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# Analysis Of Comparitive Methods for Edge Enhancement Filters

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***Abstract:****Edge enhancement filters are used to sharpen the intensity differences in the images. There exist certain methods, which are used to diagnose the basis of Edge Enhancement Filter. Each method uniquely evaluates the potentiality of edge enhancement filter. It is significant to distinguish these methods to realize which method is efficient. Analysis is made on the functionality of each method by comparing behavioral aspects of each method.*

***Keywords:*** *Convolution, Edge Enhancement Filter, Threshold.*

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## I. Introduction

There are many types of filters used to improve the effectiveness of the captured images [1]. Our interest is 'Edge enhancement filter', which is used to enhance the change in the intensity values in the image. Sometimes it is crucial to recognize even minor changes in intensity values [7]. This recognization can be made dynamic by choosing a threshold, which indicates up to what extent the intensity values can be identified [3]. Threshold value signifies the proportion of edges to be identified to retain the similarity as that of the original image [2]. Each unique threshold identifies certain range of intensities. The principle, how edge enhancement filter works i.e. its behavioral aspects can be analyzed through certain methods. Each method uniquely describes the behavioral aspects of edge enhancement filters. The functionality of each of these methods are discussed and compared to identify the better method.

## II. Background

Edge information that is present initially in the original image may or may not be highlighted by Edge Enhancement Filter. As edges are represented according to their pixel positions, number of edge Pixels are suitable to predict whether or not desirable edge pixels have been identified [7].

Derivation of a probability measure determining how many edges have been identified from the actual number of edges is described below.

Let P denotes the probability of identifying edges from image S, then
P = (number of edges identified)/ (initial number of edges)

P determines a probabilistic measure to study the behavior of Edge Enhancement Filter.

## III. Analysis of comaprative methods for edge enhancment filters

Peculiar methods, which are used to determine the functionality of Edge Enhancement Filters, are:

- Error Rate
- Paired Ones and Single Ones
- Pair Wise Difference

**A brief description of these methods is as follows:**

**3.1 Error Rate:**

Let 'ne' represents the number of edges present in the original image.
Let 'nd' represents the number of edges detected using appropriate edge enhancement filter.
Error rate is given by,

Error rate= ne/ nd, Error rate factor is indirectly proportional to the efficiency measure.

We calculate error rate for each image obtained after applying threshold.

For example consider the source image in Fig 3.1,

| | | | | |
|---|---|---|---|---|
| 4 | 4 | 4 | 3 | 2 |
| 4 | 4 | 4 | 5 | 1 |
| 4 | 4 | 4 | 1 | 2 |
| 2 | 1 | 3 | 2 | 5 |

Fig 3.1

| | | |
|---|---|---|
| 0 | 10 | 10 |
| 30 | 20 | 0 |

Fig 3.2

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 30 | 20 | 0 |

Fig 3.3

Fig 3.2 represents the output obtained by applying Laplacian filter at threshold value 0. Fig 3.2 represents the output obtained by applying Laplacian filter at threshold value 10. The number of edges present in the original image i.e. N (O) is 5. N (C) denotes the number of edges after applying filter.
For Fig 3.2,
Error Rate= N (O)/N (C) = 5/4 = 1.25
For Fig 3.3,
Error Rate= N (O)/N (C) = 5/3 = 1.66

Minimum Error Rate indicates more effectiveness of the output. As the threshold value increases, the number of edges gets decreased and thus the error rate increases.
3.2 Paired ones and single ones:
This counts the paired ones and the number of single ones in each binary image, which is obtained by every threshold.

For example, consider the binary image in Fig 3.4.

| | | | | |
|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 | 1 |

**Fig 3.4**

There are 5 paired ones and 3 single ones in Fig 3.4.

Ones in binary image indicate the presence of edge. As the threshold value increases, the number of edges decreases and the number of paired ones and single ones also decreases. The more number of paired ones the more is the efficiency of the output.

**3.3 Pair-wise Difference:**

According to this method, subtractions are performed on successive positions in the source image and the image obtained through each threshold value. Let S be the source image and $T_i$ represent the image obtained after applying threshold value 'i'. To apply this method all pixel values in the original image should posses same neighborhood count similar to the filter used. As the filter used in this example is of 8 neighborhood value, every pixel value in the original image should also have same value. Remaining pixel values are ignored. The desirable source image after removing unnecessary pixel values is as in Fig 3.5.

| | | |
|---|---|---|
| 4 | 4 | 5 |
| 4 | 4 | 1 |

Fig 3.5

On applying this method on Fig 3.2 results as follows,
(4-0) + (4-10) + (5-10) + (4-30) + (4-20) + (1-0)
= -48

On applying this method on Fig 3.2 results as follows,
(4-0) + (4-0) + (5-0) + (4-30) + (4-20) + (1-0)
= -28
The lesser the Pair Wise Difference, the more is efficiency of the filter. As the threshold value increases, the number of edges decreases and the Pair Wise Difference increases.

## IV. Results and analysis

The above discussed methods are illustrated by considering a sample image, on which both Laplacian and Sobel filters are applied individually to derive comparative analysis.

**Fig 4.1**

On applying certain threshold values after applying Laplacian Filter on Fig 4.1, will result as follows.

**Fig 4.2:** Theshold=125

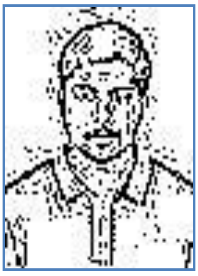

**Fig 4.3:** Threshold=128

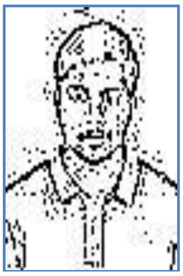

**Fig 4.4:** Threshold=130

**Fig 4.5:** Threshold=132

**Fig 4.6:** Threshold=134

**Fig 4.7:** Threshold=140

The results obtained after applying discussed methods on Laplacian filtered threshold outputs are tabulated as follows:

**Table 1**

| Threshold | 125 | 128 | 130 | 132 | 134 | 140 |
|---|---|---|---|---|---|---|
| Error Rate | 2.70 | 3.72 | 4.45 | 5.00 | 5.86 | 8.48 |
| Paired Ones | 482 | 350 | 280 | 250 | 212 | 135 |
| Single Ones | 460 | 335 | 304 | 269 | 233 | 184 |
| Pair wise difference | 762942 | 811875 | 833857 | 846247 | 861073 | 888721 |

These tabulated values for each threshold value on Fig 4.1 are represented graphically as follows. X-values represent the threshold values and Y-values represent the corresponding method value.

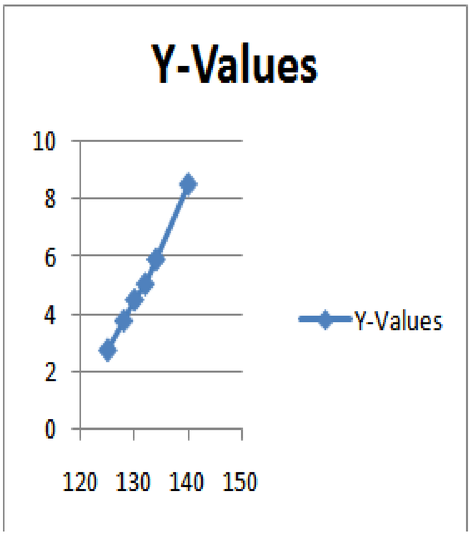


**Fig 4.8:** Error Rate

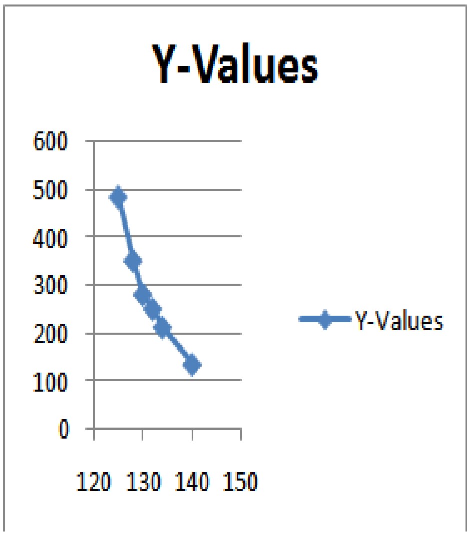


**Fig 4.9:** Paired Ones

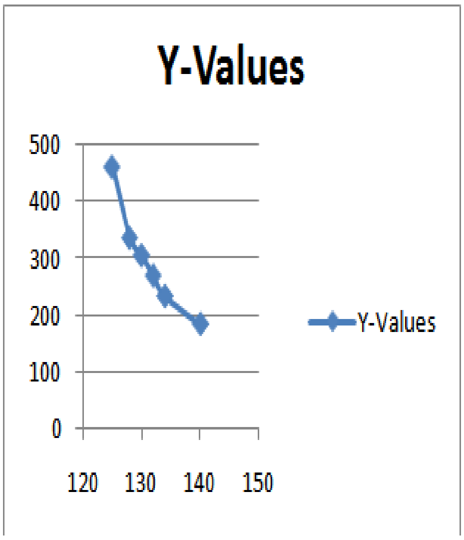


**Fig 4.10:** Single Ones

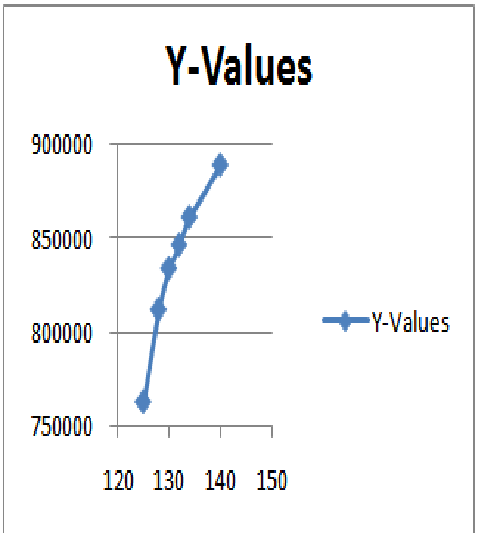


**Fig 4.11:** Pair Wise Difference

On applying certain threshold values after applying Sobel Filter on Fig 4.1, will result as follows.

Fig 4.12: Threshold=125

Fig 4.13: Threshold=127

Fig 4.14: Threshold=130

**Fig 4.15:** Threshold=133

**Fig 4.16:** Threshold=135

**Fig 4.17:** Threshold=137

The results obtained after applying discussed methods on Sobel filtered threshold outputs are tabulated as follows:

**Table 2**

| Threshold | 125 | 127 | 130 | 133 | 135 | 137 |
|---|---|---|---|---|---|---|
| Error Rate | 2.96 | 3.88 | 4.91 | 5.93 | 6.82 | 7.68 |
| Paired Ones | 559 | 430 | 341 | 277 | 238 | 212 |
| Single Ones | 180 | 130 | 101 | 95 | 88 | 77 |
| Pair wise difference | 779148 | 817778 | 844255 | 861808 | 873152 | 881692 |

These tabulated values for each threshold value on Fig 4.1 are represented graphically as follows. X-values represent the threshold values and Y-values represent the corresponding method value.

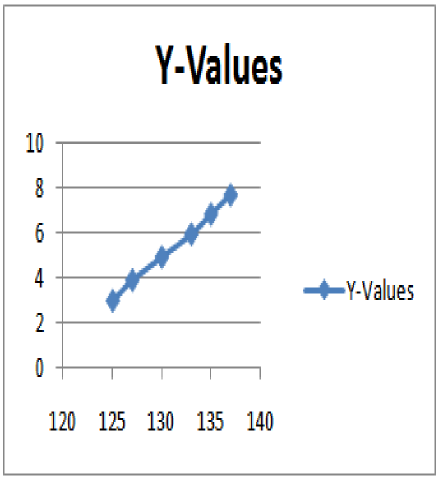


**Fig 4.18**: Error Rate

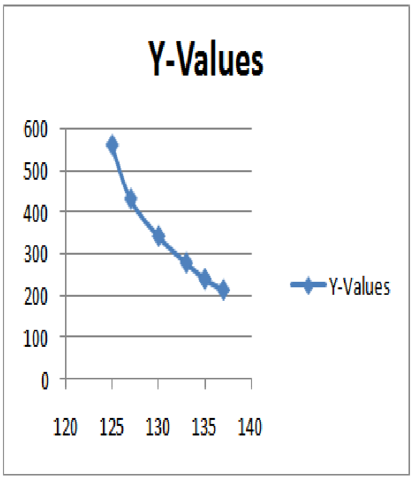


**Fig 4.19:** Paired Ones

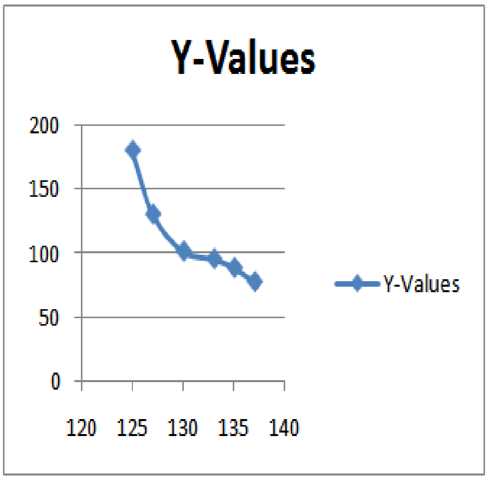


**Fig 4.20:** Single Ones

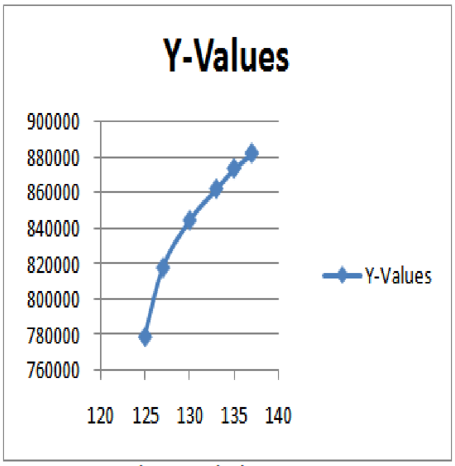


**Fig 4.21:** Pair Wise Difference

## V. Conclusion

Analysis on the results obtained by each method is made by considering the threshold outputs of both Laplacian and Sobel filters. The following observations are made:

**a)** On comparing threshold outputs 125 and 128, many edges got reduced indicating a difference in the number of edges.

**b)** On comparing threshold outputs 128 and 130, the change is negligible i.e. almost similar.

**c)** On comparing threshold outputs 130 and 132, there is no much difference.

**d)** On comparing threshold outputs 134 and 140, the difference is even higher than the previous differences.

***A. Laplacian:***

The effectiveness of each method is determined by comparing the results obtained by respective method on every threshold output Fig. 4.2 – Fig. 4.7 obtained using Laplacian filter as shown in Table 1.

1) Error Rate: This method keenly represents the major and minor changes in the intensity values. This method is maintaining a good pace on all the observations mentioned above.

2) Paired Ones and Single Ones: This method clearly represents the changes described in observations 'a', 'b' and 'c', but it could not identify the major change mentioned in observation'd'.

3) Pair Wise Difference: This method yields to detect the change in intensities, but according to the observations stated above, this method could not able to represent the changes with a proper variation.

***B. Sobel***

The effectiveness of each method is determined by comparing the results obtained by respective method on every threshold output Fig 4.12 – Fig 4.17 obtained using Sobel filter as shown in Table 2.

1) Error Rate: This method signifies the observation 'b' as there is a bit higher increasing rate than all the other differences. It also behaves respectively with the other observations.

2) Paired Ones and Single Ones: Observation 'a' is justified but according to observation 'b', the change must be greater but this method could not able to represent a major change.

3) Pair Wise Difference: This method signifies the observations 'c' and'd', as this method similar change similar to the respective observations made. But this could not justify the observation 'b', as the difference is not maintained higher compared to all the differences.

From the above observations made, the effectiveness of method is given in decreasing order as follows:

Error Rate > Paired Ones and Single Ones > Pair Wise Difference

Hence it is clear that **"**Error Rate**"** method is efficient method among these methods.

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