REAL TIME HIGH DYNAMIC RANGE IMAGE USING MULTIPLE EXPOSURE FUSION

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Abstract- A multiple exposure fusion to enhance the dynamic range of an image is proposed. The construction of high dynamic range images (HDRIs) is performed by combining multiple images taken with different exposures and estimating the irradiance value for each pixel. This is a common process for HDRI acquisition. During this process, displacements of the images caused by object movements often yield motion blur and ghosting artifacts. To address the problem, this paper presents an efficient and accurate multiple exposure fusion technique for the HDRI acquisition. Our method simultaneously estimates displacements and occlusion and saturation regions by using maximum a posterior estimation and constructs motion-blur-free HDRIs. Discrete wavelet transform is applied in order to decompose an input image into different sub bands. Then the high frequency sub bands as well as the input image are interpolated. Then all these sub band are combined to generate a new high resolution image by using inverse DWT (IDWT).Then to achieve a fused image.

Keywords- Dynamic Range Images (HDRI), Markov Random Field, Maximum A Posteriori, Discrete Wavelet Transform, Multiple Exposure.

I. INTRODUCTION

"High dynamic range imaging (HDRI) is a set of techniques that allows a far greater dynamic range of exposure than normal digital imaging techniques. The intension is to accurately represent the wide range of intensity level found in real scenes, ranging from direct sunlight to the deepest shadows"[1]. The human visual system can capture a wide dynamic range irradiance, where the dynamic range of charge coupled device or complementary metal oxide semiconductor sensors in most of today's camera does not cover the perceptional range of real scenes[1]. It is important in many applications to capture a wide range of irradiance of natural scene and store it in each pixel [2].

In the last decade, to capture the HDRI many techniques have been proposed based on the multiple exposure principle in which the HDRI is constructed by merging some photographs short with multiple exposures. Many of the techniques assume that a scene static during taking photographs [3]. The motion of object causes motion blur and ghosting artifacts. such as video coding and stereo vision, many displacement estimation method is proposed; simply applying them in to the multiple exposure fusion often fails since the intensity level of the images are significantly different due to the failure of camera response curve estimation[4]. Low and high exposure causes blackout and whiteout to some regions of the images. The case of low exposure, noise such as thermal noise and dark current sometimes make the displacement estimation difficult.

In this paper, an algorithm of the HDRI estimation based on the markov random field (MRF) model. The HDRI by taking in to consideration displacements ,underexposure and overexposure (saturation) and occlusions. The occlusion and the saturation are clearly classified and then separately treated, which results in the accurate removal of ghosting artifacts[4,5].

In the application of CG, a high dynamic range image (HDRI) is widely used for high quality rendering with image based lighting. HDR imaging technologies have been developed and some HDR sensors are commercially available. They are used for in vehicle cameras, surveillance in night vision [6]. Discrete wavelet transform is applied in order to decompose an input image into different sub bands. Then the high frequency sub bands as well as the input image are interpolated. Then all these sub band are combined to generate a new high resolution image by using inverse DWT(IDWT).

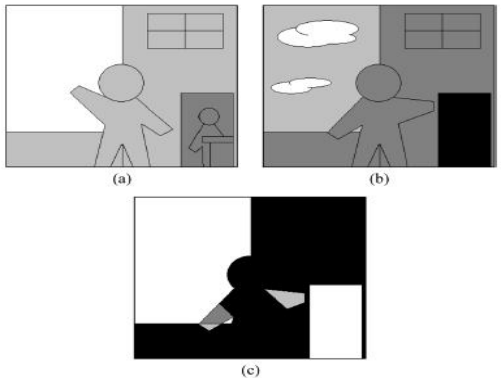


Fig.1 Example of multiple exposure images: (a) High exposure, (b) Low exposure, (c) Occlusion (gray), and saturation (white).

The displacement estimation may fail due to 1) Occlusion, 2)Saturation, that is, underexposure and overexposure, and 3) differences in intensity caused

by the failure of the camera response curve estimation. Fig. 1 illustrates an example of two exposures, where some regions of the high-expo-sure image is overexposed [white region in (a)] and underexposed [black region in (b)]. There may be three types of regions where correspondence between the images is hard to find:

1) Occlusion [marked by light gray in (c)];
2) Saturation (overexposure marked by white); and
3) both of the two (dark gray).

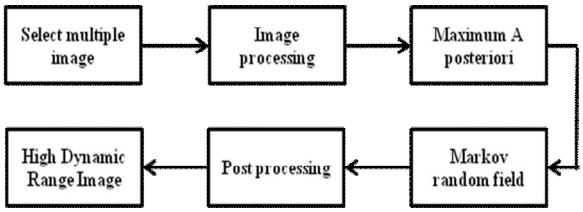


Fig 2.Block Diagram of multiple Exposure Fusion for High Dynamic Range Image.

II. MULTIPLE EXPOSURE FUSION

The HDRI is constructed by combining multiple images. The procedure for the HDRI acquisition is informally described as follows.

1) The images are acquired with different exposure settings:
Assume that the exposures are set by changing shutter speed, while the aperture is fixed, and obtain a set of ordinary low dynamic range images with 8 bits/channel. In general, there is a nonlinear relationship between the pixel values of the 8-bit images acquired by a camera and the values of actual irradiance.To compensate for this nonlinearity.
2) Select a main image from the multiple exposure images. For each of the other images, the displacement from the main image, which is mainly due to object movements, is found. In practice, select an image with medium exposure as the main image in a default setting. Furthermore, the occlusions and underexposed and overexposed regions are found for the images. This is done by the MAP-based motion compensation method.
3) To improve the accuracy for discriminating the occlusion and the saturation (i.e., underexposed and overexposed regions), Then employ the post processing method.
4) Then combine the images to create the HDRI.
In image processing, computer graphics, and photography, exposure fusion is a technique for blending multiple exposures of the same scene into a single image.

High dynamic range imaging (HDRI or just HDR), the goal is to capture a scene with a higher dynamic range than the camera is capable of capturing with a single exposure. However, because no HDR image is ever created during exposure fusion, it cannot be considered an HDR technique.

A. Image Processing
Image processing concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region. In a sophisticated image processing system it should be possible to apply specific image processing operations to selected regions. Thus one part of an image (region) might be processed to suppress motion blur while another part might be processed to improve color rendition. Sequence of image processing.

B. Maximum A posteriori
vector, as well as the occlusion and saturation ration are detected by the MAP estimation. The estimates displacement and occlusion and saturation region by using Maximum A posteriori estimation and constructs motion blur free HDRIs.

The estimates displacement and occlusion and saturation region by using Maximum A posteriori estimation and constructs motion blur free HDRIs.The displacement.

C. Markov Random Field
MRF construct the HDRI by taking consideration displacements, underexposure and overexposure and occlusion MRF used for motion compensation. Estimate the following two classes, as well as the displacement vector. Markov Random Fields (MRFs) are defined as probabilistic models over undirected graphs.

D.Post processing
Post processing determines the region of the occlusion and the saturation and obtains the displacement vector except this area. Using the above algorithm, we can determine the regions of the occlusion and the saturation and obtain the displacement vectors, except in these areas. Next, it is necessary to combine the images using the information. Due to space limitation, here, consider only the case where i^p has lower exposure than i^q . Thus, the underexposed area i^q of is also underexposed in i^p When i^p has higher exposure than i^q, the underexposure and overexposure are inversely treated in the following algorithm. And combined the image using the information.

III. MOTION COMPENSATION MRF MODEL:

Underexposed or overexposed. Moreover, is effective only when a scene is static. Since moving objects cause the motion blur, it is required to compensate the displacement as much as possible. The compensation is usually done by two steps, i.e., global motion and local displacement compensation steps. In our method, we assume that the global motion (e.g., motion caused by camera shake) has been already compensated by some image alignment algorithm. Here, we focus on the local displacement

compensation. The exposure times of all the images are known, and images and have been made linear to irradiance values by the photometric camera. The field is defined on the sampling lattice.

O is a binary random field that indicates whether each pixel belongs to the occlusion. Random variable $_{Ok,l}$ on each site (k,l) takes 0 or 1 according to the following rule:

$$O_{k,l} = \begin{cases} 1 & if\, i^{q}_{k,l}\, is\, in\, class\, I \\ 0 & otherwise, \end{cases} \quad (k,l) \in \Lambda \qquad \ldots 1$$

Binary process $O_{k,y}$ indicates the occlusion. The saturation is defined by the region of the underexposure and overexposure in image. i^{q} This is also a binary random field that indicates the following saturation.

$$S_{k,l} = \begin{cases} 1 & if\, i^{q}_{k,l}\, is\, in\, class\, II \\ 0 & otherwise, \end{cases} \quad (k,l) \in \Lambda \qquad \ldots 2$$

In our method, instead of O and S, we estimate complement O variables S and , which have "0" in the cases of Classes I and II respectively. Since all of these three fields mostly consist of some regions of similar values, they can be considered as the MRFs.

In our approach, we simply search the closest value within a window for the hole caused by the occlusion, whereas, in the saturated area, we do not compensate for the motion . For the regions where pixel intensities vary between images due to failure of the camera response curve estimation, we treat them the same way as the occlusion. In the end, we need to estimate the following two classes, as well as the displacement vectors:

1) Class I are regions that include the occlusion and intensity mismatch caused by the failure of the camera response curve estimation, and
2) Class II are regions of the saturation, that is, underexposure and overexposure.

Since all of these three fields mostly consist of some regions of similar values, they can be considered as the MRFs. Our estimation problem is to find the most likely fields d ,o , s and by using observed images i^{p} and i^{q} that is, maximizing the posterior probability, the posterior probability is written by,

$$= \frac{P(d,\bar{O},\bar{S}|i^{p},i^{q}}{P(i^{p})} = \frac{P(i^{p}|d,\bar{o},\bar{s},i^{q})P(d,\bar{o},\bar{s}|i^{q})}{P(i^{p})}$$

$$= \frac{P(i^{p}|d,o,s,i^{q})P(d|o,s,i^{q})P(o|s,i^{q})P(s|i^{q})}{P(i^{p})} \qquad .3$$

Since the denominator of is independent to variables and d,o,s the problem to solve is stated as the maximization of the numerator, that is, our MAP estimation is

$$\max_{d,\bar{o},\bar{s}}\{P(i^{p}|d,\bar{o},\bar{s},i^{q})P(d|\bar{o},\bar{s},i^{q})P(\bar{o}|\bar{s},i^{q})P(\bar{s}|i^{q})\} \qquad \ldots 4$$

Then, MAP estimation can be replaced by the minimization problem of the energy function From (4) and (5) can formulate the following problem

$$\min_{d,\bar{o},\bar{s}}\{U(i^{p}|d,\bar{o},\bar{s},i^{q}) + U(d|\bar{o},\bar{s},i^{q}) + U(\bar{o}|\bar{s},i^{q}) + U(\bar{s}|i^{q})\} \qquad \ldots..5$$

The second term of is a cost imposed on displacement vectors. Since the displacement generally occurs due to object movements, the displacement vectors should be smooth. Formulation of Energy Functions Since the difference in pixel values of i^{q} and its corresponding pixel in i^{p}. final HDRI while an accurate motion estimate is not necessary, use the minimum value of the following energy function as, Define the energy function as follows:

U(d|$\bar{o}$,s.i^{q})

$$\sum_{(k,l)\in\Lambda} \bar{O}_{k,l} \times \bar{S}_{k,l} \times \{ \sum_{(m,n)\in N^{2}_{k,l}} \|d_{k,l} - d_{m,n}\|^{2} \} \qquad \ldots.6$$

Where, $N^{2}_{K,l}$ is a block around center pixel (k,l). Note that we use different notations for $N^{2}_{K,l}$ since they have different sets of sites on neighborhood. In practice, we use 3✕3 blocks. The third and forth terms in are constraints on the region of O and S. Since the occlusion mainly depends on objects and the failure of the camera response curve do not happen in an isolated pixel.

IV. DISCRETE WAVELET TRANSFORM BASED IMAGE FUSION

Discrete wavelet transforms (DWT) are applied to discrete data sets and produce discrete outputs. Transforming signals and data vectors by DWT is a process that resembles the fast Fourier transform (FFT), the Fourier method applied to a set of discrete measurements.

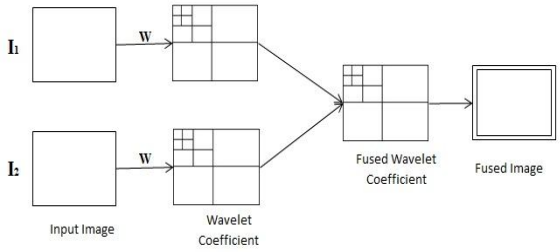


Fig 3. Fusion of the wavelet transforms of two images

These techniques are proposing an DWT fused image. The proposed technique uses DWT to decompose a image 1 and image 2 into different sub bands. Discrete wavelet transform is one of the recent

wavelet transform used in image processing.DWT decomposes an image in to different sub band images, namely low-low(LL),low-high(LH),high-low(HL),high-high(HH).adding to the image 1 and image 2 sub bands and interpolated input image are combined by using inverse DWT (IDWT).To achieve a fused image.

A. ALGORITHM IMPLEMENTATION STRATEGY

1. The image are required with different exposure setting. Assume that the exposure set by changing shutter speed.The aperture is fixed. The photometric camera calibration is performed for the input image.

2. Select the main image from the multiple exposure images. This is done by the MAP-based motion compensation method. This method acquires three images:

a) Medium Exposure
b) Over Exposure
c) Under Exposure

3. Estimate the following two classes:
Class I) Occlusion (O)
Class II) Saturation(S)

4. Then used markov Random Field (MRF) method, Estimate the following three fields:
1. Displacement vector field (d).
2. Occlussion field (O)
3. Saturation field (S)

5. Employ the post processing (image fusion),
6. Combined the image to create the HDRI.

B. Algorithm for DWT fused Image

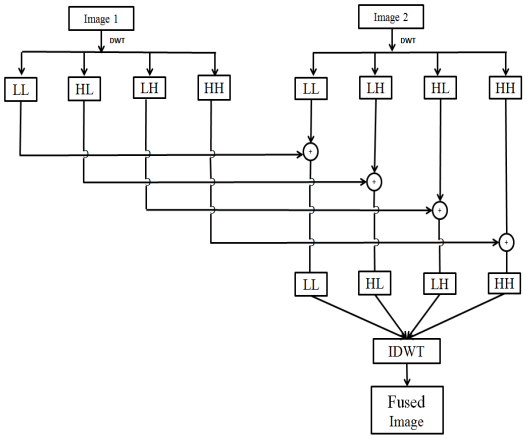


Fig 4. The proposed DWT Fused Image Algorithm

C. Fusion Matrices

1.Entropy

The images used were selected from a range of capture to the camera image provided in Matlab. A script was programmed to calculate the entropy He of an image using the equation,

$$Entropy = -\sum_{i,j=0}^{k-1} x(i,j)\log_2[x(i,j)] \quad \ldots 7$$

Where, x(i,j) is the probability of grey level l(that can be computed analyzing the image histogram) and the dynamic range of analyzed image is[0,k-1].Two further images were added to act as controls and help confirm or disprove the effect of image entropy on compression. and showing to the result of entropy.

2. PEAK SIGNAL NOISE RATIO (PSNR)

PSNR can be obtained by using the following formula;

$$PSNR = 10\log_{10}\left(\frac{R^2}{MSE}\right) \quad \ldots 8$$

Where R is the maximum fluctuation in the input images(255 in here as the images are represented by 8 bit gray scale represented have been used) and MSE (Mean Square Error) is representing the MSE between the given input image I_m and original image I_{org} which can be obtained by the following:

$$MSE = \frac{\sum_{i,j}((I_{in}(i,j) - I_{org}(i,j))^2}{M \times N} \quad \ldots.9$$

Where, M and N are the size of images.

3. Standard Deviation

The standard deviation is the most common measure of variability, measuring the spread of the data set and the relationship of the mean to the rest of the data. If the data points are close to the mean, indicating that the responses are fairly uniform, then the standard deviation will be small. Conversely, if many data points are far from the mean, indicating that there is a wide variance in the responses, then the standard deviation will be large. If all the data values are equal then the standard deviation will be zero. The standard deviation is calculated using the following formula,

$$S = \frac{\sqrt{\Sigma(X-M)^2}}{n-1} \quad \ldots. \quad 10$$

Where, Σ= Sum of, X = Individual data point, M=Mean of all data point, n = Sample size (number of data point).

Mean (M)

The mean is the sum of the observations divided by the number of observations. The mean is calculated using the following formula,

$$M = \frac{\Sigma(X)}{N} \quad \ldots 11$$

Where, Σ= Sum of ,X = Individual data points ,N = Sample size (number of data points).

4. TONE MAPPING-(scaling of illuminanace information)

A luminance scaling (i.e. tone mapping) function to brighten the darker regions of the image and a local tone mapping function to suppress the resulting over-

exposed, brighter regions of the image. The tone mapping module commences by applying a luminance scaling process to the lowly-exposed image, to generate an initial middle-gray tone image. Since I_L contains under-exposed darker regions, it is necessary to apply a greater scaling effect to the darker regions to brighten region.

$$\bar{L}_k = \exp\left(\frac{1}{N}\sum_{x,y}\log(\delta + L_k(x,y))\right), \qquad L_k \in \{L_L, L_H\}$$

$$L(x,y) = \alpha\frac{\bar{L}_H}{\bar{L}_L}L_L(x,y) \qquad \ldots.12$$

Where, $\bar{L}_I$ and $\bar{L}_H$ are the log-average luminance of I_L and I_H respectively, and are used to objectively measure whether the scene has a low-gray, middle-gray or high-gray tone. N is the total number of pixels in I_L or I_H and ∂ is a very small value used to avoid the unreasonable log 0.

L_L (x,y) is the luminance value of pixel (x,y) in L_L and is normalized to the interval [0, 1].
the luminance of the L_L low-exposed image is scaled to an overall luminance L .The luminance images of two typical lowly- and highly-exposed images (i.e., L_L and L_H , respectively) and shows the corresponding globally-scaled luminance image (i.e., L).

V. WORK IMPLEMENTED

The proposed methods generate three Images, a) Normal Exposure Image, b) Under Exposure Image, c) Over Exposure Image. Using histogram stretching. Normal Exposure Image, Under Exposure Image and Over Exposure Image

Camera capture to Image I

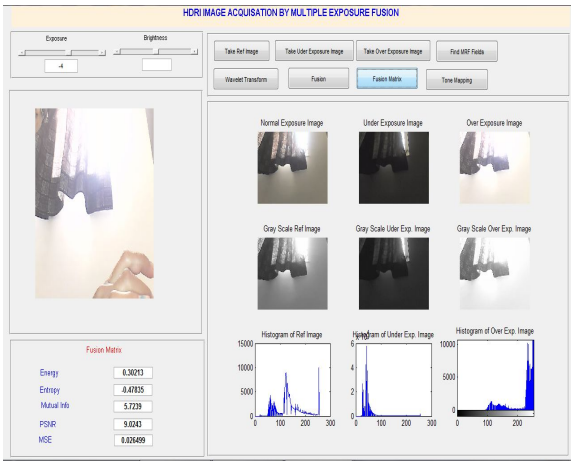
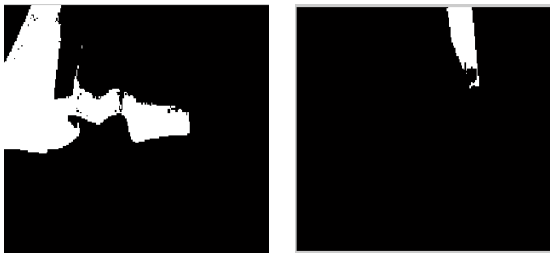


Fig5.Multiple Exposure Images I. (a) Normal Image (Histogram),(b) Under Exposure Image (Histogram),(c) Over exposure Image (Histogram).

In this experiment, used three set of images called normal exposure, under exposure, over exposure of size 640×480. Image sequence consists of different exposures in the presence of camera motion. Current high dynamic range technique uses multiple Exposure images that are acquired using different exposure times. The histogram three images are shown in fig 5 Because each image is captured with different exposure, the corresponding histogram are based towards a particular luminance range, which means that the dynamic range is limited to corresponding brightness level. Fig.5 most images acquired by a consumer images device are capture under various dynamic environments.

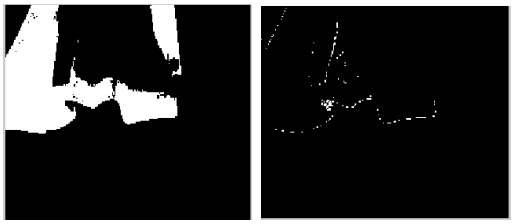
Histogram is a graphical representation of the pixels exposed in your image. The left side of the graph represents the blacks or shadows, the right side represents the highlights or bright areas and the middle section is mid-tones. How high the peaks reach represent the number of pixels in that particular tone. Each tone from 0-255 (o being black and 255 being white) is one pixel wide on the graph, so imagine the histogram as a bar graph all squished together with no spaces between each bar.

Saturation and occlusion field
Under exposed and over exposed portion of Image 1



(a) Under Exposed Portion **(b) Over Exposed Portion.**

Result-Saturation and Occlusion field of Image 1



(c) Saturation Field. **(d) Occlusion Field**
Fig 6. Occlusion and Saturation field.

Fused Image using DWT

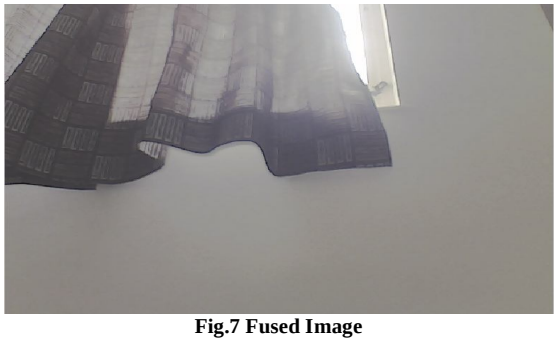


Fig.7 Fused Image

Our result shows from fused image and tone mapping images. Image fusion is the process that combines information from multiple images of the same scene. Implement Discrete Wavelet Transform on both the source images to create wavelet lower decomposition. Fuse each decomposition level by using different fusion rule like simple average, simple maximum ,simple minimum,(i.e. LL,LH,HL,LL)etc. Carry Inverse Discrete Wavelet Transform on fused decomposed level, for reconstruction on of final fused image.

Tone Mapping



Fig.8 Tone Mapping

Tone mapping attempting to reproduce real scenes characterize by a wide luminance range on display device with only a limited capability, over exposure show in fig.8 the brighter region are well exposed at expense on the darker region of the image which are under exposed As a result, the details in the brighter regions are accurately recorded, but the recorded color information in the darker regions is noisy or lost. In this case, the darker regions of the scene are well-exposed, but the brighter regions are overexposed. tone mapping scheme is required to map (or com-press) the high dynamic range (HDR) luminance of the real world scene to the low dynamic range (LDR) luminance capabilities of the display device in order to accurately reproduce the realistic image.

TABLE I

Results for Reference, Under Exposure and Over Exposure Image of size 640 × 480, used parameter mean, standard deviation, energy, entropy, contrast and variance

	Mean	Std	Energy	Entropy	Contrast	Variance
Reference Image	136.061	47.449	0.0467	-4.7893	0.1361	0.4314
Under Exposure	48.8718	28.578	0.0372	-1.3843	0.0718	0.3348
Over Exposure	223.823	44.452	0.0376	-8.6068	0.1483	0.4175

TABLE II

Energy	0.30213
Entropy	-0.47835
Mutual Info.	5.7239
PSNR	9.0243
MSE	0.026499

Matrix Fusion

Result for fusion matrix Image-I under Exposure and over Exposure.

CONCLUSION

In this method, multiple image-based HDRI using local histogram stretching. As over-exposed, normal-exposed, and under-exposed images, from a multiple input image using local histogram stretching.HDR image by fusing three local histogram stretched images. For this reason the method provides easy acquisition using a camera capture images using a tripod for acquiring images, the MAP based method estimate occlusion, saturation portion of the images and then construct the HDRI by moving artifacts. The method can compensate for effect of motion, the occlusion and the saturation and can obtain motion blur free HDRIs.DWT to decompose an image into different sub band images have been interpolated. An image is interpolated with half of the interpolation factor used for interpolation the high frequency sub bands. After wards all this images have been combined using IDWT to generate the super resolved imaged (i.e. fused image).Shows to the result for fusion matrix and under exposure, over exposure and reference image.

Publications based on the work
Publications in Journals

1. Varsha Borole*,Dr.Y. S Angal, “Color SensitivityMultiple Exposure Fusion using High Dynamic Range Image”,Journal of Engineering Research and Applications ISSN : 2248-9622, Vol. 4, Issue 2(Version 1), February 2014, pp.734-736.

EPGCON paper publication

2. Varsha Borole, Dr.Y.S.Angal,“High Dynamic Range Image Acquisition by Multiple Exposure Fusion”, EPGCON PAPER PRESENTATION in k.k. Wagh COE Nashik.pp.166.

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