Development of data driven adaptive edge detectors for image processing

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Abstract: In most vision processing activities, the early stage involves identifying the features in an image that provide cues to structure and properties of the object in the scene. Most common features in an image or in a scene are edges. Edges are significant local changes in intensity within an image. Most important goal of edge detection is to produce a line drawing from an image representing the scene. The significant features of an image such as line, curve and corners can be extracted from edges. During the stage of discovering and exploring the information from an image of that scene, edge detection is the most important and early-stage activity and as such it is prominent active area in image processing. Most popular edge detection algorithm such as Robert, Sobel, Canny, Prewitt and Laplacian of Gaussian (LoG), etc. are currently in use. This paper emphasis on an experimental study of limitations of conventional edge detectors and to devise a novel approach to resolve the conflicting issues i.e., limitations of these edge detectors in adaptive space utilizing novel methods such as Bi-dimensional Empirical Mode Decomposition (BEMD), Image Empirical Mode Decomposition (IEMD), Complete Ensemble Empirical Mode Decomposition (CEEMD) and Multivariate Decomposition techniques. Further, to study the performance of these modified edge detectors on the images of complex scenes which are of societal and agricultural importance.

Keywords: Bi-dimensional Empirical Mode Decomposition (BEMD), Edge Detection, Image Processing.

1. INTRODUCTION
An image is characterized as a 2D work \( G(x,y) \) where \( l(x,y) \) are spatial coordinates, and the sufficiency of \( G \) anytime pair of directions \( (x,y) \) is called the power of a picture. At the point when \( G \) and \( (x, y) \) are in constrained range then it is called as computerized picture. A picture can likewise be depicted as 2-dimensional cluster which is resolved in terms of sections and lines. By considering an image, it comprises of set of components where each component is called as pixel. Each pixel has esteem at specified areas. There are numerous kinds of picture specifically black and white image, binary image, 8-bit and 16-bit shading position. Each picture is comprised of pixel matrix.

1.1 Image Processing
Digital Image Processing is a technique of processing a digital image using digital computer. We use image processing algorithms, to either enhance the quality of the image or to retrieve valuable information from the image. Many image processing techniques have been developed in last couple of
years. Many of the image processing technique is used to extract useful information from an image. Image processing technique is becoming more popular since it is easily available for personal computers and may other software’s. Digital image processing is a technique of performing some set of operations on an image in order to obtain some useful information from it or for the purpose of image enhancement. The applications of Image Processing are Medical Imaging, Finger-Print Recognition, Face Recognition, Automated Traffic Controlling Systems etc. As of now many techniques have been developed using edge detection for extracting edges from an image.

1.2 Edge Detection
Edge location is a kind of Image Segmentation procedures which decides the nearness of an edge or line in an image and diagrams! them in a suitable manner. The principle motivation behind edge identification is to rearrange the picture information so as to limit the measure of information to be handled. For the most part, an edge can be characterized as the pixel limit that associate 2 separate districts with adequacy traits, for example), unique consistent luminance! and improvement esteems in the picture. In this work, we present strategies for edge division of pictures; we utilized five procedures for this class; Sobel administrator method, Prewitt system, Laplace strategy, Canny strategy, Roberts system, and they are contrasted with each other so as with pick the best procedure for edge recognition portion picture. These methods applied on one picture to pick base speculations for division or edge identification picture. In this project an endeavour is made to contemplate the exhibition of most normally utilized edge discovery procedures for picture division and furthermore the correlation of these methods is completed with an analysis by utilizing MAT LAB programming. We will utilize the edges to discover coinciding between objects. Edge location is a procedure engaged with picture handling which assists with finding the edge or a line in a predefined picture and gives them in a suitable manner. The key significant motivation behind edge discovery is to portion the picture with the goal that information included will be limited.

1.2.1 Bi-dimensional Empirical Mode Decomposition
The Empirical Mode Decomposition was recently presented with a new time-frequency analysis tool to non-stationary and non-linear signals. As Empirical Mode Decomposition is self-adaptive and is able to find the intrinsic modes of the signal. It does not have any implication on optimality. Some instance may arise where certain optimality will be considered hence, we need a decomposition of signal and reconstruction scheme. We will give a modified version of empirical mode decomposition algorithm. For this purpose, two formulations are proposed. Firstly, signal which utilizes a linear weighting for the Intrinsic Mode Functions (IMF). Secondly, algorithm adopts a bidirectional weighting. Bi-directional weighting mainly will not use weights for IMF modes. The two empirical mode decomposition methods proposed will extend the capability of traditional empirical mode decomposition which will be well matched for optimal Signal Recovery MATLAB simulation studies have been done to showcase the application of the proposed optimal empirical mode decomposition algorithms to denouncing problem.

The developments going on in the analysis of the non-linear and non-stationary data have received large attention by the Image Analyst. As we know that Huang in 1998 introduced the Empirical Mode Decomposition in Signal Processing this is related to only seismic and biomedical signals. The main intention of our method is to apply the Empirical Mode Decomposition to texture extraction and image filtering this is widely recognized as a difficult and challenging computer vision problem. The development of an algorithm based on Bi-Dimensional Empirical Mode Decomposition to extract features at different scales/frequencies. Hence these features are called Intrinsic Mode Functions these functions are extracted by a shifting process. The Bi-Dimensional shifting process is realized using classical operators to detect local maxima and it’s all because of radial basis function for surface interpolation.
\[ s(x) = p_m(x) + \sum_{i=1}^{N} \beta_i \varphi(|x - x_i|), \quad x \in R^d, \beta_i \in R \quad \ldots \ldots \ldots \ldots \quad (1.2.1) \]

As shown in the equation (1.2.1) the performance of the texture extraction algorithms is demonstrated using the Bi-dimensional Empirical mode decomposition method in the experiment with both synthetic and natural images.

### 1.2.2 Ensemble Empirical Mode Decomposition

A new Ensemble Empirical Mode Decomposition (EEMD) was introduced. This new technology involves filtering a gathering of background noise signal (information) and combines the mean as the last obvious outcome. Limited not minuscule, plentifulness repetitive sound important to compel the outfit to deplete every single imaginable modification in the filtering procedure, therefore making the distinctive scale signs to gather in the correct Intrinsic Mode Functions (IMF) directed by the dyadic channel banks. As EEMD is a period space examination technique, the additional background noise arrived at the midpoint of out with adequate number of preliminaries; the main persevering part that endures the averaging procedure is the segment of the sign (unique information), which is then treated as the valid and increasingly physical important answer. The impact of the additional background noise; in this way, the additional commotion examines the segment of the sign of practically identical scale in one IMF. With this troupe mean, one can segregate scales ordinarily with no from the prior passionate premise decision as in the abnormality test for the first EEMD estimation. This new system utilizes the full ideal situation of the quantifiable characteristics of tedious sound disturb the sign in its real course of action neighbourhood, and to check itself ensuing to filling its need; thusly, it addresses an impressive improvement over the first EMD and is a truly upheaval helped data examination methodology.

### 2. LITERATURE SURVEY

It gives the brief explanation about the various traditional edge detection techniques and the existing work related to the edge detection in image processing domain. The purpose of edge detection is to reduce amount of data to be processed at the same time preserving the structural properties for processing an image. In a Grey scale image the edge is a basic segregating feature that it is used to separate the regions which the grey level is low or high with in different values of the edge. If an image consists of noise then it is very difficult to detect an edge, we know that if noise is high frequency component and because of this noise true edges will not be detected. If we process a noisy image we end up with distorted or blurred image.

#### 2.1 Steps in Edge Detection

The 3 steps of detecting an edge is as follows,

- **Smoothing an image**: In the first step noise is reduced to maximum extent and image filtering is performed in order to improve the performance and to obtain the best possible result
- **Detection of an edge**: In this step edges are identified and extracted based on the specified threshold value.
- **Localization of an edge**: This step is used to select candidate edge point and candidate which are true are considered as proper edges for future reference. \[1\][2]

#### 2.1.1 Performance Criteria

The following parameters are used for determining the performance criteria of edge detectors and they include,
1. **Good Edge Detection:** The probability of failing to mark the true edges must be low and as well as probability of marking non edge points falsely should be low. [2]

2. **Good Edge Localization:** The points which are marked as the edges must be more accurate for finding true edges. [2]

3. **Single response for single edge:** If more than 2 edge response is detected for same edge, then only edge should be considered as true edge.

In the below shown Fig. 2.1.1(a) gives the Noise and the step edge is shown in Fig. 2.1.1(b) and Fig. 2.1.1(d) and the outputs of the convolutions are in the Fig. 2.1.1(c) and Fig. 2.1.1(e). All these figures mark the centre of the edge at the local maximum in the output of the convolutions.

Thus, filter in Fig. 2.1.1(d) performs much better than that in Fig. 2.1.1(b) because of the threshold value of the latter chosen for the detection of the edges. [1][3]

2.2 **Classification of Edge Detectors**

The edge detectors are broadly classified as Gradient based edge detector and Laplacian based edge detectors. Gradient based detectors are also called as first-order edge detectors and Laplacian based edge detectors are also said to be second-order edge detectors. Fig 2.2.1 depicts the classification of edge detectors.
2.2.1 Gradient based Edge Detector
Most edge discovery techniques deal with the supposition that the edge happens where there is an irregularity in the force work or a precarious power slope in the picture. Utilizing this presumption, if one takes the subordinate of the force an incentive over the picture and discovers focuses where the subordinate is most extreme then the edge could be found. The slope is a vector, whose parts measure how quick pixel esteem is changing with separation in the x and y bearing. [4]

2.2.2 Laplacian based Edge Detector
The Laplacian is a 2-D proportion of the second subordinate of a picture. The Laplacian of a picture features areas of fast force change and is in this manner frequently utilized for edge discovery zero intersection edge finders. The Laplacian is regularly applied to a picture that has first been smoothed with something approximating a Gaussian smoothing channel to decrease its affectability to commotion. The administrator ordinarily takes a solitary dark level picture as info and produces another paired picture as yield. The zero intersection locator searches for places in the Laplacian of a picture where the estimation of the Laplacian goes through zero for example focuses where the Laplacian changes sign. Such focuses frequently happen at edges in pictures for example focuses where the power of the picture changes quickly, yet they likewise happen at places that are not as simple to connect with edges. It is ideal to think about the zero-intersection identifier as an element finder as opposed to as a particular edge locator. Zero intersections consistently lie on shut shapes, thus the yield from the zero intersection identifiers is typically a double picture with single pixel thickness lines indicating the places of the zero intersection focuses. [5]

2.3 Classical Operators
Some of the classical edge detectors also called the traditional edge detectors namely Canny, Sobel and Prewitt edge detectors are explained in detail below.

2.3.1 Canny Edge Detection
The traditional canny edge detection method is commonly used in grey scale image processing. But this classical edge detection algorithm was unable to deal with colour images and the parameters in the algorithms were difficult to determine. [2]

Edges are used to distinguish boundaries in an image and hence problem of basic importance in image processing. Edges which is present in an image are location with high intensity contrasts or a change
in intensity from one pixel to other. Edge detection of an image reduces amount of data to be processed, while retaining the important structural properties in an image. The Canny edge detector is one among the famous optimal edge detector. He was very much successful in achieving his ideas and goals and methods which can be found in his own paper named "A Computational Approach to Edge Detection". In this paper he followed list of methods in order to improve edge detection. The basic thing is error rate should be very low as possible. The basic thing is image should not be missed out and hence there should not be any response to non-edges. The second thing is that the Edge points should be localized in the best way. In other words, the distance between the edge pixels as found by the edge detector and the actual edge should be at minimum. A third criterion is that only one response should be given for one edge i.e., one edge provides one response. Based on these three criteria, the canny edge detector initially smooths the image to reduce the noise. Smoothing helps to reduce noise. It is used to find image gradients in order to showcase region with very high spatial derivative. The region found through algorithm suppresses any pixel that is not at maximum. [1]

2.3.2 Steps of Canny Edge Detection
Canny edge detection method which has received much attention during the recent years due to its many applications in different fields. Edge detection is one of those challenging problems and up to date, there is no technique that provides a robust solution to all situations and different applications that edge detection method may encounter. The steps followed by canny method are as follows. [1][2][3]

Step 1: Noise Reduction by Smoothing: Image is smoothed by reducing the intensity of the noise present in the image. A Gaussian Filter is used to reduce the noise in the image.

Step 2: Finding Gradients: Detection of the edges where the grey scale intensity is maximum. Most of the times the sobel operator is used to determine the gradient of each pixel in an image to detect the edges. Gradients in both x(Gx) and y(Gy) directions are determined and the magnitude of the gradient at each pixel is calculated.

Step 3: Non-Maximum Suppression: It is carried out to preserve the local maxima of the gradient of the image.

Step 4: Hysteresis Thresholding: The output of the non-maximum suppressions contains local maxima created by the noise. For avoiding the problem of streaking two thresholds are used.[1]

2.3.3 Sobel Edge Detector
Sobel operator is an edge detection technique that is used to calculate gradient approximation of the image for detecting an edge. For each pixel of an image this operator provides gradient vector or normal vector. It takes image as an input and calculate magnitude and direction. But compared to Robert computation speed is very less but kernel size is large so less sensible to noise as compared. Having bigger mask, errors which are produced due to noise effect is minimized by local averaging method. It uses set of 3*3 convolution kernels or masks. Maximum edges are identified with respect to the perpendicular angle. The sobel operator is shown below. [4][5] The Gradients Gx, Gy is used to determine gradient with x and y direction respectively.
2.3.4 Prewitt Edge Detector

The function of Prewitt edge detector is a type of edge detector which is similar to that of sobel Edge detector but will be having different kernels, performance of Prewitt is better compared to that of Sobel edge detector. The Gradients Gx, Gy is used to determine gradient with x and y direction respectively. [4][5]

2.4 Bi-dimensional Empirical Mode Decomposition

We, propelled imaging is persistently created in various applications, for example object affirmation, satellite imaging, biomedical, Internet, etc. The image quality spoils as a result of the tarnishing of a couple of sorts of fuzz. This clatter pollutes the image during getting, transmission and limit. Thus, the upheaval decline is a critical development in picture assessment and the essential most noteworthy development to take before the photos are readied. The Bi-dimensional Empirical Mode Decomposition (BEMD) has made better approaches to manage taking care of filtering and denoising pictures. Better nature of results is performed than existing breaking down procedures, for instance, Fourier Transform and Wavelets Transform strategies. [6]

The BEMD is particularly sensible for picture taking care of, for instance, surface examination, picture filtering and denoising. It is a nonlinear and self-flexible channel and it is a profitable system appeared differently in relation to the next philosophy reliant on wavelet root or Gabor Transforms. The BEMD separates an image into various leveled fragments called a Bi-dimensional Intrinsic Mode Functions (BIMFs) and a development, this rot relies upon the close by spatial assortments or sizes of the image.

This paper presents the BEMD approach arranged in DWT system for picture denoising and its assessment with the most used methodologies in the denoising space as the center channel, DWT change strategy and the ordinary procedure BEMD reliant on histogram one. It shows the effect of the number of IMFs isolated on the visual idea of a denoised picture in terms of Peak Signal to Noise Ratio (PSNR) and Mean Squared Error (MSE). The accompanying fragment presents the most gigantic of the Bi-dimensional Empirical Mode Decomposition (BEMD) and the nuances execution of the sifting process. [7]
3. SYSTEM DESIGN

An edge is easily visible and is easily perceivable and are the significant boundaries between the different regions of the image showing different intensities. The intensity may be due to the pixel value of the image or due to the light gradient. But we focus on the edges that are due to the different pixel intensities.

Initially, in the beginning of the process an image is given as the input to different classical edge detection algorithms. The classical edge detection techniques involve Canny, Sobel and Prewitt edge detection techniques. These techniques have their own merits and demerits.

The advantage of these classical edge detection algorithms is that these techniques are easy in implementation and are very easy to understand because these algorithms are very simple. The limitation of the techniques is that these techniques are not able to remove the noise from the image. Noise include white noise and the partial gaussian noise. Hence most of the edges that are detected by these techniques contain noise as very major component. Hence, to eliminate noise from the image the methodology in this work is based on utilizing the potential ability of Bi-dimensional Empirical Mode Decomposition (BEMD). Another method called Image Empirical Mode Decomposition (IEMD). Both BEMD and the IEMD methods decompose a given image into various Intrinsic Mode Functions (IMF’s) of different spatial frequency using the image input itself i.e. that these methods are Data Driven. They help in reducing the white noise as well as the partial gaussian noise.

![Flow Diagram of the Edge Detection Algorithm](image-url)
3.1 Flow of Traditional Edge Detectors

Traditional edge detectors like the Canny, Sobel and the Prewitt are the most important edge detection algorithms. It is observed from the literature survey that Canny Edge detector is one of the most optimal edge detection algorithms compared with all other traditional edge detection algorithms. The flow diagram of the canny edge detector is shown in fig 3.2.1. It is because the canny edge detection algorithm has a very error rate compared to the other traditional edge detection techniques.

![Flow Diagram of the Canny edge detection](image)

Fig 3.1.1 Flow Diagram of the canny edge detection

The other traditional edge detection techniques face the problem of detecting the false edges as against to detecting the true edges and even produces a thin or a thick line. These problems are mainly due to the interpolation of the noise with the pixels. To avoid interpolation of noise with the image, the image is primarily provided as the input to the Bidimensional Empirical Mode Decomposition (BEMD) algorithm which results in a set of Intrinsic Mode Functions (IMF’s) and here we consider only those IMF’s in which noise has been eliminated and gives fine edges including all the micro edges.

If the output of the BEMD algorithm is provided as the input to the traditional edge detectors namely Canny, Sobel and Prewitt methods, then these methods are expected to provide better performance than earlier as the noise present in the image has already been eliminated by BEMD algorithm. Hence, the edges will be detected more accurately and thus image segmentation will be more accurate and provides a way to improve the performance of the edge detection techniques adaptively.

Another limitation of the classical edge detector is that there may be the possibility of malfunctioning at the corners curves, and where the grey level intensity function varies. The algorithms may not find the correct orientation of an edge in a direction due to the usage of the
Laplacian filter. Some filters like the Gaussian filter may use the complex computations and may detect the false or the zero crossings which may lead to detection of the false edges.

Sometimes there may be problem of the edges missing due to the selection of the wrong and irrelevant threshold values in the traditional edge detection algorithm. The threshold value is the value of the gradient above which a pixel is detected as the edge. There is another parameter called the Sigma value. The Sigma value indicates the amount of blurring that is needed to be done for the noise. Both the threshold and the sigma values help in determining the correct edge. But due to the wrong selection of these values there may be an edge missing resulting in false edge detection.

BEMD helps in detecting the true edges and there are no missing edges as the noise will already been eliminated in the process of decomposing the image into various IMFs’ and hence this new way of edge detection technique will be helpful accurately identifying the edges without any error. This can be used in practical applications where it is very important to get the correct and accurate edges without any false edges.

The Primary objective of the work is to detect and discover the most common features of an image using the edges. During the discovering and exploring the information from an image, edge detection is most important and early-stage activity and the most prominent active area in the image processing. BEMD and IEMD are those techniques that play a very crucial role in this process of detecting the accurate edges of an image in the process. The adaptive and the data driven method, improves the performance Of the image processing by eliminating the noise and providing accurate edges for image segmentation. Edge identification is troublesome in up roaring pictures, as both the edge and, the commotion contain high recurrence content. Hence it is very difficult to eliminate the noise without disturbing the pixel value of the edges. BEMD succeeds in differentiating the noise and the edges and provides a adaptive way called the data driven way to detect and analyze the edges of the image. If the output of this BEMD is provided as the input to the traditional algorithms it gives high performance and better-quality edges.

4. SYSTEM IMPLEMENTATION

4.1 Data Collection

The novel approach of edge detection takes input from different domain. The input image is taken from the various domains of interest and they include the images from the satellite, the images captured by the drones for agricultural importance and the military purpose, the images that are taken to do research on the wildlife using the drones in the forest and the wildlife sanctuary. All these sources of the images are for the societal and environmental importance. It is because they have a wide range of application in the society and helpful in the development and the sustainable usage of the natural resources present on the globe.

4.2 Data Processing

The image that we provide to the edge detection algorithm is considered as the data. Image that is needed to be processed and analyzed for various applications has a very large size. It is because the image is a high dimensional matrix of pixels. Each pixel of the image contains a large information about the image.
In Digital image processing a pixel is smallest element or the smallest unit of the image. Any point in the image corresponds to a pixel, the value of a pixel at that point is the intensity of the light at that point. Each pixel stores a value proportional to the light intensity at that location. As each pixel stores the information at a single point location, it has a very huge amount of information stored in it. So, the matrix of the pixel values (image) has a very large amount of information regarding the scene. Hence it becomes potentially difficult to process the entire image for any application. It is also a time-consuming process.

To avoid processing of the entire pixels of the image, edge detection plays a very crucial role. Edge detection is the early stage in most of the vision processing activities. The early stage involves identifying the features of an image. The edge detection process is the vital process in the image processing. It helps in identifying the significant and the most important features of the image. Hence, it reduces the amount of the data needed to be processed, as the entire image is not being processed only the significant features of the image will be processed. It reduces the time required to process the entire image.

Images that are received by the satellite, the images received by the drones for the military purpose will be of very huge size. Even the images for the agricultural importance will be very large in size. Hence edge detection of these images leads to the identification of the significant and important features and helps in reducing the amount of data that is to be processed for the purpose of analyzing. Large data will be compressed into a small useful data named as the edge of the image.

4.3 Data analysis

The intrinsic mode components obtained from each method are carefully analyzed and the IMF which is physically meaningful is subjected to edge detection process using traditional edge detectors such as Canny, Sobel, Prewitt. In this method of combining BEMD with the traditional edge detectors expected to provide superior edge detection performance and some of the weaknesses of traditional edge detectors expected to be masked or eliminated.

4.4 Steps to Decompose Image into IMFs

Steps to decompose an image into IMF are as follows,

Step1: To first IMF is gotten with the picture itself as info signal

\[ h_{10}(m, n) = x(m, m) \]  

(4.3.1)

The main record shows the IMF number, \( l = 1, \ldots, L \), and the subsequent list demonstrates the emphasis number, \( k = 1, \ldots, K \), in the filtering procedure; \( m \) and \( n \) speak to the two spatial measurements thus the name Bi-dimensional Empirical Mode Decomposition or 2D - Empirical Mode Decomposition as shown in equation (4.3.1). To locate the following IMF, utilize the buildup relating to the recently discovered IMF as information signal given by equation (4.3.2) below.

\[ h_{20}(m, n) = r_1(m, m) \]  

(4.3.2)

Step 2: The positions along with the amplitudes of all local maxima and the local minima of the input signal is to be found.
Step 3: Make the upper envelope by spline addition of the nearby maxima and the lower envelope by spline introduction of the neighborhood minima. Denote the envelopes as $e^+(m, n)$ and $e^-(m, n)$, respectively.

Step 4: For each position $(m, n)$, figure the mean of the upper envelope and the lower envelope shown below in equation (4.3.3).

$$e_{lk}(m, n) = (e^+(m, n) + e^-(m, n))/2$$

The sign $e_{lk}(m, n)$ is added to as the envelope mean.

Step 5: Take away the envelope mean sign from the past sign given by equation (4.3.4):

$$h_{lk}(m, n) = h_l(k-1)(m, n) + e_{lk}(m, n)$$

This is one emphasis of the filtering procedure. The subsequent stage is to check if the sign $h_{lk}(m, n)$ from stage 4 is an IMF or not. The procedure stops when the envelope mean sign is sufficiently close to zero given below by equation (4.3.5).

$$|e_{lk}(m, n)| < \varepsilon \forall (m, n)$$

The estimation of $\varepsilon$ in the stop basis influences the EMD so that if it isn't sufficiently little, at that point there won't be an adequate number of IMFs to isolate every inborn mode in the signal. Then again, if the number $\varepsilon$ were excessively little, the cycles will take long time.

Step 6: Check if the mean sign is sufficiently close to zero, in light of the stop measure. If not, rehash the procedure from stage 1 with the subsequent sign from stage 4 as the info signal an adequate number of times. At the point when the stop rule is met, the IMF $c_l(m, n)$ is characterized as the last aftereffect of (4) by equation (4.3.6).

$$c_l(m, n) = h_{lk}(m, n)$$

After the IMF is found, characterize the buildup as below equation (4.3.7).

$$R_l(m, n) = h_0(m, n) - c_l(m, n)$$

Step 7: The following IMF is found by beginning once again from stage 1, presently with the buildup as the info signal as below equation (4.3.8).

$$h(l+1)0(m, n) = r_l(m, n)$$

Steps (1) to (7) can be rehashed for all the resulting $r_j$. The EMD is finished when the buildup, preferably, doesn't contain any extrema focuses. The sign can be communicated as the total of IMFs and the last buildup.

5. EXPERIMENTAL RESULTS

In this paper, we have experimented various edge detection techniques such as Sobel, Prewitt, and canny. All of these are traditional edge detection techniques. But providing original image shown in fig 5.1(a) as input directly to the traditional edge detection techniques, output will not have more detailed edges and original edges.
So, we came up with a new adaptive traditional edge detector which consists of various processes as follows. As shown in fig 5.1(a) we use the original image as the input to the BEMD (Bi-dimensional empirical mode decomposition) which is of the size 480x480x3, where the original image is a RGB coloured image which consist of 3 layers i.e. Red layer component of 480x480 pixel, Blue layer component of 480x480 pixel and a Green layer component 480x480 pixel. But we cannot have this 3-layer image to be given as a input to BEMD algorithm, so we convert that original image into a grayscale image which is of the size 480x480 pixel size as shown in Fig5.1(b).

We add up some Gaussian noise to the grayscale image of value between 0.1 and 0.2 to beat already present noise in the image and finally fed that noisy grayscale image into BEMD function for producing the IMF’S (Intrinsic Mode Function) as shown below.
The fig 5.1(c), 5.1(d), 5.1(e), 5.1(f) and 5.1(g) shown above are the output of the BEMD function from RUN1. Fig 5.1(c) shown above is of the size 480x480 pixel is the IMF1 of RUN1 which as some noise and much of the edges are not visible. So, fig 5.1(d), 5.1(e), 5.1(f) and 5.1(g) are of the size 480x480 pixels and the edge are visible as IMF number increases in this case IMF5 as visible edges as compared to other 4 IMF’s. Also, some of the micro edges are not visible in IMF 1, 2, 3, but in IMF 4 and 5 micro edges are visible and it can be improved by sharpen those IMF’s.
In obtained IMF’s as shown above some of them are having low and high frequency. Mean IMF1 contains having high frequency components and we know that even noise is of high frequency. So Mean IMF1 will be having high frequency noise interpolated along with it and thus, will not be having better quality edges or the true edges, since it mostly consists of high scale noise. Then we have obtained subsequent IMF’s whose frequency values goes on decreasing as the IMF number increases. In this case Mean IMF5 is the highest IMF obtained and will be having lower frequency components where noise will be eliminated completely, hence it contains high quality edges and accurate edges as compared to another Mean IMF’s. In the subsequent Fig 5.7 shown below gives comparison of canny edge detector with different threshold values for different IMF’s. Different threshold value having high threshold value 0.20 and low threshold value of 0.17. also, high threshold value of 0.30 and low threshold value of 0.20, but in the threshold value between 0.22 and 0.27 which as obtained a best output image with that threshold value and is considered as the final Canny output image. But Canny has a best edge detection property as compared to other traditional edge detector like Sobel and Prewitt. So canny edge detector with BEMD consider to be best way for Data Driven Adaptive Edge Detectors for Image Processing.

| LT=0.17   | LT=0.22   | LT=0.20   |
|-----------|-----------|-----------|
| HT=0.20   | HT=0.27   | HT=0.30   |

![Edge Detection Images](image1.png)
Mean IMF 5 given as input to Prewitt operator.

Grayscale given as input to Prewitt operator.

In above shown Fig 5.8 is the output image of Prewitt edge detector with a threshold value of 0.02 and Prewitt edge detector doesn’t have much micro edges visible in the output image as shown above. But as compared to Sobel in some better in terms of edge detection of macro and micro edges. Fig 5.9 shown above is the output of Sobel edge detector with the threshold value of 20. Sobel doesn’t have that much edge detection as compared to canny and Prewitt.

From the experimental results we can conclude that canny has a best edge detection property as compared to other traditional edge detector like Sobel and Prewitt. So canny edge detector with BEMD consider to be best way for Data Driven Adaptive Edge Detectors for Image Processing. Canny gives the best edge detection when given the threshold between 0.22 and 0.27 for ensembled IMF 5 where all the noise will be eliminated by the process of noise beating.

6. CONCLUSION AND FUTURE ENHANCEMENTS

The edge detector performance criterion and methods of evaluation provide us a good understanding of possible ways of finding out the effectiveness of each edge detection technique. From the result obtained, Canny, Sobel and Prewitt prove to have more sensitive and time-consuming. But in cases
where simplicity and speed are not dominant factors, Canny, Sobel, and Prewitt could be very suitable and robust. Sobel operator will spot out noise found in real-world image as edges though and the detected edges could be thick. The Canny edge detector does the same algorithm to solve these problems by first blur those real world image slightly and then applying an algorithm that effectively thins the edges. In Prewitt presence of noise false edges get detected. The first-order derivative is more affected by noise as compared to other operators. The Laplacian technique of detecting the edge by using zero-crossing techniques. The LoG can reduce noise due to the presence of the Gaussian filter. As compare to all operator Canny Edge detector is the better in noise suppression and micro edge detection.

The results shows that traditional edge detection performance can be improved when combined with BEMD on grayscale images. However, efficient is needed in terms of speed and recognition of the edges in images rate to determine the choice of the best algorithm needed for Development of Data Driven Edge Detectors for Image Processing. Future work will focus on finding and further improving the edge detector to achieve higher and accurate detection in real-time. With speed in mind, fast processors will also be investigated. The different modern edge detectors like empirical mode decomposition and many other techniques will be studied and the results of these techniques will be analyzed to get the best adaptive edge detection techniques for various images like a flame and the nest of gazelle.

We have used the BEMD function to extract the IMF from the image to give as an input to the traditional edge detection technique. In future work, we may complete the ensemble empirical mode decomposition technique, where it has much accurate output and less noise image output.

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