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A Study on Multi Camera Image Quality Analysis

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Abstract: As Image quality analysis is one of the most important measures in image research. The Objective of quality analysis is to check the quality of an image or to generate a better transformation for future automated image development. The quality of image can be monitored in two ways that is subjective & objective. In the past years various subjective & objective techniques have emerged for image quality analysis but those are valid for single camera images. Very less work has been done in quality assessment of Multi-camera images. The quality of multicamera images can be influenced by various factors such as camera features, calibration of camera, and number of camera units used for capturing the event. Multicamera images have two types of distortions: - a) Photometric distortion & b) Geometric distortion. The relative distortion between two or individual camera images are the main factor while evaluating the required quality of final image. Both these distortion can be measured in terms of index as Luminance, contrast (LC index), spatial motion (SM) & edge-based structural. The entire indexes are then combined and processed to obtain the perceived quality of multicamera image. This work describes a review on different image quality analysis techniques with different quality parameters and various types of distortion in the image.

Keywords: PSNR, SSIM, MSE, MSSSIM, MIQM.

I. INTRODUCTION

In the previous decade, multi-view images have gained tremendous interest which satisfied the demand for advanced multimedia products. Applications in the field of surveillance, advertisement, distance learning, medical training, and entertainment are the core areas which got benefited. The key advantage of multi-view applications is its interactivity where the user can define the viewpoint within the captured scene. In the last decade, subjective evaluation has been dominant over performance metric in multi-view videos and image processing. Ideally, image and video quality are best assessed through subjective evaluation, but the use of subjective testing are inefficient and time consuming hence subjective methods are not applicable in environments which requires real-time processing.

Therefore, the definition of an objective metric or set of metrics that can predict the perceived quality of images and videos in multi-view applications are vital to the development of these applications. Due to the nature and applications of multi-camera systems there are some multi-view distortions which are not common in single-camera images and videos. In [1], distortion types are characterized and examples showed that single-view objective image quality measures are not adequate for multi-view perceptual quality assessment. This paper describes that geometric and photometric distortions can be analyzed in terms of luminance, contrast, spatial motion and edge-based structure components.

II. DISTORTION TYPES IN MULTICAMERA IMAGE SYSTEM

Distortions types in multicamera system can be differentiated as photometric & geometric. As discussed the distortion in multicamera images are measured w.r.t luminance & contrast index (LC), spatial motion index (SMI) and edge based structural index (EBSI). The photometric distortion are mostly measured by the LC index & EBS index while geometric distortion are measured by spatial motion index (SM) and edge based structural index (EBS). Each distortion has different impact on the overall image quality. To get the high quality image, we will distinguish both the distortions & their impact on the multicamera images in details [1] [9].

Photometric Distortion:
Photometric distortion in a single camera image is defined as the breaking down of video quality that attracts visual attention, such as video noise, blur in picture, and artifacts. Photometric distortion can be intrinsic which is a part of the video signal due to the acquisition device or it may be extrinsic due to applications, such as lossy compression, transmission over distorted line. In multi-camera systems, photometric distortions are the visible variations in brightness levels and color gamut which are observed on the entire displayed image. The source of this variation can be the non-homogeneity between individual camera properties or the post production applications, such as compression. This type of distortion is called Variational Photometric Distortion (VPD).

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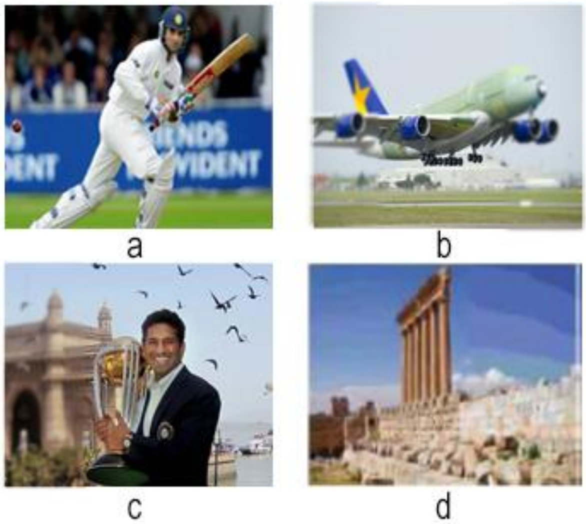


(a) No distortion (left), compressed (right). (b) Blurred (left), blurred (right). (c) Blurred (left), compressed (middle), no distortion (right). (d) Compressed (left), no distortion (middle), compressed (right).

Fig.1. Examples of photometric distortion

Geometric Distortion:
The geometric distortion can be defined as the shifting of pixels or overlapping of pixels on each other in the image. For a multicamera image the particular scene is too captured by number of cameras from different positions or by different angles. The example of such system is shown in figure.1.
The fig. 1 shows the three different cameras configurations which are placed to capture the event. As due to different camera positions with different angles in short with different orientations with camera calibration parameters the geometric distortions will be created in creating the multicamera images.

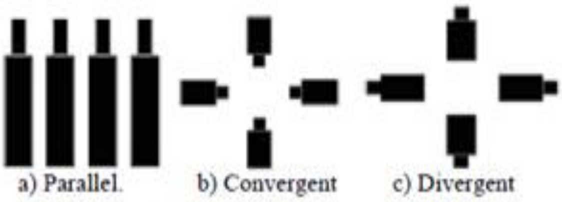
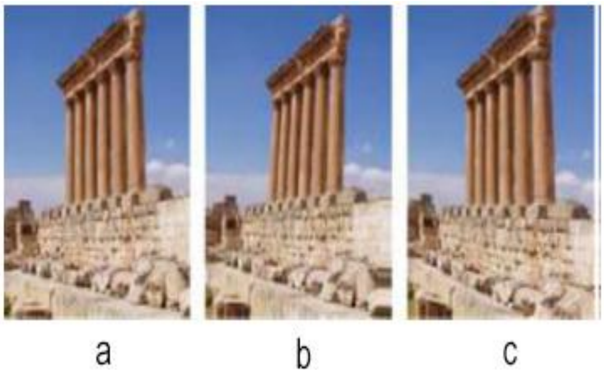


Fig. 2 Three possible camera configurations, i.e., parallel view, convergent and divergent view.

The geometric distortion can be stated as the shifting of pixels or overlapping of pixels on each other on the image. In a multicamera image specific scene is captured by number of cameras from different positions or from different angles. The example of such a system is shown in figure.1.
The figure shows three different cameras configured and placed to capture an event. Due to different camera positions and different angles in short with different orientations and with camera calibration parameters, the geometric distortions will be created in creating the multicamera images.

The Geometric distortion can be divided in two ways:- linear geometric distortion and angular geometric distortion. The linear geometric distortion occurs during the rotation and translation in motion. In this position the pixels gets shifted or overlapping of pixels happened. The angular geometric distortion occurs during the mapping like 3-D plane to 2-D plane. 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

IMAGE QUALITY ANALYSIS
The image analysis is connected with the extraction of data measurement or information from an image by automatic or semi-automatic methods. The image analysis is differentiated from other types of image processing such as coding, restoration, and enhancement of the image. In an image analysis system the final output is usually numerical output rather than a picture or image. [11].

The method used for extracting information from an image is known as image analysis techniques. An image composed of edges and shades of gray edge corresponding to fast change in gray level and thus corresponds to high frequency information. Shades in the image correspond to low frequency information. Separation (filtering) of high frequency information means edge detection. An edge is the external information of image. The internal features in an image can be found using texture and segmentation. These features depend on the reflective property. Segmentation of an image means separating certain features of the image, while treating other part as a background. If the image consists of a number of features of interest then we segment them one after the.

Texture of an image is quantitatively described by its roughness and is related to the spatial repetition period of the local structure. It is necessary to segment the image based upon the uniform texture before measurement. Image feature is a distinguishing characteristic of an image. Spectral and spatial domain are the main methods used for feature separation Motion of an object studied from multiple images, separated by varying periods of time. [12].

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Fig.4a Original Image

Fig. 4b Distorted Image (Photometric)

QUALITY PARAMETER CALCULATION

Texture index: Texture index includes mostly two algorithms SSIM and MSSIM the SSIM algorithm is considered a single-scale approach that achieves its best performance when applied at an appropriate scale. Moreover, choosing the right scale depends on the viewing conditions, for example viewing distance and the resolution of the display. Therefore, this algorithm lacks the ability to adapt to these conditions. This drawback of the SSIM algorithm motivated researchers to design a multi-scale structural similarity index (MS-SSIM). The advantage of the multi-scale methods, like MS-SSIM, over single-scale methods, like SSIM, is that in multi-scale methods image details at different resolutions and viewing conditions are incorporated into the quality assessment algorithm. In MS-SSIM algorithm after taking the reference and test images as input, this algorithm performs low-pass filtering and down sampling (by factor of 2) in an iterative manner.

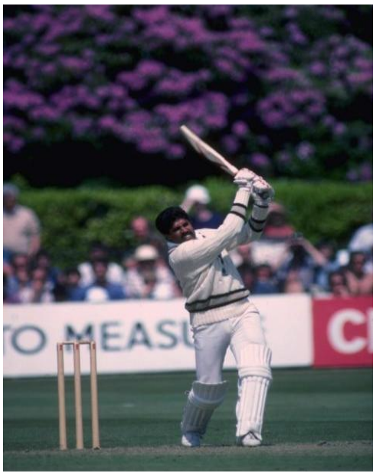

Figure 5a: Original Image

Figure 5b: Distorted Image (Geometric)

Visual information fidelity (VIF):

VIF algorithm models natural images in the wavelet domain using Gaussian scale mixtures (GSMs). Images and videos that are taken from natural environment by using high quality capturing devices operating in visual spectrum are classified as natural scenes. A simple ratio of the two information measurements relates very well with visual quality

$$VIF = \frac{\sum_{j \in subbands} I(\vec{C}^{N,j}; \vec{F}^{N,j} \mid s^{N,j})}{\sum_{j \in subbands} I(\vec{C}^{N,j}; \vec{E}^{N,j} \mid s^{N,j})}$$

There is simple method to calculate VIF by extracting diagonal of correlation coefficient matrix between two images to be compared.

The correlation coefficient matrix of n random variables X1, ..., Xn is the n × n matrix whose i,j entry is correlation (Xi, Xj), If the measures of correlation used are product-moment coefficients, the correlation matrix is the same as the covariance matrix of the standard random variables Xi / σ (Xi) for i = 1, ..., n. This applies to both the matrix of correlations ("σ" is the population standard deviation), and to the matrix of sample correlations ("σ" denotes the sample standard deviation). Consequently both matrix are a positive-semi-definite matrix.

The Correlation Coefficient Matrix (CCM) is symmetric because the correlation between Xi and Xj is the same as the correlation between Xj and Xi.

PSNR/ MSE:

The Peak signal to noise ratio is an engineering term for the ratio between the maximum possible powers of a signal to the power of noise that affects the fidelity of its representation. Since signals have a wide dynamic range, Peak signal to noise ratio is reffer in logarithimic decibel scale.

Peak signal to Noise ratio is most commonly used to measure the quality of reconstructed lossy compression codecs (e.g., image compression). The signal in this case is the original data and the noise is the error caused by

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compression. When comparing compression codec, PSNR is an approximation to human Perception of reconstruction (POR) quality. A higher PSNR indicates higher reconstruction quality. PSNR is most easily defined by means of mean squared error (MSE). Given a noise-free m × n monochrome image and its noisy approximation K, MSE / PSNR is defined as:

$$MSE = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

$$\begin{aligned} PSNR &= 10 \cdot \log_{10}\left(\frac{MAX_I^2}{MSE}\right) \\ &= 20 \cdot \log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \\ &= 20 \cdot \log_{10}(MAX_I) - 10 \cdot \log_{10}(MSE) \end{aligned}$$

Multi-camera image quality measure (MIQM):
MIQM is a combined measure of LC index, Motion index and Texture index which supposed to give better outcome of quality assessment of multi-view camera images as compared to other quality parameters. The MIQM values range between 1 for minimum distortion and 0 for maximum distortion.

CONCLUSION

In this paper we study the different types of distortion in Multicamera images, their assessment by using the techniques like statistical parameters and by MIQM in objective ways. We Observed that MIQM shows the large range of Image Quality analysis and it analyses the perticular image interms of Luminance and contrast index (LC) , spatial Motion index and Texture Index.

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