Use of Dark Channel and Boundary Constraints for Single Image Dehazing

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Abstract- Imaging devices are getting more intelligent day by day due to shear amount of research being carried out to facilitate the imaging algorithms. Now a day's pictures are the essential part of everybody's existence in this planet and the each portable device has the individual camera with them. These cameras are not having that much image enhancement like professional cameras or other specialized imaging devices. The pictures were captured are arbitrary and affected by environmental circumstances like fog, moisture, dust particles and light intensities which can be reduced up to certain level during post processing of images. In this work an image dehazing technique is proposed and analyzed with respect to its structural similarity index (SSIM) and color difference (CIEDE2000). The proposed dehazing algorithm is based on estimation of various parameters like dark channel estimation, boundary constraints estimation and atmospheric light etc. The enhanced values of both the figure of merits are shown in the results section and significantly improvementsshows over previous techniques.

Keywords - De-Hazing, Boundary Constraints, Dark Channel Estimation, Atmospheric Light, Gamma.

I. INTRODUCTION

Features perceived from a scene are valuable sources of information for many human activities. This is also true when an increasing number of autonomous machines are being deployed for industrial applications. The use of images in computerised intelligent systems can be found in robotic welding, object detection, aerial surveillance, remote sensing of the environment, data security, and others.

However, digital images captured in adverse environmental conditions often suffer from loss of contrast and colour distortion, such deficiencies hinder these images taken as the source of valuable information from being applied for further applications. Therefore, it is necessary to investigate into image processing algorithms for image contrast enhancement and recovering the true counterpart of degraded images.

Computer vision systems work in two types of environment indoor and outdoor. Indoor environments offer greater control of parameters such as scene light and depth maps. Also, they are immune to the effects of weather degradations. Indoor image processing applications such as image retrieval and automatic event detection systems based on image enhancement techniques give acceptable results with minimum processing time. Therefore, computer vision systems have enjoyed great success in real time processing for indoor environments. Outdoor environments are susceptible to many natural conditions such as ambient light and weather conditions. This translates to greater uncertainity in scene light and depth maps. Therefore image enhancement based techniques have lower reliability for computer vision systems in outdoor environments. This is because enhancement based techniques are not based on mathematical analyses and do not account for unknown depth discontinuities in the scene. Image restoration based techniques give better perceptual image quality but at the cost of large processing time. Hence, unfortunately most computer vision systems have not enjoyed success when deployed in uncontrolled real time outdoor environments.

Studies on improving vision in a bad weather conditions began in the late 90s. Bad weather conditions such as fog, haze and rain greatly reduce the visual quality of outdoor systems. The performance of outdoor systems such as object detection, obstacle detection and video surveillance are adversely affected by the bad weather conditions.

Therefore, clear visibility is essential for these systems. In fact, most of the current vision systems are also designed to perform well with clear visibility. So, the poor visibility is a major challenge for many applications of computer vision. It is greatly influenced by the characteristics of light, such as its intensity and color. Intensity and color are altered by its interactions with the atmosphere. These interactions can be broadly classified into three categories, namely, scattering, absorption and emission. Scattering is most significant factor in the case of poor visibility. In general, the exact nature of scattering is highly complex and depends on the types, orientations, sizes and distributions of the particles constituting the atmosphere. Weather conditions differ mainly in the types and sizes of the particles involved and their concentrations in space.

1.1 shows the weather conditions and associated particle types, sizes and concentrations. Fig. 1.1 shows 3 images of the same scene captured under different bad weather conditions.

Fig.1.1 Image at different bad weather condition.

Haze is constituted of aerosol which is a dispersed system of small particles suspended in gas. Haze has a diverse set of sources including volcanic ashes, foliage exudations, combustion products, and sea salt. The particles produced by these sources respond quickly to changes in relative humidity and act as nuclei (centers) of small water droplets when the humidity is high. Haze particles are larger than air molecules but smaller than fog droplets. Haze tends to produce a distinctive gray hue and is certain to affect visibility.The main objective of this work is to develop techniques based on enhancement and restoration for improving the interpretability or perception of quality in the foggy and hazy image based on a novel image dehazing approach using dark channel and boundary constraint estimation.

II. HAZE MODEL

Generally, bad weather conditions always affect the visibility of images. Under bad weather conditions, the contrast and color of the images are drastically degraded. To improve the contrast of weather degraded images generally used image processing methods are histogram equalization, unsharp masking and contrast stretching. But, the effects of weather cannot be completely removed by these techniques. In other words, it is simply not possible to expect consistent success without studying and modeling of the atmospheric conditions. So for deweathering of images it is essential to consider both of these methods (enhancement and physical methods) which can significantly remove the weather effects from the images.

Imaging in poor weather is often severely degraded by scattering due to suspended particles in the atmosphere such as haze and fog. Based on the type of the visual effects, bad weather conditions.

a. Atmospheric Scattering Mechanisms

Atmospheric scattering is the cause of image degradation in bad weather condition. It is the redirection of electromagnetic energy by particles suspended in the atmosphere or by large molecules of atmospheric gases. Poor weather caused by atmospheric particles, such as fog, haze, etc., May significantly reduces the visibility and distort the colors of the scene. In general, the exact nature of scattering is highly complex and depends on the types, orientation, size and distributions of particles constituting the media, as well as wavelengths, polarization states, and directions of the incident light. Two models of atmospheric scattering i.e. attenuation and airlight, are summarize followed by the discussion on wavelength dependency of scattering.

b. Attenuation and Airlight

The pictorial description of the optical model describing image capturing in the presence ofatmospheric particles is shown in Fig. 2.1. Here, the reflected light beam coming straight froman object point to the camera is called direct transmission (or direct light). The reflected light beam coming from an object point, gets attenuated due to scattering by atmospheric particles. The attenuation model describes the way light gets attenuated as it traverses from an object point to the camera. This phenomenon is termed as attenuation, which reduces contrast in the scene. As shown in Fig. 2.1, small amount of Light coming from the environmental illumination is scattered by the atmospheric particles, and coming toward camera. This leads to the change in color of the object. This phenomenon is termed as airlight. The image taken with the camera depends both on attenuation and airlight.

Digital images have been applied in a large number of applications including object detection, surveillance, terrain classification and many others. However, a large proportion of images captured in outdoor environment are degraded due to the particles in the atmosphere and the interference of air-light, which can be represented by haze in general. To prevent haze from downgrading the satisfactory performances of digital images in various outdoor vision applications, a large amount of research for image de-hazing has been initiated due to a mass of demand for high quality images.

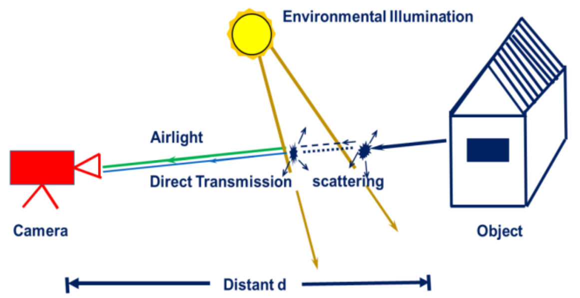

Fig.2.1 The pictorial description of the optical model.

In most image based applications, input images of high information content are often required to ensure that satisfactory performances can be obtained from subsequent processes. Manipulating the intensity distribution is one of the popular methods that have been widely employed. However, this conventional procedure often generates undesirable artifacts and causes reductions in the information content. Due to the great significance of image contrast enhancement and the existing disadvantages inherited with the available algorithms, it is necessary to conduct further research in enhancing image contrast. By expanding the intensity according to the polarity of local edges, an intermediate image of continuous intensity spectrum is obtained. Therefore, the resultant image is with better image details; hence possesses more valuable features which can be adopted for following applications.

However, images containing over-range pixels will appear with artefacts, to hinder which a manipulation named image compression is required. To achieve dehazed image a novel image dehazing approach using dark channel and boundary constraint estimation has proposed in this work.

III. PROPOSED METHODOLOGY

A novel image dehazing approach using dark channel and boundary constraint estimation is proposed in this examination work implemented and simulated in MATLAB image processing tool and simulation MATLAB environment.Since airlight is energy scattered in air, airlight tends to be locally smooth in a scene, i.e., local airlight remains constant in a similar depth. In contrast, the original radiance in a scene tends to vary significantly, naturally showing a variety of colors. When the scene has isolated radiance into a small patch in an image, the variation of scene radiances within a patch tends to decrease significantly to form a cluster with a similar color vector, assuming that the real world scene is a set of small planar surfaces of different colors. Then, one can estimate transmission values with certain natural image statistics within a patch based on the local smoothness assumption on scene depths. Fig. 3.1 shows the block representation of proposed approach. The fundamental elements through which hazed image passed of proposed approach are discussed below. In proposed approach first Hazzy image is loaded to process in MATLAB image processing environment. Estimate dark channels following with atmospheric light after dark channel estimation apply grave value correction algorithm. Calculate and estimate boundary constraintscalibrate intensities and finely apply tone mapping on hazzy image and a significantly dehazed image has obtained.

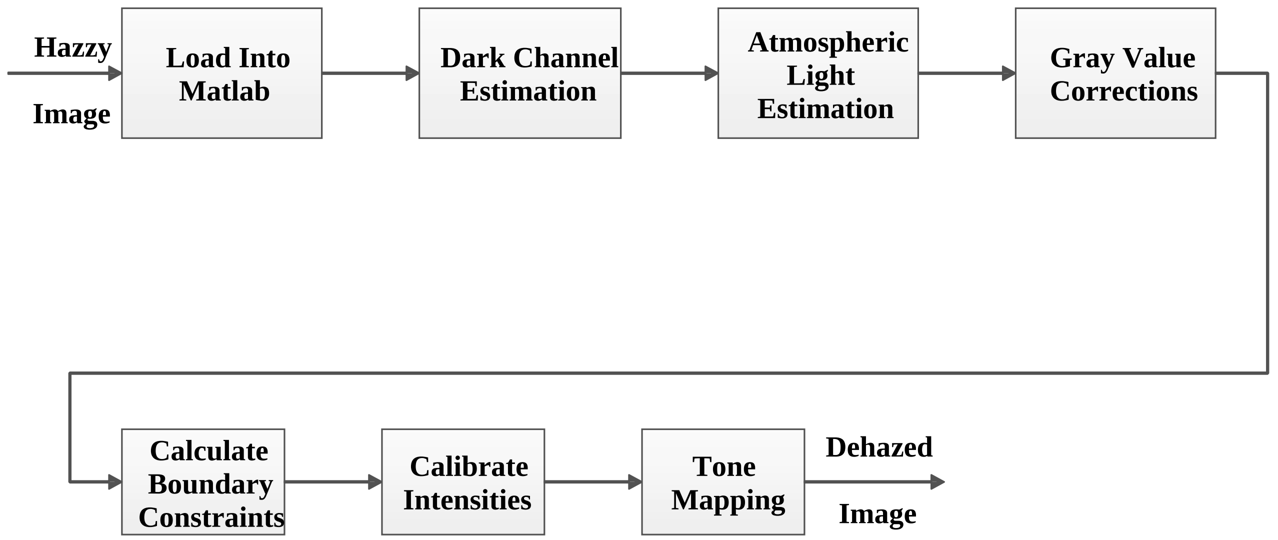

Fig.3.1 Block diagram proposed novel image dehazing approach.

1. Dark Channel Estimation

Dark channel prior is a statistics of outdoor image dehazing. It is based on the way that the neighborhood patches in the haze free images whose intensity is low at least one color channel out of available color channel. This data is utilized by dark channel prior technique to improve the quality of image. The Dark Channel Prior is based on the key perception on open air haze free images that something like one color channel has a few pixels whose intensities are low and near zero, which implies that the minimum intensity in such a patch is near zero. The model broadly used to depict the arrangement of a hazy image in computer vision and computer graphic. This design gives the entrance to whole pixel neighborhood each clock cycle once the buffer is filled.

2. Atmospheric Light Estimation

Itcan be seen that the brightest pixel of the entire image can be more brightest than the environmental light, which isn't suitable for exact air light estimation. Thusly, the best 0.1 percent brightest pixels in the dark were picked to expand the accuracy. The relating pixels in the input image with most noteworthy intensity are then chosen for the estimation of environmental light. This algorithm performs well notwithstanding when there are no pixels at infinite distance in the image and capacities all the more robustly.

3. Gray Value Correction

In the proposed approach a gray value correction algorithm is used, the gray value of the center point in each line is treated as the reference value; the gray value in two sides is corrected by using the reference value.

4. Boundary Constraint Estimation

Real-time regularization dehazing method using boundary constraints restore the haze-free images by exploring the boundary constraints on the transmission function. Instead of pushing a single pixel, push an image patch. This process stops when any pixel in the patch touches the boundary. This gives the estimate equivalent to that using the dark channel prior.

5. Intensity Calibration

Based on the polarity of the pixel-wise edge, the dynamic range is iteratively extended while keeping up the shape of the info image histogram. With this progression, fine features are improved with the data content expanded from intensity development. Furthermore, so as to keep the intensities to the allowed dynamic locale, a compression stage is incorporated into the final contrast upgrade method. The combination of the compression and expansion processes together guarantees that all the permitted intensities are utilized to pass on scene features. In the compression step, low counts in the expanded image histogram are expanded by combining intensities with the following higher one. This procedure makes the dispersion in the upgraded image progressively uniform. Based on the state of most extreme data, the uniform dissemination of intensities adds to an expansion in entropy.

6. Tone Mapping

In computer graphicsand image processing a tone mapping system is utilized to outline set of one color to another to approximate the high-dynamic-range images appearance in a medium that has anincreasingly limited dynamic range.

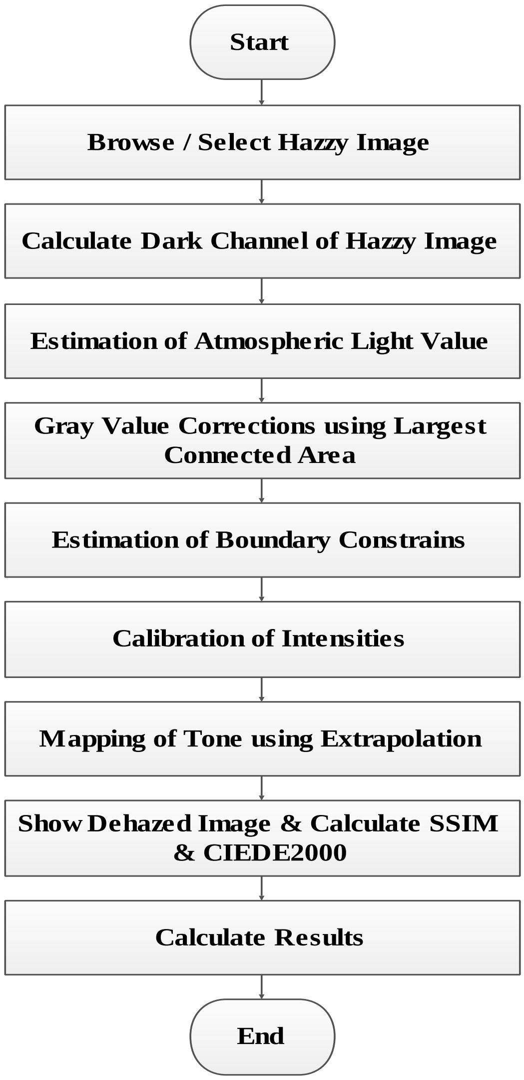

Fig. 3.2 Process flow of proposed novel image dehazing approach.

Fig. 3.2 shows the process flow and steps of execution and simulation of proposed algorithm in proposed work in MATLAB image processing environment.

IV. SIMULATION RESULTS

In the hazy and foggy conditions, the shading and differentiation of open air scene diminishes. This fundamentally diminishes the quality of captured images, which is basic for all outside imaging frameworks. To defeat this issue, a image dehazing and defogging is critical.

In this work, a novel algorithm has present restoration of image based on methodology for haze removal from a hazy input image. The way toward eliminating haze from an image requires the information of physical qualities of the scene. One of the qualities is the airlight. This is light originating from the ecological enlightenment and dissipated by the atmospheric and coming towards camera. Another critical characteristic is a transmission guide or depth map of the scene. This depth is estimated from the camera to the object in the scene. If airlight and depth map are known, then the problem of removing haze can be resolved with ease.

The entire system has been implemented in MATLAB. The system has been tested using sample test image. The test set consisted of all the 4 different degraded photos. All images were modified by adding haze to them. The proposed dehazingapproach, the haze remover technique uses the simplified dark channel prior with the combined tone mapping.

A sample of three test images and their equivalent dehazed images are shown in Figures 4.1, 4.2, 4.3, and Figures 4.4 respectively. For Test Image 1, Fig. 4.1, it can be seen that results from Hazzy image left and Simulated Dehazed Images of church right hand side in figure respectively. On the other hand, Fig. 4.2 Hazzy and Simulated Dehazed Images of couch, Fig.4.3 Hazzy and Simulated Dehazed Images of flower1,Fig. 4.4 Hazzy and Simulated Dehazed Images of lawn1. It can be observed that from table 1 Table 1: Parametric Comparison of SSIM and CIEDEF2000 the perfrmance of proposed algorithm has significant improvement in terms of SSIM and CIEDEF2000. This indicates that the proposed algorithm has oustanding.

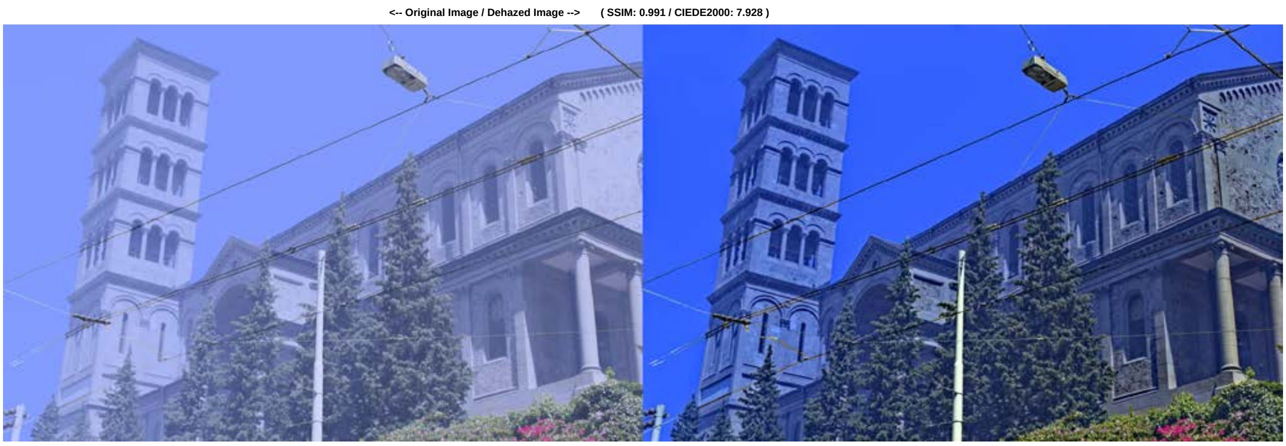

Fig. 4.1 Hazzy and Simulated Dehazed Images of church.

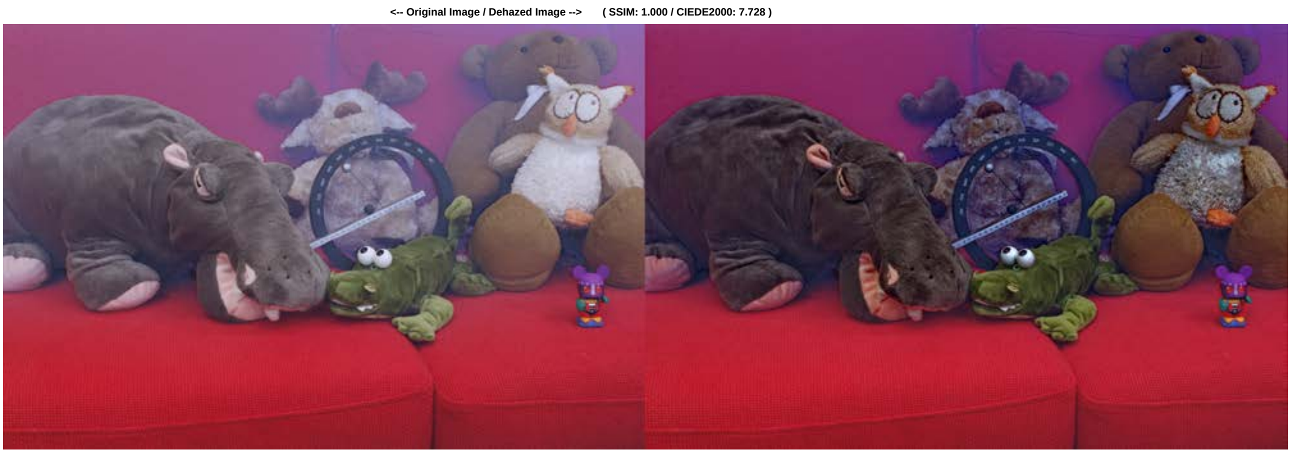

Fig. 4.2 Hazzy and Simulated Dehazed Images of couch.

Fig.4.3 Hazzy and Simulated Dehazed Images of flower1

Fig. 4.4 Hazzy and Simulated Dehazed Images of lawn1.

Table 1: Parametric Comparison of SSIM and CIEDEF2000

Image	***SSIM***		***CIEDEF2000***	
	Previous [1]	***Proposed[Our]***	***Previous [1]***	***Proposed[Our]***
church	0.84	***0.991***	7.077	*7.928*
couch	0.861	***1.000***	3.404	*7.728*
flower1	***0.898***	***0.988***	10.911	*13.093*
lawn1	0.84	***0.985***	***6.196***	*16.607*

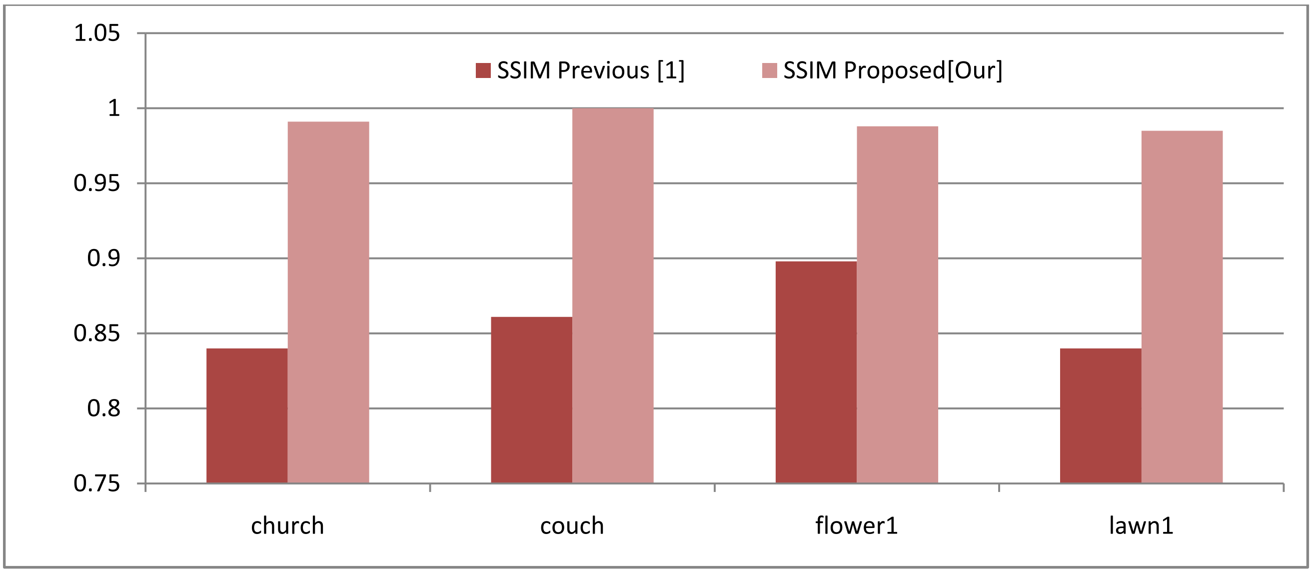

Fig.4.5 SSIM Graphical Comparison

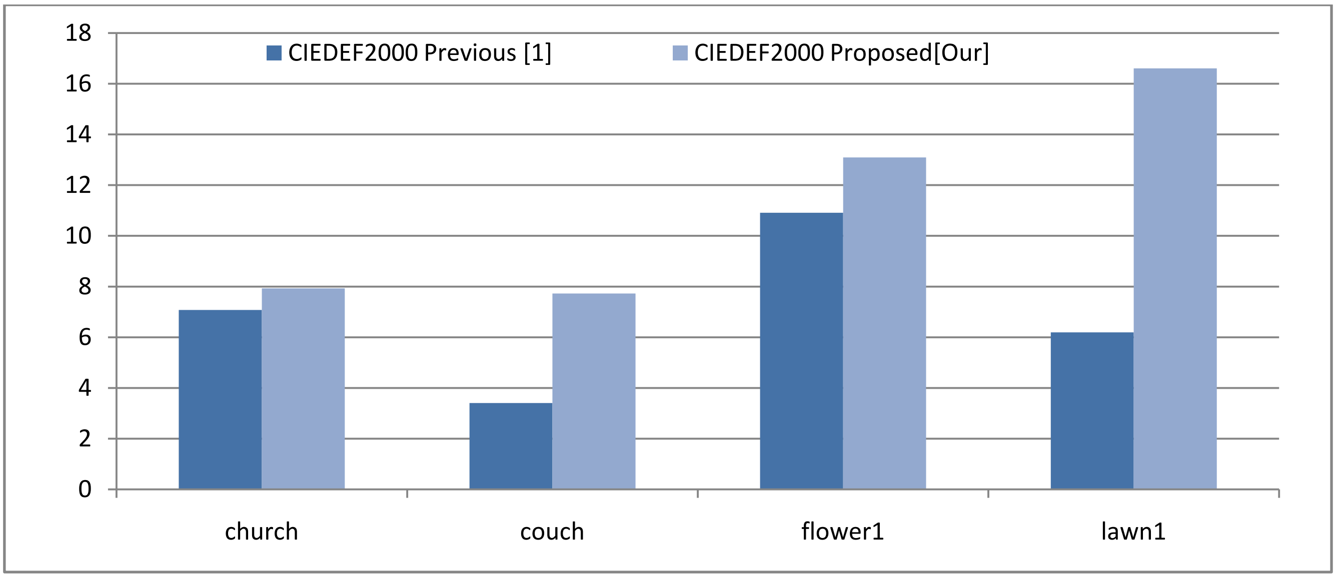

Fig.4.6 CIEDEF2000 Graphical Comparison.

The graphical representation of comparison parameters of image evaluation are shown in Fig. Fig.4.5 SSIM Graphical Comparison and Fig. 4.6 CIEDEF2000 Graphical Comparison.

V. CONCLUSION AND FUTURE SCOPES

The proposed research is focused on image de-hazing and contrast enhancement, due to their recent wide applications in various areas. To overcome the shortcomings of existing algorithms, an approach for enhancing the quality of digital images has been presented. The method, novel image dehazing approach using dark channel and boundary constraint estimation, is developed aiming at reducing viewing artefacts and increasing the information content in the output image. These objectives are accomplished using image dark channel and boundary constraint estimation process in order to prevent artefact generations. Through this operation, image intensity levels are maximised to provide more precise image details. However, this process will lead to the over-range phenomenon for pixel intensities. A comparative analysis of proposed algorithm with existing algorithm has been also carried out in tabular form and its graphical examination has also illustrated in MATLAB image processing environment. From the basis of results examination in terms of SSIM Graphical Comparison and CIEDEF2000 Graphical Comparison it is can be concluded that proposed algorithm best suited for Hazzy image processing application.The digital images processed by the proposed method can provide more objects detail, improved features, better image saturation and richer information content, which can then be used for various further applications.In future the potential future research will focus onRefinement for the hazy image model and to resolve color distortion in image dehazing process.

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