Interpolation algorithm with Edge Enhancement for Image and Video Processing – A Comparative Study

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ABSTRACT: Image enhancement is an important processing task in image processing field. By applying image enhancement blur or any type of noise in an image can be minimized, so that the resultant image quality is better. Image enhancement can be obtained by different interpolation and edge detection techniques.The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. These edges are detected using various edge detection techniques like sobel, canny, prewitt and Roberts edge detection methods. Interpolation is applied on edge detected Image interpolation is process of finding unknown pixel values from known pixel values. Here we are using bilinear, bicubic and cubic-spline interpolation techniques for image and video processing. Here we are comparing these edge detection and interpolation techniques to determine which technique is suitable for different applications. This is done by comparing parameters like MSE, PSNR and 2-D correlation.

KEYWORDS: Image enhancement, sobel, canny, prewitt, Roberts, Interpolation, Bilinear, Bicubic, Cubic Spline, MSE, PSNR, 2D CORRELATION

I.INTRODUCTION

Digital image processing is an ever expanding and dynamic area with applications reaching out into our everyday life such as medicine, space exploration, surveillance, authentication, automated industry inspection and many more areas. Edge detection is a basic operation in image processing, it refers to the process identifying and locating sharp discontinuities in an image, the discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination. It is a very important first step in many algorithms used for segmentation, tracking and object recognition. Edge detection is a process of locating an edge of an image. Edges consist of meaningful features and contained significant information. It's reduce significantly the amount of the image size and filters out information that may be regarded as less relevant, preserving the important structural properties of an image (Yuval, 1996). Applying an edge detector to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, The image quality reflects significant information in the output edge and the size of the image is reduced. The problems of storage, transmission over the Internet and bandwidth could be solved when edges are detected (Vincent, 2007). Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when images are divided into areas corresponding to different objects.

Image Interpolation is a method of estimating the values at unknown points using the known data points. Interpolation is the primary technique used for image scaling. Image scaling is the process of taking a source image and extending it to create a large image.Image scalar technique is process of resizing a digital Image that involves a trade-off between efficiency, smoothness and sharpness. An obvious application of image scaling is to scale up images to fit high-definition television (HDTV) and scale down the high-quality pictures or video frames to fit the minimize liquid crystal display panel of the tablet PC.

Image enhancement is an important processing task in image processing field. By applying image enhancement, blur or any type of noise in the image can be removed so that the resultant image quality is better. Image enhancement is used in various fields like medical diagnosis, remote sensing, agriculture, geology, oceanography.The polynomial- based methods are nearest neighbour interpolation, bicubic interpolation, and bilinear interpolation. One of the simplest methods is nearest neighbour interpolation, where each interpolated output pixel is assigned to the value of nearest sample point in the input image. . So it is unable to use in high quality imaging applications. The advantage this method are easy to implement and computationally fast, but it does not give good quality of images. . Bilinear interpolation method which uses linear interpolation can be performed in both horizontal and vertical directions. This method is most widely-used because it reduces the blocking and aliasing effects. The interpolated surface is smoother than corresponding surfaces obtained by above mentioned methods bilinear interpolation and basic interpolation method. Hence this is the best among linear methods. The interpolated value in this is the weighted average of 16 closest pixels. The cubic spline interpolation is a piecewise continuous curve, passing through each values.
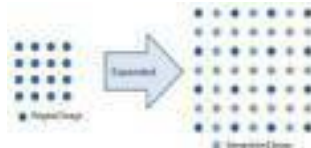

Fig 1: Interpolation

size to a larger size by finding the average (Mean) of its neighbor pixels. Image processing finds various Analysis of an image is important to know about features of the respective image which is needed for further processing. The analysis requirements are enhancement and edge detection. Therefore different interpolation and different edge detection techniques are came into existence. It is very important to choose appropriate approach for the enhancement of an image needed for specific application. The better approach towards specific applications can be obtained by comparing these methods with respect to various parameters. We use different parameters like MSE, PSNR and 2-D correlation for determining better method for specific application.

The objectives of this paper are listed:

1. To review literature on Image Interpolation and Edge detection techniques.

2. To arrive at design specification of different Interpolation techniques for image and video.

3. Comparison of these techniques with respect to various parameters.

The proposed work is implemented using MATLAB. MATLAB has many built-in functions which provides many tools. Linear computations, data analysis, signal processing, quadrature, numerical solutions and many other types of scientific computations all are supported by the MATLAB tools. The most used algorithm is state-of-art algorithm.

II. DESIGN AND IMPLEMENTATION

In our paper, we are dealing with Image enhancement which is an important processing task in image processing field. By applying image enhancement, blur or any type of noise in the image can be removed so that the resultant image quality is better. The image scaling algorithms can be split into two types: adaptive and non-adaptive methods. The non-adaptive methods are cubic spline interpolation, bicubic interpolation, and bilinear interpolation.
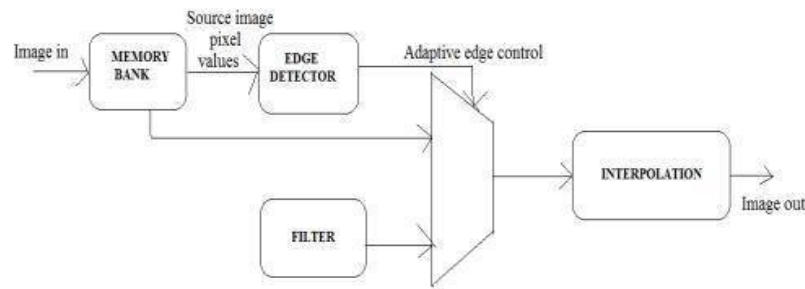
Fig 2: Block diagram

The aim of coordination packet that is generated by a node with message is to inform its path about the frequency channel decided for the message copying.

Fig 2 shows the block diagram of an adaptive edge enhanced scalar architecture. It consists of a sobel filter, edge detector, and bilinear interpolation. Initially, a color image is converted into gray level image using MATLAB. Now gray level image converted into binary image. This binary image is resized and written into a text file. Store the binary image (Text file) into the RAM. Read the Text File from memory Bank. Memory bank provides the input to the sobel filter and edge detector.

EDGE ENHANCEMENT

Edge detection is a basic operation in image processing, it refers to the process identifying and locating sharp discontinuities in an image, the discontinuities are abrupt changes in pixel intensity which characterize boundaries of objects in a scene. It significantly reduces the amount of the image size and filters out information that may be regarded as less relevant, preserving the important structural properties of an image. The purpose of detecting sharp changes in the image brightness is to capture important events. Applying an edge detector to an image may significantly reduce the amount of data to be processed and may therefore filter out information that may be regarded as less relevant, The problems of storage, transmission over the Internet and bandwidth could be solved when edges are detected. Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when images are divided into areas corresponding to different objects. Common edge detection algorithms include SOBEL, CANNY, PREWIT, ROBERTS.

SOBEL EDGE DETECTOR

Sobel operator is also used to detect two kinds of edges in an image:

  ☐   Vertical direction

  ☐   Horizontal direction

The SOBEL operator performs a 2-D spacial gradient measurement on an image and so emphasizes regions of high spatial frequency that corresponds to edges. Edge areas define strong intensity contrasts which darker or brighter. Gradient magnitude is given by

$$|H| = \sqrt{H_x^2 + H_y^2}$$

(1)

The angle of orientation of the edge giving rise to spatial gradient is given by,

$$Angle = tan (Hy/Hx) \qquad (2)$$

The kernel for Sobel is given by:

-1	0	+1
-2	0	+2
-1	0	+1

H_x

+1	+2	+1
0	0	0
-1	-2	-1

H_y

Vertical mask
This mask works exactly same as the Prewitt operator vertical mask. There is only one difference that is it has "2" and "-2" values in center of first and third column. When applied on an image this mask will highlight the vertical edges.

How it works
When we apply this mask on the image it prominent vertical edges. It simply works like as first order derivate and calculates the difference of pixel intensities in a edge region. As the center column is of zero so it does not include the original values of an image but rather it calculates the difference of right and left pixel values around that edge. Also the center values of both the first and third column is 2 and -2 respectively.

Horizontal
Above mask will find edges in horizontal direction and it is because that zeros column is in horizontal direction. The only difference between it is that it have 2 and -2 as a centre element of first and third row.

How it works
This mask will prominent the horizontal edges in an image. It also works on the principle of above mask and calculates difference among the pixel intensities of a particular edge. As the center row of mask is consist of zeros so it does not include the original values of edge in the image but rather it calculate the difference of above and below pixel intensities of the particular edge. Thus increasing the sudden change of intensities and making the edge more visible.

CANNY EDGE DETECTOR

The Canny edge detection algorithm is known to many as the optimal edge detector.

The canny edge detector first smoothens the image to eliminate and noise. It then finds the image gradient to highlight regions with high spatial derivatives after the edge directions are known, non-maximum suppression now has to be applied.

Non-maximum suppression is used to trace along the edge in the edge direction and suppress any pixel value that is not considered to be an edge. This will give a thin line in the output image. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (non-maximum suppression). The gradient array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. The kernel for canny is given by:

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

The magnitude or edge strength of the gradient is then appropriated using the formula:

$$|G| = |Gx| + |Gy|$$

PREWITT EDGE DETECTOR

The edge detection algorithms are basically divided into two steps. The first step of edge detection requires the evaluation of derivatives of the image intensity. This operation is as shown in Fig. The

algorithms of first derivative or first difference based operator are the simplest one that is why it is selected for implementation on hardware device. It is defined in magnitude form as the sum of the magnitudes of vertical and horizontal gradient.
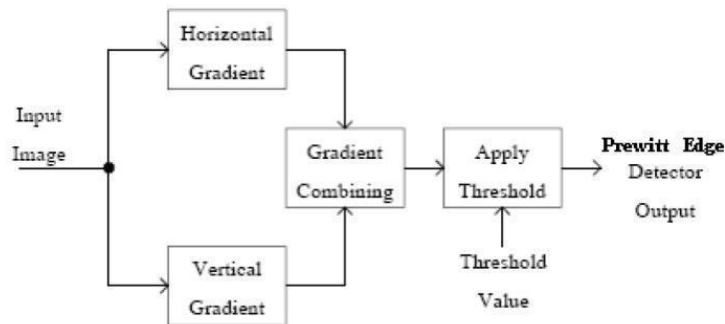
Fig 3: Operation of prewitt-edge detection algorithm

The kernel for Prewitt is given by:

-1	0	+1
-1	0	+1
-1	0	+1

Gx

+1	+1	+1
0	0	0
-1	-1	-1

Gy

The gradient magnitude is given by:

$$G = \sqrt{G_x{}^2 + G_y{}^2}$$

ROBERTS EDGE DETECTOR

BRIEF DESCRIPTION

The Roberts operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial gradient which often correspond to edges.

HOW IT WORKS

In theory, the operator consists of a pair of 2×2 convolution masksas shown in figure. One mask is simply the other rotated by 90°. This is very similar to the Sobel operator. The kernel for Roberts is given by:

+1	O
O	-1

O	+1
-1	O

Gx   Gy

These masks are designed to respond maximally to edges running at 45° to the pixel grid, one mask for each of the two perpendicular orientations. The gradient magnitude is given by:

$$\mathbf{G} = \sqrt{\mathbf{G}_x{}^2 + \mathbf{G}_y{}^2}$$

The angle of orientation is given by:

$$\theta = \arctan(Gy/Gx) - 3\pi/4$$

INTERPOLATION

DEFINITION OF INTERPOLATION: Interpolation is a process of constructing the new data points with known data points. It is important to construct the points within the range of data points.

The interpolation algorithms are classified into different types:

Non-adaptive interpolation algorithms.
Adaptive interpolation algorithms.

ADAPTIVE INTERPOLATION

Adaptive interpolation method operates based on the structure of the image with different intensity of pixel values.

NON-ADAPTIVE INTERPOLATION

In the non-adaptive interpolation algorithms, irrespective of the contents of the image the computations are done. This kind of algorithm is usually employed in applications like adobe Photoshop cs5.

BILINEAR INTERPOLATION

In this method, the average of the four closest pixels is calculated to find the interpolated point. Here the linear interpolation is done in both horizontal and in vertical direction hence the name bilinear interpolation. The interpolation kernel for this is:

U(x) = {0 {1-|x|

|x|>1

|x|<1

Where, x is the difference between the interpolated point and the actual point.
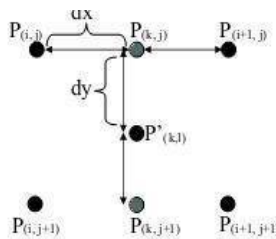

Fig4: Bilinear interpolation

Bilinear interpolation is an operation that determines the intensity from the weighted average of the four closest pixels to the specified input coordinates, and then assigns that value to the output co-ordinates. The key point of this idea is to perform linear interpolation first in one direction, and then again in the other direction. Fig depicts a block which includes four input pixels P(i, j), P(i+1, j), P(i, j+1), and P(i+1, j+1), where i=[0…M] and j =[0…N]. The M and N are the width and height of the original image. The temporary pixel P(k, j) is calculated by linear interpolation in x direction with P(i, j) and P(i+1, j), where i≦k≦i+1. Also, the temporary pixel P(k, j+1) can be calculated with P(i, j+1) and P(i+1, j+1).The temporary pixel P(k, j) and P(k, j+1) can be obtained by,

$$P_{(k,j)} = (1-dx) \times P_{(i,j)} + dx \times P_{(i+1,j)} \qquad (1)$$

$$P_{(k,j+1)} = (1-dx) \times P_{(i,j+1)} + dx \times P_{(i+1,j+1)} \qquad (2)$$

Where, dx is the scale parameter in horizontal direction. After interpolating in horizontal direction, the output pixel P'(k, l) can be calculated by linear interpolation in y direction with P(k, j) and P(k, j+1) as ,

$$P'_{(k,l)} = (1-dy) \times P_{(k,j)} + dy \times P_{(k,j+1)} \qquad (3)$$

Where, dy is the scale parameter in vertical direction. Based on the horizontal linear interpolations as shown in Eqs.(1) and (2), and the vertical linear interpolation as shown in Eq.(3), output pixel P'(k, l) of the bilinear interpolation can be obtained by only one-stage as,

$$P'_{(k,l)} = (1-dx) \times (1-dy) \times P_{(i,j)} + (1-dx) \times dy \times P_{(i,j+1)} +$$

$$dx \times (1-dy) \times P_{(i+1,j)} + dx \times dy \times P_{(i+1,j+1)} \qquad (4)$$

BICUBIC INTERPOLATION

This method includes the average of sixteen closest pixel's values to get the interpolated point. The sharpness of the image is very high compared to the

bilinear interpolation method. The clarity of the image is also high in this bicubic interpolation method. This is formulated as:

$$\{3/2|x|3-5/2|x|2+1 \qquad 0<=|x|<1$$

$$U(x) = \{-1/2|x|3+5/2|x|2-4|x|+2 \qquad 1<=|x|<2$$

$$\{0 \qquad 2<|x|$$

Where, x is the difference between the interpolated point and the actual point.

In image processing, bicubic interpolation is often chosen over bilinear interpolation or nearest neighbor in image resampling, when speed is not an issue. In contrast to bilinear interpolation, which only takes 4 pixels (2×2) into account, bicubic interpolation considers 16 pixels (4×4). Images resampled with bicubic interpolation are smoother and have fewer interpolation artifacts.

CUBIC SPLINE

Spline Interpolation

In the mathematical field of numerical analysis, spline interpolation is a form of interpolation where the interpolant is a special type of piecewise polynomial called as spline.
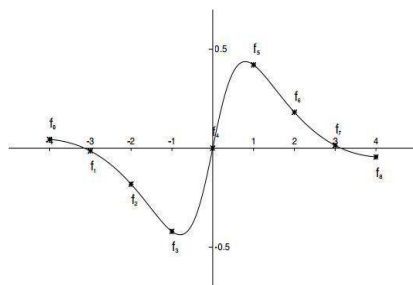
Given a tabulated function fk = f(Xk), k=0,.......,N,

A spline is a polynomial between each pair of tabulated points,but one whose coefficients are determined slightly,non-locally.The non-locality is designed to guarantee global smoothness in the interpolated function upto some order of derivative. They produce an interpolated function that is continues through to the second derivative. Splines tend to be stabler than fitting a polynomial through the N+1 points, with less possibility of wild oscillations between the tabulated points.

Cubic Spline

A cubic spline is a spline constructed of piecewise third-order polynomials which pass through a set of m control points.The second derivative of each polynomial is commonly set to zero at the end points,since this provides a

boundarycondition that completes the system of m-2 equations. This produces a natural cubic spline and leads to simple tridiagonal system which can be solved easily to give the coefficients of the polynomials.

FLOW CHART
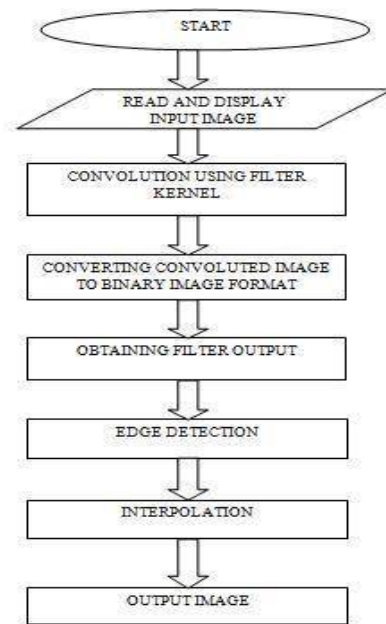
III. RESULTS AND CONCLUSION

Results of the paper are discussed here. It shows the comparison of different interpolation techniques with different edge detection techniques. From the results, we get to know which is better approach for an application. In this paper different images are considered for analysis.
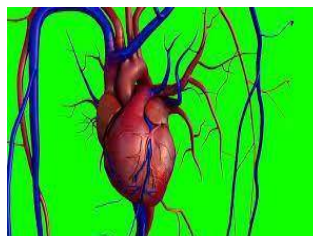

Fig 5 : Input Image

This image is analysed by considering different parameters like MSE, PSNR, and 2-D CORRELATION.
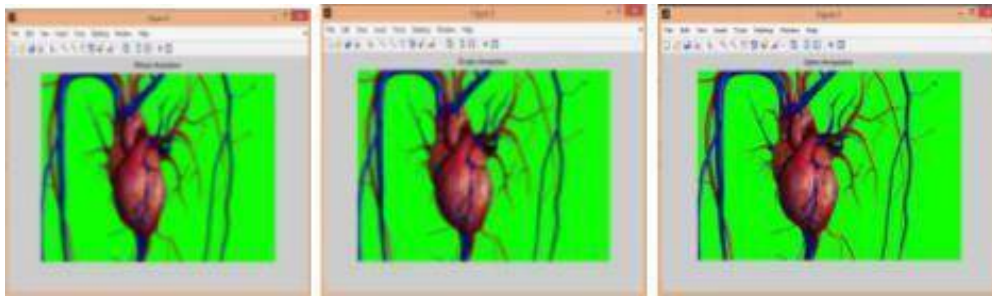
SOBEL EDGE DETECTION

CANNY EDGE DETECTION

PREWITTS EDGE DETECTION

ROBERTS EDGE DETECTION

	BILINEAR			BICUBIC			CUBIC SPLINE		
	MSE(dB)	PSNR(dB)	2D CORR(dB)	MSE(dB)	PSNR(dB)	2D CORR(dB)	MSE(dB)	PSNR(dB)	2D CORR(dB)
SOBEL	6.271635	32.183189	0.997888	4.498789	35.068892	0.998976	3.782737	36.57468	0.999234
CANNY	6.279849	32.171820	0.997887	4.506551	35.053918	0.998975	3.787479	36.563798	0.999234
PREWITT	6.271826	32.182924	0.997888	4.499589	35.067347	0.998976	3.782222	36.575864	0.999234
ROBERTS	6.269514	32.186127	0.997890	4.496276	35.073744	0.998977	3.786397	36.566281	0.999233

Table 1 : Comparative result
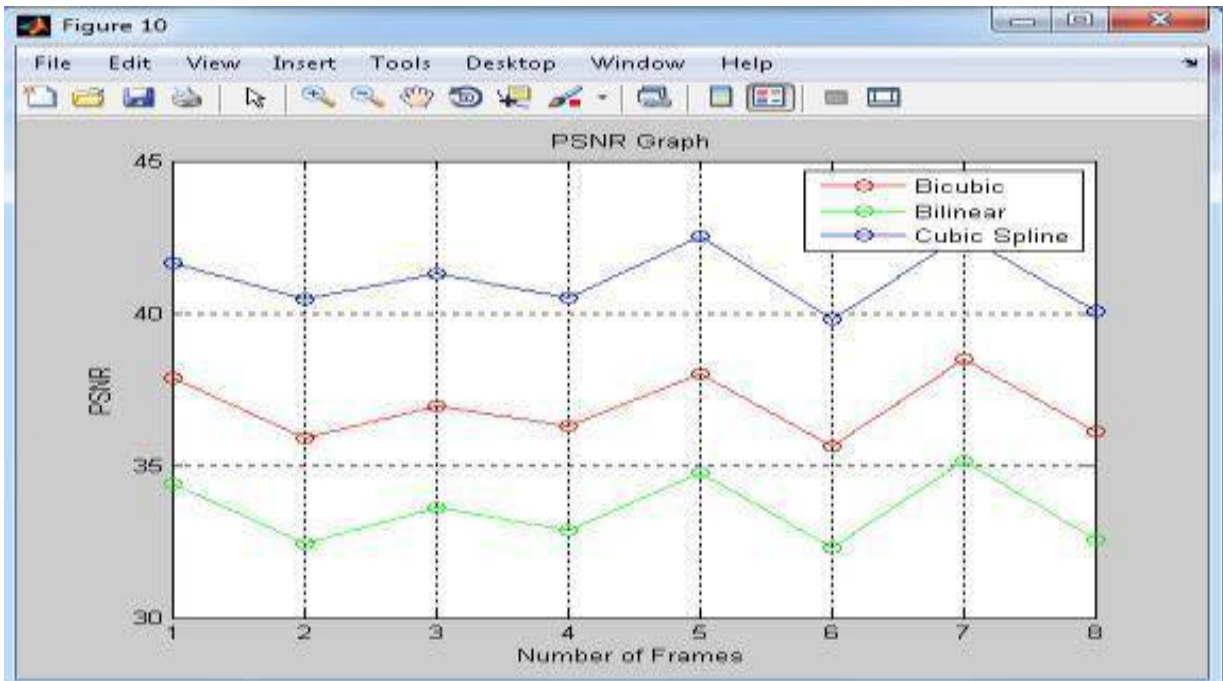
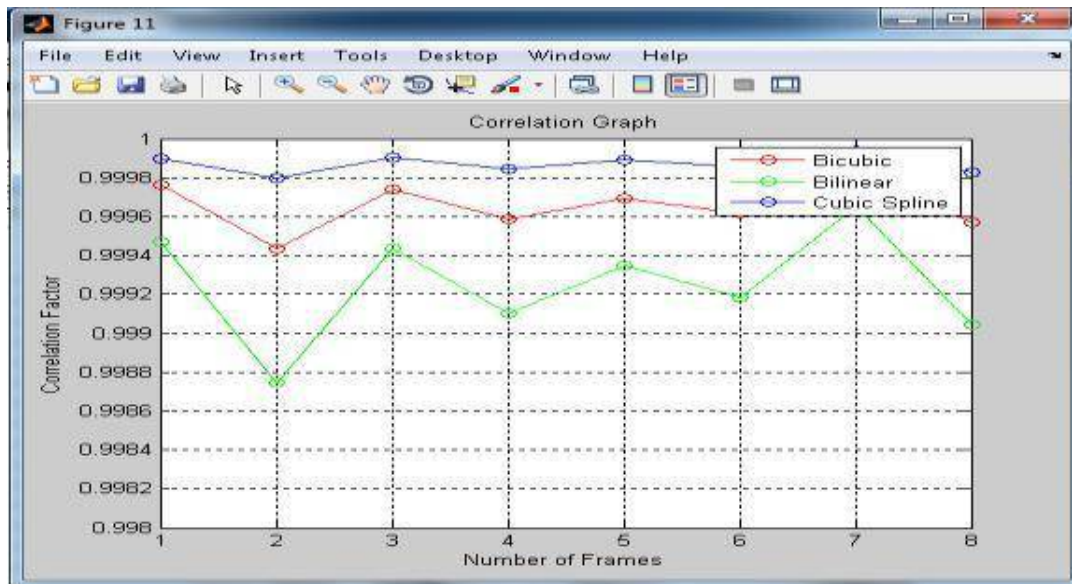Fig 6 : RESULTS OF VIDEO PROCESSING PSNR Graph

Fig 7: 2D- CORRELATION Graph

Here, different edge enhancement and interpolation techniques are used in order to increase the quality of an image. It is important to determine better approach for different applications. In this paper we have used different parameters like MSE, PSNR, 2-D CORRELATION to differentiate and to determine the better technique for image and video processing. Graphical representation for video and tabular representation for image makes the analysis easy. From the tabular representation we have found that cubic spline is more efficient compared to other two interpolation techniques

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