Papers Reviewing

An Efficient Edge Detection Approach to Provide Better Edge Connectivity for Image Analysis

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Outline:

Introduction

1981 Made an attempt for detecting the edges based on its local good form.

1998 Edges detection without being misled by the noises

2006 Proposed a supervised learning-based algorithm for edge and boundary detection.

2011 Minimize the image segmentation issues to that of edge detection .

2017 Focus on resolving the limitations of a traditional canny method.

PROBLEM CONSTRAIN

02

Edge detection techniques

first order methods

Sobel & Prewitt edge detectors.

second order methods

Laplacian & Canny ,

Spatial Domain

Frequency Domain

(Recall)

Canny Edge Detection Algorithm:

1. Smooth image (only want “real” edges, not noise).
2. Calculate gradient direction and magnitude.
3. Non-maximum suppression perpendicular to edge.
4. Threshold into strong, weak, no edge.
5. Connect together components.

Limitations of spatial domain methods

Operator	Technique	Pros				Cons			
Sobel	SPO1	Simplicity	DEO	NN	NN	SN	Inaccurate	NN	NN
Laplacian	SPO2 /ZC	DEO	FCD	NN	NN	RFEE	SN	NN	LAPLACIAN
Canny	GAUSSIAN	PERROR	LR	ISNR	BDSNC	Complex	Computations	FCD	TC

SPO1- Spatial First Order, SPO 2 -Spatial Second Order, ZC -Zero Crossing, DEO -Detection of edges and their orientation, SN - Sensitivity to noise, FCD -Fixed characteristics in all directions, RFEE -Respond to few existing edges, PERROR -Use probability for error rate finding, LR -Localization and response, ISNR - Improved signal to noise ratio, BDSNC -Better detection specially in noisy conditions, FZC -False zero crossing, TC -Time consumption.

Improved Canny
Edge Detection Algorithm (ICA)

1. Image Gradient Calculation.
2. Adaptive thresholding.

Traditional Canny Edge a 2 × 2 neighboring area operator →

$$G_x = \begin{bmatrix} -\frac{\sqrt{2}}{4} & 0 & \frac{\sqrt{2}}{4} \\ -1 & 0 & -1 \\ -\frac{\sqrt{2}}{4} & 0 & \frac{\sqrt{2}}{4} \end{bmatrix}$$

$$G_y = \begin{bmatrix} \frac{\sqrt{2}}{4} & 1 & \frac{\sqrt{2}}{4} \\ 0 & 0 & 0 \\ -\frac{\sqrt{2}}{4} & -1 & -\frac{\sqrt{2}}{4} \end{bmatrix}.$$

Improved Canny Edge Detection Algorithm (ICA)

1. Image Gradient Calculation.
2. Adaptive thresholding.

There are two types of typical images:

1. Images with Less edge information.
2. Images with Rich edge information.

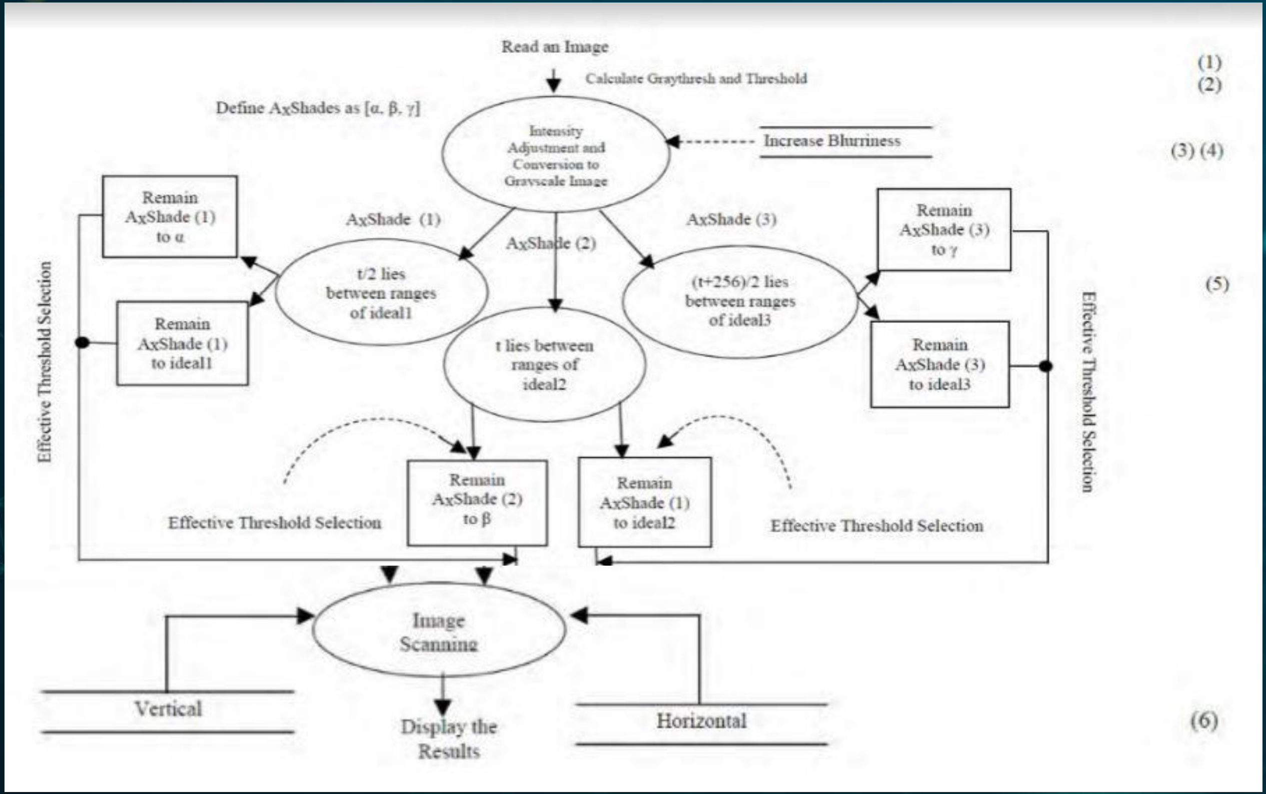
The threshold selection greatly correlated with the mean of gradient magnitude and standard deviation.

PROPOSED ALGORITHM

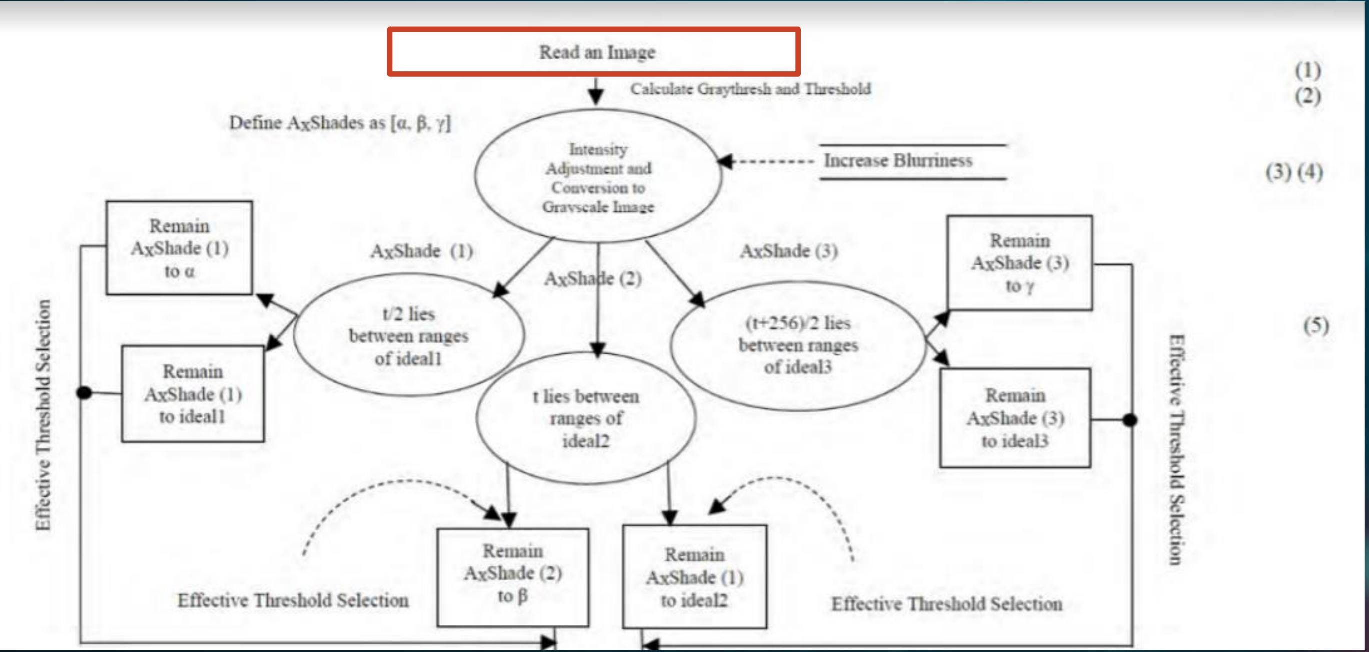
03

ALGORITHM B- EDGE

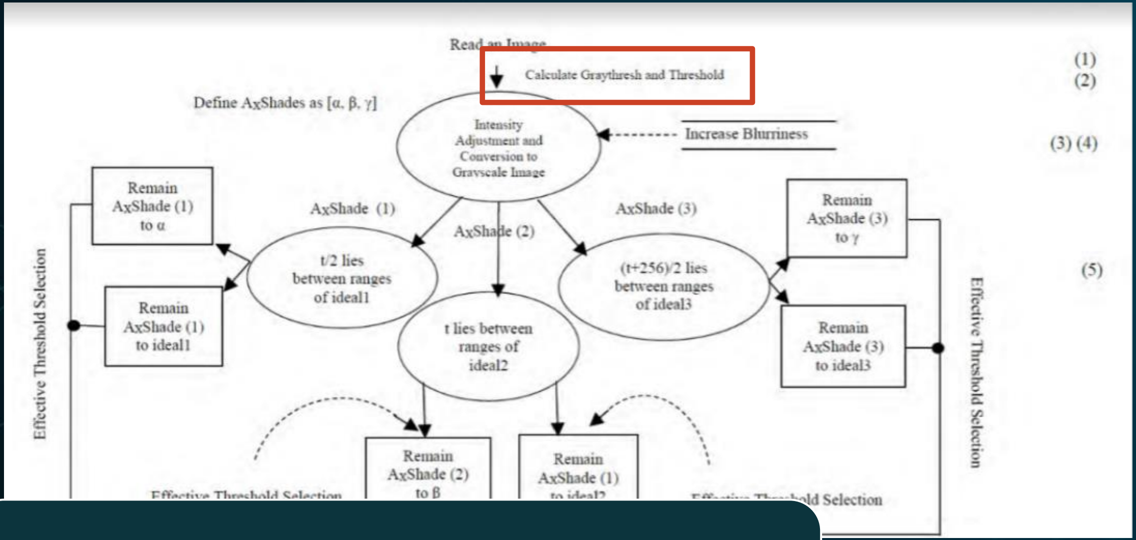
Consist of 6 Step



Step 1: Read image



Step 2: Graythresh and Threshold Computation Phase):

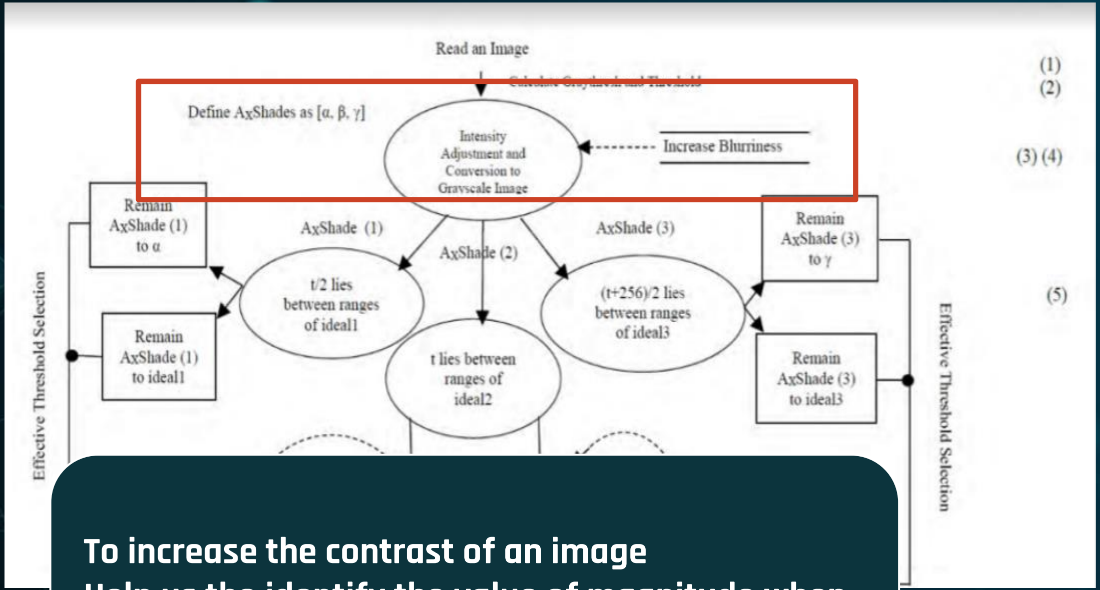


Gray thresh provides an average of an image

$$\psi = \frac{\left(\sum_{\alpha=1}^{n} \sum_{\beta=1}^{m} ara\right)}{m \cdot n}$$

m and n depict the pixel dimensions and ara is an array of an input image.

Step 3: (Intensity Adjustment Phase):



To increase the contrast of an image
Help us the identify the value of magnitude when implementation the blurriness

The corresponding threshold value (φ) of an image is then computed by

$$Phi = \frac{\psi \cdot 20}{8.33}$$

Step 3: (Intensity Adjustment Phase):

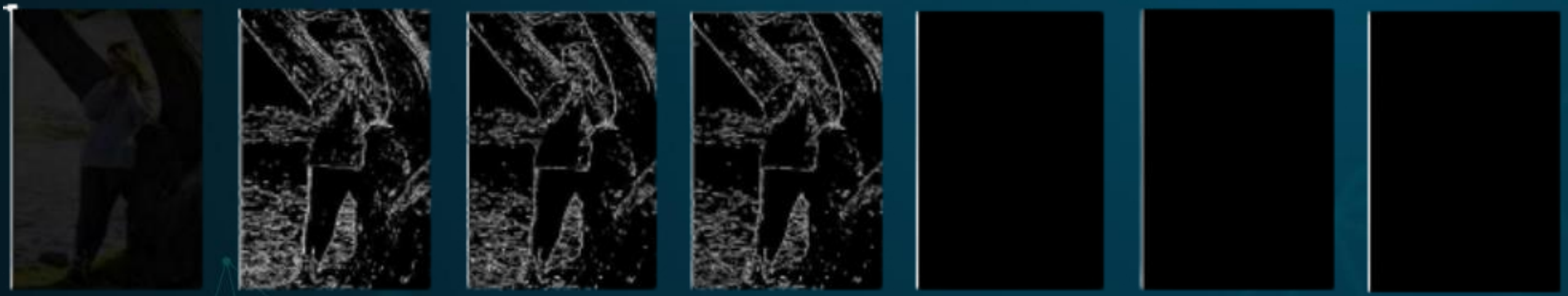


Image 1.2 1.93 **20/8.33** 3 3.15 3.6

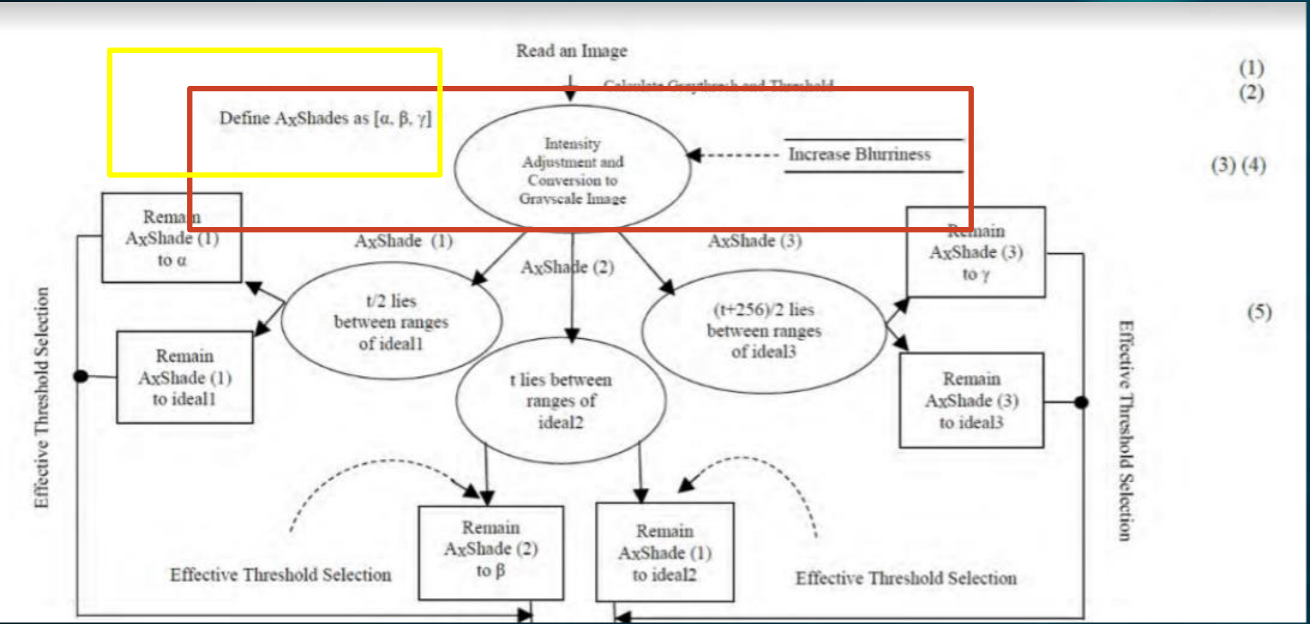
Edge Thickness

** a value greater than 20/8.33 —> results to a higher (φ) value.
Lead to implementation of blurriness with a high magnitude which results in high smoothness and reduction in edge information.

** a lesser value than 20/8.33, results to a lower (φ) value.
This leads to implementation of blurriness with a low magnitude which results in double edges and automatic noise generation.

Step 4: (Grayscale Conversion Phase):

grayscale image technically --> variates in an intensity range of 0-255
Multiple threshold approach



Step 4: (Grayscale Conversion Phase):

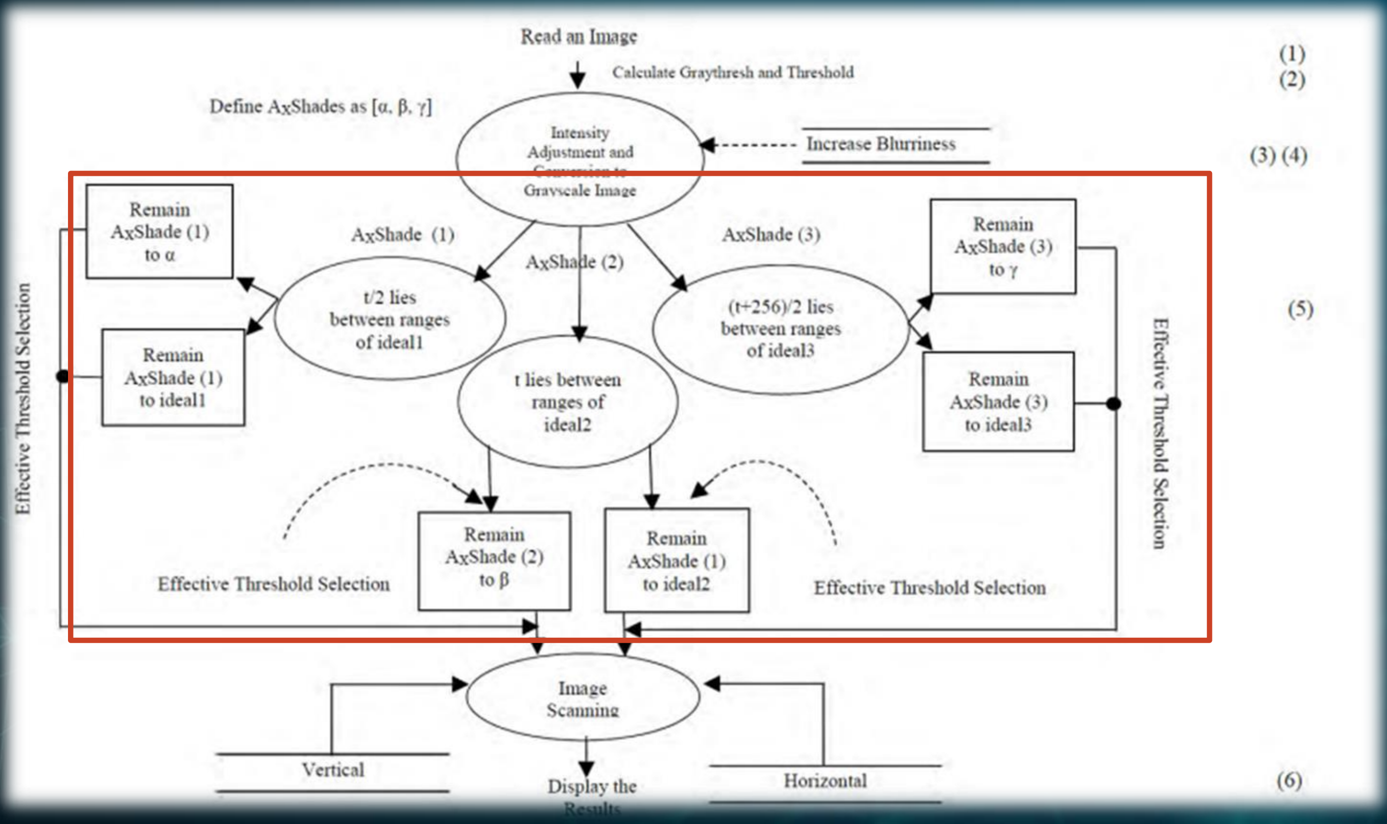
Multiple threshold approach -->threshold selection is based on automatic simulated results

Original image | 40, 104, 150 | 64, 70, 150 | 64, 70, 170 | 24, 85, 170 | 64, 85, 170

Edge Connectivity

- Intensity 64 is represent low intensities and high intensities (lower than 64 and grater than 220)
- Intensity 85 represent the grayscale shade (values between 70 -120.)
- Intensity 170 changes on intensity that lead to creation of double edges.

Step 5 : (Best Solution Selection)



Step 5 : (Best Solution Selection)

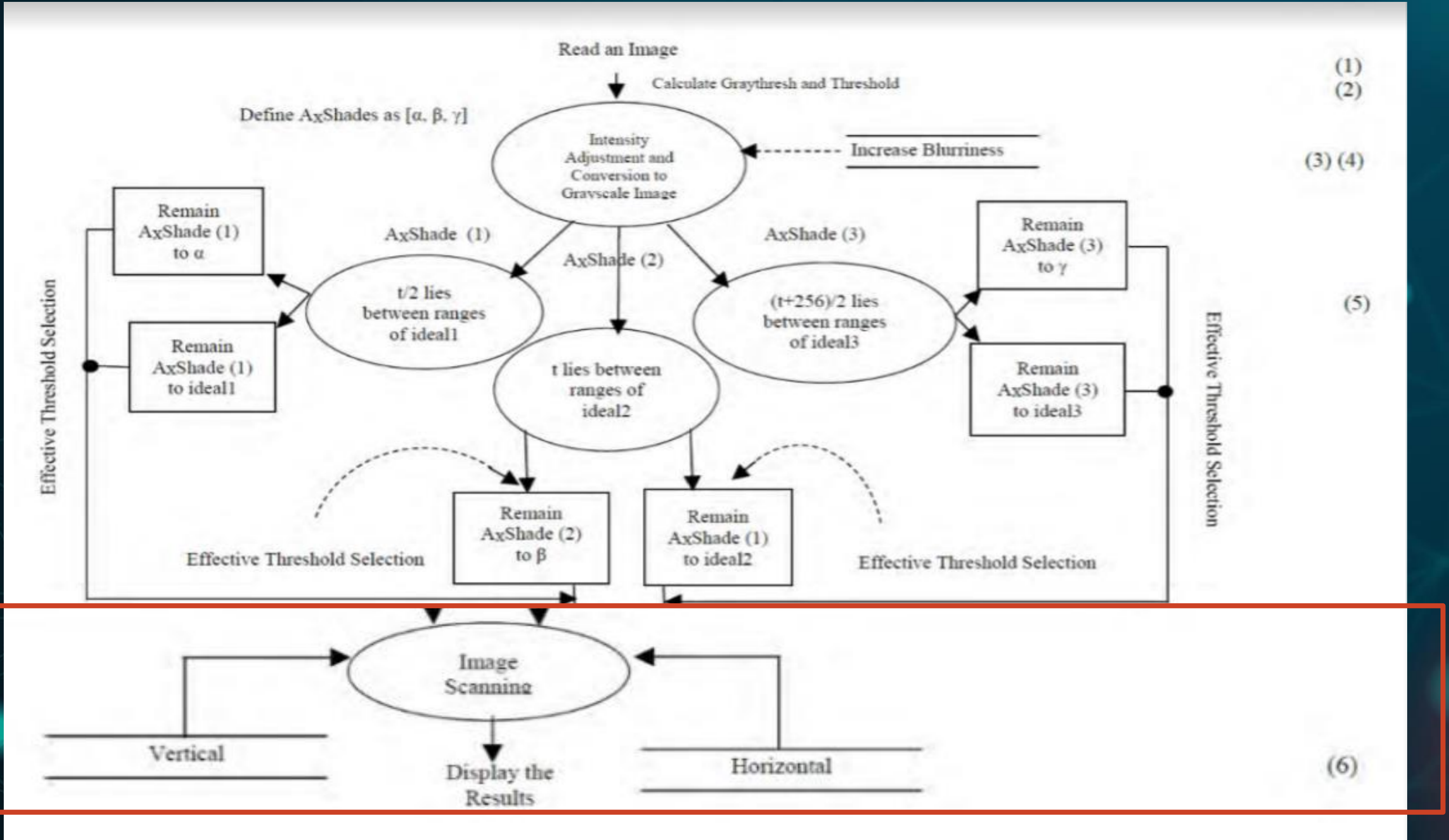
01 Initialize a zero array O to any user defined size [α, β].

02 Once the three thresholds are identified from step 4

03 Then scanning over the pixels horizontal direction is applied and detected edge pixels of the object will be updated in the empty array O

04 Finally, the array is called and the resultant edged image is revealed. It is performed

Step 6 : repeat step 5 vertical



04

Results

SIMULATION RESULTS WITH PERFORMANCE ANALYSIS

01 QUALITATIVE ANALYSIS

02 QUANTITATIVE ANALYSIS

03 ENTROBY

04 MSE (Mean Squares Error)

Berkeley dataset (BSDS500)

170 Training

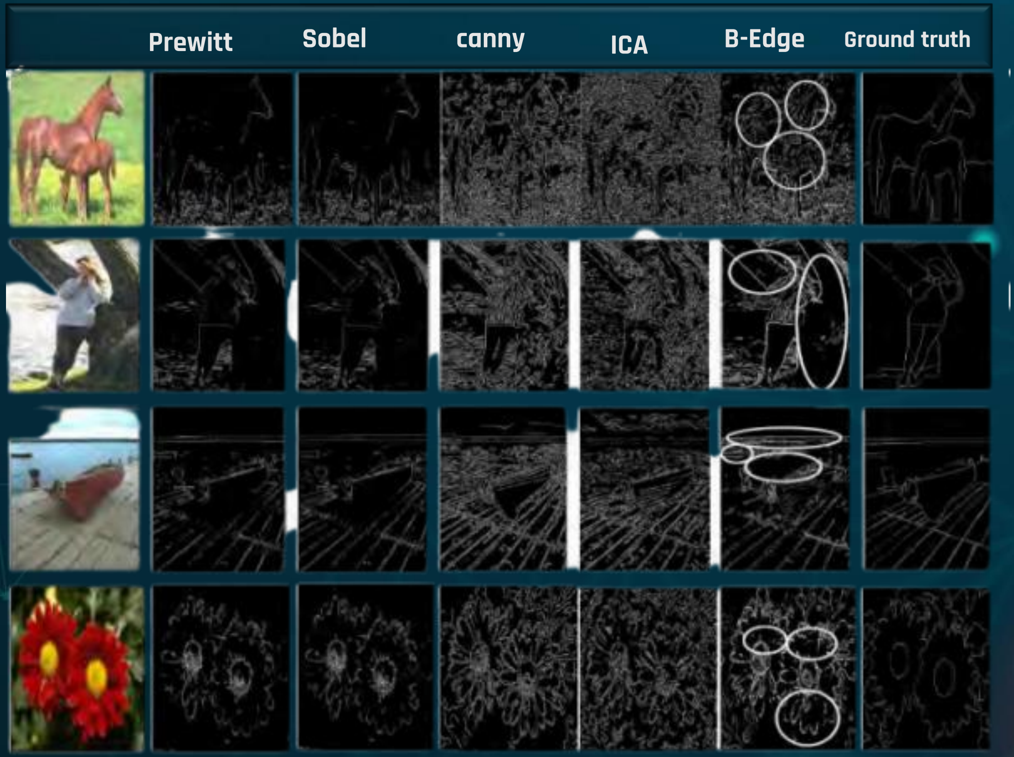
200 Testing

Qualitative analysis

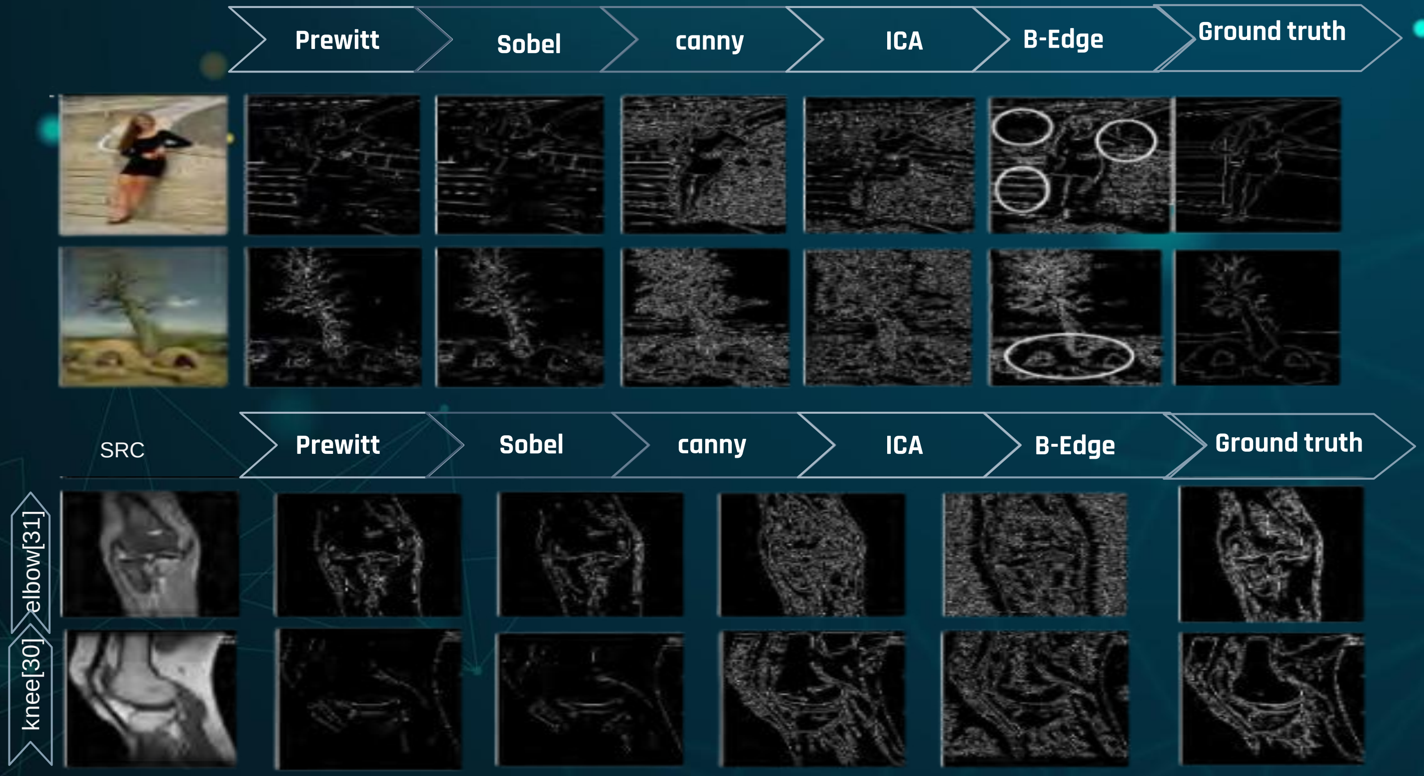
- Prewit's and Sobel's results are marginally similar to the ground truth as less continuity in the detected edges

- Many more enhancements have been observed from the Canny's results, but It have more connected edges.

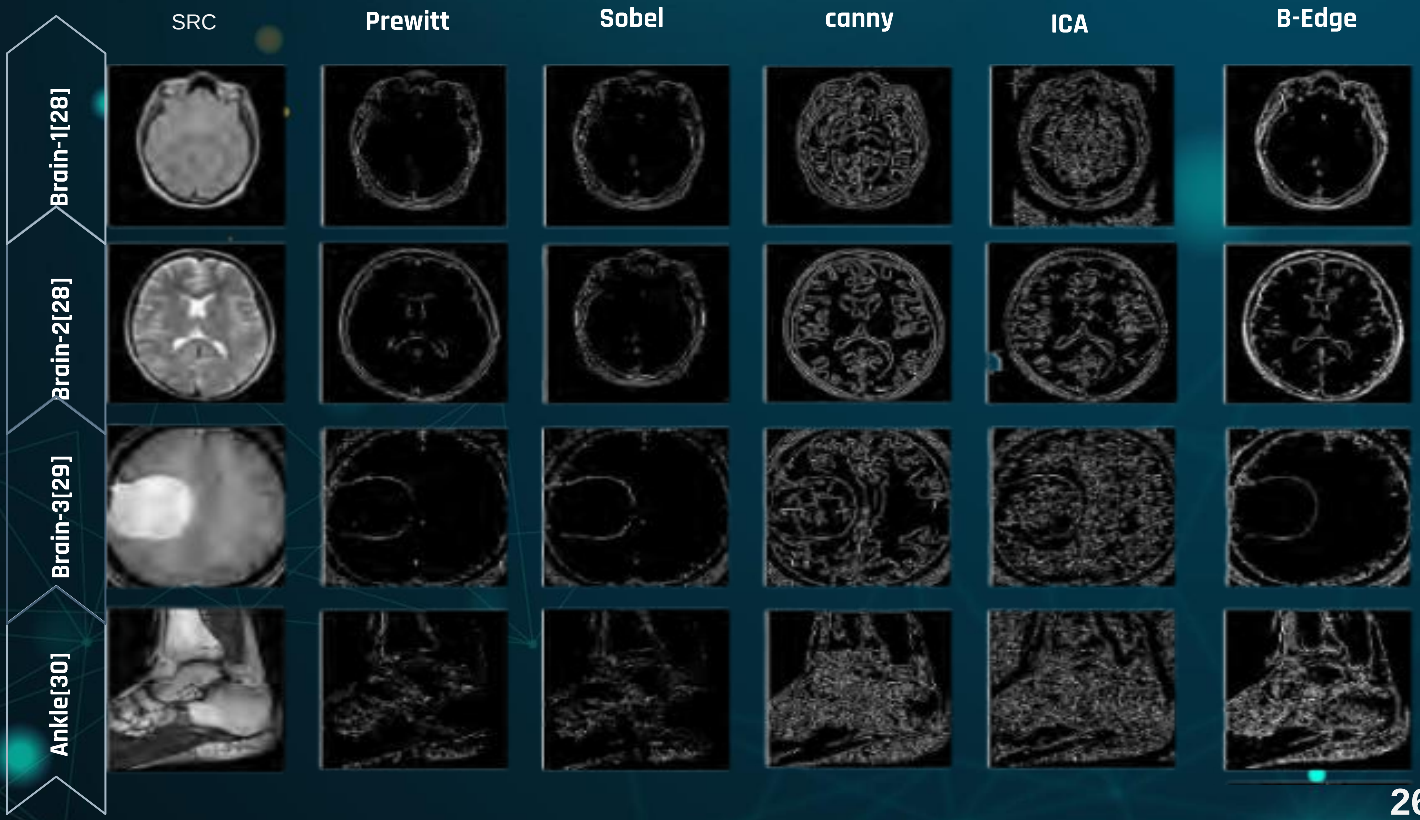
- B-edge has success- fully identified the object's edges



Qualitative analysis



Qualitative analysis



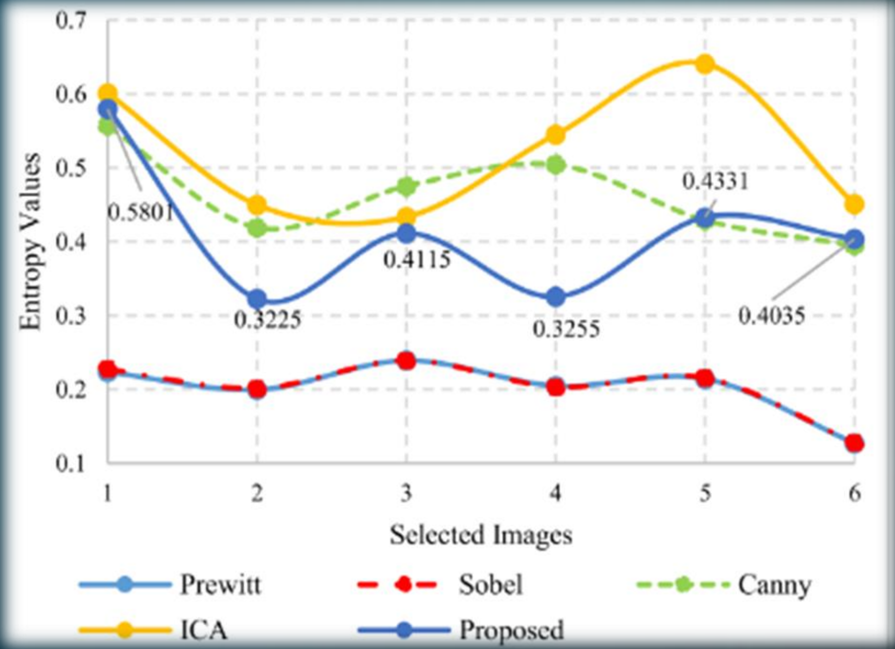
QUANTITATIVE ANALYSIS

01 ENTROBY

02 MSE (Mean Squares Error)

ENTROPY

$$H(I) = -\sum_{i=0}^{L} p_i \log p_i$$



MSE (MEAN SQUARE ERROR):

$$MSE = \frac{1}{mn}\sum_{0}^{m-1}\sum_{0}^{n-1}\|O(s,t) - P(s,t)\|^2$$

MSE (MEAN SQUARE ERROR):

Images	Prewitt	Sobel	Canny	ICA	B-Edge
IM-1	0.15597	0.15673	0.17082	0.32940	**0.14685**
IM-2	0.14734	0.14729	0.15686	0.28950	**0.09797**
IM-3	0.15931	0.16111	0.13635	0.31830	**0.09585**
IM-4	0.16223	0.16199	0.11671	0.36080	**0.11524**
IM-5	0.13330	0.13354	0.08525	0.28010	**0.04550**
IM-6	0.13530	0.13503	0.07159	0.13810	**0.07078**
IM-7	0.15850	0.15745	0.14240	0.13470	**0.14175**
IM-8	0.15142	0.15170	0.10331	0.14199	**0.09075**
IM-9	0.16933	0.16949	0.14372	0.14160	**0.13991**
IM-10	0.13170	0.13143	0.08902	0.14100	**0.04619**
IM-11	0.14164	0.14230	0.09997	0.11270	**0.06220 8**
IM-12	0.15579	0.15653	0.15114	0.15200	**0.13701**
IM-13	0.14470	0.14488	0.09821	0.14520	**0.08516**
IM-14	0.13745	0.13782	0.12766	0.19240	**0.06650**
IM-15	0.13226	0.13311	0.07231	0.15140	**0.03703**
IM-16	0.14093	0.14152	0.10654	0.12181	**0.05531**
IM-17	0.13260	0.13262	0.07763	0.13727	**0.03714**
IM-18	0.15371	0.15402	0.10484	0.11311	**0.10098**
IM-19	0.15486	0.15424	0.24302	0.20833	**0.09355**
IM-20	0.15150	0.15168	0.11152	0.11736	**0.08903**
IM-21	0.13160	0.13225	0.08714	0.13462	**0.05459**
IM-22	0.14333	0.14358	0.09447	0.11602	**0.06180**
IM-23	0.14650	0.14631	0.10521	0.16043	**0.08690**
IM-24	0.17968	0.18210	0.17828	0.19799	**0.14607**
IM-25	0.13620	0.13629	0.12181	0.13122	**0.04835**
IM-26	0.14567	0.14574	0.14651	0.14984	**0.05902**
IM-27	0.15342	0.15339	0.15869	0.15590	**0.11985**
IM-28	0.14225	0.14247	0.12469	0.13431	**0.04878**
IM-29	0.15356	0.15391	0.12315	0.17359	**0.04448**
IM-30	0.15043	0.15093	0.12708	0.15352	**0.06144**

Conclusion

05

Conclusion

Advantages

- The algorithm is efficient for detecting the object edge with less noise
- It provides a better entropy value.

Drawbacks

- Data set used is very small to detect the efficiency of the algorithm
- The algorithm is not appropriate for some medical image
- The time computation needs to be improved.

Reference: Mittal, M., Verma, A., Kaur, I., Kaur, B., Sharma, M., Goyal, L. M., ... & Kim, T. H. (2019). An efficient edge detection approach to provide better edge connectivity for image analysis. *IEEE access*, *7*, 33240-33255.

THANKS!

Do you have any questions?

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