

A Survey on Super Resolution Image Enhancement using Structural Similarity Index Technique

Shameera Shirine M¹, Charulatha A R²

PG Scholar, Department of Computer Science, Stella Maris College, Chennai, India ¹

Assistant Professor, Department of Computer Science, Stella Maris College, Chennai, India ²

ABSTRACT: Digital Image Processing is a quickly developing field with growing application. Digital Image Process has a large scope of application. One such application is Super Resolution in Image Processing. Super Resolution is a set of technique which enhances the image resolution. This paper provides a survey on the current techniques used to enhance blurred and noisy images using super resolution technique.

KEYWORDS: Super Resolution, Image enhancement, PSNR, HVS, Structural similarity (SSIM) index.

I. INTRODUCTION

Digital image process is an action performed for the improvement of image data. Its areas of application are in remote sensing, forensic sciences, medical imaging, industrial automation and business application. Some of the methods used in digital image processing are image compression and image enhancement. Image compression is the method of encrypting or transforming an image file in such a way that it occupies less space than the original file. Some of the common image compressions techniques are Fractal, Wavelets, Chroma sub sampling, transform coding, Run-length encoding and Lossy and Lossless compression techniques. Image enhancement is the technique of further modifying or altering an image file. It sharpens the blurred images and removes noise particles present in the images which resulting in improving the quality of the image. Some commonly used image enhancement techniques are de-noising, segmentation, filtering, artificial light source, de-hazing, image sharpening, and edge enhancement.

Techniques which are used in digital image processing for the image enhancement are as follows:

- i. De-noising:** This method is used to remove blemishes and pollution particles produced by the sensor and circuitry of a scanner or digital camera. This technique is used to remove the image noise which originates in film grain and in the compulsory shot noise of an ideal photon detector. Simple noise removal can be performed by filtering.
- ii. Defogging:** This technique is used in removing fog, blemishes, and rain or pollution particles from image and improves the quality of the image. Image fogging uses many algorithms such as Gaussian, Flickering, Fast, SVM and Context modelling.
- iii. Segmentation:** Image segmentation is the process of dividing a digital image into multiple segments and it clubs a set of pixel with same features like colour, intensity and texture. The main objective of segmentation is to simplify or change the image representation into something that is more significant and easier to analyse. Some of image segmentation methods are Threshold, Clustering based, Edge based and region based.

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iv. **De-Hazing:** Under bad weather, outdoor images have poor visibility due to absorption and scattering by atmospheric particles in haze. The poor visibility affects not only photography but also computer vision applications for outdoor environments for object detection. De-hazing which is removing haze is an important process as it produces visually appealing and highly improved performance of computer vision tasks. Some of the techniques used in De-hazing:

- Degradation model
- Dark channel prior
- DCP-based image de-hazing

v. **Filtering:** The application areas includes smoothing, sharpening, removing noise, and edge detection. Filtering helps in smoothening and removal of the blemishes in an image. The process used to apply filters to an image is known as twist, and may be applied in either the spatial or frequency domain. Methods used in filtering are:

- Low Pass Filtering
- High Pass Filtering
- Directional Filtering
- Laplacian Filtering

vi. **Edge Enhancement:** A filter used to enhance the edge contrast of an image or video to enhance its acutance. It is done by spotting the sharp edge boundaries such as edge between the content and background of a contrasting colour and increasing the contrast at areas immediately around the edge. This effect of creating more defined edges when seen from a typical distance is called overshoot and undershoot[13].

There are numerous properties which decides the edge enhancement applied to an image. The most common is un-sharp masking with parameters like amount, radius or aperture and threshold.

Amount. Controls the level to which contrast in edge detected area is enriched.

Radius or aperture. Impacts the size of edge to be detected or enriched and the size of area around the edge which will be reformed by enrichment. A radius which is small results in enhancement applied to sharper, finer edges confined to a smaller area.

Threshold. Adjusts the sensitivity of edge detection technique a lesser threshold value results in high subtle boundaries of colour being recognised as edges. A very less threshold value might result in small parts of film grain, surface texture or noise which can be misidentified as being an edge [13].

vii. **Super Resolution:** Super resolution is the technique of generating a high resolution image from low resolution images. High resolution image offers a high pixel solidity and thereby more details about the original scene. The need for high resolution is common in computer vision applications for better performance in pattern recognition and analysis of images. High resolution is of importance in medical imaging for diagnosis. Many applications require zooming of a specific area of interest in the image wherein high resolution becomes essential.

Super-resolution is based on the knowledge that grouping of low resolution (noisy) sequence of images can be used to generate a high resolution image or image sequence. Thus it attempts to renovate the original scene image with high resolution given a set of perceived images at lower resolution. The general approach considers the low resolution images as resulting from resampling of a high resolution image. Recent advances in image and video sensing have intensified user expectations on the visual quality of captured data [17]. Due to restrictions like camera cost, power, memory size and limited bandwidth, it is not always possible to get high resolution image [15]. Image super-resolution produces a high-resolution image using one or more low-resolution images [16].

The subject has become really popular research area due to fact that High Resolution images containing more data which does not directly exist in the low resolution images. Resolution is determined by the pixel density [12].

III. LITERATURE SURVEY FOR SUPER RESOLUTION

Super Resolution refers to denote the number of pixels in an image and it is measured in pixel Per Inch (PPI). SR technique reduces the image's blurring and used in many image processing applications. SR technique applied in an improvement of

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test images, compressed video and image enhancement, medical imaging process and satellite and aerial imaging. In this paper the different methods for super-resolution are discussed.

- i. Peak-Signal-To—Noise Ratio.
- ii. Human Visual Based Measure.
- iii. Structural Similarity Index.
- iv. Deep Convolutional Networks.
- v. Sparse-Representations.

Some of the methods are discussed below:

1.1 Peak-Signal-To—Noise:

Signal-to-noise ratio (SNR) is a mathematical measure of image quality based on the pixel difference between two images [3]. The SNR measure is an estimate of quality of reconstructed image compared with original image. PSNR is defined as in (2)

$$PSNR = 10 \log \left(\frac{s^2}{MSE} \right) \quad (2)$$

Where $s = 255$ for an 8-bit image. The PSNR is basically the SNR when all pixel values are equal to the maximum possible value.

1.2 Human Visual Based Measure:

Human Visual System (HVS) is another approach of measuring image quality [1], [2], [4], [8]. The HVS is a method that uses human eye as a reference. The main idea is that humans are interested in different attributes of the image other than taking it as a whole. These attributes include brightness, contrast, texture, orientation.

1.3 Structural Similarity Index:

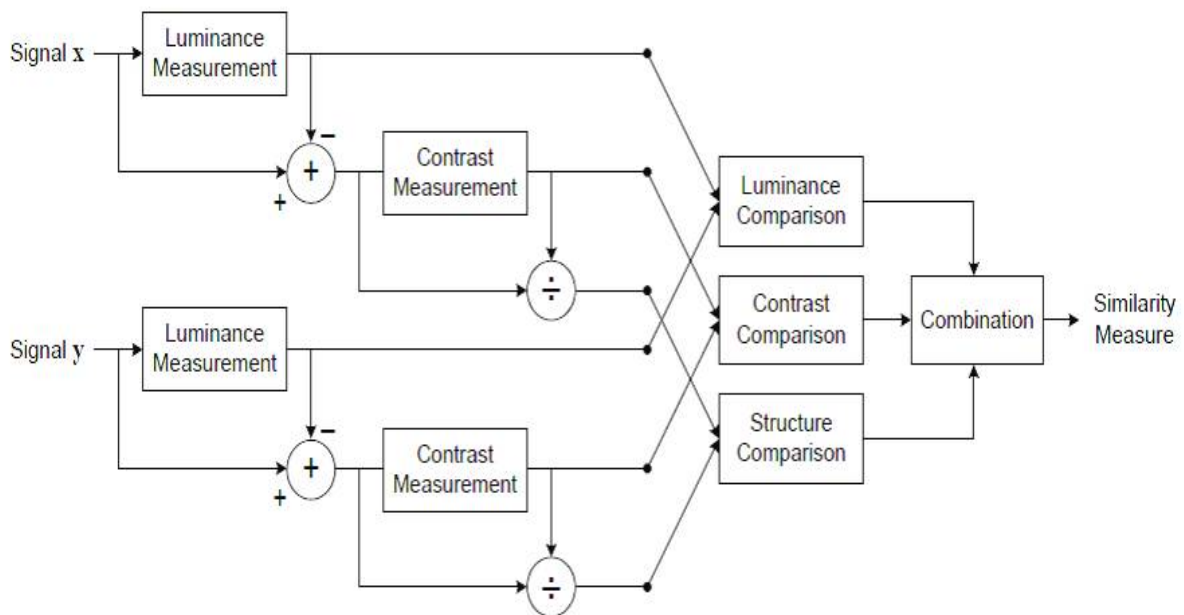


Fig.1: Diagram of Structural Similarity Index (SSIM) measurement system

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Structural similarity provides an alternative and complementary approach to the problem of image quality assessment [3]–[8]. It has been shown that a simple implementation of this methodology, namely the structural similarity (SSIM) index [4], can outperform state-of-the-art perceptual image quality metrics.

The mean structural similarity index is computed as follows: Firstly, the original and distorted images are divided into blocks of size 8 x 8 and then the blocks are converted into vectors. Secondly, two means and two standard derivations and one covariance value are computed from the images as in (8), (9), and (10). Structural similarity index measure between images x and y is given by (11).

$$\mu_x = \frac{1}{T} \sum_{i=1}^T x_i \quad \mu_y = \frac{1}{T} \sum_{i=1}^T y_i \quad (8)$$

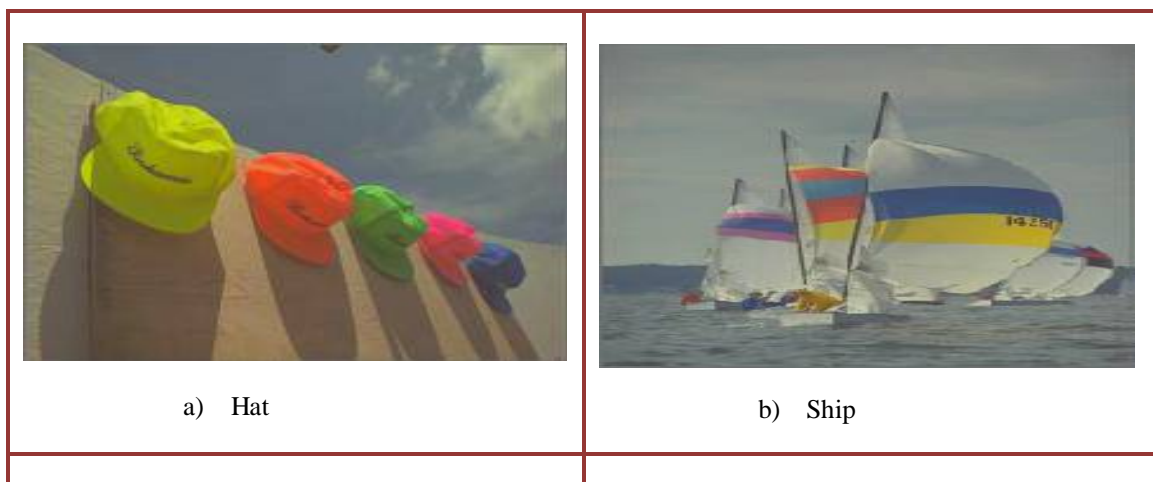
$$\sigma_x^2 = \frac{1}{T-1} \sum_{i=1}^T (x_i - \bar{x})^2 \quad \sigma_y^2 = \frac{1}{T-1} \sum_{i=1}^T (y_i - \bar{y})^2 \quad (9)$$

$$\sigma_{xy}^2 = \frac{1}{T-1} \sum_{i=1}^T (x_i - \bar{x})(y_i - \bar{y}) \quad (10)$$

$$SSIM(x, y) = \frac{(2\mu_x\mu_y+c_1)(2\sigma_{xy}+c_2)}{(\mu_x^2+\mu_y^2+c_1)(\sigma_x^2+\sigma_y^2+c_2)} \quad (11)$$

IV. COMPARATIVE STUDY

All used Image quality metrics are objective measurements that are automatics and mathematical defined algorithms. After applying some distortion (contrast enhancement) to the original four images, see Fig.2, we got the distorted nine images included here, see Fig.3, and the image quality is applied to theses distorted images and the results are compared in Table 1[12].



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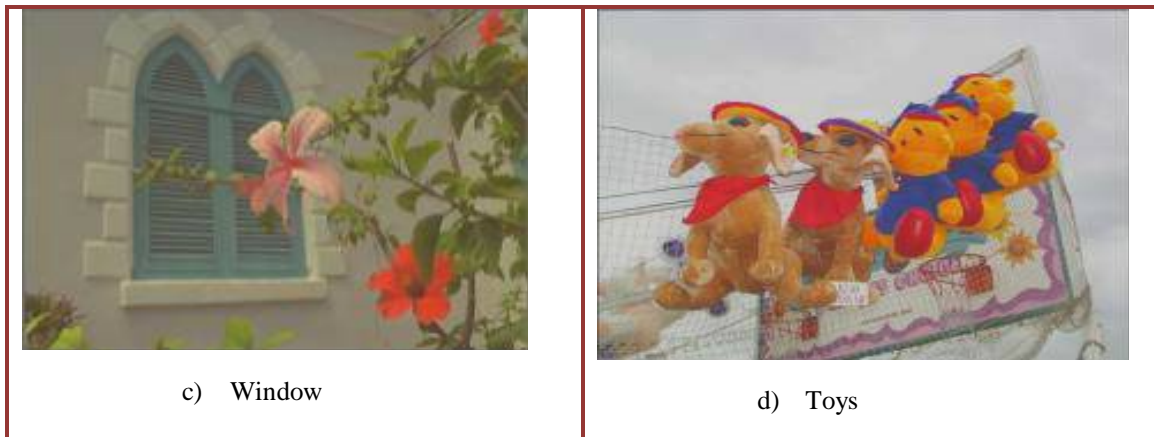


Fig.2: The four images from (a) to (d) using SSIM method [12].



Fig.3: Distorted images from (a) to (d) using SSIM method [12].

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Image	PSNR	SSIM	HVS
Hats	18.4	0.78	0.34
Ship	12.0	0.55	2.68
Window	13.1	0.57	1.04
Toys	15.17	0.86	0.35

Table: 1 comparison of PSNR, SSIM, HVS using the above methods [12].

V. CONCLUSION

According to this survey paper the Structural Similarity index (SSIM) algorithm when compared to Human visual system (HVS) algorithm is less complicated and uses mathematical formulae to convert low resolution image into high resolution image by one or more low resolution images and proves to be an efficient method to achieve image enhancement.

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