# A REVIEW ON MULTICAMERA IMAGE QUALITY ANALYSIS

Mahesh G. Chinchole, Sanjeev N. Jain,
Student, Professor, chinchole.mahesh@gmail.com, sanjeev_n_jain@yahoo.com, 09579163885

**Abstract—** Image quality analysis is one of the most important measures in image research. The Objective of quality analysis is to check quality of an image or to provide a better transform representation for future automated image development. The image can be view in two way as single view or single camera image and multiview or multicamera image. The quality of image can be assessed in two ways subjective & objective. In several last year's various subjective & objective methods have been developed for image quality analysis but for single camera images. No such research has been made on multiview or multicamera images. As per the rising demand of multiview applications, the development of this era is becoming fundamental step. The quality of multicamera image can be influence by various factors such as camera features, its calibration process, & number of cameras used for capturing the event with their orientation. In multicamera image there are basically two types of distortion are identified, Photometric distortion & Geometric distortion. The relative distortion difference between two or individual camera images is the main factor while evaluating the required quality of final image. Both the distortion can be measured in terms of index as Luminance, contrast, spatial motion & edge-based structural. Then these entire indexes are combined and processed to get the perceived quality of multicamera image. This paper will provide a review on various image quality analysis techniques with various quality parameters and various types of distortion in the image.

**Keywords** — VGA, FTV, PSNR, SSIM, MSE, MSSSIM, VSNR, MIQM.

## INTRODUCTION

From a last decade, the electronics and computing technology are rapidly developing. As per the demand from the consumers they are taking the rapid growth but with this growth their cost are also rapidly decreasing. Day to day, the application requirement of the customers is also rapidly increasing. If we consider the multimedia products then for capturing the scenario high quality cameras are required. So to satisfy the demand, the features of the cameras must increase to use them in various applications like video conferencing, sight-seeing, advertisement, security, medical etc. [1] [2].

Digital images are undergoes wide range of variety of distortions during image acquisition, image processing, compression, storage, transmission & reproduction of image any of which results in degradation in a visual quality. [3] [4]. The distortion is also created due to camera shake during exposer creating motion blur which prevents from obtaining high quality images [5].

As electronic field is fast growing, so step by step there is improvement in quality of image due to improvement in camera configuration. In the past we use video graphics accessories (VGA) camera but due to improvement in camera configuration today we are using the high definition cameras [6]. If we talk about the image quality, the quality of an image can be determined in two ways: Subjective & Objective [1] [6] [7]. In recent years, there is large interest in creating objective image quality analysis methods which automatically predicts human behaviors in calculating image quality. Such measures have large applications in the evaluation, control, design & optimization of image acquisition, communication, processing & display system. According to availability of reference image, they can be classified as full reference, reduced reference & no reference algorithm. In full reference, the reference image is fully accessible while evaluating the distorted image. In reduced reference only partial information about the reference image is available. In no reference no access to original image [8]. The aim of the multicamera image system is to boost the consumers understanding further than the service provided by single camera system. The multi-view video is a succession of images captured by different cameras at different locations [9]. The examples of multicamera image are not only panoramic videos or images but also in FTV (free view point), 3DTV & stereoscopic videos as well as pictures [10].In Panoramic videos, the basic image plane is increased to cover the larger areas with increased in other planes like cylindrical & spherical [9]. In Panoramic video applications, multiple cameras are used to capture a particular scene. The outputs of these cameras are then combined to emulate the performance of a much costlier multi mega pixel wide angle video camera. In stereoscopic video two cameras are used to capture two views of an object from slightly different positions. Then a 3 D impression of these scene is created by projecting the 2 D slightly different scene on the retina of each eye. The human brain creates the impression of depth through physiological fusing of the stereoscopic pairs [1][9]. Even though each of the earlier mentioned applications suffers from artificial visual artifacts that are exclusive to its mean of presentation, they all share similar acquirement apparatus and pre-compositing processing block. The acquirement apparatus involves multiple cameras placed under specific arrangement to capture multiple views of a actual world picture. The captured pictured are then calibrated photometrically and geometrically before being composited to display. Many Different views captured by multiple different cameras may vary in terms of color, brightness, noise level, and direction. The calibration process derives the necessary information to map each of the views dimensions into the real world or the reference view dimensions. The apparent scene for each of the multicamera applications is an output of the compositing algorithm, which is normally a function of the captured scenes, camera calibration, and scene geometry. Hence, defining a single quality measure that would capture the apparent quality of all multicamera applications is impossible considering the difference in the means of presentation and the view compositing algorithms for each application[1][2][3].

## DISTORTION TYPES IN MULTICAMERA IMAGE SYSTEM:-

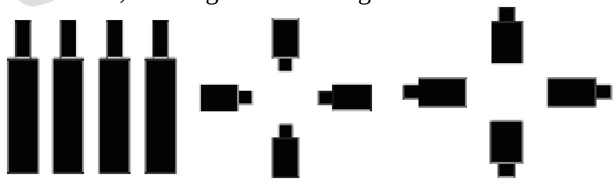
Distortions in multicamera system can be classified as photometric & geometric distortion. As we discussed earlier the distortion in multicamera images are measured interms of luminance & contrast index, spatial motion index and edge based structural index. The photometric distortion are mostly measured by the luminance & contrast index & edge based structural index while geometric distortion are measured by spatial motion index and edge based structural index. Each distortion has the different impact on the overall image quality. Now to get the high quality image we will distinguish both the distortions & their impact on the multicamera images in details [1] [9].

**Photometric Distortion:** When in a image its features decreases which attracts the human visual attention e.g. blur, noise, color gamut, motion blur then such a distortion is known as photometric distortion. In a Multicamera system, the photometric distortions are the visible variations in brightness levels & color gamut across the entire displayed image due to nonuniformility between individual camera properties or the post processing applications like compression, such a distortion can be called as variational photometric distortion. The examples of the photometric distortion are given here.

(a) No distortion (left), compressed (right). (b) Blurred (left), blurred (right).
(c) Blurred (left), compressed (middle), no distortion (right). (d) Compressed (left), no distortion (middle), compressed (right).

**Fig.1. Examples of photometric distortion**

**Geometric Distortion:** For a multicamera system a particular scene can be captured by multiple number of cameras with every camera having different positions and configurations. Some of the different camera configurations are shown here. Fig. 2 shows three possible camera configurations, i.e., parallel view, convergent and divergent view.



a) Parallel. b) Convergent c) Divergent

**Fig. 2 Three possible camera configurations, i.e., parallel view, convergent and divergent view.**

Due to different camera configurations and errors in estimating the camera parameters can create the geometric distortion. The geometric distortion means the visible structural misalignments and discontinuity in the observed image due to geometric errors. The geometric distortion can be defined in two ways by planner distortion and perspective distortion. The planner geometric distortion

occur during rotation and translation of the image while perspective distortion occurs during mapping of image from 3 D plane to 2 D plane of the image [9].
Fig. 3 shows two examples of geometric distortions in multicamera images.

(a) Original (b) Planar (rotation). (c) Perspective.(no distortion).

**Fig. 3. Example of geometric distortion in a single-view image.**

The image Fig. 4(a) is composited of two sub-images with a 5% overlap. The left view of image Fig. 4(a) was, respectively, distorted whereas the right view was left undistorted prior to renewal. The result is rigorous perceptual distortion that is very obvious on the face. The image Fig. 3(c) is comprised of three sub-images with a 20% overlap between every two adjoining views. Two levels of perspective and planar distortions were applied to the left and right views, respectively. The center view is undistorted. The resulting multiview image has noticeable misalignments and discontinuities. Hence, the geometric distortions in single camera translate to misalignment and discontinuities in the reconstructed multiview image. Unlike photometric distortions where distortions translate as abrupt changes that occur across the whole image, geometric distortions attract perceptual attention especially around connecting edges and overlapping areas. Geometric distortions in single-view images have been considered in. The authors proposed a complex wavelet domain image similarity that is insensitive to spatial translations. The proposed model assumes that single-view image perceptual distortions caused by spatial scaling, rotation, and translation are irrelevant. Though, this assumption is not accurate for multicamera images, where discontinuities, misalignments, blur, and double imaging can result in catastrophic distortions. Therefore, a rigorous multicamera image visual quality assessment must account for geometric distortions[1][2].

(a) Perspective. (b) Planar (rotation).

**Fig.4. Example of geometric distortion in multicamera images.**

**IMAGE QUALITY ANALYSIS**: The image analysis is concern with the extraction of measurement, data or information from an image by automatic or semiautomatic methods. The image analysis is distinguished from other types of image processing such as coding, restoration, and enhancement. In image analysis system the ultimate output is usually numerical output rather than picture or image. [11]. The techniques used for extracting information from an image are known as image analysis techniques. An image composed of edges and shades of gray. Edge is corresponding to fast change in gray level and thus corresponds to high frequency information. Shade is corresponds to low frequency information. Separation (filtering) of high frequency information means edge detection. An edge or boundary is the external information of image. The internal features in an image can be found using segmentation and texture. These features depend on the reflectivity property. Segmentation of an image means separating certain features in the image. While treating other part as a background if the image consists of a number of features of interest then we can segment them one at a time. Texture of an image is quantitatively described by its roughness. The roughness index is related to the spatial repetition period of the local structure. It is necessary to segment the image based upon uniform texture before its measurement. Image feature is a distinguishing characteristic of an image. Spectral and spatial domain is the main methods used for feature separation Motion of an object studied from study of multiple images, separated by varying periods of time [12].

**TECHNIQUES USED FOR IMAGE QUALITY ANALYSIS:**

**1. Morphological Image Processing:** In Morphological Image Processing the spatial form or structure of objects within an image are modified. Morphological technique is a powerful technique to extract features from an image. In Morphological Image Processing Dilation, erosion, and skeletonization are three basic Morphological operations.

**i) Dilation:** In dilation an object grows constantly in spatial level. The dilation process thickens the image. The structuring element decides the amount to which the image should be thickened. The structuring element is a part of the image. The morphological transformation dilation (+) adds two sets using vector addition. The dilation process can be done by performing vector addition of the pair of elements for both the sets X and B.

Example:

X ={(1,0),(1,2),(1,2),(2,2),(0,3),(0,4)}
B = {(0, 0), (1, 0)}
X(+)B = {(1,0),(1,2),(1,2),(2,2),(0,3),(0,4),(2,0),(2,2),(2,2),(3,2),(1,3),(1,4)}

The input image as shown below in Fig. (5) and the dilated image is as shown in Fig(6)


Fig(5): Input Image


Fig(6):Dilated Image

**ii) Erosion**: In erosion an object shrinks constantly. The structuring element decides the extent to which the image should be shrinks. Erosion (-) combines two sets using vector subtraction of set elements is the dual operator of dilation. Both erosion & dilation are not an invertible transformation.

Example:

X={(1,0),(1,2),(1,2),(2,2),(0,3),(0,4)}
B={(0,0),(1,0)}
X(-)B = {(0,3),(1,3),(2,3)}

The result of Erosion operation with a disk of radius 2 is shown in Fig.(7) & the result of Erosion with a disk of radius 8 is shown in Fig. (8).


Fig(7):Erosion with a disk of radius 2


Fig(8):Erosion with a disk of radius 8

**iii) Skeletonization:** Skeletonization outcome in a stick figure representation of an object.

**2. Hit-or-miss transformation:** To find the local patterns of pixels, the hit-or-mass transformation is used. It is the morphological operator that finds collections of pixels with certain shape properties such as corners, or border points. The hit-or-miss transformation operates as a binary matching between images X and the structuring element (B1, B2).

It can be expressed by using erosion and dilations as[13]:

X (x) B = (X (-) B1) ∩ (Xc (-) B2) = ( X (-) B1 ) \ (X (+) B2)

**3. Texture Analysis:** Texture can be defined as the properties that represent the surface or structure of an image. In another way it cab be also defined as 'It is the repeating pattern of local variations in image intensity.'

The Texture analysis can be done in three ways:

**i) Structural approach:** Structural approach represents structure by well defined primitives and a order of spatial arrangements of those primitives. It provides good symbolic description of the image[12].

**ii) Statistical approach:** In contrast to structural approach , statistical approach do not attempt to understand explicitly the hierarchical structure of the texture[12].

**iii) Model-based approach:** In Model based texture analysis, attempt using fractal and stochastic, attempt to interpret an image texture by use of, generative image model and stochastic model correspondingly. The model parameters are estimated and then used for image analysis [12].

**4. Edge Detection Method:** An edge map array E(j, k) is produced by some edge detector , such that E(j, k) = 1 for a detected edge and E(j, k) = 0 if not. Thus texture measure is defined as

$$T(j, k) = \frac{1}{w^2} \sum_{m=-w}^{w} \sum_{n=-w}^{w} E(j+m, k+n)$$

Where w is the dimension of the observation window [12].

**5. Autocorrelation Methods:** A region of texture will exhibit a higher correlation than a region of fine texture. Thus texture coarseness should be proportional to the spread of the autocorrelation function.

The Autocorrelation function can be stated as

$$A_F(m, n) = \sum_j \sum_k F(j,k) F(j-m, k-n)$$

For a computation over a w × w window with $-T \leq m, n \leq T$ pixel lags[12].

**6. Mean Square Error (MSE):** In MSE an error signal is obtained by subtracting the test signal from the reference and then calculating the average energy of the error signal. The MSE is the simplest and most extensively used, full reference image quality measurement. It is given by [14][15]

$$MSE = \frac{1}{MN} \sum_{i=1}^{M} \sum_{j=1}^{N} (x(i,j) - y(i,j))^2$$

**7. Peak Signal Noise Ratio (PSNR):** PSNR is the largely used objective metric because of its clear meaning & less complication. It quantifies the quality of the image by measuring the error in intensity between two different images[1]. In between reference image & test images PSNR is simple function of the (MSE) mean squared error which provides a baseline for objective image analysis. It is defined as it is the ratio of maximum possible power to corrupting noise which affects illustration of image[14][15]. It is given by in db as:

$$PSNR = 10 \log_{10} \frac{(2^n - 1)^2}{\sqrt{MSE}}$$

**8. Structural Similarity Image Metric (SSIM):** An alternative & complementary approach provided by the structural similarity index metric to the image quality measurement. SSIM proposed by [1] & [2] is based on the assumption that human visual system is extremely personalized to extract structural information from the viewing scenario [15]. Structural Similarity Image Metric (SSIM) is a very famous method for quality measurement of motionless images. The SSIM index has been applied pixel by pixel or window by window or frame by frame and the overall index will be calculated as the average of one of the quality scores. [14][15].

The SSIM is defined as

$$SSIM = l_{i,j}^{\alpha} \; c_{i,j}^{\beta} \; s_{i,j}^{\gamma}$$

Where $l_{i,j}$ & $c_{i,j}$ are the luminance & contrast comparison function of i & j computed, $s_{i,j}$ is the structure comparison function of i & j computed.

The metric $S_{i,j}$ of all macroblocks can be calculated as

$$S_{i,j} = \frac{\sigma_{ij} + C_2}{\sigma_i \sigma_j + C_2}$$

$\sigma_{ij}$ is the correlation coefficient(CC) between i & j. $C_2$ is a constant avoid instability when the denominator tends to zero. α, β, & γ are three positive parameters used to adjust the relative importance of the three component [1][14][15].

**9. Multi scale SSIM (MS-SSIM):** This method is an extension of the SSIM, also proposed for the motionless images. It also applied pixel by pixel or window by window or frame by frame on the luminance component of the image and the overall MS-SSIM index will be computed as average of the above quality score.[1][14][15]

**10. Visual Signal to Noise Ratio (VSNR):** This is also one quality measurement method and used for motionless images. It also applied pixel by pixel or window by window or frame by frame on the luminance component of the image and the overall MS-SSIM index will be computed as average of the on of the above quality score.[12]

## LATEST METHOD FOR IMAGE QUALITY ANALYSIS:-

**Multicamera Image Quality Measure[MIQM]:-**

The Quality analysis of multicamera images can be complete by three index measures name as Luminance and Contrast Index, Spatial Motion Index, and Edge-Based Structural Index. There are various multicamera applications [1]. In this a single camera is typically selected as a reference for estimating the imaging plane or geometry [1][3]. The measures which are present are full-reference and aim at assessing the image quality for multicamera systems. Here the reference is defined as the set of images captured by perfectly the same set of cameras, and the planes of these cameras are perfectly united horizontally and vertically with the camera selected to be the reference for the imaging plane or geometry[1].

## A. Luminance and Contrast Index

This index measures sudden local change in luminance and contrast around structured regions. Such changes are common in multicamera images. Multicamera images captured by cameras looking at different parts of the scene are subject to non-uniform levels of distortion due to the difference between different cameras or different levels of view processing. To capture such variation, a measure that is a combination of luminance $L_{I,J}$ and contrast $C_{I,J}$ comparison functions is used, and it is adjusted to give higher weights for structured regions. Let $L_{I,J}$ be the luminance comparison function, between the two images $I$ and $J$ , computed to each macroblock in the images. The matrix $L_{I,J}$ of all macro blocks is calculated as follows:

$$L_{ij} = \frac{2\mu_i \mu_j + C_1}{\mu_i^2 + \mu_j^2 + C_1}$$

Similarly, the matrix $C_{ij}$ of all macroblocks is calculated as:

$$C_{ij} = \frac{2\sigma_i \sigma_j + C_2}{\sigma_i^2 + \sigma_j^2 + C_2}$$

where $C_{ij}$ is the contrast comparison function between $I$ and $J$ computed on each macroblock.

where $I$ is the original image and $J$ is the distorted image; $\mu_i$ is the mean intensity of image $I$, and $\sigma_i$ is the standard deviation of the intensity values of $I$. The mean and standard deviation are all calculated on the macroblock level. $C_1$.and $C_2$ are constants included to avoid instability when the denominator is close to zero[1].

## B. Spatial Motion Index.

Due to the pixel shifting the geometric distortion are occur in multicamera images compare to reference image. In this a motion vectors are used to evaluate the pixel shifting compare to reference image. The motion vector $v = [v_m, v_n]$ at a macroblock location $[1+ms, 1+ns]$ of the distorted image $J$ relative to the reference image $I$ is evaluated over a area of $p \times p$. The values of displacement are then normalized leading to the relative motion inductor at $[m, n]$ is computed as:

$$\eta[m, n] = \frac{\sqrt{\upsilon_m^2 + \upsilon_n^2}}{\sqrt{2p^2}}$$

Due to the changes in intensity values in photometric distortions nonzero motion inductor values are obtained which are random and spatially inconsistent while in geometric distortions motion vectors are spatially consistant. The entropy $\varepsilon[m, n]$ of $\eta[m, n]$ values at $[m, n]$ is calculated within a spatial window of $w \times w$ macroblocks for $w >> p$ as:

$$\varepsilon(m, n) = -\sum_{i=0}^{L} p(\eta_i) \log_2 (p(\eta_i))$$

where $L$ is the number of distinct inductor values. Then the motion consistency index can be calculated as by multiplying relative motion inductor at each macroblock, $\eta[m, n]$, with the entropy as[1]:

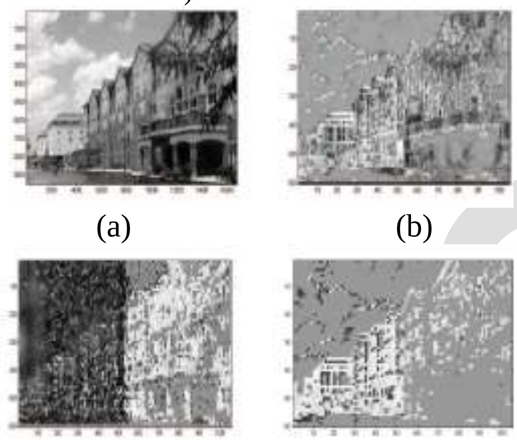
$$\varsigma(m,n) = \varepsilon(m, n)\, \eta(m,n)$$

## C. Edge-Based Structural Index.

The structural information might loss due to photometric & geometric distortions. Such loss includes degradation in texture quality or lost image components on intersection or overlapping areas. The locations of variations of intensity values and the relative intensity values at these locations are known as spatial edges. When an image is blurred or quantized the locations of the spatial edges are conserved; however, the intensity values of these edges change. In geometric distortions, such as translations and rotations, the spatial edge locations change where there relative intensity is preserved. Hence, by comparing the local edge information, the loss of structural information due to both photometric and geometric distortions can be captured. To calculate the edge-based structural index, reuse the mapped texture randomness index. For $M \times N$ total macroblocks, the index is computed as follows:

$$E_{ij} = \frac{1}{MN} \sum_{m=0}^{m} \sum_{n=0}^{n} \left( 1 - \left| \frac{T_i[m.n] - T_j[m.n]}{T_i[m.n]} \right| \right)$$

$E_{i,j}$ values range between 1 for minimum distortion and 0 for maximum distortion. It is observed from Fig. 9 (d) that the structural losses represented by the edge-based structural index are mainly concentrated on the blurred view at the right; notice that the majority of the pixels are gray indicating structural losses. The figure also shows some scattered dark pixels on the left side. These pixels are caused by the geometric distortions. Structural losses in geometric distortions may occasionally occur around a macroblock boundary in a low-structured region (the clouds region in the left view).



(a) (b)

(c) (d)

Fig.(9) Index maps. (a) Distorted multiview image. (b) Luminance and contrast index map. (c) Motion index map. (d) Edge-based structural index map.

Also the blur in the image can be removed by the equation of a Gaussian function is:
In one dimensions,

$$G(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2}{2\sigma^2}}$$

In two dimensions, The equation of a Gaussian function is:

$$G(x, y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{x^2+y^2}{2\sigma^2}}$$

The index mentioned in the above section are combined over a various or all proportions to get a single quality measure that summarizes the visual distortions in multiview images. The MIQM is given as multiplication of all above:

$$MIQM_{i,j} = LC_{i,j}\, S_{i,j} E_{i,j}$$

The MIQM values ranges between 1 for minimum distortion and 0 for maximum distortion [1].

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## CONCLUSION

In this paper we study the different types of distortion in Multicamera images, their assessment by using the techniques like Morphological Image Processing, Hit-or-miss transformation, Texture Analysis, Edge Detection Method, Autocorrelation Methods, MSE, PSNR, SSIM, MSSSIM, VSNR and finally by MIQM in objective ways. We Observed that MIQM shows the large range of Image Quality analysis i.e it analyses the image interms of Luminance and contrast index, Spatial Motion index and in Edge-Based Structural Index.

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