FRACTIONAL CALCULUS BASED VIA EDGE APPRECIATION ACT IN DIGITAL IMAGE PROCESSING
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ABSTRACT

Edges of a digital image are containing a type of important information that can be determined by applying detectors with different methodology. Various studies are carried out by researcher for detection of edges, lines, and spots in digital image and define the two generic approaches: (1) differential detection and (2) model fitting are used. This project work, studies of edge detection method is carried out. A hybrid technique which is based on the fractional derivative and canny model are developed. The proposed method considered the three types of error accompanying during edge detection which are (1) missing valid edge points, (2) failure to localize edge points, and (3) classification of noise fluctuations as edge points.

Keywords: Wavelet scales correlation, Edge detection, Image denoising, and Entropy reduction

I. INTRODUCTION

Digital image contents are various features which have important objectives in field of computer vision and image processing. Because of these images processing is a mostly used area in few decade years for research. Digital image contains different features such as scene and objects, shape, size, colour, and orientation. Identification of these features from image is the first requirement in digital image processing and computer vision before any interpretation. Hence, for extraction of the feature regions for identification detection of the objects edges is required and this reveals the significance requirement of the edge detection in image vision and processing [1-2]. Edge detection is a process which detects the edge presence and its location such as sharp changes due to the colour intensity (or brightness) in to image. Since, the edges present in the images are due to the colour change, which is nothing but the high frequency information. This abrupt change in images provides the information about the depths, surface orientation, information of the objects, change in material properties and various scene presents in to the images. Identification of this features are beneficial in various application such as image enhancement, segmentation, recognition, morphing, restoration, registration, compression, retrieval, watermarking, hiding, feature detection and etc. [3].

II. INTRODUCTION TO DIGITAL IMAGE PROCESSING

The term digital image processing generally refers to processing of a two-dimensional image by a digital computer. A digital image is an array of real or complex number represented by a finite number of bits used for digital image processing and in this finite number of elements, each of which has a particular location and value. These elements are referred to as picture elements, image elements, pals, and pixels. Pixel is the term most widely used to denote the elements of a digital image [2]. An image may be defined as a two-dimensional function \( f(x, y) \) where \( x \) and \( y \) are spatial (plane) coordinates and the amplitude of at any pair of coordinates \( (x, y) \) is called the intensity or gray level of the image at that point. When \( x, y \) and the amplitude values of \( f \) are all finite discrete quantities the image is called digital image.

Digital image processing methods has a broad spectrum of principal applications, such as

- Remote sensing via satellites and other spacecraft’s.
- Image transmission and storage for business applications.
- Medical processing, radar, sonar and acoustic image processing.
- Robotics and automated inspection of industrial parts

Image processing typically attempts to accomplish following basic classes of problems [3]

- Image representation and modelling is the fidelity or intelligibility criteria for measuring the quality of an image or the performance of a processing technique.
• Image enhancement is the process of improving the quality of a digitally stored image by manipulating the image and alters the image to make its meaning clearer to human observer.

• Image restoration is concerned with filtering the observed image to minimize the effect of degradations.

• Image analysis is concerned with making quantitative measurements from an image to produce a description of it and it involves the study of feature extraction, segmentation and classification techniques.

III. TECHNIQUES OF EDGE DETECTION

Figure 1 shows the basic block diagram of edge detection process. Computing a measure of edge strength is an important process. Edge present in images has high frequency information as a form of sharp changes in form of brightness. In this block, enhancement of the high frequency information is taken place. Afterward, determination of local directional maxima has estimated by finding the change in local orientation of the edges. Gaussian smoothing is used after for smoothing of detected edges. Thresholding processes are applied in smooth edge images for deciding the edges. At last, edges linking are used for interconnecting the detected edges [1, 2, 5].

![Figure 1: Block diagram of edge detection process](image)

IV. PROPOSED METHODOLOGY

The proposed model for image de-noising are processed by the given block diagram shown in Figure 2. First, image is acquired and imported in MATLAB as matrix format. Each element of the matrix is representing a pixel and possesses the gray value in the range between 0 to 255. Proposed edge detection method consists of three main processes for detection of edges from the digital images. Edges strengthening for improving the edge power from the input image. After strengthening of edges localization of the edges by use of input images as reference images. At last after detection of edges smoothing the edge information to find the clear edge information. Each of these blocks is described in details by using the flow graph of the proposed method shown in figure 3.

![Figure 2: The proposed model for image de-noising](image)
V. PERFORMANCE ANALYSIS

In this chapter performance and result analysis of the proposed edge detection method are assessed. The edge detection method was applied to different images like Flower.jpg, stone.tiff, bag.png, cameraman.tif, barbara.jpg, and corresponding result for each images are discussed. To evaluate the performance of the whole process are divided into two classes one is visibility analysis matrix and second is result analysis.

Quality analysis

In this project simulated performance of the edge detection of the images are done using MATLAB. To evaluate the performance of the proposed method various format of reference image considered i.e. jpg, png, tif and figure 4 show the set of reference image.

5.1 Effect of fractional order in reference image

For study of proposed method different level of the fractional derivative of the images are obtained and shown in below figure. As seen in figure as increase the order of the fractional derivative edges are more clear. Hence by taking the fractional derivative of the images it is clear that the edges are improved for all images. However, the increases in order above 1 also incorporate the loss in low frequency information. Figure 5-6 shows the different reference images and its fractional derivative images of order 0.3, 0.55, 0.8, 1.05 and 1.55.
5.1.2 Comparison of proposed methods with various edge detector methods

Proposed edge detection methods are simulated by using MATLAB software and its performance are compared with the mostly used edge detector. In MATLAB the mostly used edge detection technique has predefined function. Canny, Prewitt, Sobel and Log based predefined edge detector are used for comparative analysis method. Edge detector results for reference images are shown in figure 7-8. From the figure it is seen that the all techniques have capability for detection of edge. Sobel and Prewitt based edge detection technique can able to find the major edges from the images. While the fine edges are unable to detect by using the Sobel and Prewitt based method. Canny, Log and proposed method have capability to find the fine edges also. The proposed method has more advantages as compare to the Canny and Log because it has capability of extraction of small changes in colour and features.

Figure 5: Fractional derivative image of the reference images with order
(a) 0.3, (b) 0.55, (c) 0.8, (d) 1.05, (e) 1.55.

Figure 6: Fractional derivative image of the reference images with order
(a) 0.3, (b) 0.55, (c) 0.8, (d) 1.05, (e) 1.55.

Figure 7: Input and edge detected images with different methods
(a) input, (b) canny, (c) sobel, (d) prewitt, (e) log, and (f) alpha = 0.3
From the results it is found that the proposed method shows the better performance as compare to the Canny, Sobel, Prewitt and Log based edge detection techniques. Fractional derivative based method has advantages over other edge detection techniques because of the use of fractional derivative. The fractional derivative improves the high-frequency (HF) portion of signal while increasing the order of the fraction derivative frequency of the signal also increase in nonlinear rapid growth. At the same time, fractional differential reserves the low-frequency (LF) portion of signal also at certain degree non-linearly. Hence, the advantages of fractional derivative are utilized in proposed method. Improvement of the high frequency information enhances the edges information and extraction of the edges after the enhancement provides the proper edge information of the reference images.

5.1.3 Assessment using Quantity analysis parameter

Figure of merit (FOM)

Three major types of error accompanying when edge detection process are carried out: (1) missing valid edge points, (2) failure to localize edge points, and (3) classification of noise fluctuations as edge points. Figure 9 shows the typical edge segment in an image. Pratt has introduced a figure of merit that balances these three types of error. The figure of merit is defined by

$$FOM = \frac{1}{\max(\text{RI,EDI})} \sum_{1}^{RI} \frac{1}{1 + ad^2}$$

(5.1)

Where RI is the reference image, EDI is the edge detected image, a is scaling constant and d is the separation distance of an actual edge point normal to a line of ideal edge points. For each edge detection process, the threshold parameter decides the achievement of the process and based on that the figure of merit can determine. When figure of merit calculated by using the reference edge images then the maximum rating of the figure of merit will be 1. While in this project input image is taken as reference image hence, the maximum value of the figure of merit subject to the maximum allowable correct detection rate.

Figure 9 Indications of edge location

(a) Image segment (b) ideal indication, (c) fragmented indication, (d) offset indication, (e) smeared indication
Table 5.1 Figure of merit of various image for different methods

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Image \ Method</th>
<th>canny</th>
<th>Sobel</th>
<th>Prewitt</th>
<th>Log</th>
<th>proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flower.jpg</td>
<td>60.53</td>
<td>24.2</td>
<td>23.86</td>
<td>43.64</td>
<td>60.87</td>
</tr>
<tr>
<td>2</td>
<td>Stone.tiff</td>
<td>65.47</td>
<td>43.99</td>
<td>42.84</td>
<td>61.72</td>
<td>68.06</td>
</tr>
</tbody>
</table>

5.1.4 Effect of fractional derivative order in edge detection method

After comparison with various method of edge detection fractional derivative approach is finding to be superior than other method. After this the effect of the fractional order in edge detection is determine. For the fractional order 0.3, 0.55, 0.8, 1.05 and 1.55 are consider. And results are shown in figure 10-11. From the results it is clearly visible that by increasing the fractional order the sharp change in the image can be possible to extract as edges. While by increasing the order also increase the chances of the false detection of the edges because by increasing the order of the fractional derivative high frequency signal improve which also improve the noise associated with images. Hence, the noise of the signal also considers as edges by proposed method.

Figure 10: input and edge detected images with different fractional order
(a) input, (b) alpha = 0.3, (c) alpha = 0.5, (d) alpha = 0.8, (e) alpha = 1.05, (f) alpha = 1.55

Figure 11: input and edge detected images with different fractional order
(a) input, (b) alpha = 0.3, (c) alpha = 0.5, (d) alpha = 0.8, (e) alpha = 1.05, (f) alpha = 1.55
Further the figure of merit also calculated for different order and shown in figure 5.19 and table 5.2. It is found that the increase in order increase the figure of merit but increasing the order more than 1 has no use. Order more than one incorporate the noisy signal only there is no improvement in figure of merit.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Image\Method</th>
<th>canny</th>
<th>sobel</th>
<th>Prewitt</th>
<th>Log</th>
<th>proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flower.jpg</td>
<td>60.87</td>
<td>63.81</td>
<td>74.79</td>
<td>85.977</td>
<td>85.97</td>
</tr>
<tr>
<td>2</td>
<td>Stone.tiff</td>
<td>68.06</td>
<td>76.27</td>
<td>84.05</td>
<td>88.45</td>
<td>88.45</td>
</tr>
</tbody>
</table>

### VI. CONCLUSION

The existing edge detection methods are based on integer-order differential approaches. In this research, we propose a novel mathematical method based on fractional differential operation for contrast and texture enhancement to restore image features. The fractional-order approaches can describe any phenomenon in a better way than integer order approaches. For greyscales images, the gray-level values between neighbouring pixels have high correlation. That is why, we can apply fractional differential to enhance texture details for neighbouring gray-level values. Therefore, it is evident that fractional differential can preserve image feature where there is a change in gray level. Proposed edge detection method performances are checked by the use of figure of merit parameter. In this project simulated performance of the edge detection are done using MATLAB and figure of merit are used and determine the fractional order is providing the better edge detection. From the results it is found that the proposed method is improve the Figure of merit as compare to the other techniques. And also find the fractional order less than one provide the better edge information while use of more than one order also incorporate the noise with edge images.

As we know that at presents many areas such as medical, defences, industries etc. are used image as information. Information about the features in images is important for detection of the image feature. Hence, use of the proposed method in this application can be utilized for edge detection. Study of fractional derivative based edge detection also important because it has a capability to extract the sharp change in to the images.

### VII. REFERENCES

4. Bo Li and Wei Xie, Image de-noising and enhancement based on adaptive fractional calculus of small probability strategy, Neurocomputing, 175(A), pp.:704-714, 2016.