Image Compression and Inpainting for Distorted and Damaged Images Using K-NN Algorithm

[1]Yasir Ashraf Khajawal, [2]Rupinder Kaur

[1]Dept. of ECE, Doaba Institute of Engineering & Technology, Punjab Technical University, India
[2]Doaba Institute of Engineering & Technology, Punjab Technical University, India

Abstract

Image inpaintingdeals with the issue of filling-in missing regions in an image. Inpainting images with distortion, damage or corruption is a challenging task. Most existing algorithms are pixel based, which develop a statistical model from image characteristics. One of the primary burdens of these methodologies is that, their viability is constrained by the surrounding pixels of the destroyed part. Subsequently, good performance of these strategies is acquired just when the images have particular consistency. Images in the frequency domain contain sufficient data for image inpainting and can be utilized as a part of data recreation e.g., high frequency indicates image edges or textures, which motivates conducting image inpainting in the frequency domain. In this paper, we use KNN method which will utilize the DCT coefficients in the frequency domain to remove the distortions. We look for an adequate representation for the functions and utilize the DCT coefficients of this representation to produce an over-complete dictionary.

The two main objective of this paper is inpainting and compressing images with noise (after denoising/inpainting). This paper analyzes coding algorithm of JPEG image and proposes a K-Nearest Neighbor (KNN) approach to performinpainting in the DCT Coefficients to get a more optimized compression ratio. The proposed methodology is expected to outperform the compression ratio of the Baseline JPEG Algorithm dealing with images having cracks and distortions. The reason behind this is that images having distortions will have anomalies in the distorted parts which will contribute to the size of the image. If those distortions are removed before compression, the output will be more optimized.

Keywords

Image Inpainting, K-Nearest Neighbor (KNN), JPEG Algorithm

I. Introduction

In this Digital age where bulk of data is getting transferred each and every second, different compression methods are a necessity. By being able to compress images to a small fraction of their original size, we can save a significant amount of disk space. Likewise transportation of images starting from one computer then onto the next gets to be simpler and quick. Image compression Algorithms can be categorized into: Lossy and Lossless. As the name states, decompression after lossless compression yields the same input image.Lossy compression brings about loss of information and the decompressed image is not precisely the same as the first.

Tricky part comes when we do a compression of damaged/ distorted images using a compression algorithm like JPEG. Since, the redundancies cannot be removed in the damaged parts of the image the size of the compressed image is more.We use KNN method which will utilize the DCT coefficients in the frequency domain to remove the distortions first before using any compression algorithm. This way we are not only able to restore the damaged image but also drastically reduce the size of the compressed image using any compression method.

II. Image Inpainting Techniques

The dominant type of redundancy within images originates from their representation method. Each digital image is composed of discrete points, called pixels. The value relevant to each pixel is the result of sampling from light or color intensity in the original image domain. Natural images consist of separate areas indicating the object surfaces or sceneries. Because the light intensity and color in such areas are approximately constant, the relevant values for pixels are highly correlated. Every pixel in such areas is likely to be of the same or very close value compared with the adjacent pixels. In this case, images suffer from a high level of spatial correlation. Hence, representing the image by storing all pixel values results in a large amount of redundancy.

Instead of using a simple copy, we can approximate the indefinite pixels of the area by a linear combination of several best matching patches (i.e. of K nearest neighbors, K-NN), this way exploiting self-similarities within the image.

Instance Based Learning algorithms basically stores some or the majority of the training examples and defers any speculation exertion, until another query instance is further anticipated. Actually known cases and experiences is applied for particular cases or experiences to new circumstances. They can along these lines, construct query specific local models, which endeavor to match the training samples just in an area around the query instance alluded to as lazy learning method. It simply discovers a set of the nearest neighbors and develops a local model focused on them. Examples of the sorts of neighborhood models include Nearest Neighbor (NN), K Nearest Neighbor (KNN) and Locally Weighted Regression (LWR). NN local models just choose the closest point and utilize its output value. The outputs of the nearby points are averaged and utilized by KNN.

A. KNN Algorithm

K-NN is utilized for regression or classification. Here we are going to do classification. To do restoration, the closest neighbor of a pixel is considered. Here K>1 is considered, i.e. an aggregate of k neighbors of every pixel can be considered in a closed window of 8x8. In the 2d matrix of image components, every component has a certain correlation with its closest components. We can write algorithms by considering this property, and use the mean of all the closest neighbors to replace a damaged pixel. Hence a decent level of restoration is guaranteed by this method. The algorithm proposed will complete an iterative methodology wherein the mean intensity is discovered and further substitution of noisy pixel is carried out. Consider an input picture Pi, given us a chance to characterize a pixel at a position (q,r) in the info picture. The computation of the likelihood of event of each one neighbor of Pi(q,r) is performed first. The mean worth is acquired by utilizing the accompanying representation Eq. (1), for a sum of k neighbors in that window.

$$M = \sum_{i=1}^{K} X_i \; P(X_i) \tag{1}$$

Eq. (1) gives the mean of all neighboring points of a specific pixel. This gives a value what we call as a "good pixel value". Hence the good pixel value replaces the central corrupt pixel. This guarantees the removal of the tainted pixels and restoration of the given image.

III. Related work

Vahid Bastaniet.al. [1] proposed an algorithm for image compression focused around an imageinpainting system. Initially the image regions that can be precisely recuperated are located. At that point, to lessen the information, data of such locales is evacuated. The remaining information other than essential details for recovering the removed regions are encoded to deliver output data. At the decoder, an inpainting method is applied to retrieve removed regions using information extracted at the encoder. The image inpainting technique utilized partial differential equations (PDEs) for recovering data. It is intended to accomplish superior performance in terms of image compression criteria. This algorithm was analyzed for different images. A high compression ratio of 1:40 was achieved at an acceptable quality. Trial results demonstrated achievable obvious quality improvement at a high compression ratio compared with JPEG. The PSNR and SSIM of the sample images, demonstrated that the proposed technique outperformed JPEG at high compression ratios, for example, 1:40 (0.2 bpp) and were more outstandingin low structured and low textured pictures.

Li Qianget.al. [2] proposed a novel algorithm that uses compressed sensing (CS) in thefrequency domain rather than most existing algorithms which are pixel based, to recreate corrupted images. With a specific end goal to reconstruct image, the authors first disintegrated the picture into two functions with diverse basic characteristics - structure component and textual component. They looked for a meager representation for the functions and utilized the DCT coefficients of this representation to produce an over-complete word dictionary. Experimental results on real world datasets showed the adequacy of their method in image inpainting. The method is contrasted with three state-of-the-art inpainting algorithms and it showed favorable circumstances regarding both quantitative and qualitative aspects. The proposed system can viably repair images contrasted with three other pixel-based image inpainting systems referred in the paper, particularly when the image is met with a large destroyed region. The method ensured good image quality with the structure being decently restored, and the PSNR is generally high. Likewise, there is a much better advantage in terms of time spent.

Christine Guillemotet.al. [3] depicted an examplar-based picture inpainting algorithmlocally linear neighbor embedding technique with low-dimensional neighborhood representation (LLE-LDNR). The inpainting algorithm first searches the K nearest neighbors (K-NN) of the input patch to be filled-in and linearly combine them with LLE-LDNR to synthesize the missing pixels. Linear regression is then introduced for enhancing the K-NN search. The performance of the LLELDNR with the enhanced K-NN search method is surveyed for two applications: loss concealment and object removal. Instead of using a similarity kernel, the weights are processed utilizing locally linear embedding with low-dimensional neighborhood representation (called LLELDNR in the sequel). The technique is a variation of locally linear embedding (LLE) where the weights are computed on a low-dimensional neighborhood of the input vector instead of being computed in the high-dimensional data space as in LLE. The algorithm searches for an approximation of the known pixels of the input patch from its K-NN. This principle is known as neighbor embedding (NE). The paper considers linear regression for enhancing the K-NN search as well as for estimating unknown pixels. Experimental in two applications (loss concealment and object removal) show superior performances of the LLE-LDNR solution over other neighbor embedding solutions. Although, only comparisons with NLM and LLE are given here, tests have indicated better performance over with Non-Negative Matrix Factorization too. The results likewise demonstrated further gains when utilizing the proposed improved K-NN search utilizing linear subspace mappings in the context of inpainting.

Li Zhiqianget.al. [4] disintegrated the coding algorithm of JPEG, advances the JPEGencoder and decoder control processes. They showed the encryption and decryption of image by using Logistic sequence. Results demonstrated that this method not just save storage space for other helpful data, additionally enhanced the transmission efficiency and security in the transmission process. The article combines JPEG compression algorithm with chaotic encryption algorithm, which can viably save the storage space for image and guarantees the secure transmission of image information. In this paper, the actual characteristics of DSP hardware platform were taken into consideration. They utilized the static image compression algorithm to compress image. Since DCT transform is the most lengthy part in the image processing, this article is planned the FDCT transform and FIDCT transform systems focused around DM6437 hardware, which is not just quickening the processing speed of JPEG compression, additionally enhancing the general efficiency of computing. From software simulation and hardware implementation, it is verified that this system can be utilized as a part of image compression and encryption fields.

Mitchell A. Golneret.al. [5] proposed a region based variable quantization scheme, wherethe quantization granularity in diverse preselected regions of the image is varied at the discretion of the user. The techniques developed in this work are compatible with the popular JPEG Still Image Standard for compression of continuous-tone grey-scale and color images. Further, region selection techniques and algorithms that complement variable quantization techniques are introduced. The paper introduced three masks: step, linear interpolated, and raised cosine interpolated, that control the transition in the quantization granularity between regions of diverse compression ratios in an image. The paper likewise incorporates a point by point discussion of simulation results utilizing the proposed methodology. At the point when the strategies recommended were used, the subjective visual quality significantly enhances for comparable compression ratios of standard JPEG implementation, or proportionately, a higher compression ratio is accomplished for the same subjective visual quality. Likewise, in conjunction with the variable quantization technique, they introduced step, linear interpolated, and raised cosine interpolated masks that control the quantization granularity in transitions between regions of different compression ratios. The application of linear and raised cosine interpolative masks is found to be subjectively useful when the difference in fidelity between regions is large. The region selection can be performed manually or automatically according to predetermined requirements. The region selection, including the use of pattern recognition to identify regions containing features such as color and geometry, can be easily automated by adding a layer that can identify and assign the appropriate quantization values. Note also that, although the VQJPEG encoder and decoder developed here are DCT based, the extension of the technique to wavelet-based JPEG could be the subject of future research.

Gopal Lakhaniet.al. [6] It is a well observed characteristic that when a DCT block is traversed inthe zigzag order, the AC coefficients generally decrease in size and the run-length of zero coefficients increase in number. The author introduced a minor change to the Huffman coding of the JPEG baseline compression algorithm to exploit this redundancy. For this reason, DCT blocks are partitioned into groups with the goal that each one band can be coded utilizing a different code table. Three implementations are introduced, which all move the end-of- block marker up amidst DCT block and use it to show the band limits. Experimental results are compare reduction in the code size acquired by their techniques with the JPEG sequential-mode Huffman coding and arithmetic coding methods. The average code reduction to the aggregate image code size of one of our methods is 4%. The methods can likewise be utilized for progressive image transmission and subsequently, exploratory results are additionally given to contrast them with two, three, and four-band usage of the JPEG spectral selection method. The encoders outperformed the JPEG sequential-mode encoder as well as the JPEG spectral selection encoder for progressive-mode transmission of images.

En-hui Yanget.al. [7] proposed a novel algorithm to find the ideal SDQ coefficient files as run-size sets among all conceivable candidates given that the other two parameters are fixed. Taking into account this algorithm, they formed an iterative algorithm to mutually optimize the run-length coding, Huffman coding and quantization step sizes. The proposed iterative algorithm attains a compression performance better than any formerly known JPEG compression results and even surpasses the cited PSNR results of some state-of-the-art wavelet-based image coders like Shapiro's embedded zerotree wavelet algorithm at the regular bit rates under comparison. Since DCT indices can be equivalently represented to as run-size pairs followed by in-class lists through run-length coding, they simply refer to coefficient index optimization as run-length coding enhancement in parallel with step size and Huffman coding advancement. In this paper, they not just proposed an extremely flawless, graph based run-length code optimization scheme, additionally introduced an iterative optimization scheme which together improves the run-length coding, Huffman coding and quantization step sizes. The proposed algorithm with an initial optimized quantization table outflanks the joint optimized scheme in different papers results by the authors for all bit rates under comparison and even surpasses the cited PSNR consequences of some state-of-the-art wavelet-based image coders like Shapiro's embedded zerotree wavelet algorithm.

Timothy K. Shihet.al. [8] proposed a versatile system, which is focused around a colorinterpolation mechanism on Digital Image Inpainting. The repairing technique checks the encompassing data of a damaged pixel and chooses the scope of references that can be utilized to process an interpolated color. The framework was tried on more than 2000 images incorporating painting, photograph, and cartoon drawing. The assessment demonstrated that their mechanism produces a very good result. Algorithm utilizes a pseudo window, which is utilized to gauge whether there exist enough data to inpaint a damaged pixel. The extent of the window can be enlarged in the event that that there is no enough encompassing information. They evaluated their methodology of inpainting algorithm by taking into account the PSNR value of the damaged image, and the PSNR value of the inpainted image. However, utilizing single PSNR value of each one picture neglects to examine the subtle elements. It is conceivable that, an imperative little divide of the inpainted picture is not decently repaired. Anyhow, the general PSNR estimation of the image is still high. Consequently, they utilized a set of multilevel PSNR values and in addition the idea of "the percentage of good picture portions" For that they decomposed an image utilizing a complete quad-tree representation. Each one level of decomposition equally divides the area into 4 quadrants. The quantity of levels relies on upon the original size of a picture. In a viable circumstance, they decomposed pictures up to 8 levels for assessment. The methodology demonstrated were helpful and gave a PSNR Value>30

IV. Proposed Solution

Existing strategies can be ordered into the accompanying classifications:

- The principal class concerns diffusion-based methodologies which proliferate level lines (called isophotes) utilizing Partial Differential Equations (PDE) or variational systems.
- The second classification concerns examplar-based inpainting methods which have been motivated from texture synthesis procedures. These methods exploit image statistical and equivalence toward oneself priors.
- An alternate class of methodologies concerns techniques utilizing sparsity priors.
- Most existing algorithms are pixel based, which develop a statistical model from image characteristics. One of the primary burdens of these methodologies is that, their viability is constrained by the surrounding pixels of the destroyed part.

Images in the frequency domain contain sufficient data for image inpainting and can be utilized as a part of data recreation. High frequency indicates image edges or textures, which motivates conducting image inpainting in the frequency domain.

In this paper, novel KNN method is proposed which will utilize the DCT coefficients in the frequency domain to remove the distortions. We look for an adequate representation for the functions and utilize the DCT coefficients of this representation to produce an over-complete dictionary.

The methodology adopted for this paper consists of the following steps:

1. **Exploration:** This approach is used to collect information about the techniques mentioned inthe papers from the journals.
2. **Reading:** This step is for gaining a thorough knowledge about the techniques by continuousreading.
3. **Deduction:** Summing up the main steps/concepts, according to the field of study.
4. **Conclusion:** Getting into a particular conclusion from the ideas gained from the above steps.The steps are repeated until the conclusion of the proposed approach is finalized.

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A. Proposed Approach

STEP 1: OBTAIN IMAGE (HAVING CRACKS AND MINOR DISTORTIONS).

STEP2: DIVIDE IT INTO 8X8 MATRIX COMPONENTS TABLE

STEP 3: CONVERTS TO GRAYSCALE

STEP 4: CONVERT TO BLACK AND WHITE (LOGICAL CLASS) AND SAVE THE POSITIONS OF 1(LUMINANCE) FROM THE MATRIX.

STEP 5: APPLY DCT TO THE MATRIX OBTAINED FROM STEP 3

STEP 6: APPLY KNN ALGORITHM TO THE POSITIONS OBTAINED FROM STEP 4, IN THE DCT COEFFICIENTS

STEP 7: APPLY QUANTIZATION TO COMPRESS THE DATA

STEP 8: Apply Variable Length Coding which includes Zigzag filtering and Run-Length Encoding or Huffman Encoding.

Fig. 1: Flow Chart

The image is converted into Black and White to retrieve the positions of cracks/distortions. In this, only luminance is shown with 1(the cracks and distortions) in the matrix. Rest every chroma component is 0. This is known as logical class.

V. Simulation Results

The network simulation is accomplished using MATLAB Version (R2012a) simulator on Windows 7 operating system.
An Image with cracks or minor distortions is obtained. This Image is compressed with a standard JPEG compression algorithm.

Fig. 2: Original Image (With Cracks)

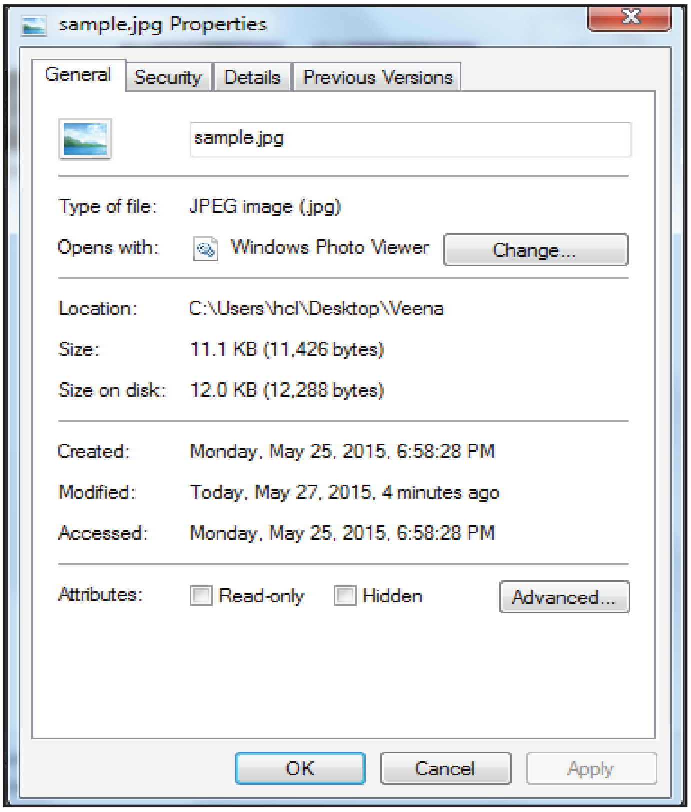

Fig. 3: Size of Newly Created JPEG File is 11.1 KB

After the Image is divided into 8*8 Matrix components table, it is converted into black and white and positions of luminance are saved which will give us the positions of damage or cracks

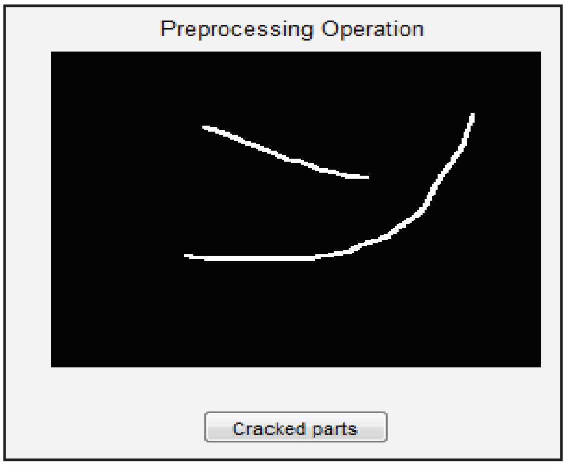

Fig. 4: Identifying the Damaged Parts of the Image

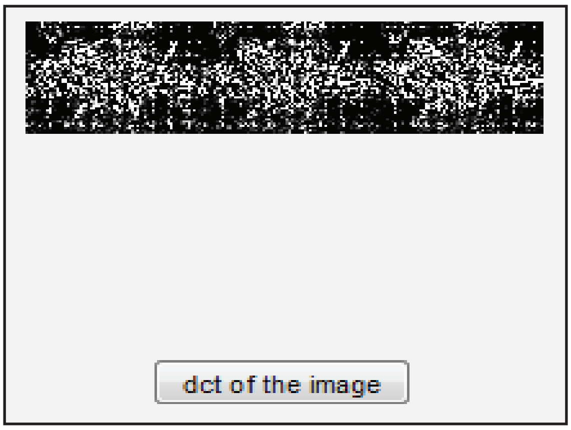

Fig. 5: DCT of the Image

Below are the results obtained after applying the KNN algorithm to recover the damaged or distorted parts of the image:

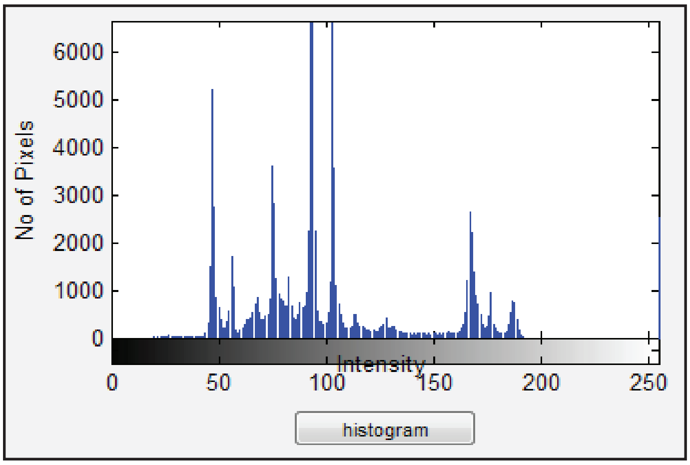

Fig. 6: Histogram (Pixels Vs Intensity)

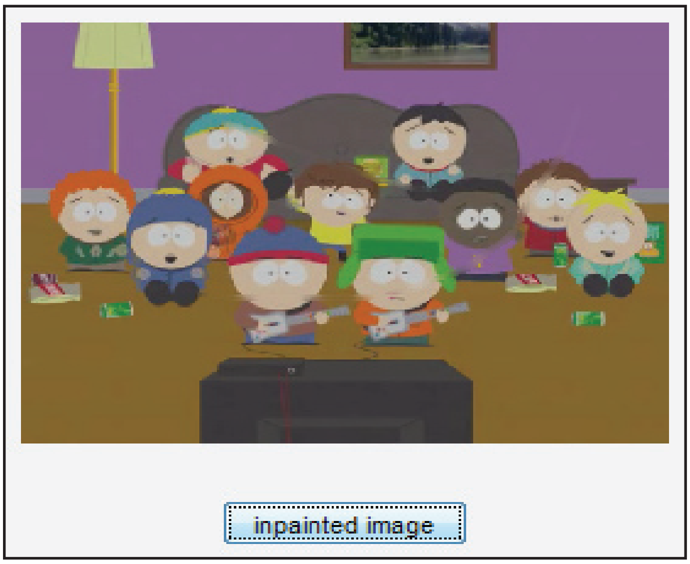

Fig. 7: Inpainted Image After Removing Cracks

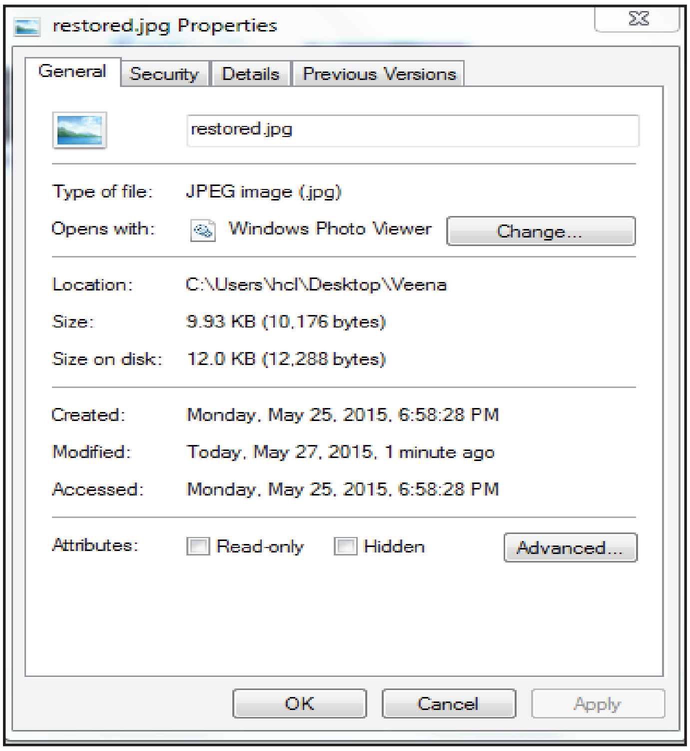

Fig. 8: Size of JPEG Compressed Inpainted Image

The final results are tabulated below. As can be seen clearly, the proposed methodology using KNN algorithm has outperformed the compression ratio of the Baseline JPEG in terms of Size, MSE and PSNR.

Table 1:

Parameter	Standard JPEG	JPEG Compression after KNN Algorithm
SIZE	11.1 KB	9.93KB
MSE	14.8	12.83
PSNR	32.4	37.8

VI. Conclusion

In our study we use K-Nearest Neighbor (KNN) approach to perform inpainting in the DCT Coefficients to get a more optimized compression ratio. The proposed methodology outperforms the compression ratio of the Baseline JPEG Algorithm dealing with images having cracks and distortions. The reason behind this is thatdamaged images will have anomalies in the distorted parts which will add to the size of the image. If those distortions are removed before compression, the output will be more optimized.

The proposed methodology gives a good PSNR value compared to the output of JPEG Baseline Algorithm. The output image from the system is expected to be visually more attractive to the Human eyes because of the removal of noise that were present before compressing the image.

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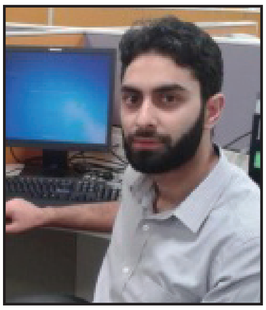

Yasir Ashraf Khajawal, M.Tech (ECE), DoabaInstitute of Engineering & Technology, Kharar, Punjab Technical University, India.

Rupinder Kaur, Assistant professor, Doaba Institute of Engineering & Technology, Punjab Technical University, India.