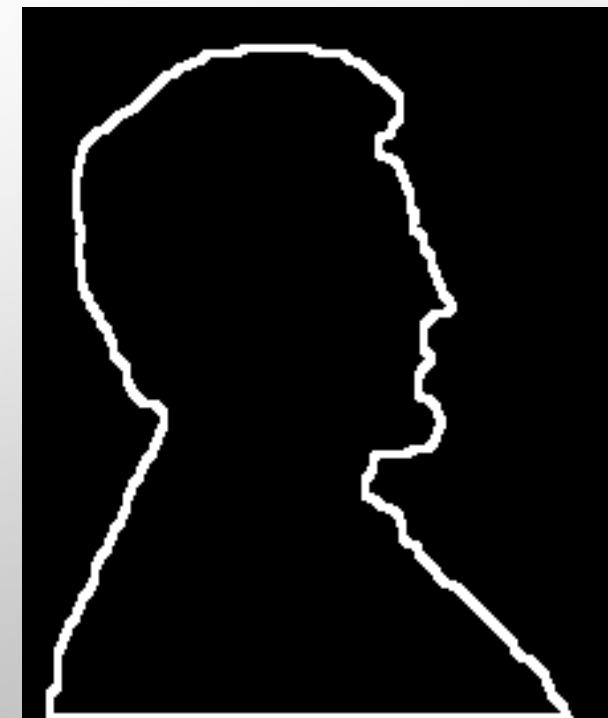
LINCOLN : 221 X 269
BINARY



BOUNDARY EXTRACTION
BY 3 X 3 SE



BOUNDARY EXTRACTION
BY 7 X 7 SE



BOUNDARY EXTRACTION – GRayscale Image

CAMERAMAN 512 X 512
PIXEL, GRayscale



BOUNDARY EXTRACTION
BY 3 X 3 SE

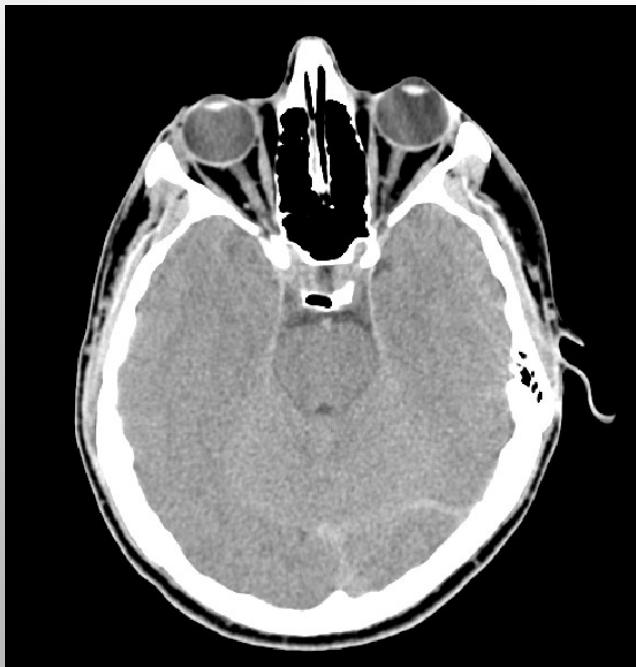


BOUNDARY EXTRACTION
BY 7 X 7 SE

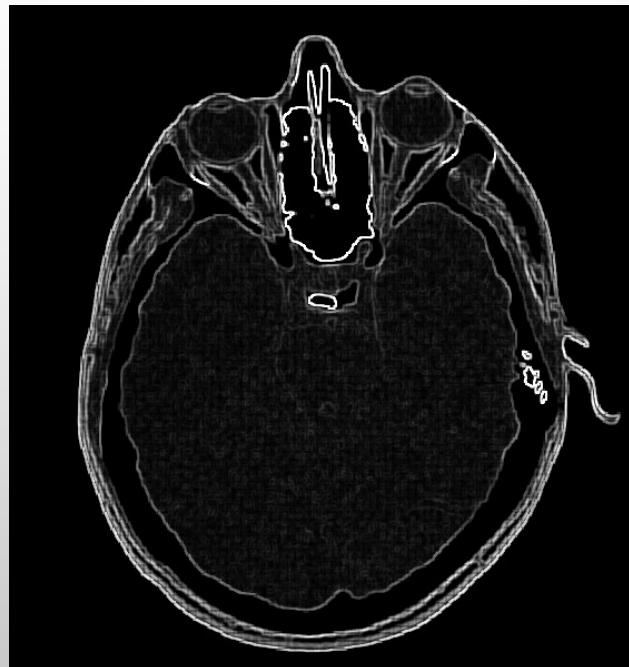


MORPHOLOGICAL GRADIENT

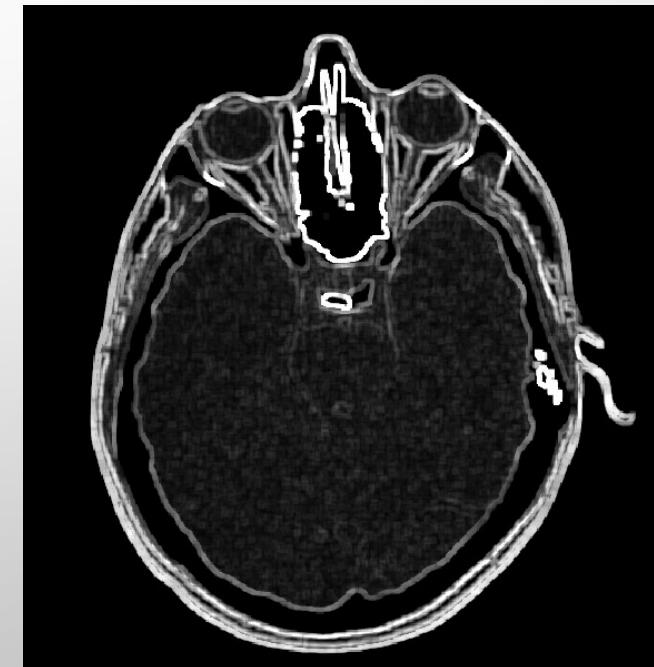
HEAD CT SCAN
512 X 512 PIXELS



MORPH. GRADIENT
USING 3 X 3 SE

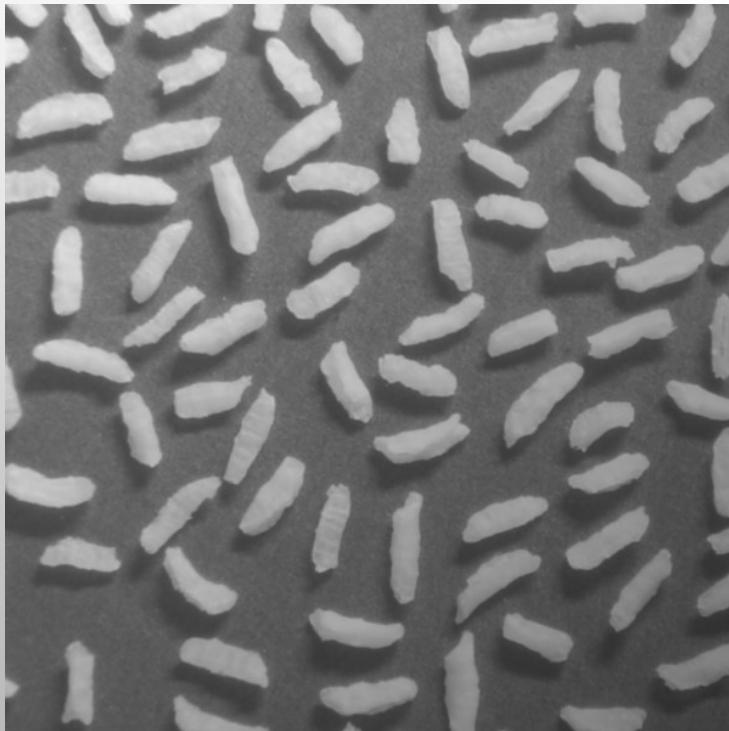


MORPH. GRADIENT
USING 5 X 5 SE

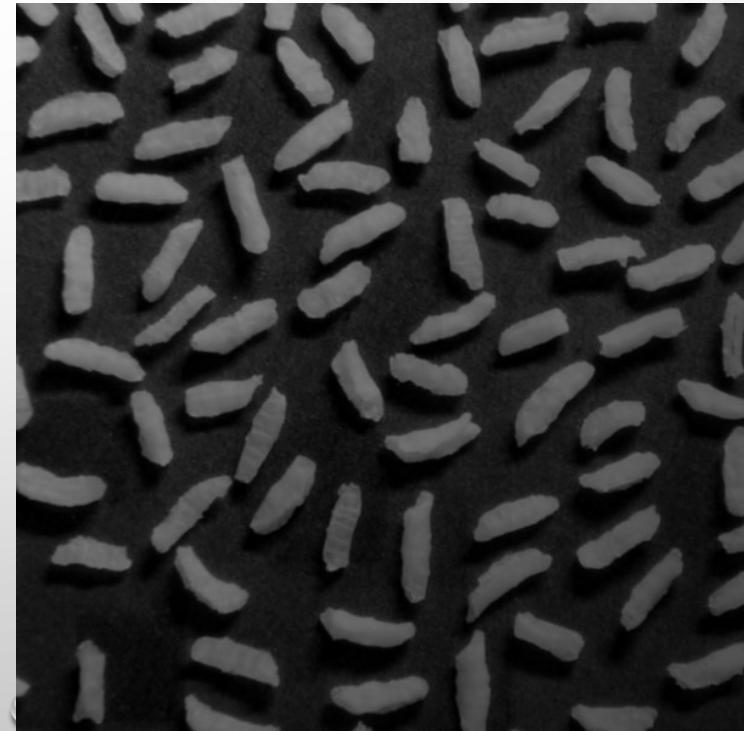


TOP-HAT TRANSFORM

RICE SHADED 600 X 600 PIXELS



TOP-HAT BY 81 X 81 SE



BOTTOM-HAT TRANSFORM

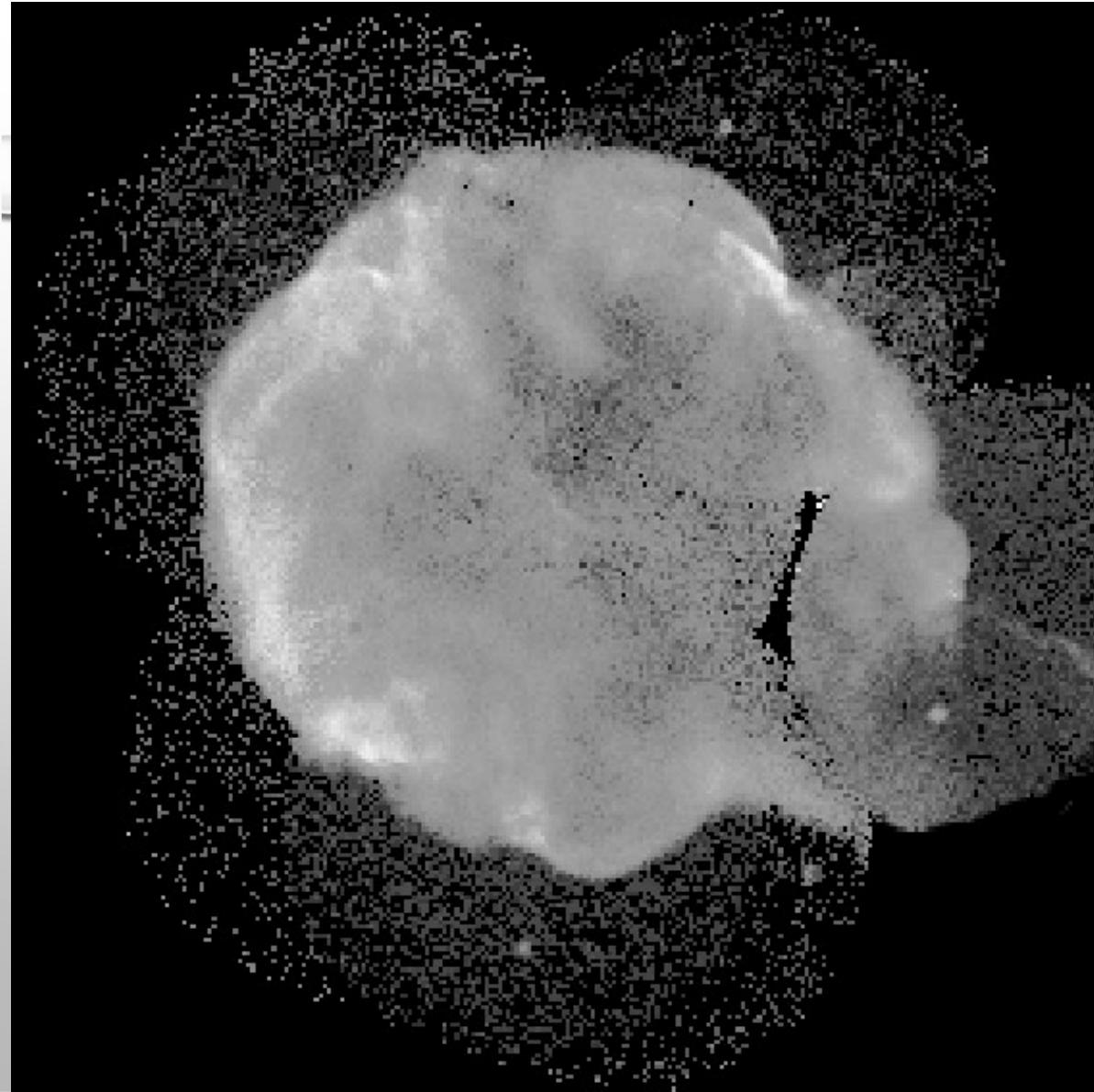
CAMERAMAN 512 X 512 PIXELS



BOTTOM-HAT BY 13 X 13 SE



MORPHOLOGICAL PROCESSING FOR NOISE REDUCTION

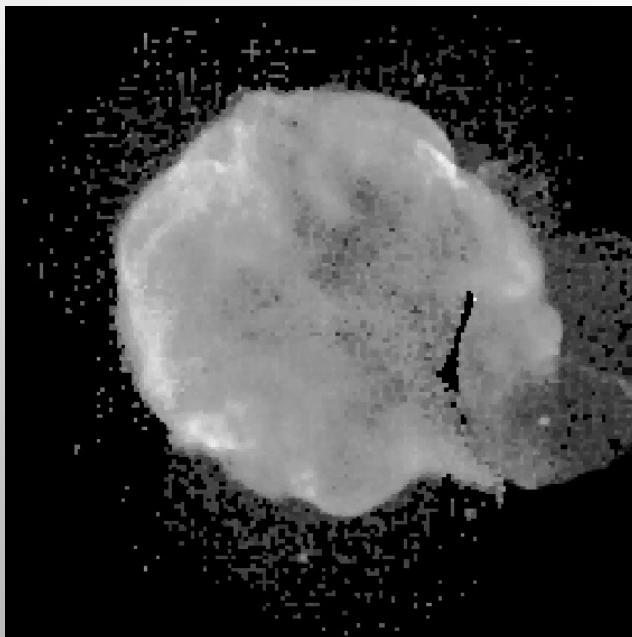


CYGNUS LOOP
SUPERNOVIA
566 X 566

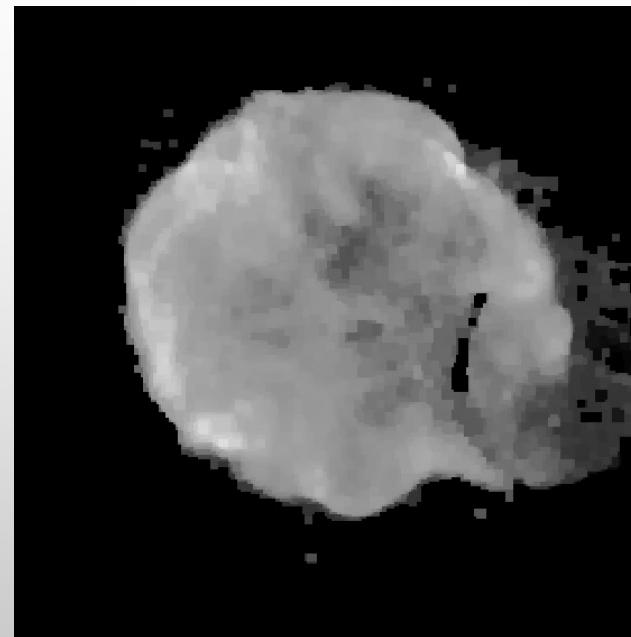
CORRUPTED BY
NOISE

MORPHOLOGICAL SMOOTHING FOR NOISE REDUCTION

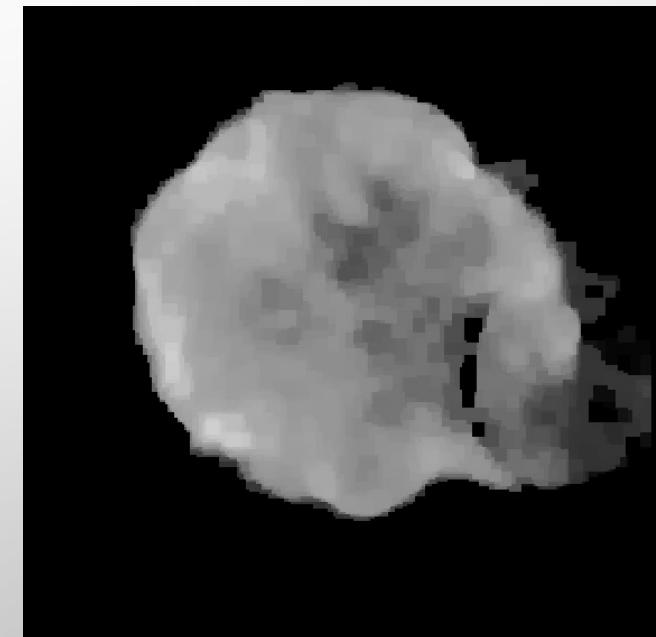
MORPHOLOGICAL SMOOTHING
WITH S.E. OF RADIUS 1 (3 X 3)



MORPHOLOGICAL SMOOTHING
WITH S.E. OF RADIUS 3 (7 X 7)



MORPHOLOGICAL SMOOTHING
WITH S.E. OF RADIUS 5 (11 X 11)



MORPHOLOGICAL SMOOTHING FOR NOISE REDUCTION

NOISY BINARY FINGERPRINT IMAGE



RESULT OF MORPHOLOGICAL SMOOTHING
WITH S.E. OF SIZE 3 X 3

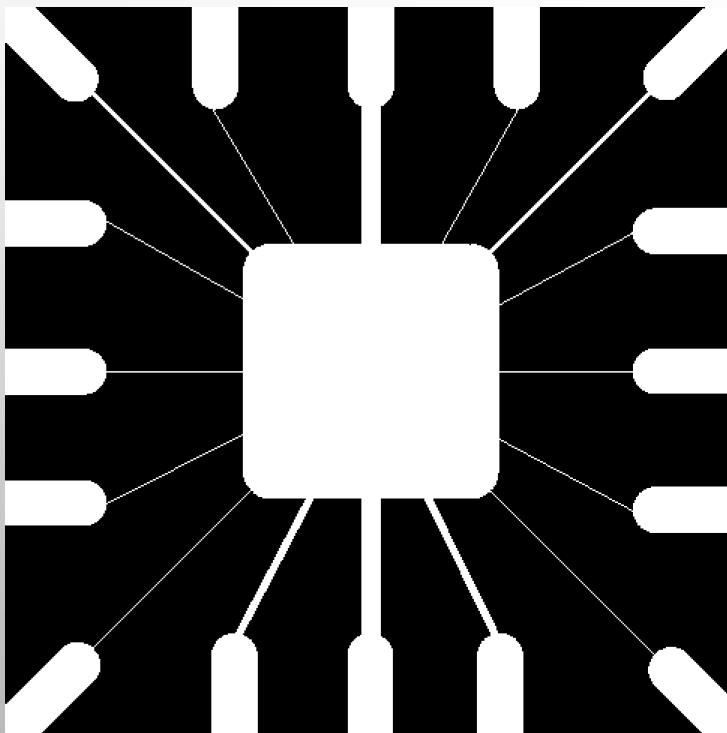


IMAGE SEGMENTATION

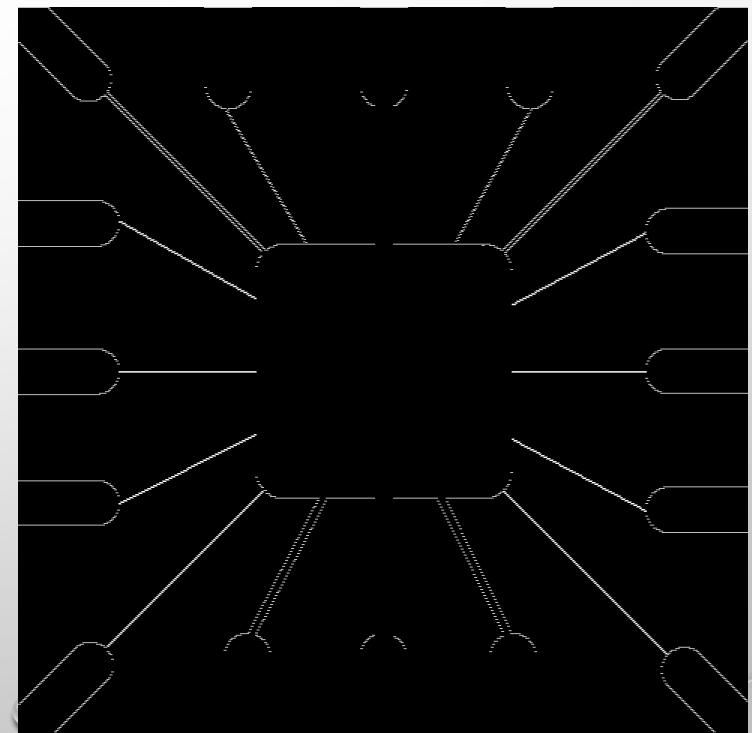
1

HORIZONTAL LINE DETECTION

486 X 486 WIRE BOND MASK
(BINARY)

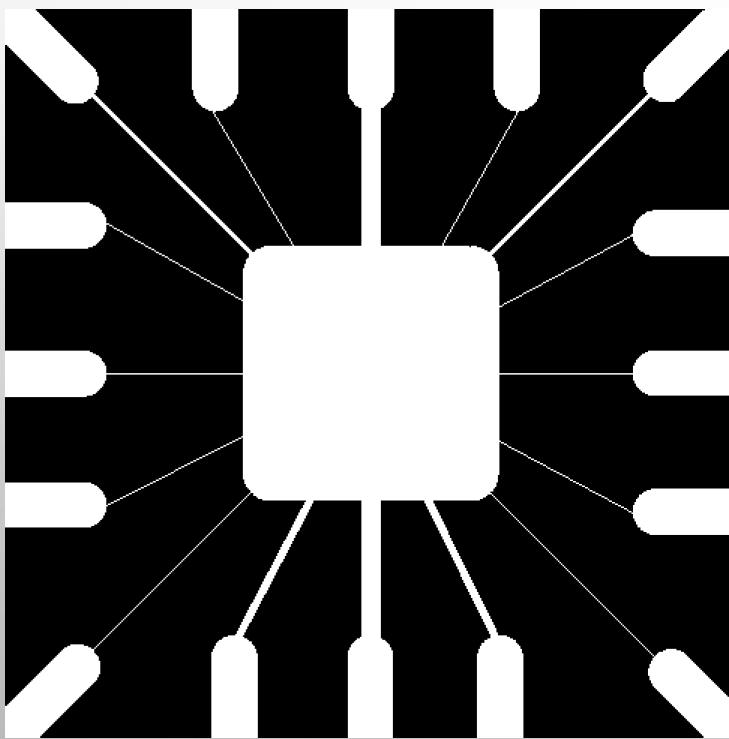


HORIZONTAL LINE DETECTION

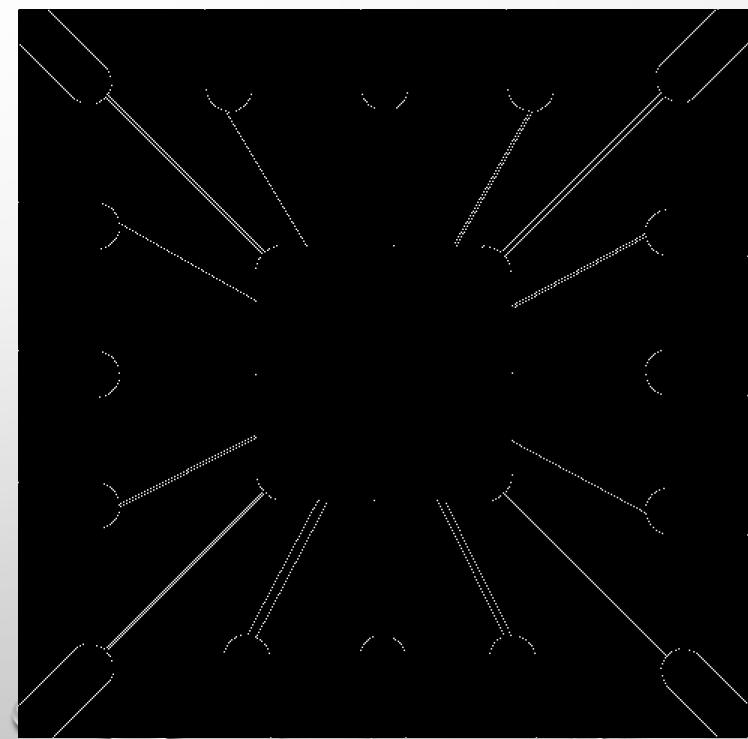


+ 45° LINE DETECTION

486 X 486 WIRE BOND MASK
(BINARY)

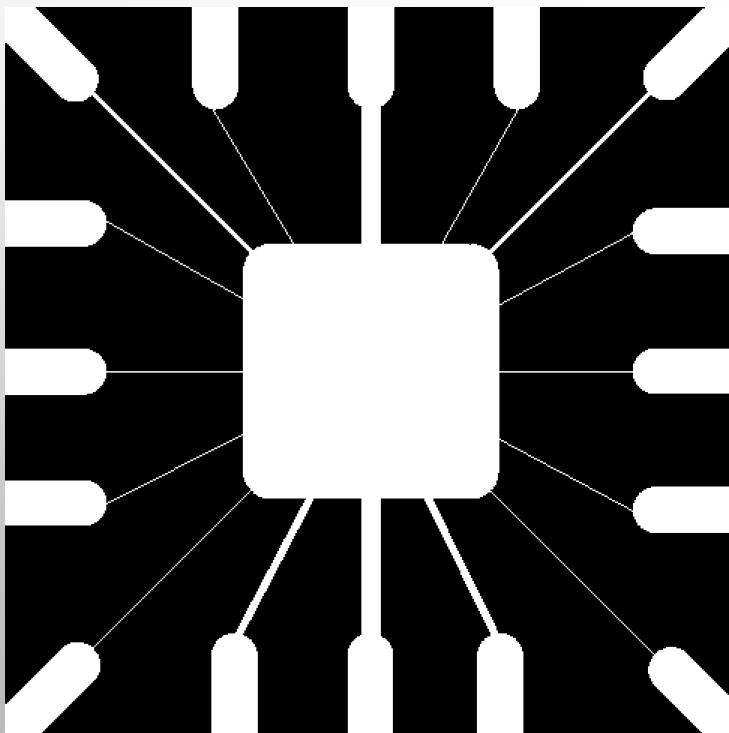


+45° LINE DETECTION

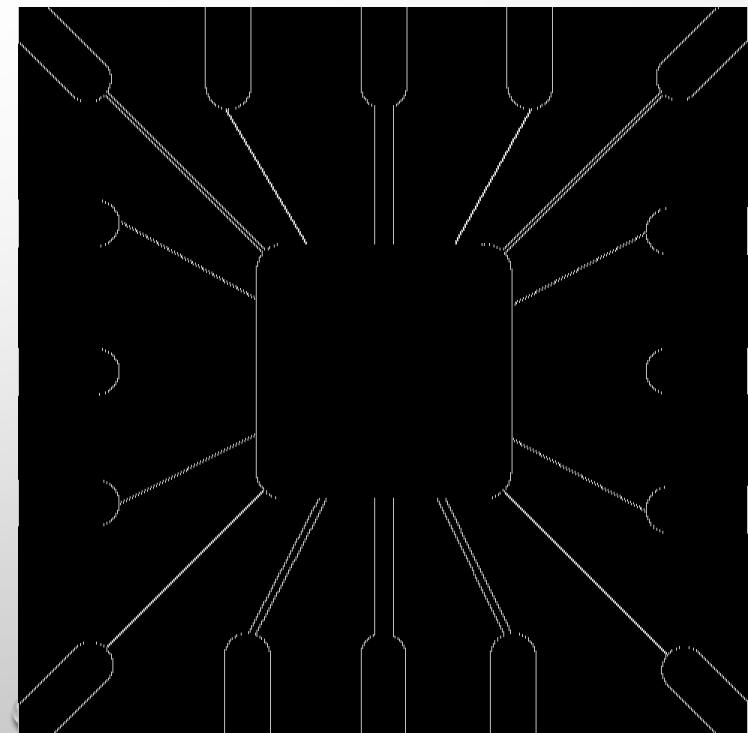


VERTICAL LINE DETECTION

486 X 486 WIRE BOND MASK
(BINARY)

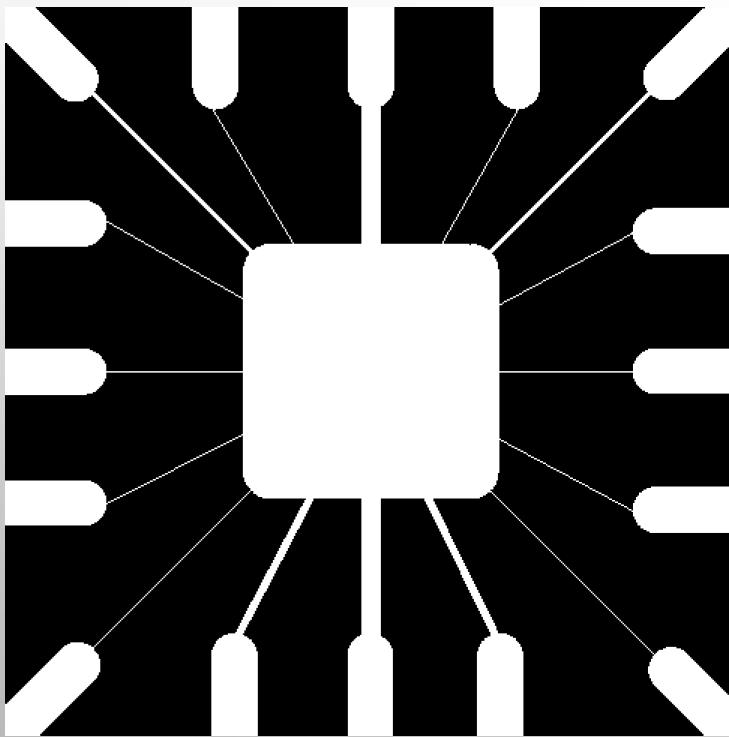


VERTICAL LINE DETECTION

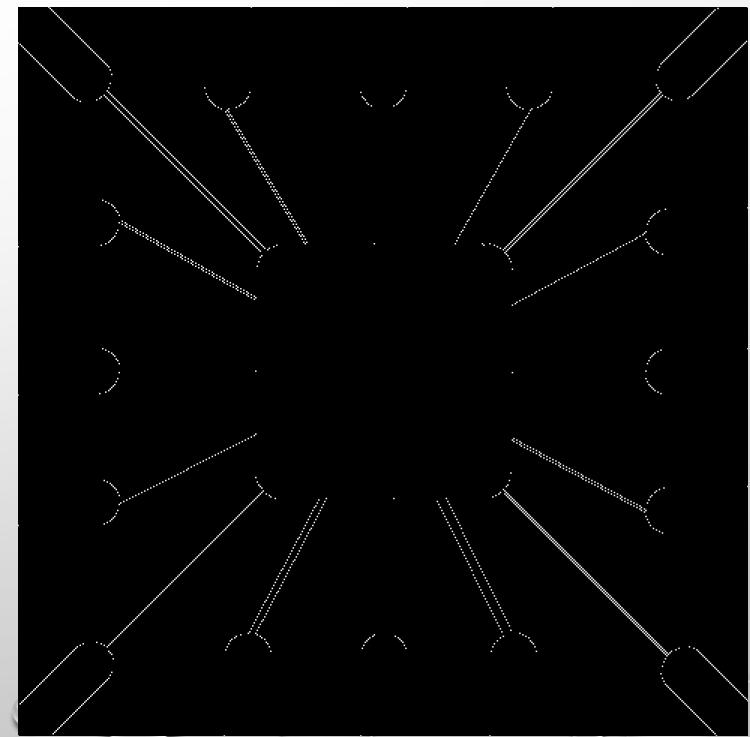


- 45° LINE DETECTION

486 X 486 WIRE BOND MASK
(BINARY)



- 45° LINE DETECTION

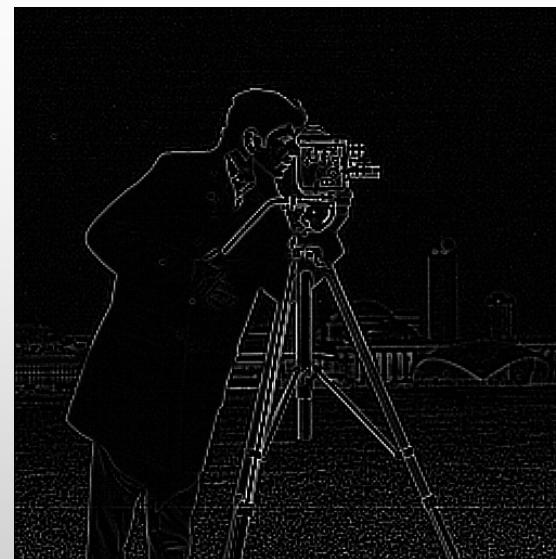


LAPLACIAN : TYPE 1

CAMERAMAN
512 X 512

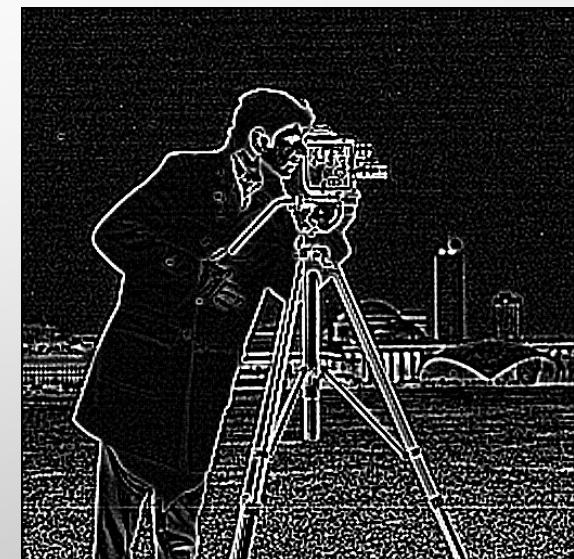


TYPE 1 : 3 X 3



$$\begin{matrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{matrix}$$

TYPE 1 : 5 X 5



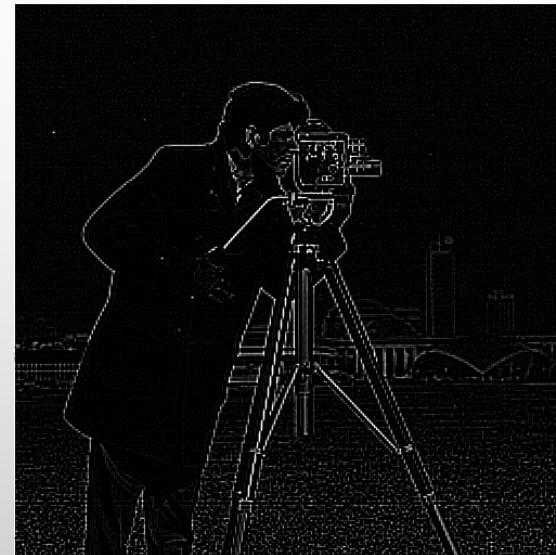
$$\begin{matrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & -24 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \end{matrix}$$

LAPLACIAN : TYPE 2

CAMERAMAN
512 X 512



TYPE 2 : 3 X 3



$$\begin{matrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{matrix}$$

TYPE 2 : 5 X 5



$$\begin{matrix} -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & 24 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \\ -1 & -1 & -1 & -1 & -1 \end{matrix}$$

LAPLACIAN : TYPE 3

CAMERAMAN
512 X 512



TYPE 3 : 5 X 5



0	0	1	0	0
0	0	1	0	0
1	1	-8	1	1
0	0	1	0	0
0	0	1	0	0

TYPE 3 : 7 X 7



0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0
1	1	1	-12	1	1	1	1
0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0
0	0	0	1	0	0	0	0

CAMERAMAN
512 X 512



LAPLACIAN : TYPE 4

TYPE 4 : 5 X 5



$$\begin{matrix} 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \\ -1 & -1 & 8 & -1 & -1 \\ 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 & 0 \end{matrix}$$

TYPE 4 : 7 X 7



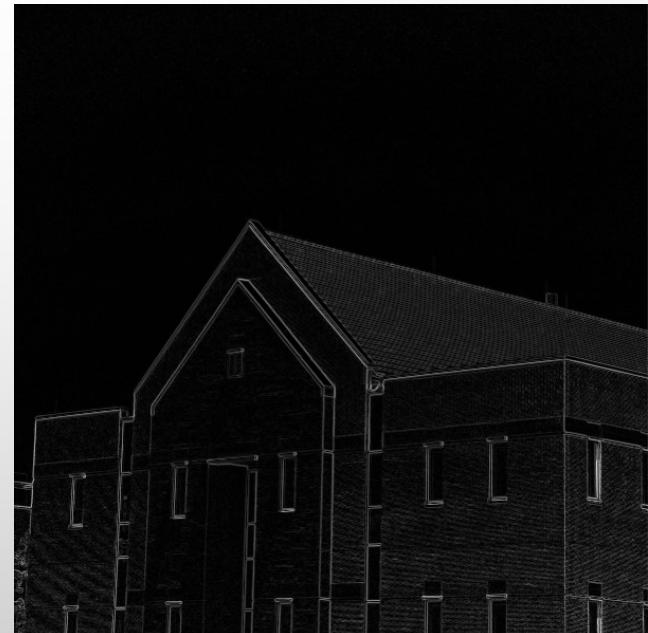
$$\begin{matrix} 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ -1 & -1 & -1 & 12 & -1 & -1 & -1 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{matrix}$$

GRADIENTS : ROBERT'S CROSS

BUILDING 600 X 600 PIXELS



ROBERT'S CROSS GRADIENTS



$$\begin{matrix} -1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 1 & 0 \end{matrix}$$

GRADIENTS : PREWITT OPERATOR

BUILDING 600 X 600 PIXELS



PREWITT OPERATOR



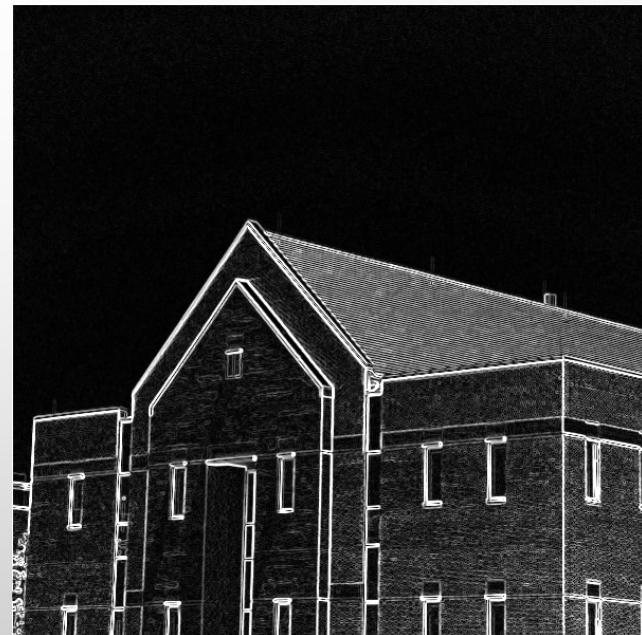
$$\begin{matrix} -1 & -1 & -1 & -1 & 0 & 1 \\ 0 & 0 & 0 & -1 & 0 & 1 \\ 1 & 1 & 1 & -1 & 0 & 1 \end{matrix}$$

GRADIENTS : SOBEL OPERATOR

BUILDING 600 X 600 PIXELS



SOBEL OPERATOR



$$\begin{matrix} -1 & 0 & 1 \\ 0 & 0 & 2 \\ -1 & 2 & 1 \end{matrix} \quad \begin{matrix} -2 & 0 & -1 \\ 0 & 0 & 1 \\ -2 & 1 & -1 \end{matrix} \quad \begin{matrix} 0 & 1 \\ 2 & 1 \end{matrix}$$

KIRSCH COMPASS : NORTH

PIRATE : 512 X 512 PIXELS



KIRSCH COMPASS : NORTH



-3	-3	5
-3	0	5
-3	-3	5

KIRSCH COMPASS : NORTH-WEST

PIRATE : 512 X 512 PIXELS



KIRSCH COMPASS : NORTH-WEST



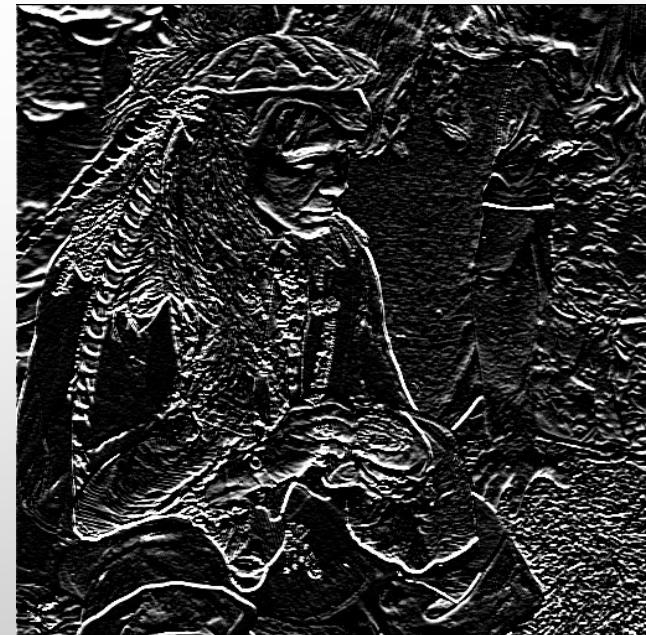
-3	5	5
-3	0	5
-3	-3	-3

KIRSCH COMPASS : WEST

PIRATE : 512 X 512 PIXELS



KIRSCH COMPASS : WEST



$$\begin{matrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{matrix}$$

KIRSCH COMPASS : SOUTH-WEST

PIRATE : 512 X 512 PIXELS



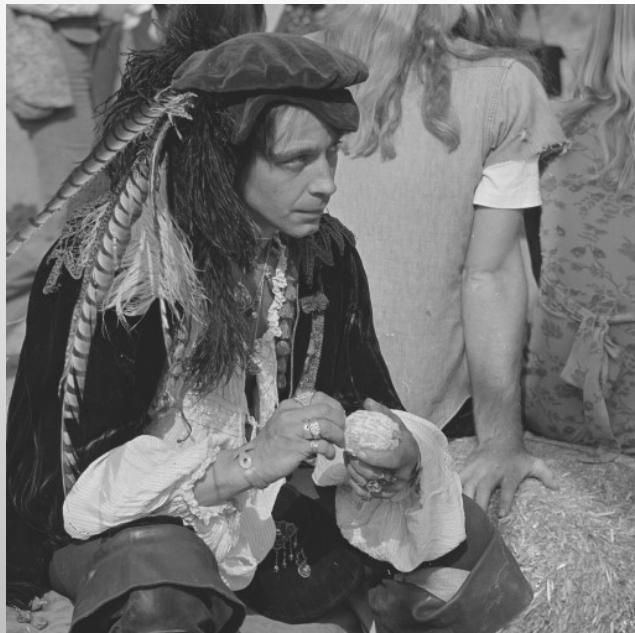
KIRSCH COMPASS : SOUTH-WEST



$$\begin{matrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{matrix}$$

KIRSCH COMPASS : SOUTH

PIRATE : 512 X 512 PIXELS



KIRSCH COMPASS : SOUTH



5	-3	-3
5	0	-3
5	-3	-3

KIRSCH COMPASS : SOUTH-EAST

PIRATE : 512 X 512 PIXELS



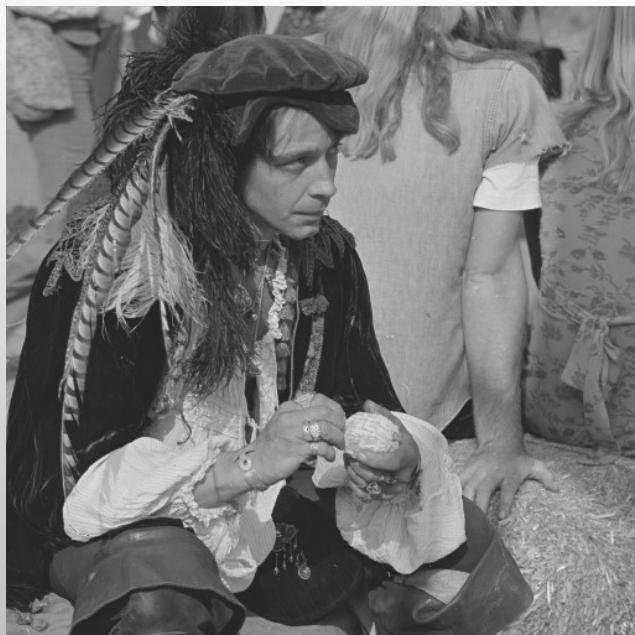
KIRSCH COMPASS : SOUTH-EAST



$$\begin{array}{ccc} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{array}$$

KIRSCH COMPASS : EAST

PIRATE : 512 X 512 PIXELS



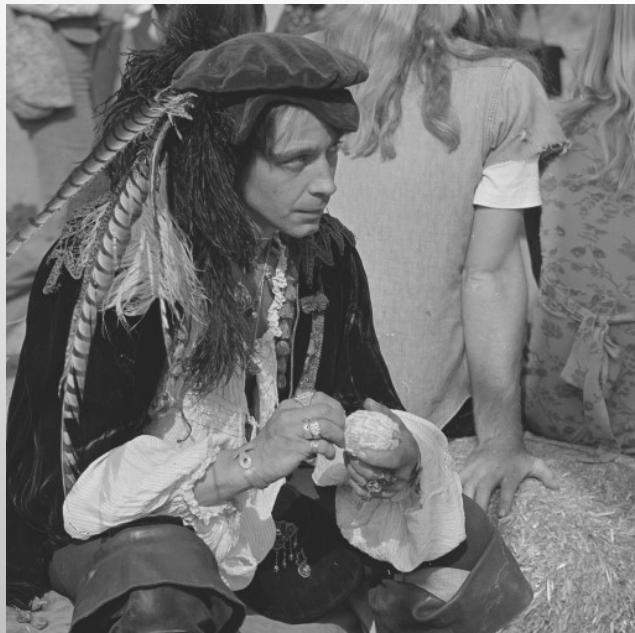
KIRSCH COMPASS : EAST



$$\begin{matrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{matrix}$$

KIRSCH COMPASS : NORTH-EAST

PIRATE : 512 X 512 PIXELS



KIRSCH COMPASS : NORTH-EAST



$$\begin{matrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{matrix}$$

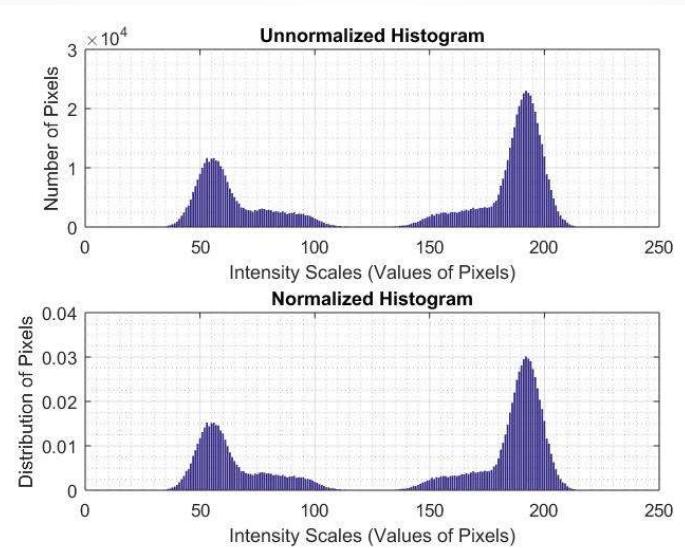
THRESHOLDING FOR NOISE REDUCTION

THRESHOLDING FOR NOISE REDUCTION

NOISY FINGERPRINT



ITS HISTOGRAM



SEGMENTATION USING GLOBAL THRESHOLDING

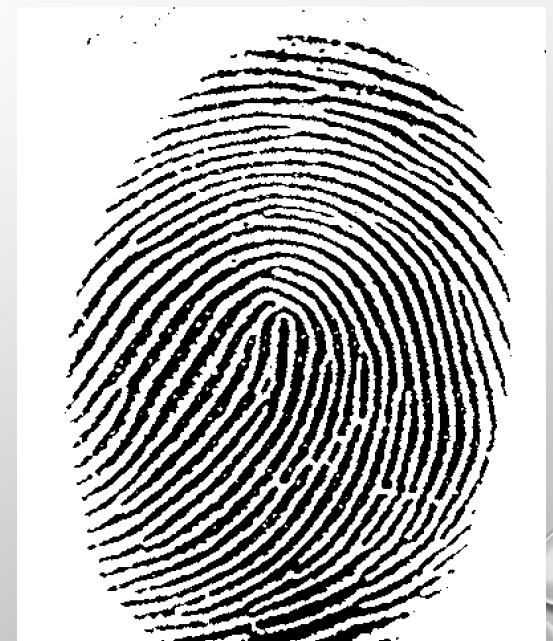
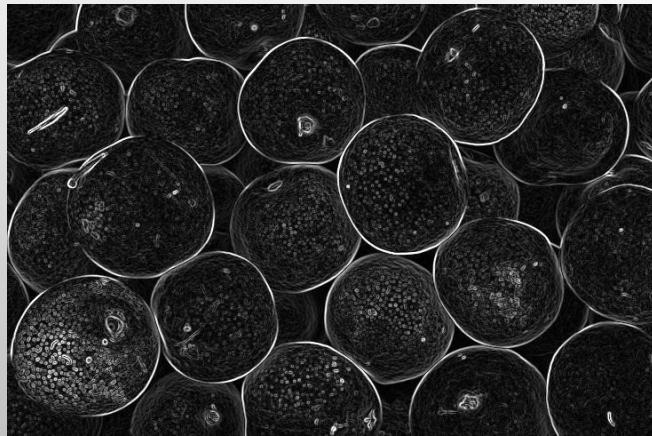




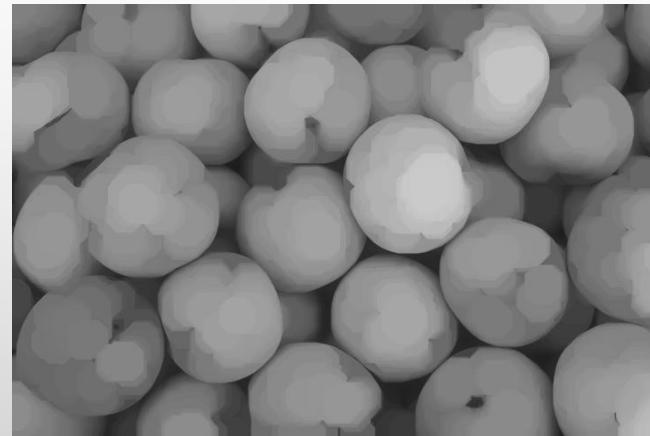
IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS

IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS

1) Gradient of image



2) Opening with SE of radius 20 (41 X 41)



3) Opening by reconstruction

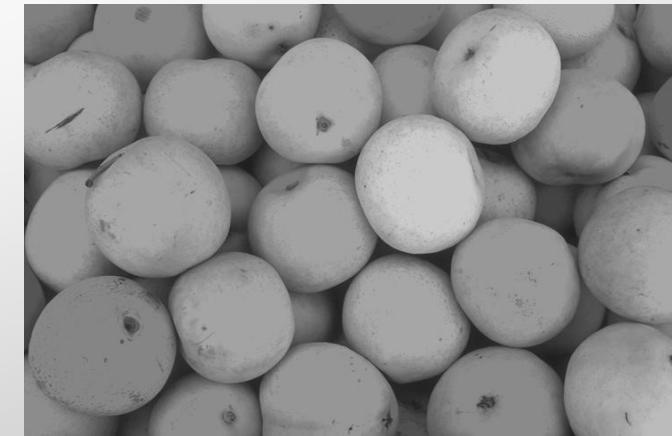
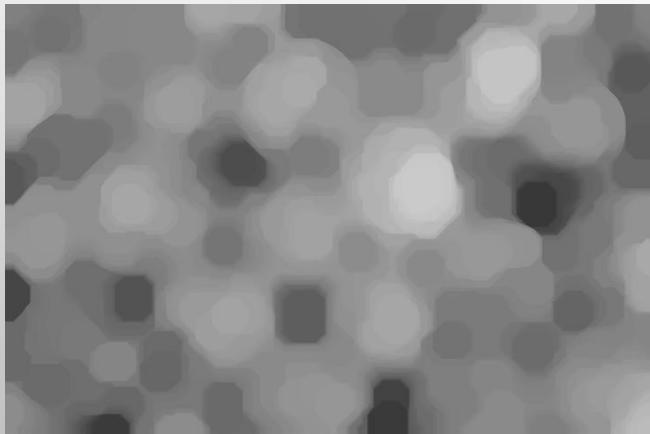
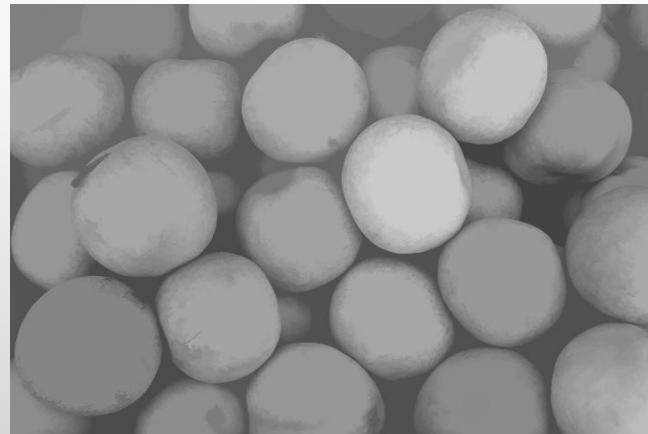


IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS

4) Closing of opening



5) Closing of opening by reconstruction



6) Regional Maxima of (5)

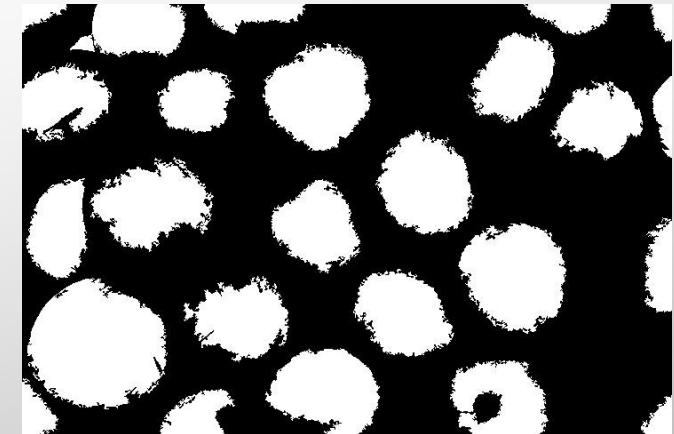


IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS

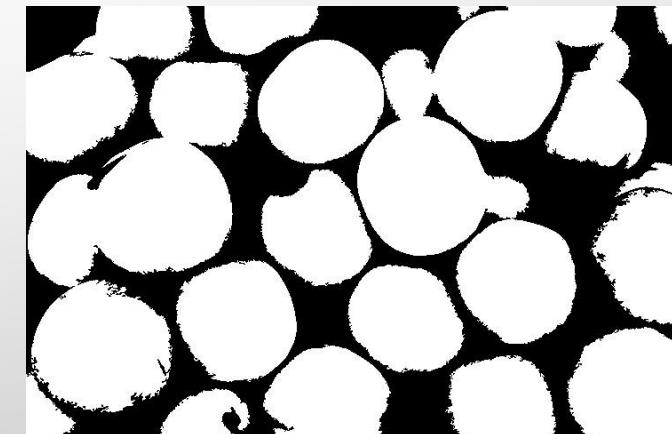
7) Regional maxima superimposed on original image



8) Modified maxima superimposed on original image



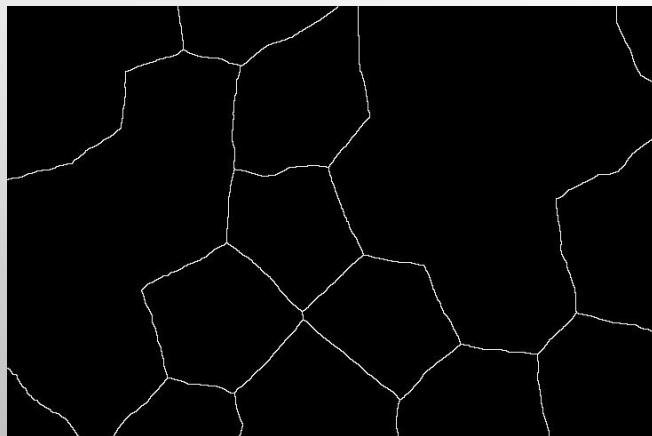
9) Opening & Closing of regional maxima with thresholding



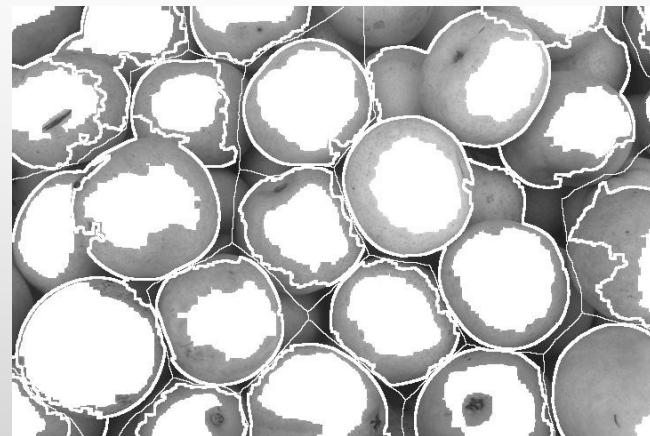
Modified Maxima is closing of regional maxima, followed by erosion of result,
Again followed by opening of previous result

IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS

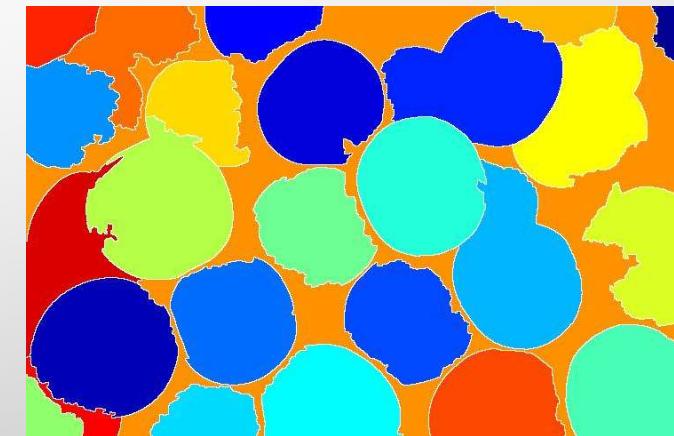
10) Ridge lines watershed



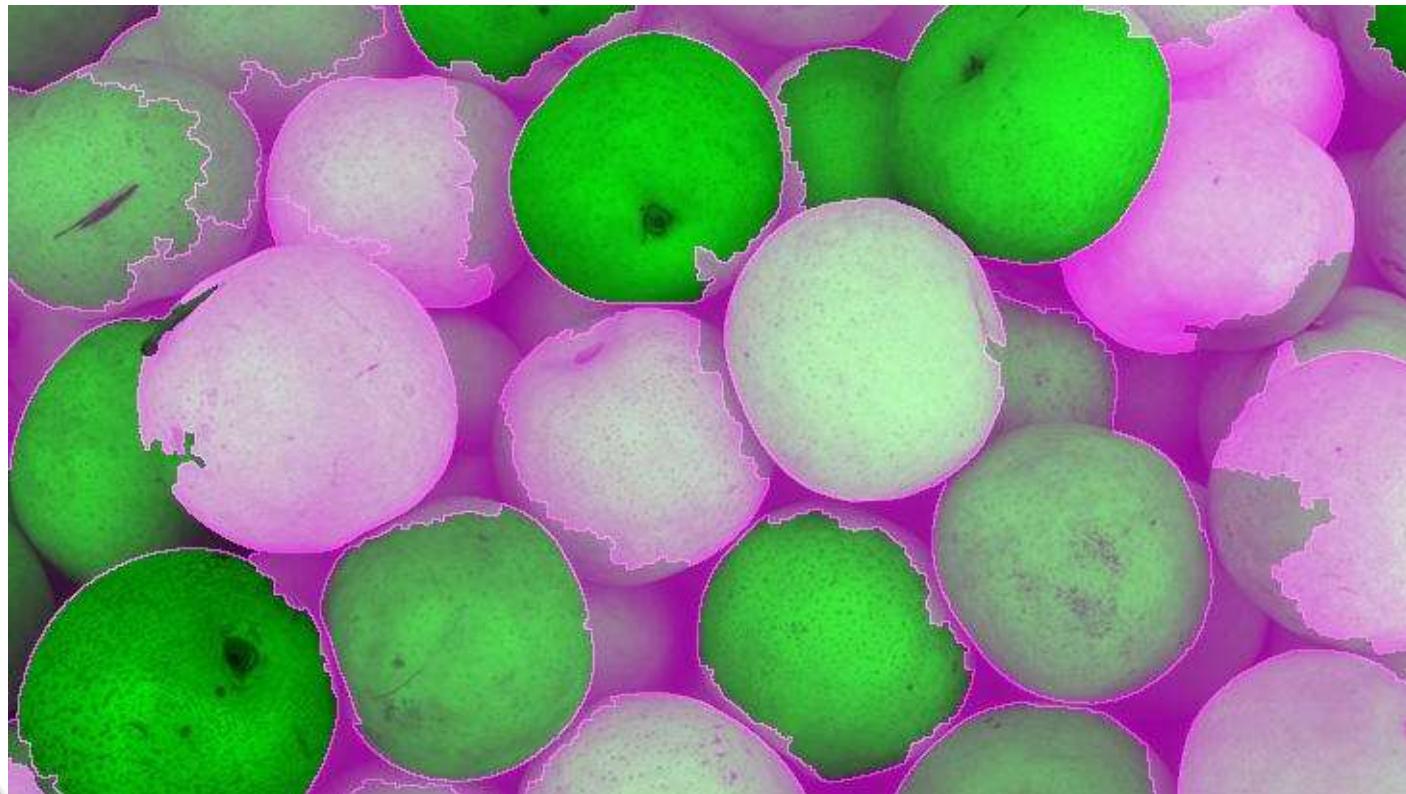
11) Combining original,
Ridge lines, Maxima



12) Colored watershed
objects

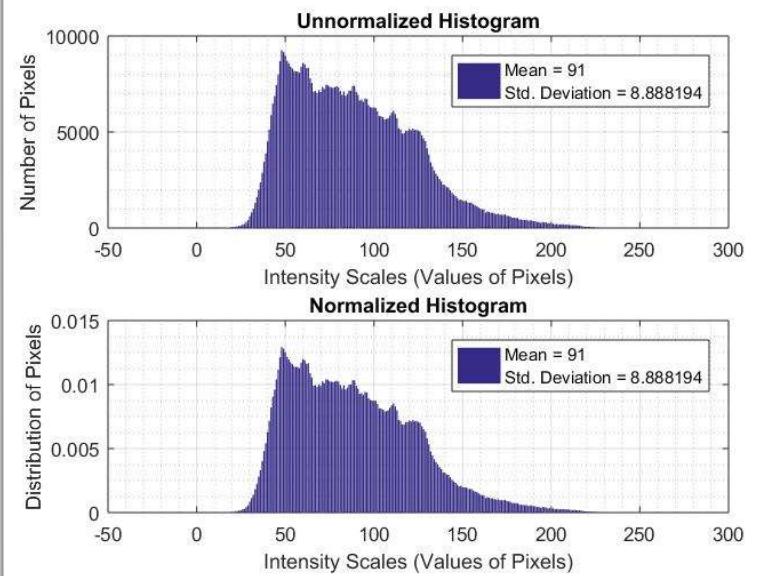


FINAL RESULT OF IMAGE SEGMENTATION USING MORPHOLOGICAL WATERSHEDS



NOISE REDUCTION

IMAGE 1



Histogram

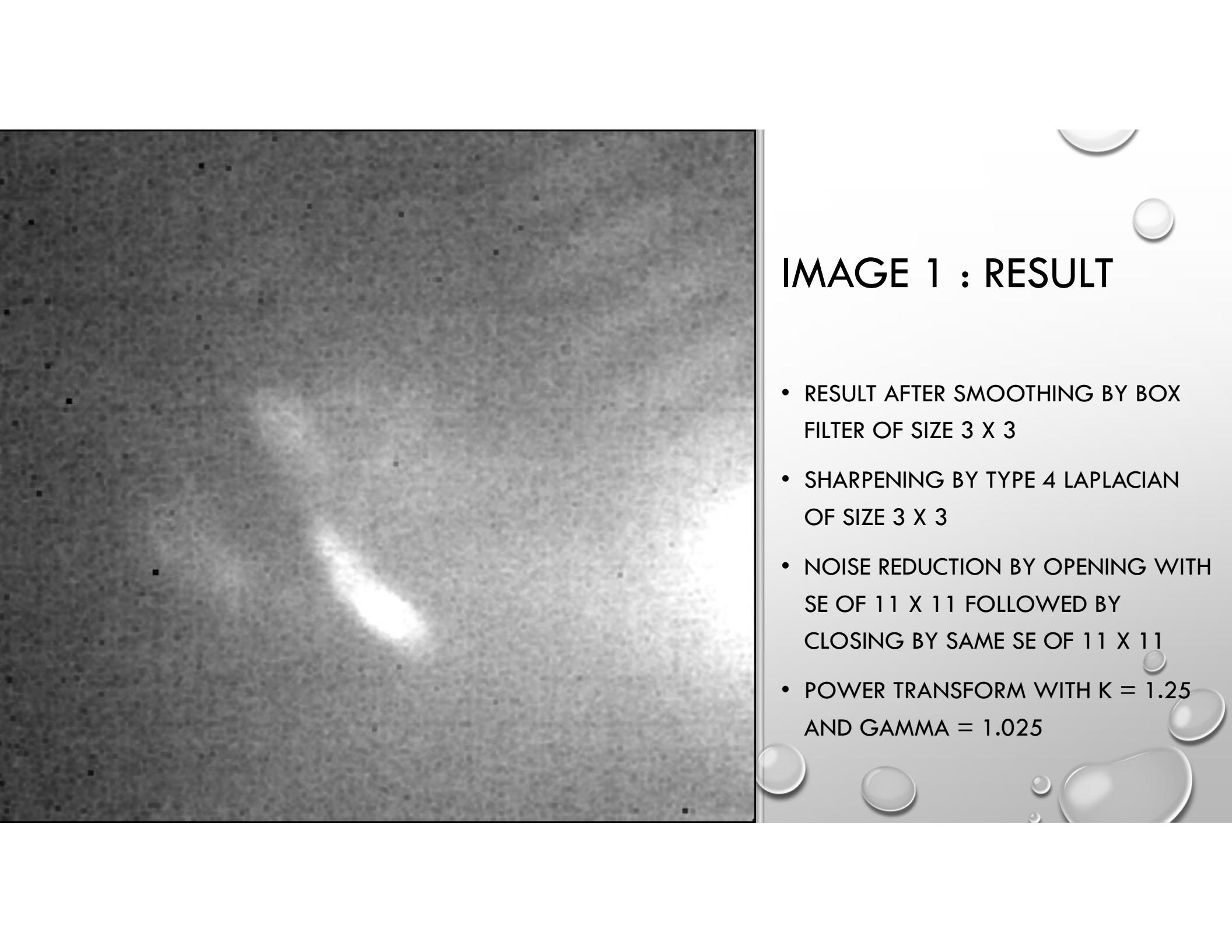
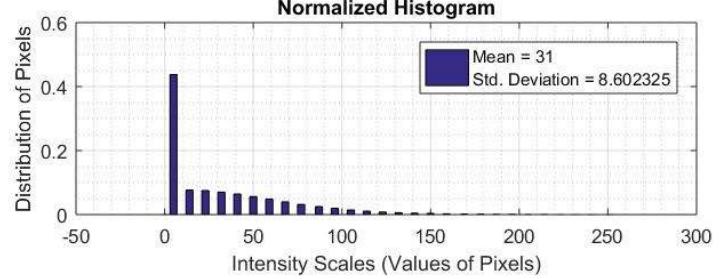
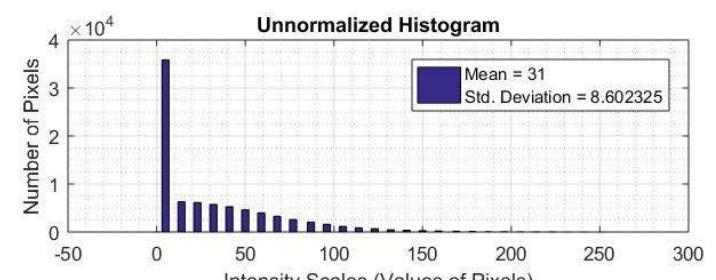


IMAGE 1 : RESULT

- RESULT AFTER SMOOTHING BY BOX FILTER OF SIZE 3 X 3
- SHARPENING BY TYPE 4 LAPLACIAN OF SIZE 3 X 3
- NOISE REDUCTION BY OPENING WITH SE OF 11 X 11 FOLLOWED BY CLOSING BY SAME SE OF 11 X 11
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.025

IMAGE 2



Histogram

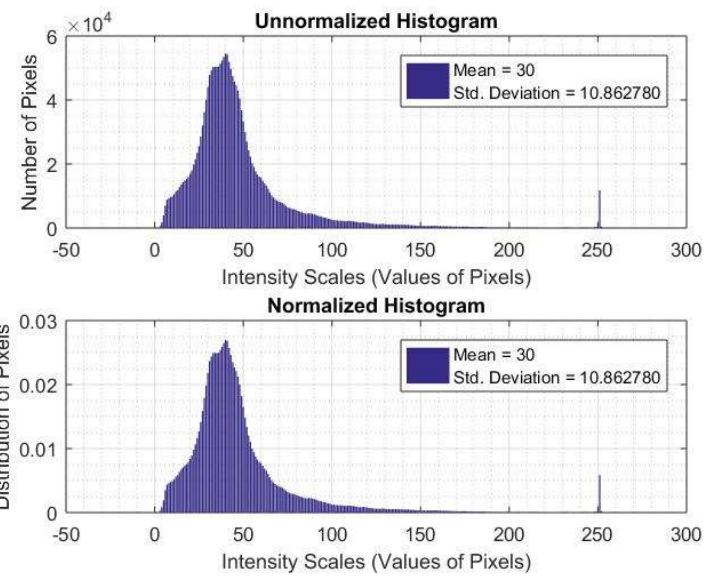


IMAGE 2 : RESULT

- RESULT AFTER SMOOTHING BY GAUSSIAN FILTER OF SIZE 5×5 WITH $K : 2$ AND $\Sigma : 2$
- SHARPENING BY TYPE 3 LAPLACIAN OF SIZE 3×3 FOLLOWED BY TOP-HAT TRANSFORM SUBTRACTED FROM IMAGE.



IMAGE 3



Histogram

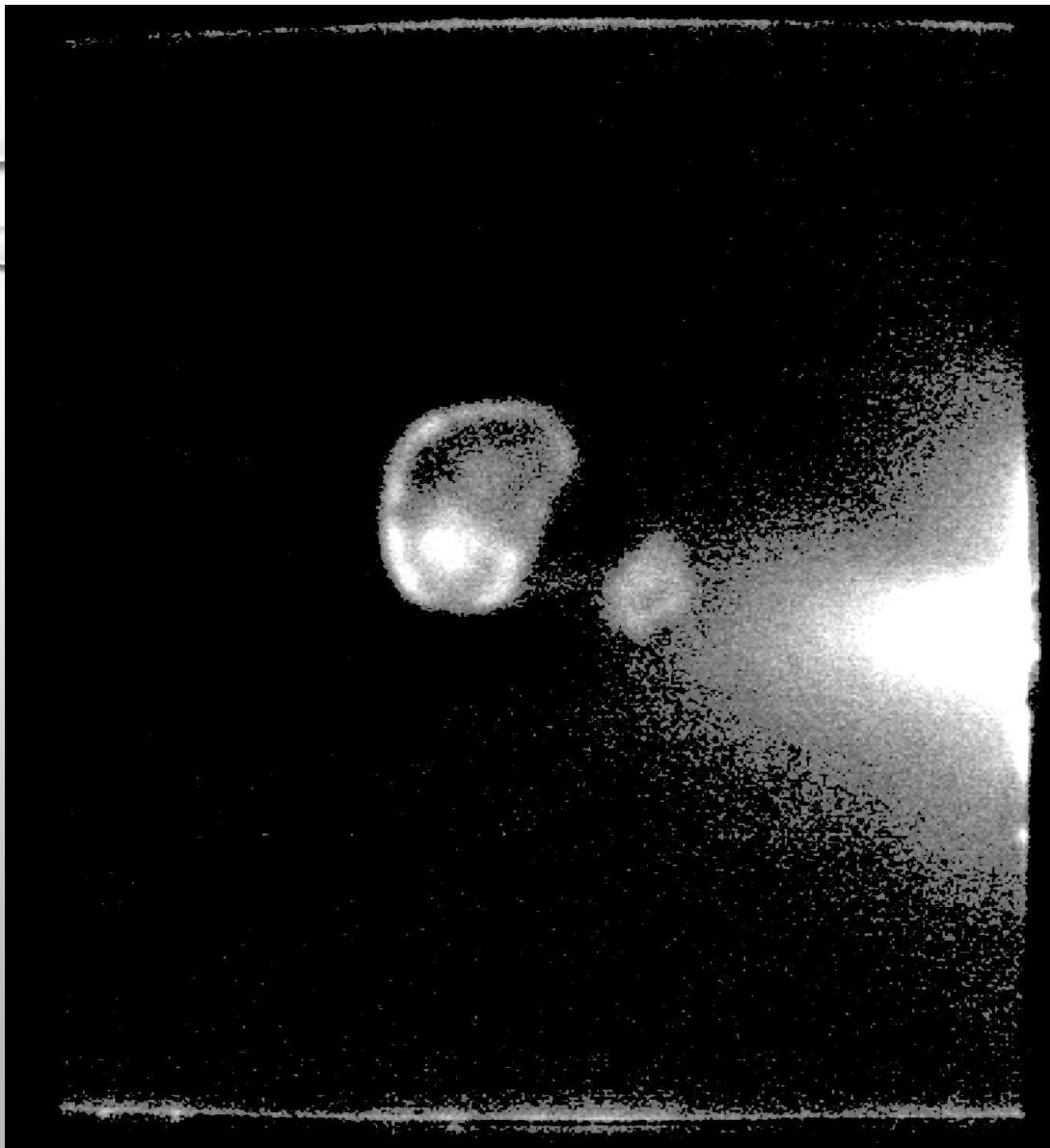
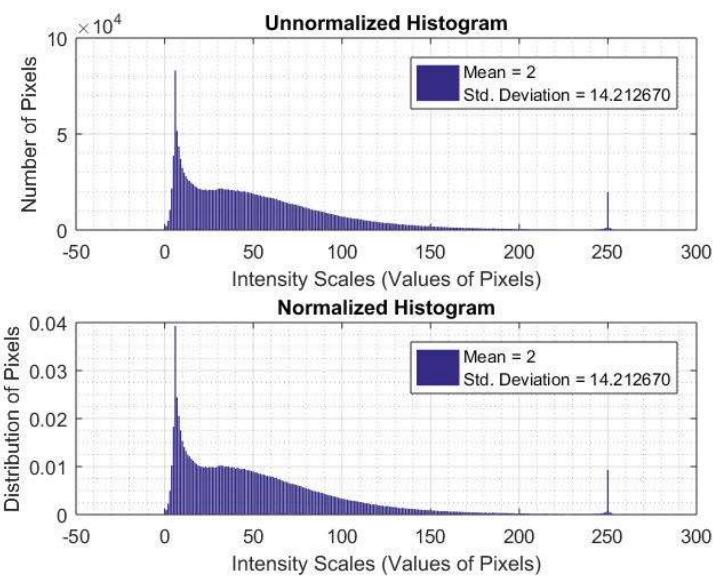


IMAGE 3 : RESULT

- RESULT AFTER THRESHOLDING WITH MOVING AVERAGES INTENSITY VALUE OF 65.
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.125
- NOISE REDUCTION BY MORPHOLOGICAL SMOOTHING.



IMAGE 4



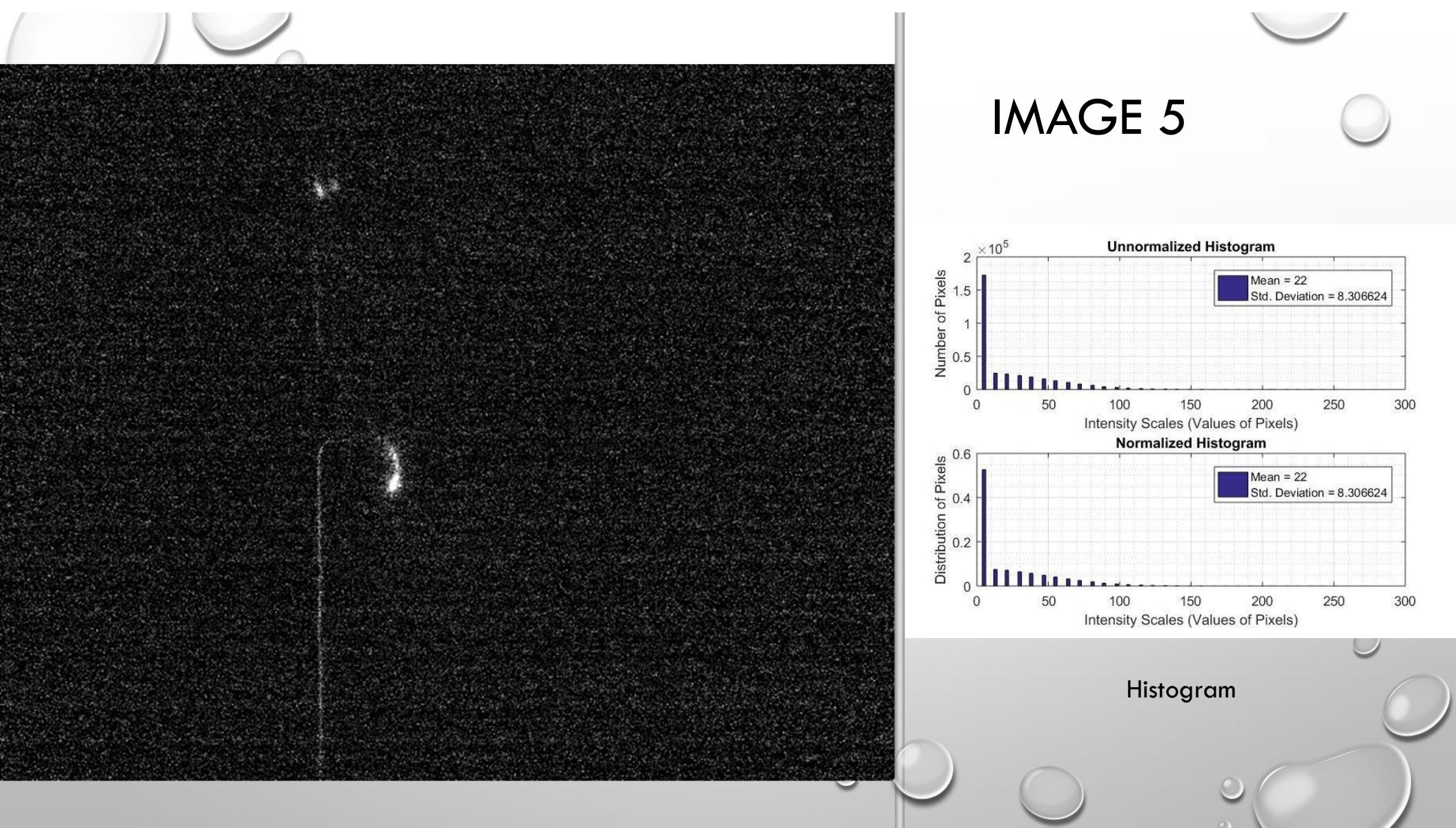
Histogram



IMAGE 4 : RESULT

- RESULT AFTER THRESHOLDING BY OTSU'S METHOD WITH INTENSITY VALUE OF 90.
- SMOOTHING WITH GAUSSIAN KERNEL OF SIZE 5×5 WITH $K = 1.25$ AND $\Sigma = 1.25$
- OPENING OF IMAGE FOLLOWED BY CLOSING OF THE RESULT OF OPENING
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.05

IMAGE 5



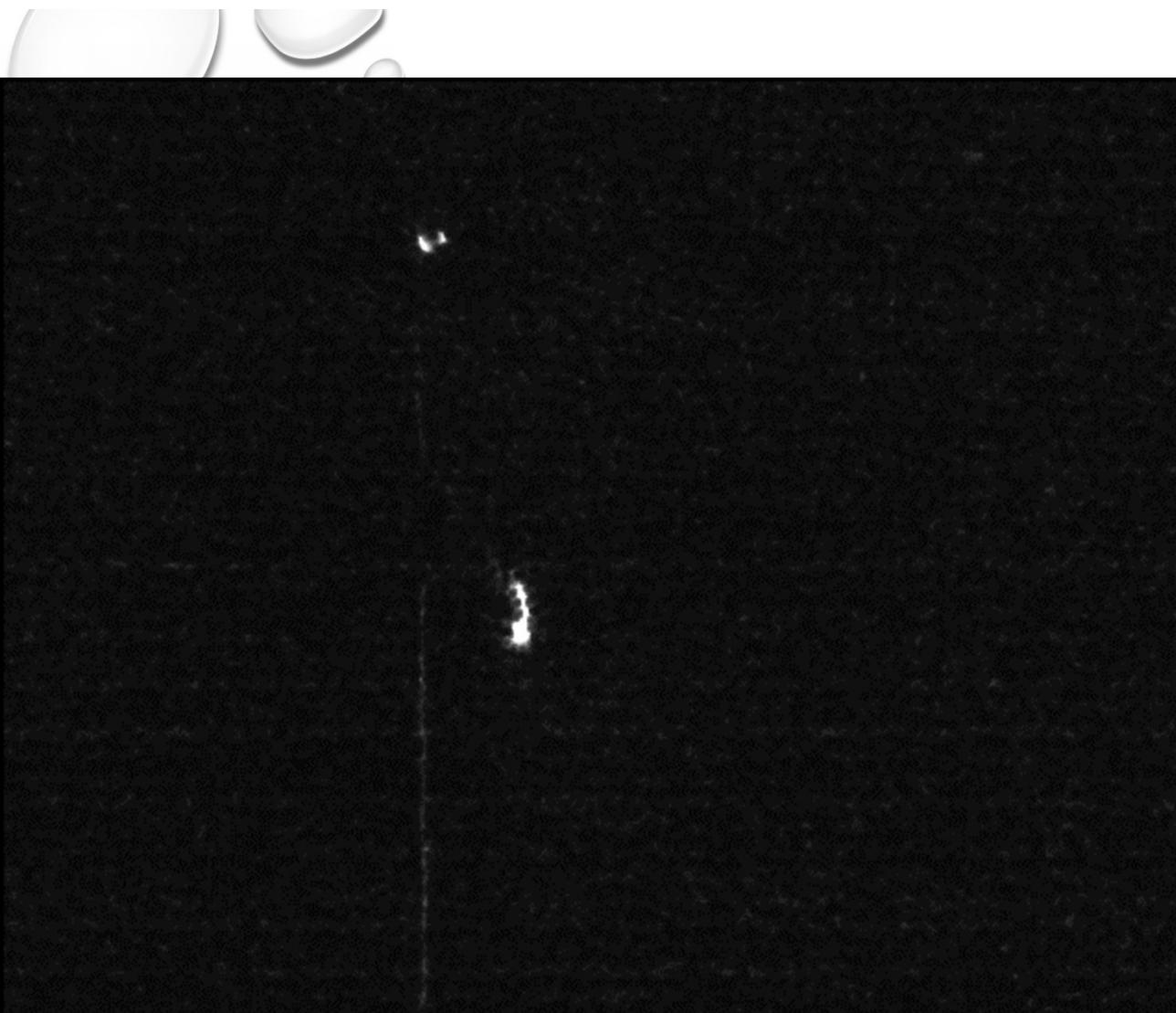
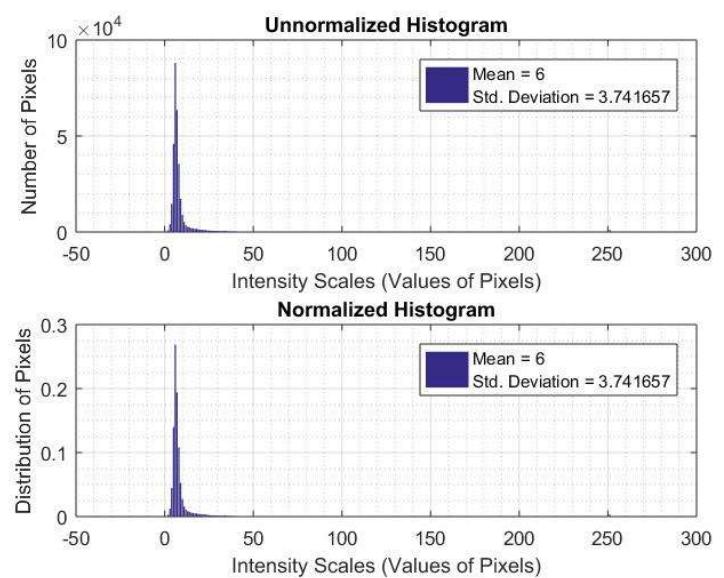


IMAGE 5 : RESULT

- RESULT AFTER LAPLACIAN OF GAUSSIAN FILTER OF SIZE 3X3 WITH $K = 1.25$ AND $\Sigma = 1.25$
- MASK = IMAGE – CLOSING OF IMAGE + BOTTOM-HAT
- IMAGE = IMAGE + MASK.
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.15

IMAGE 6



Histogram

IMAGE 6 : RESULT

- RESULT AFTER THRESHOLDING WITH INTENSITY PASS OF 0-100.
- REMOVAL OF LARGE OBJECT USING CONNECTED COMPONENT.
- MORPHOLOGICAL SMOOTHING USING 7 X 7 SE
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.125.

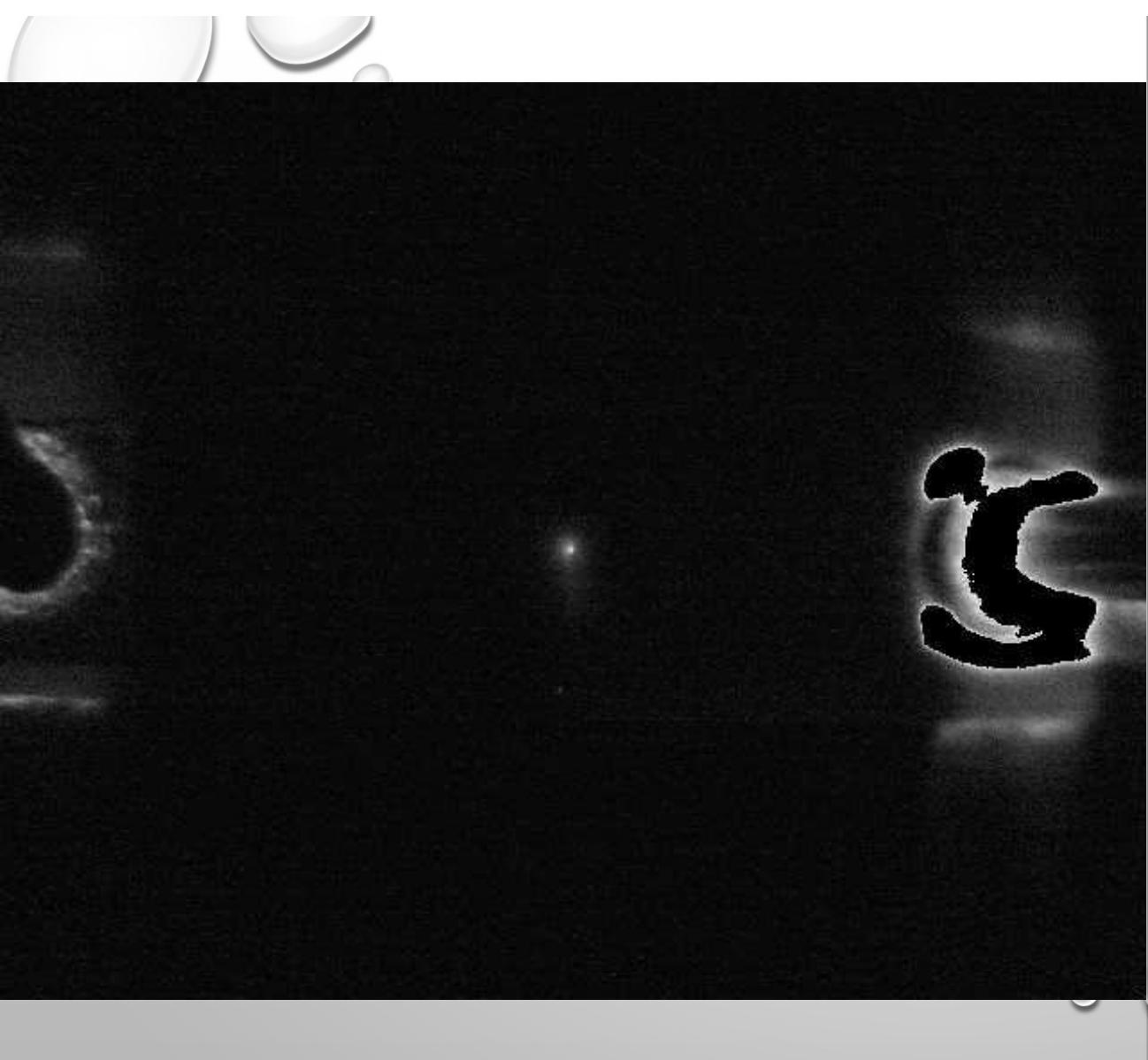
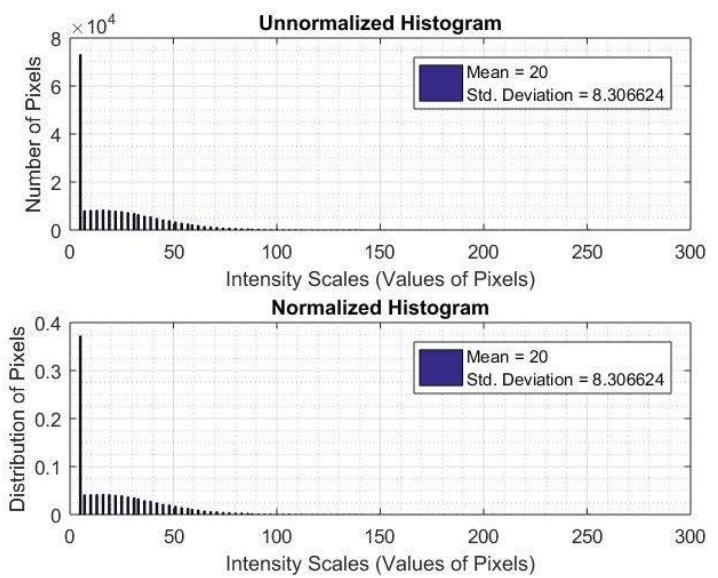


IMAGE 7

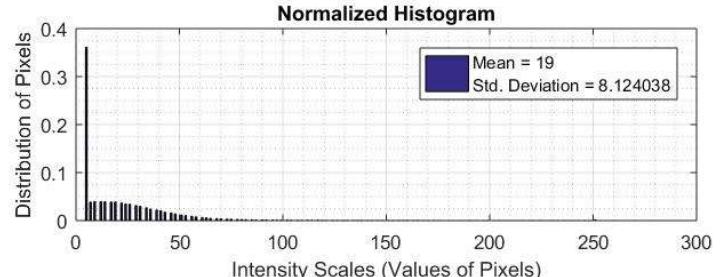
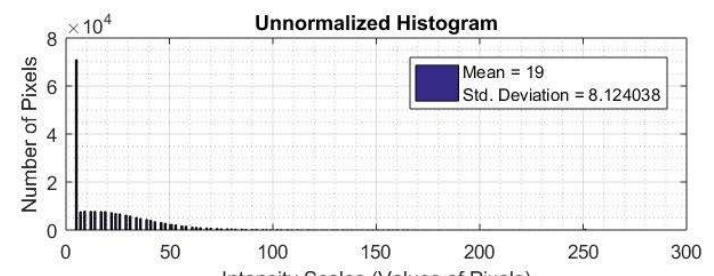
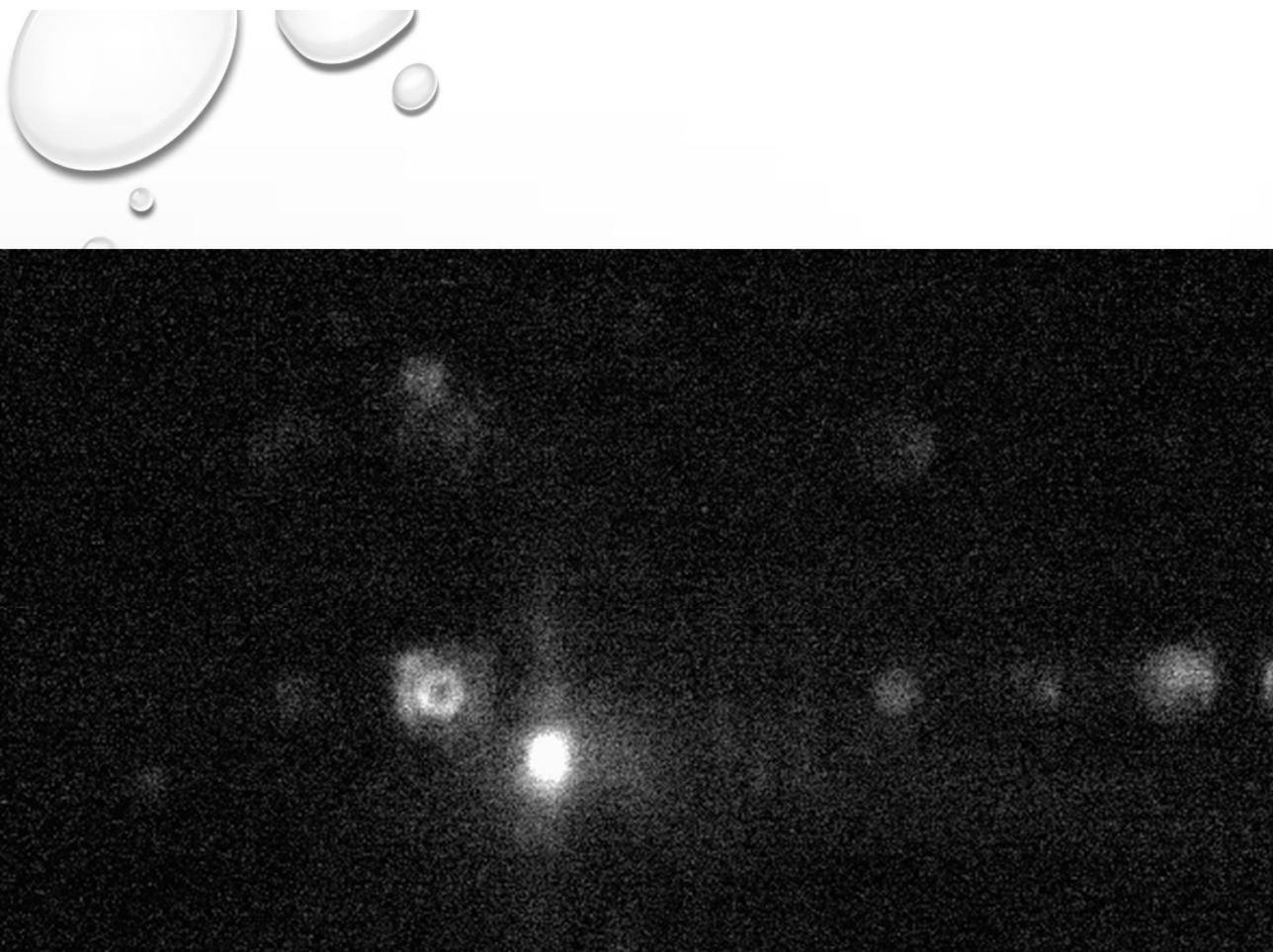


Histogram

IMAGE 7 : RESULT

- RESULT AFTER NOISE REDUCTION BY ADDITION OF MASK FROM IMAGE
- MASK = IMAGE – (TOP-HAT + BOTTOM-HAT)
- SMOOTHING BY GAUSSIAN FILTER OF SIZE 5 X 5 WITH K : 1.25 AND SIGMA : 1.25
- POWER TRANSFORM WITH K = 1.25 AND GAMMA = 1.125

IMAGE 8

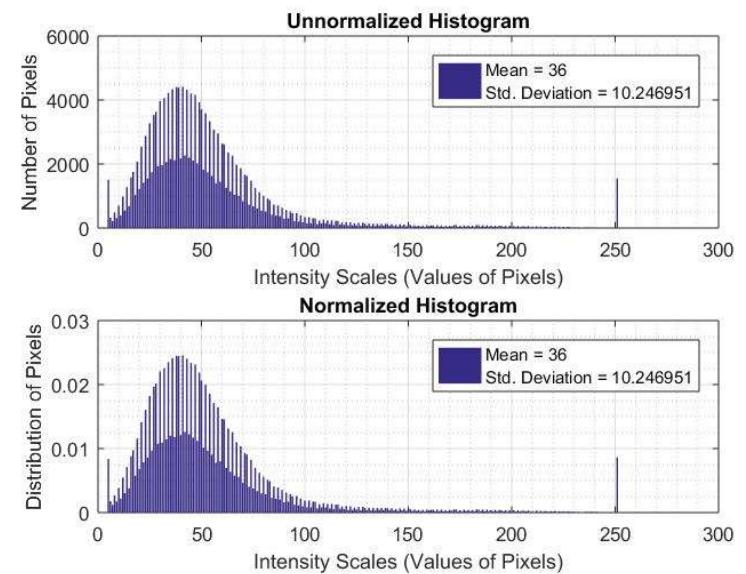
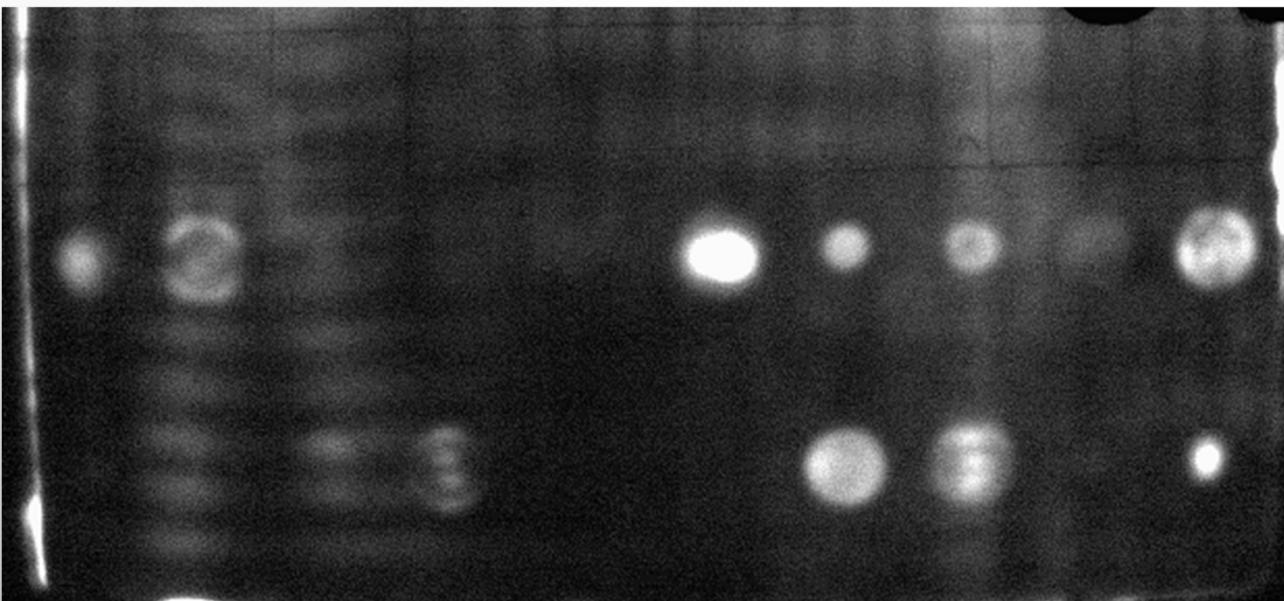


Histogram

IMAGE 8 : RESULT

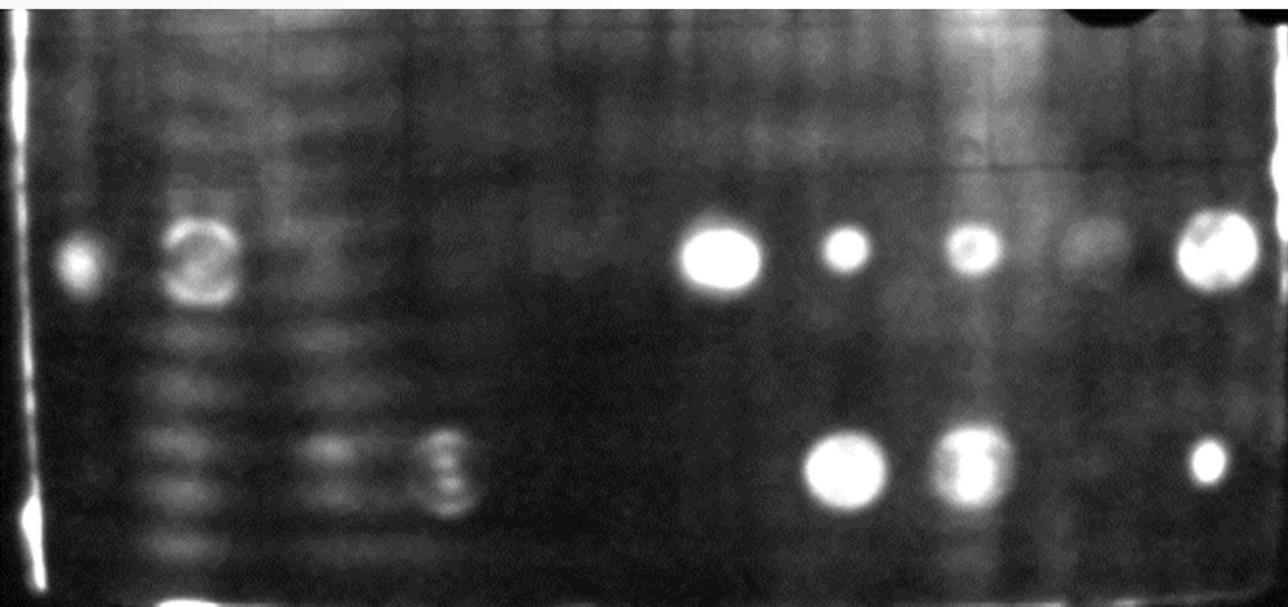
- RESULT AFTER NOISE REDUCTION BY ADDITION OF MASK FROM IMAGE
- MASK = IMAGE – (TOP-HAT + BOTTOM-HAT)
- SMOOTHING BY GAUSSIAN FILTER OF SIZE 5 X 5 WITH K : 1.25 AND SIGMA : 1.25
- POWER TRANSFORM WITH K = 1.00 AND GAMMA = 1.075

IMAGE 9



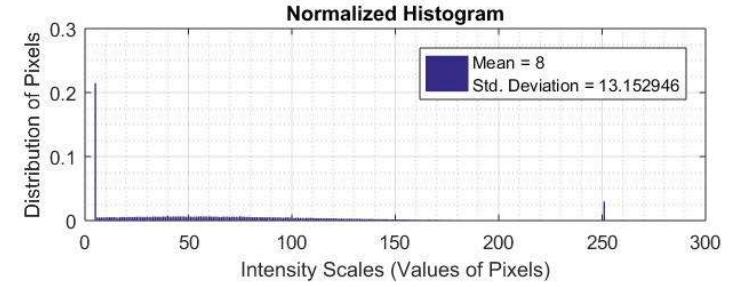
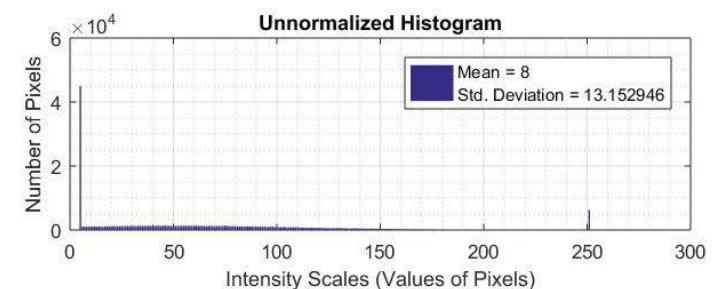
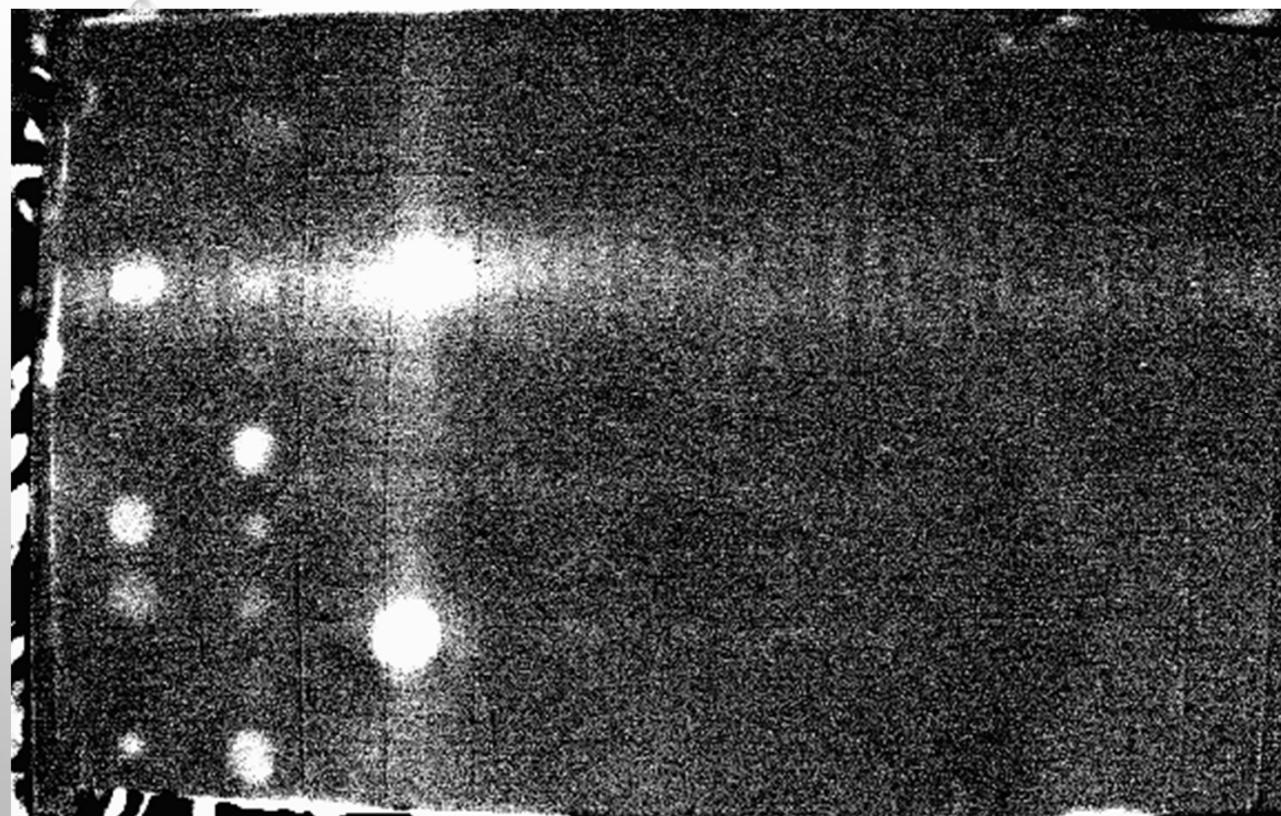
Histogram

IMAGE 9 : RESULT



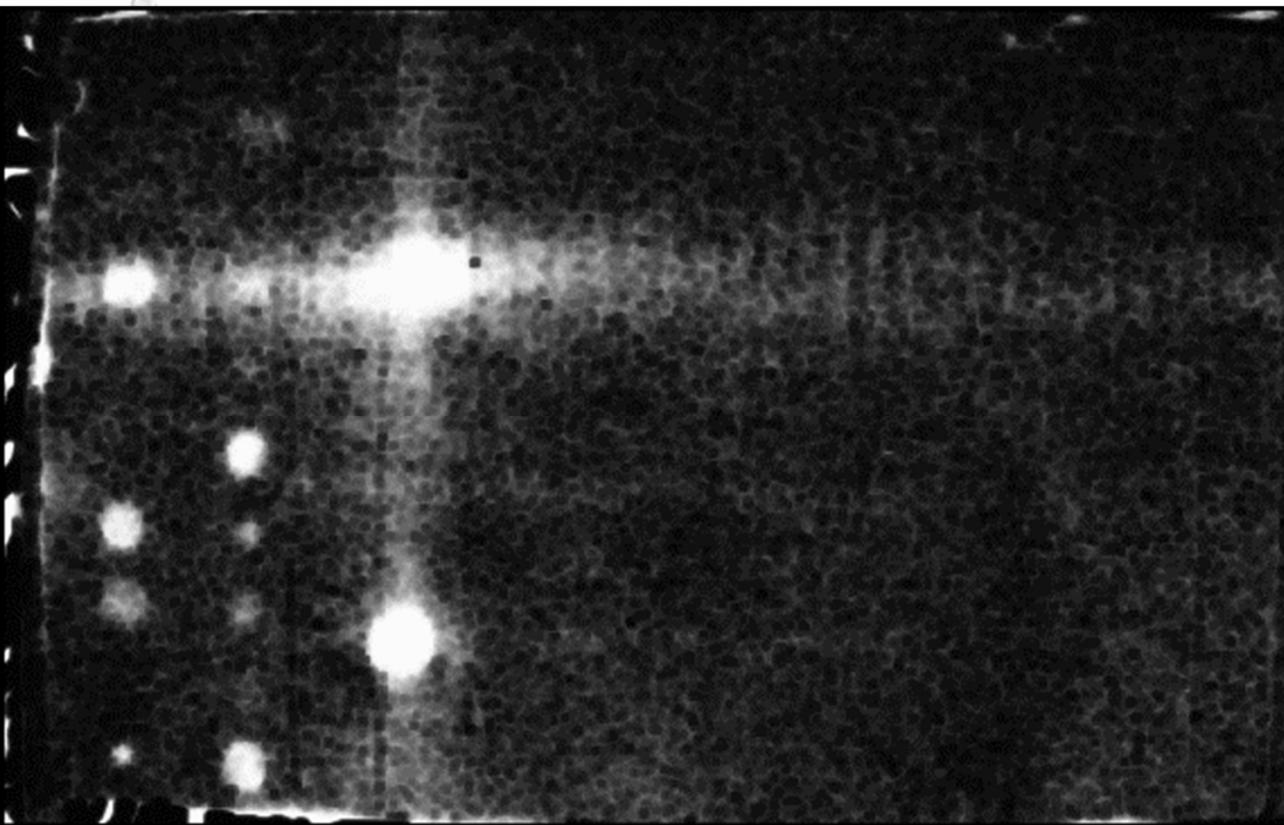
- RESULT AFTER SMOOTHING BY GAUSSIAN FILTER OF SIZE 5×5 WITH $K = 1.5$ AND $\text{SIGMA} = 1.5$
- OPENING OF IMAGE WITH RADIUS 7.
- POWER TRANSFORM WITH $K = 0.75$ AND $\text{GAMMA} = 1.125$

IMAGE 10



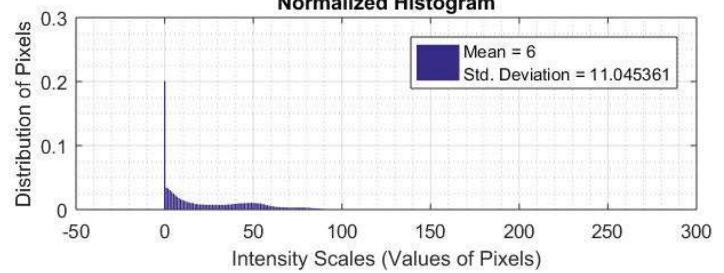
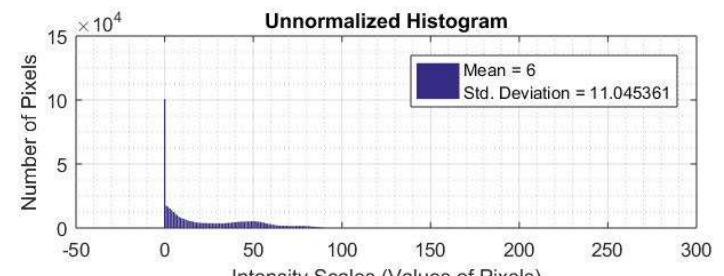
Histogram

IMAGE 10 : RESULT



- RESULT AFTER GEOMETRIC MEAN FILTER OF SIZE 3 X 3
- FINDING THE MASK USING OTSU'S THRESHOLDING METHOD.

IMAGE 11



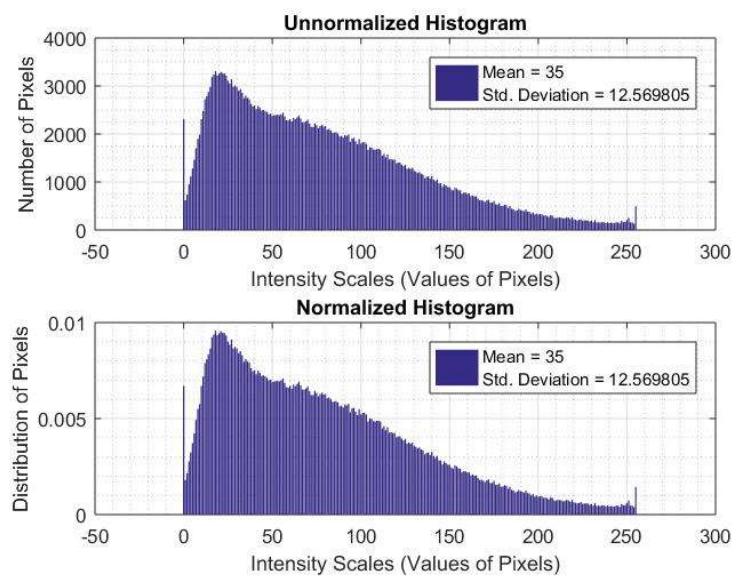
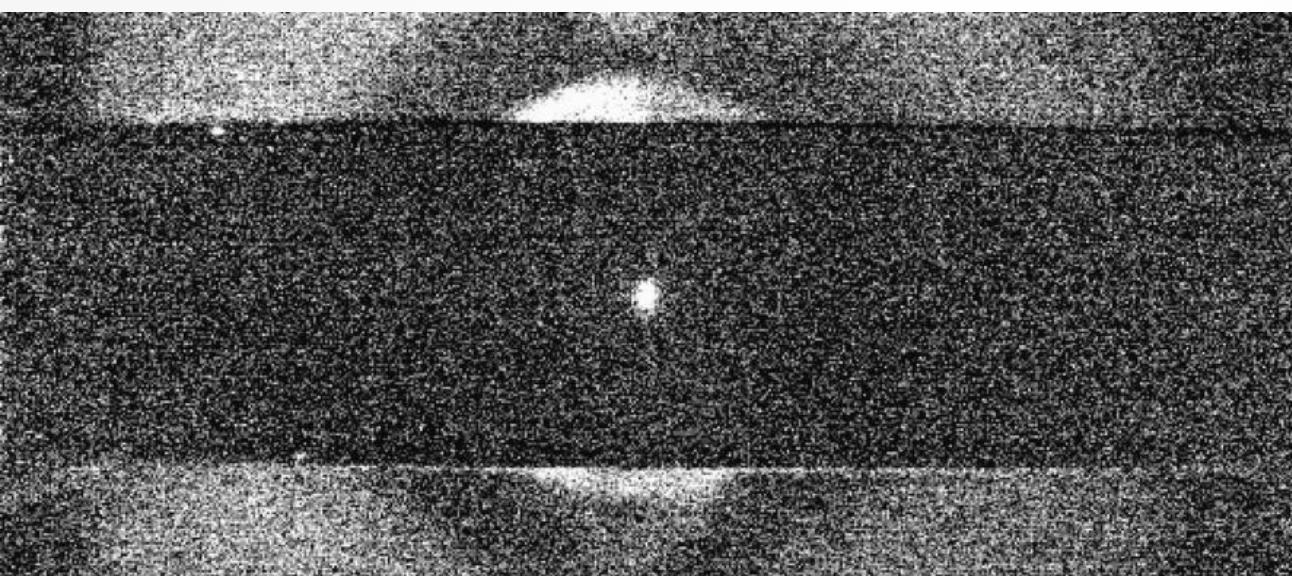
Histogram



IMAGE 11 : RESULT

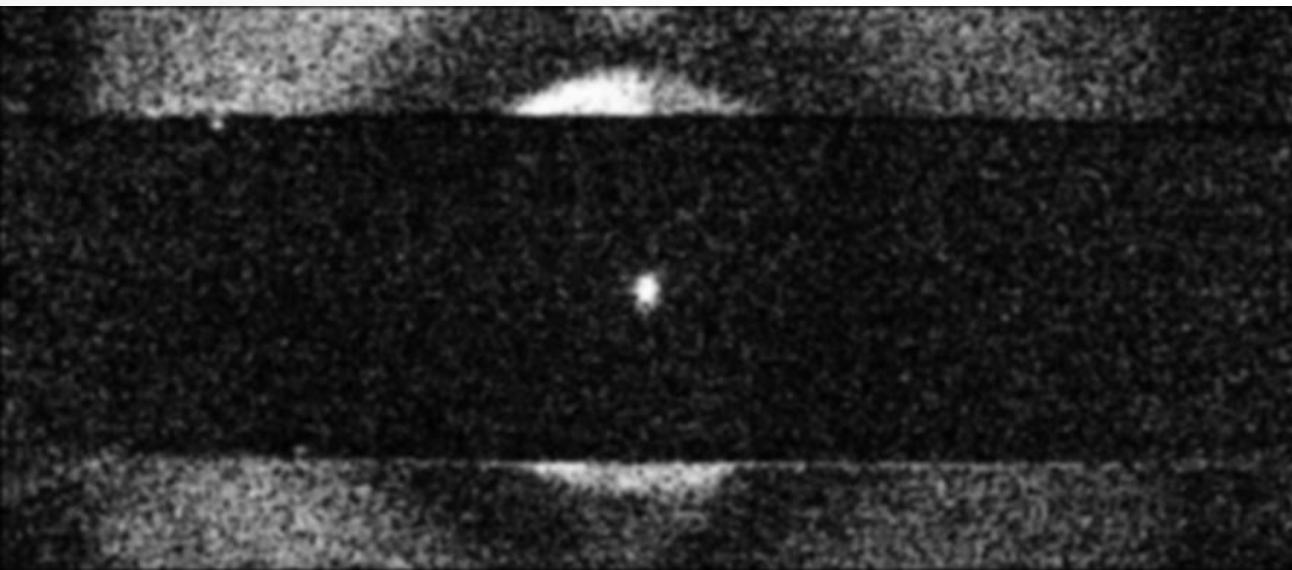
- RESULT AFTER MULTIPLE GLOBAL THRESHOLDING WITH $K_1 = 25$ AND $K_2 = 180$
- SMOOTHING WITH GAUSSIAN FILTER OF SIZE 3×3 WITH $K = 1$ AND SIGMA = 1.25
- POWER TRANSFORM WITH $K = 1.25$ AND GAMMA = 1.025

IMAGE 12



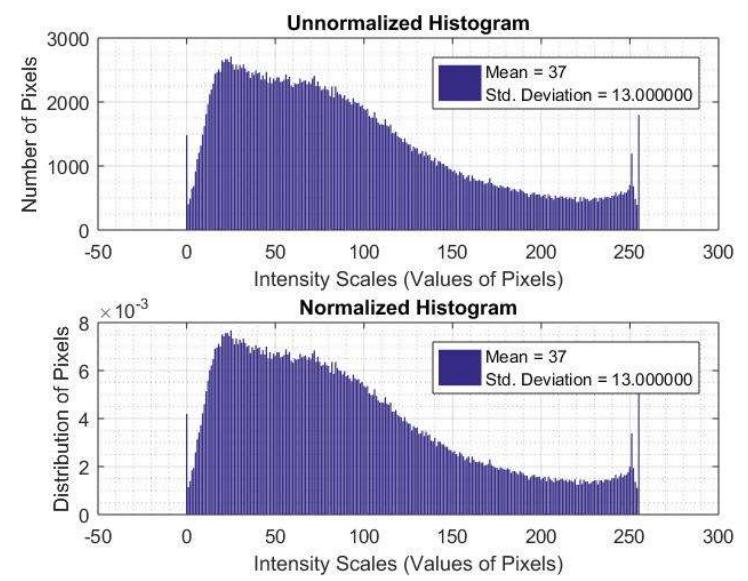
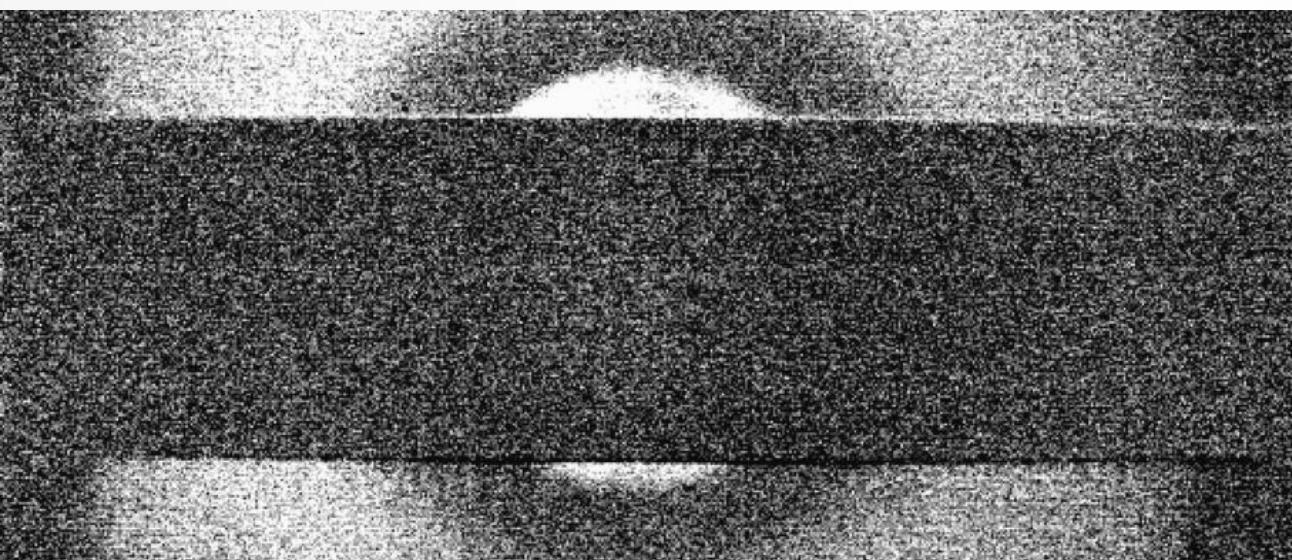
Histogram

IMAGE 12 : RESULT



- RESULT AFTER TOP-HAT TRANSFORM FOLLOWED BY BOTTOM HAT TRANSFORM WITH RADIUS OF 11 (23 X 23)
- SMOOTHING BY 5 X 5 GAUSSIAN FILTER WITH K = 2 AND SIGMA = 2

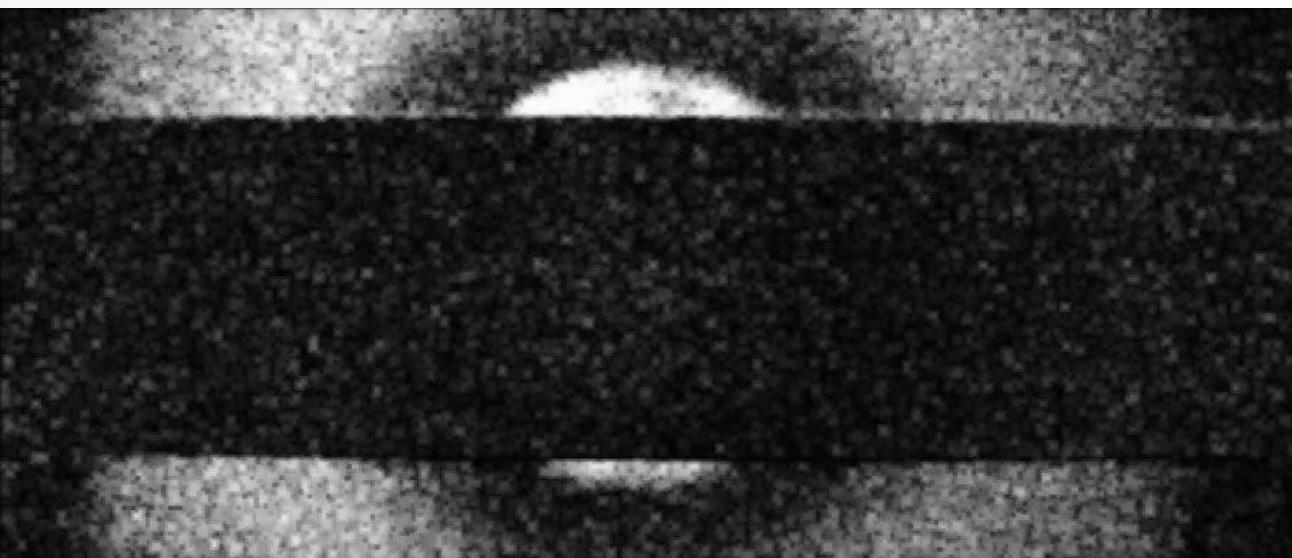
IMAGE 13



Histogram

IMAGE 13 : RESULT

- RESULT AFTER TOP-HAT TRANSFORM FOLLOWED BY BOTTOM HAT TRANSFORM WITH RADIUS OF 11 (23 X 23)
- SMOOTHING BY 5 X 5 GAUSSIAN FILTER WITH K = 2 AND SIGMA = 2



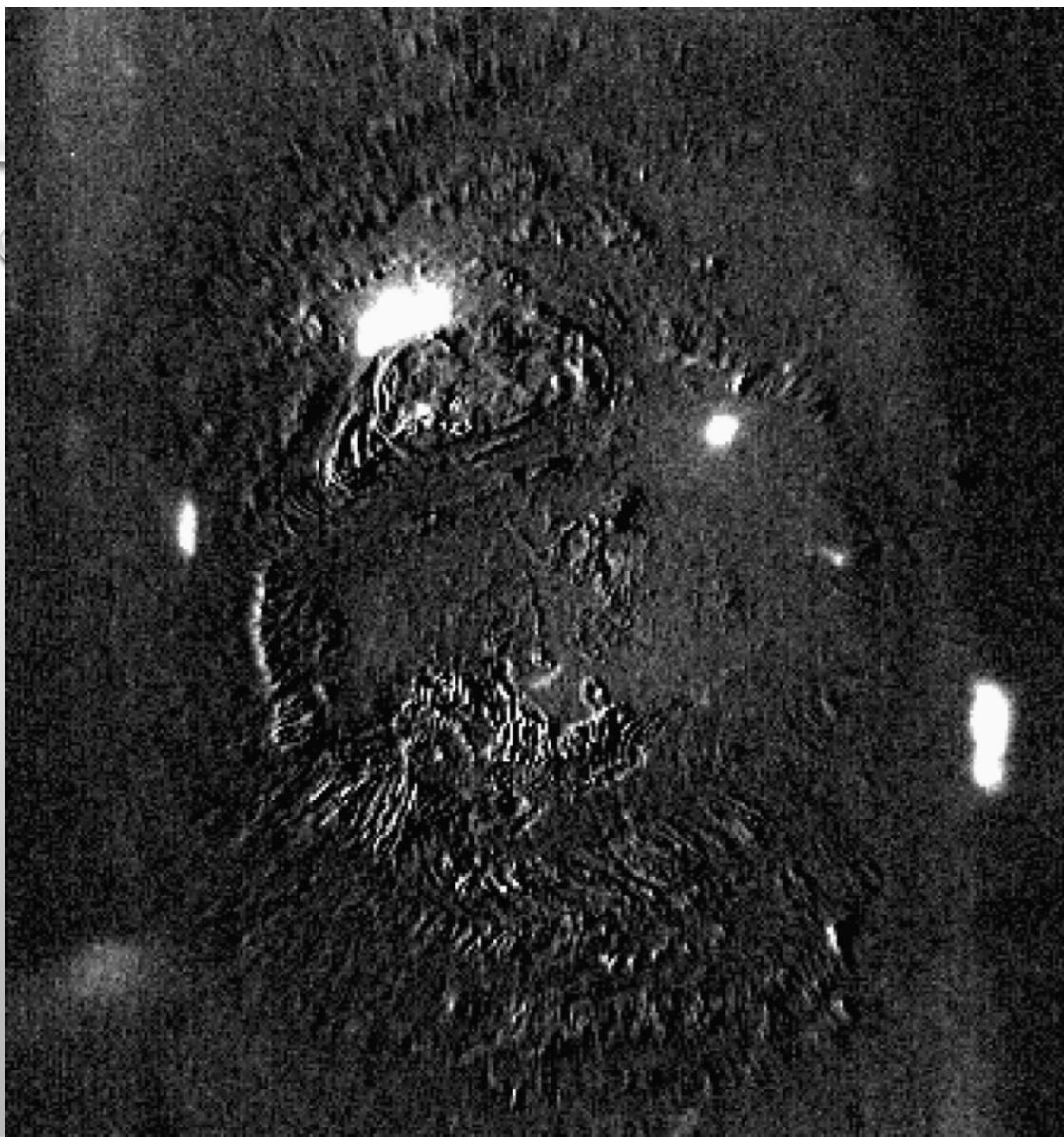
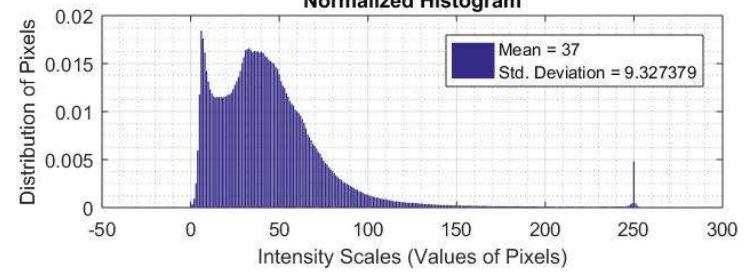
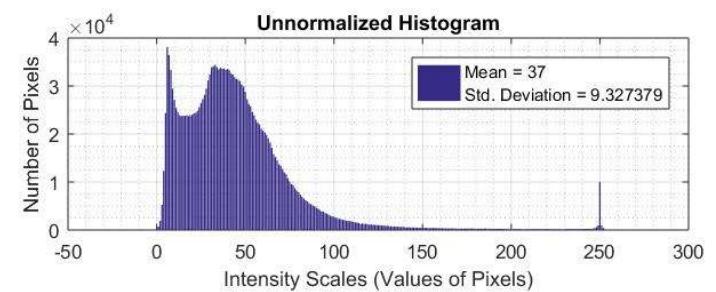


IMAGE 14



Histogram

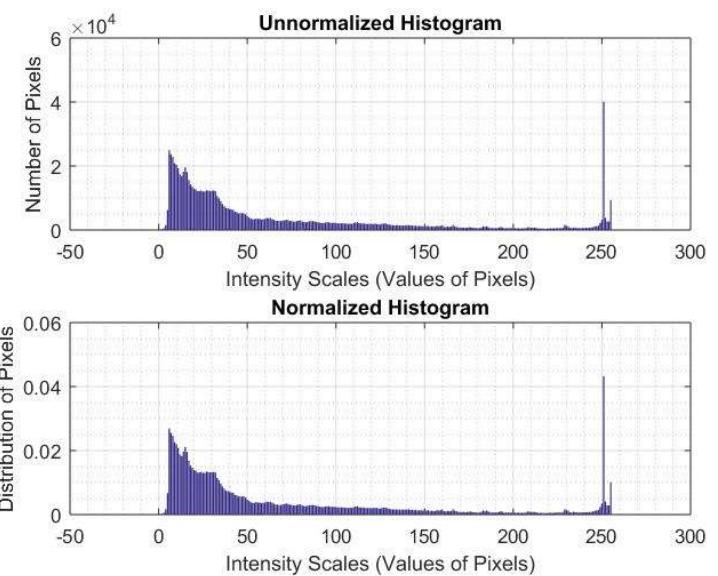
IMAGE 14 : RESULT



- RESULT AFTER BASIC GLOBAL THRESHOLDING WITH INTENSITY 37
- MORPHOLOGICAL SMOOTHING WITH SE OF SIZE 3 X 3



IMAGE 15



Histogram



IMAGE 15 : RESULT

- RESULT AFTER TOP-HAT TRANSFORM FOLLOWED BY CLOSING WITH SE 7 X 7
- SMOOTHING WITH GAUSSIAN KERNEL OF SIZE 3 X 3, K = 1 AND SIGMA = 1.25

GUI

File Tools Spatial Filtering Frequency Domain Analysis Noise Filtering Morphological Processing Image Segmentation



Intensity Transformation

Contrast Stretch	Blend Image
Negative	Intensity Boost
Thresholding	Intensity Pass
Power Transform	
1	Power Transform
Constant	
Gamma	

Image Blending	
Blender	
Bit-Plane Slicing	
Bit Plane	
Log Transform	
1	Log Transform
Constant	
Level	

Horizontal Shear	
Horizontal Shear	
Vertical Shear	
Vertical Shear	
Rotate	
Theta	
Brightness	
Brightness	

Image Information
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4/23/2018

