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Exerting Moment Algorithms for Restoration of Blurred Images

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Abstract- In this paper presents the restoration of blurred images which gets degraded due to diverse atmospheric and environmental conditions, so it is essential to restore the original image. The research outcomes exhibit the major identified bottleneck for restoration is to deal with the blurred image as an input to imaging agent employing various methodologies ranging from principle component analysis to momentary algorithms and also a set of attempts are been executed in image restoration using various algorithms. However the precise results are not been proposed and demonstrated in the comparable researches. Also detail understanding for applications of moment algorithms for image restoration and demonstrating the benefits of geometric and orthogonal moments are becoming the recent requirements for research.

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Exerting Moment Algorithms for Restoration of Blurred Images

K. Bhima [α] & Dr A Jagan [σ]

Abstract- In this paper presents the restoration of blurred images which gets degraded due to diverse atmospheric and environmental conditions, so it is essential to restore the original image. The research outcomes exhibit the major identified bottleneck for restoration is to deal with the blurred image as an input to imaging agent employing various methodologies ranging from principle component analysis to momentary algorithms and also a set of attempts are been executed in image restoration using various algorithms. However the precise results are not been proposed and demonstrated in the comparable researches. Also detail understanding for applications of moment algorithms for image restoration and demonstrating the benefits of geometric and orthogonal moments are becoming the recent requirements for research. Hence in this work we undertake the existing moment algorithms to demonstrate the outcome of moments for image restoration and evaluated the Hu, Zernike and Legendre moments and multi-order Legendre order is demonstrated in order to find the best setting of orders for image restoration. The final outcome of this work is a stable version of MATLAB based application to visually demonstrate the performance difference of Hu, Zernike and Legendre moments. The comparative performance of the application is also been demonstrated with the help of multiple image datasets such as fingerprint, bird and human face.

Keywords: image descriptors, moment algorithm, image blurring, legendre moment, image restoration.

I. Introduction

Image processing is a very active research area that has impact in several fields from remote sensing, Biometric authentication system, robotics, traffic Surveillance, to medicine. Automatic target recognition and Tracking, character recognition, 3-D scene analysis and reconstruction are only a few objectives to deal with. Since the real sensing systems are sometimes imperfect and also the environmental conditions are dynamic over time, the acquired images often The image are the for the most part frequent component of information representation and transmission due to the robust nature of information storage and the continuous effort to make digital image processing and presentation better. The studies have shown that the images contain information which is redundant and changing a value may cause errors in the calculation for further steps.

In the space of image processing, the restoration of images is the major expanse of research for many decades. Many researchers have proposed various algorithms and techniques for better restoration of images for various applications. However the collection of image is strongly dependent on the imaging agent. The quality of a image possibly will suffer from a variety of impairments, Still the key bottleneck for better restoration of images are the random distortion and blurring caused to the initial images to be provided as input to the recognition system [1] [2]. The distortion and blurriness of the images are not only dependent on the capture agent, but also depends on the environmental and human errors. The causes of blurriness are studies and classified in four major kinds. Firstly, the focal length of the capture devices, Secondly, during the capture of object in a time irrelevant scale needs to be mapped with the capture speed of the agent to avoid the blurriness [3]. Thirdly, sometimes due to environmental and human causes the stabilization of the capture devices may be disturbed causing the blurriness. Fourthly, the most unavoidable situation, where the object is in higher order of colour range but the relevant background of lower order of colour range causing the blurriness. Thus to remove the effect of blurriness of the image, the most appropriate algorithms to be deployed are the momentary calculation algorithms.

In the field of image processing, computer vision and allied fields, an image moment is a certain particular weighted average (moment) of the image pixels' intensities, or a function of such moments, usually chosen to have some attractive property or interpretation. Image moments are helpful to depict objects after segmentation. Simple properties of the image which are found *via* image moments include area (or total intensity), it's centric, and information about its orientation and Effects of moments in digital image processing for restoration cannot be ignored as supported by related researches. In general moments are the numeric values used to represent the nature of any functions and identify with the significant properties [3] [4]. The following are mostly used moments algorithms are Hu moment, Zernike moment and the well discussed Legendre algorithms.

The moments are superior to principle component analysis for image recognition especially for image recognition [5] [6] [7]. Yet the application of moments algorithms are not been studied for digital image restoration with the comparative results for blur to

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restoration algorithm efficiency mapping. Thus in this work we understand the algorithms of moments calculation proposed by Hu, Zernike and Legendre for image restoration and develop a framework for comparing the visual performance of the restoration process by applying the same algorithms.

This work also demonstrates the effect of multi order Legendre for blurred image restoration. The rest of the work is organized as in Section II we understand the basic constructions of the moment algorithms and possibilities to apply for image restoration, in Section III we consider the Legendre moment in detail, in Section IV we define the components for Blurred image restoration process, in Section V, we demonstrate the proposed framework for Blurred Image recovery using multi-order Legendre moment algorithm, in Section VI we discuss the application constructed for the visual comparison for the blurred image restoration, in Section VII we discuss the results tested on multiple image datasets and in Section VIII we discuss the conclusions and future scope of this work.

II. Image Moments

In Image processing and computer vision processing explore the calculation of image moments or finding the image descriptors is widely accepted. The moment is a calculated on certain weighted average of any pixel taking into account the neighbourhood pixel values. Often the moment is also used to calculate to understand and extract the most significant property of a continuous function [8]. The image moments are widely accepted for image processing and used by all polynomial approaches. In this work we consider the restoration techniques using moments, thus the understanding of moments will be helpful in section IV.

In case of image and vision processing calculating the image moment which is resulting in the image descriptor is performed after the image segmentation. The image properties like area, centroid, pixel values and orientation of any object in the image can be represented using the image moment.

Image moments are classified into three categories such as Raw Moments, Central Moments and Scale invariant Moments [3]. In this work, we understand the moments in details:

a) Raw Moment

For a simple two dimensional function, denoted by $f(a,b)$, the raw moment of order (x,y) can be defined as

$$M_{xy} = \int_{-\alpha}^{+\alpha}\int_{-\alpha}^{+\alpha} a^x.b^y.f(a,b).da.dy \qquad \ldots \text{Eq 1}$$

For all positive integers of x and y

The function $f(a,b)$ denoting any greyscale image with pixel intensity of I(a, b) will be denoting the moment as

$$M_{xy} = \sum_a \sum_b a^x.b^y.I(a,b) \qquad \ldots \text{Eq 2}$$

In order to simply the calculations by considering the probabilistic measure for image analysis, the Eq. 2 needs to be normalized by the

$$\sum_a \sum_b I(a,b).$$

b) Central Moment

For a simple two dimensional function, denoted by $f(a,b)$, the central moment of order (x,y) can be defined as

$$\mu_{xy} = \int_{-\alpha}^{+\alpha}\int_{-\alpha}^{+\alpha} (a-\bar{a})^x.(b-\bar{b})^y.f(a,b).da.dy \qquad \ldots \text{Eq 3}$$

Where the $\bar{a}$ and $\bar{b}$ are the generic components of the centroid of the image and can be defined as

$$\bar{a} = \frac{M_{10}}{M_{00}} \text{ and } \bar{b} = \frac{M_{01}}{M_{00}} \qquad \ldots \text{Eq 4}$$

In case of a digital image, the Eq. 4 can be represented as the following:

$$\mu_{xy} = \sum_a \sum_b (a-\bar{a})^x.(b-\bar{b})^y.f(a,b) \qquad \ldots \text{Eq5}$$

The central moments for order k can be represented as

$$\mu_{xy} = \sum_{k_1}^{x}\sum_{k_2}^{y}\binom{x}{k_1}.\binom{y}{k_2}.(-\bar{x})^{(x-k_1)}.(-\bar{y})^{(y-k_2)}.M_{k_1k_2} \qquad \ldots \text{Eq 6}$$

The central moments are considered as translation invariant.

c) Scale invariant Moment

The moment of order (x + y) where $x + y \geq 2$ can be obtained by dividing the central moment with 0^{th} moment as following:

$$M_{xy} = \frac{\mu_{xy}}{\mu_0^{(1+\frac{x+y}{2})}} \qquad \ldots \text{Eq 7}$$

The scale invariant is neutral for scale change.

III. Applicability of Legendre Moment

The most adopted method for image pattern or image restoration is the use of moments. The recent advancements demonstrate the use of moment calculation methodologies as geometric and orthogonal moments. Further studies have demonstrated that the orthogonal moments are better than the geometric moments. Among the orthogonal moments the most widely accepted method is to deploy the Legendre moment. But the application of Legendre moment is also restricted for the blurred or distorted images. Here we understand Legendre Moments in detail [3] [13]:
Legendre Moment for of order (a + b) is defined as:

$$\lambda_{ab} = \frac{(2a+1)(2b+1)}{4}\int_{-1}^{+1}\int_{-1}^{+1} P_a(i).P_b(i,j).didj \qquad \ldots \text{Eq 8}$$

Where a, b is ranging from 1 to∞.
Hence the k[th] order Legendre polynomial is written as:

$$P_k(i) = \frac{(2k)!}{2^k(k!)^2} i^k - \frac{(2k-k)!}{2^k!(k-1)!(k-2)!} i^{k-2} + \ldots \text{ K[th] Term}$$

…Eq9

Where, D(k) = k/2 or (k-1)/2, is an positive integer.

IV. Characteristics of Blurred Image

In the Blurred or noisy image, the objects vary in terms of contrast and size. The objects in the image can represent large to small item or the items with detailed visibility. The primary effect of the blurriness on the imageis to reduce the contrast and visibility of the images. The reduced visibility images causes less detailed information in the images [10] [11].

The objects in the images are generally differentiated by the pixel difference between the object and the background at the object edges. The blurriness of the image actually reduces the pixel difference at the object edges [12].

The blurriness of the image can be measured in terms of units of lengths. The length of the images denotes the blurriness of the image [Table – I].

Table I : Blur Value Range

Capture Agent Type	Range of Blur Value (In MM)
Gamma Ray Camera	10 to 2
Ultrasonic Camera	5 to 2.1
Magnetic Resonance Camera	3.4 to 1
Computed Thermography Camera	2 to 1.3
Motion Capture Camera	2.8 to 0.3
Radio Active Camera	0.5 to 0.1

V. Framework for Blurred Image Restoration Process

The two dimensional Legendre Moment for the blurred image of g (a, b) can be defined as [3] [13]:

$$L_{x,y}(g) = \int_{-1}^{+1}\int_{-1}^{+1} P_x(a).P_y(b).g(a,b).dadb \qquad \ldots \text{Eq10}$$

With the understanding of blurriness effect on the image, the image pixel will be multiplied by random value generated by the noise function.

$$L_{x,y}(g) = \int_{-1}^{+1}\int_{-1}^{+1} P_x(a).P_y(b).(f*h).dadb \qquad \ldots \text{Eq 11}$$

Legendre moment of the blurred image can be represented as

$$L_{x,y}(g) = \int_{-1}^{+1}\int_{-1}^{+1} h(i,j).(\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} P_x(a+i).P_y(b+j)\,f(a,b)dadb).didj$$

…Eq 12

Image restoration procedure using moments:-

- Capturing image using capture device.
- Captured image is stored and referred for pre processing
- Blur function is applied on Image and also calculates image moment using Legendre polynomials.
- Comparison of original blurred and restored image.

Thus the process of restoring the blurred image using Legendre Moment is presented in this work [Figure – 1].

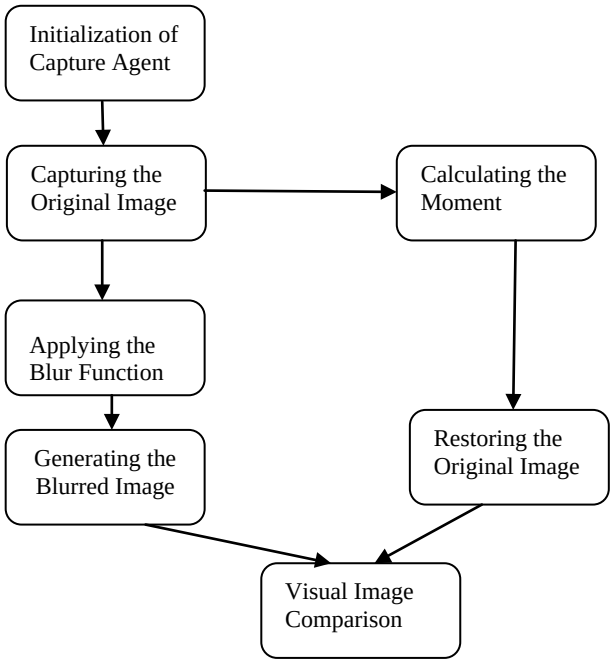

Figure 1 : Framework for Blurred Image Restoration

VI. Real Time BLurred Image Restoration

In order to prove the findings and theoretical framework proposed in this work, we provide the MATLAB implementation of this framework to test the

visual advantages of Legendre Moments over other available moments. MATLAB is a highly popular multipurpose numeric programming language for the wide variety of build in library functions ranging from image processing to higher order numeric calculation. The built in library is capable of generating matrix based calculation and graph plotting in multi-dimensional space. The MATLAB is considered as the fourth generation programming language.

In the implementation we also propose the multi order Legendre Moments to restore the blurred and noisy image.

VII. Results and Discussions

In this section, we have considered three different image dataset of fingerprint, bird and human face for restoration using various methods such as Hu, Zernike and Legendre moments.

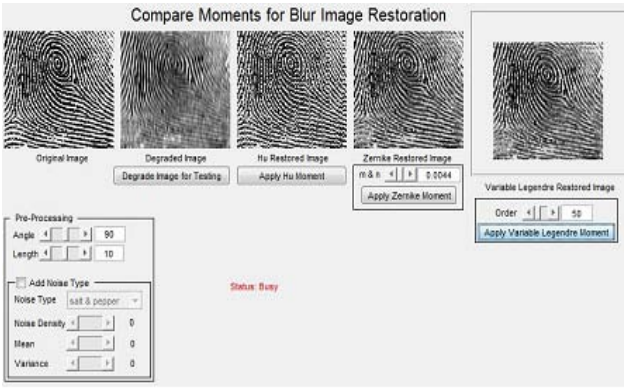

Figure 2. 1 : Restoration of fingerprint Image using moments

The input fingerprint image is blurred with length of 10mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.1].

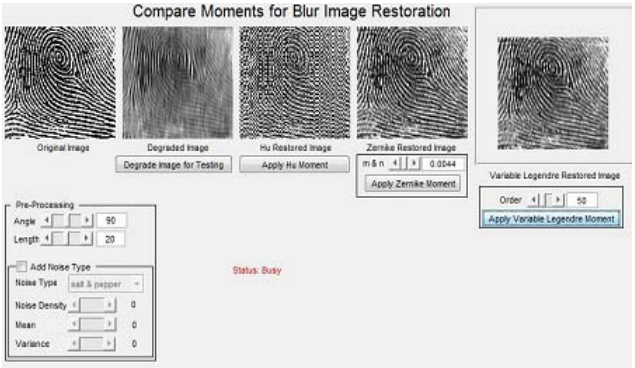

Figure 2. 2 : Restoration of fingerprint Image using moments

The input fingerprint image is blurred with length of 20mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.2].

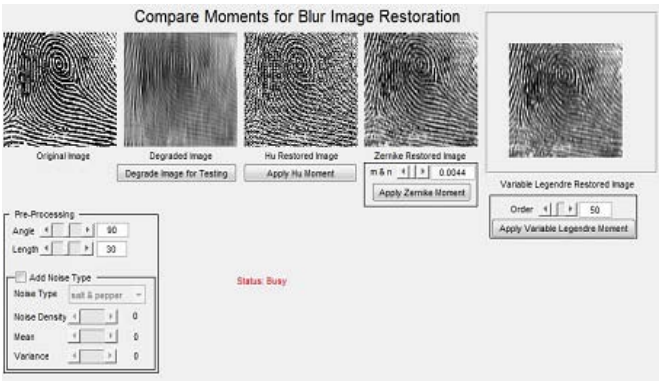

Figure 2. 3 : Restoration of fingerprint Image using moments

The input fingerprint image is blurred with length of 30mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.3].

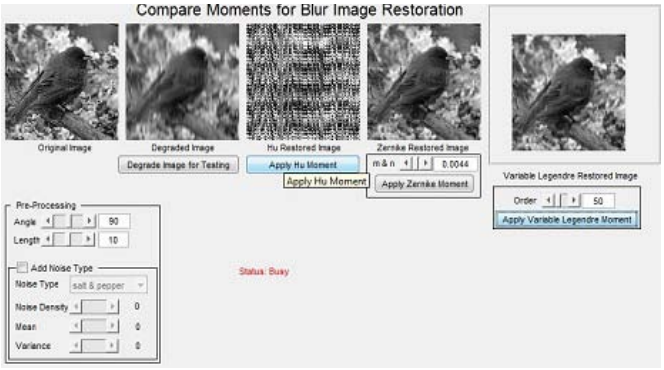

Figure 2. 4 : Restoration of Bird Image using moments

The input bird image is blurred with length of 10mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure _ 2.4].

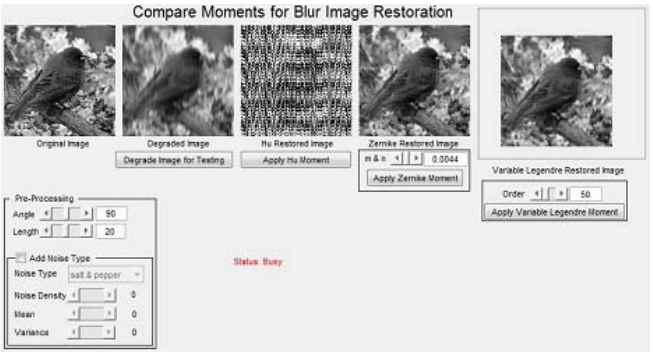

Figure 2. 5 : Restoration of Bird Image using moments

The input bird image is blurred with length of 20mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.5].

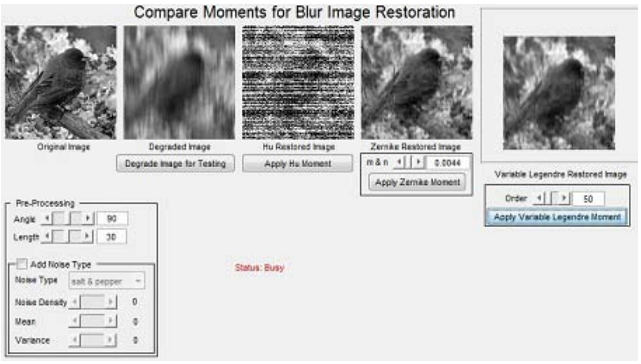

Figure 2.6 : Restoration of Bird Image using moments

The input bird image is blurred with length of 30mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.6]

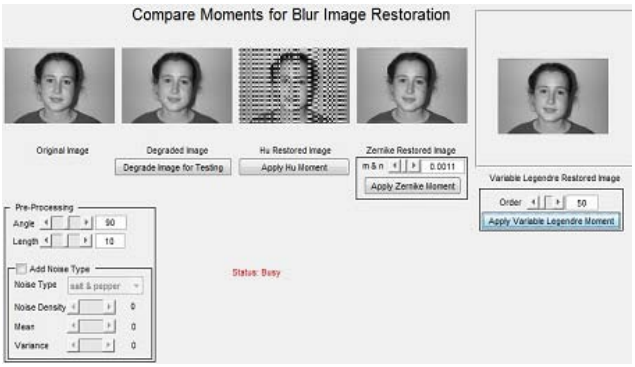

Figure 2.7 : Restoration of Face Image using moments

The input face image is blurred with length of 10mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.7]

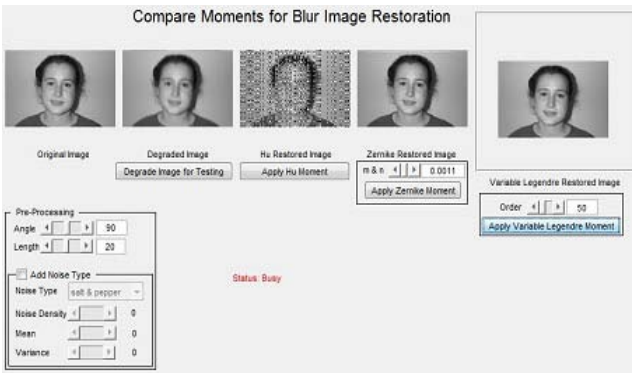

Figure 2. 8 : Restoration of Face Image using moments

The input face image is blurred with length of 20mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.8]

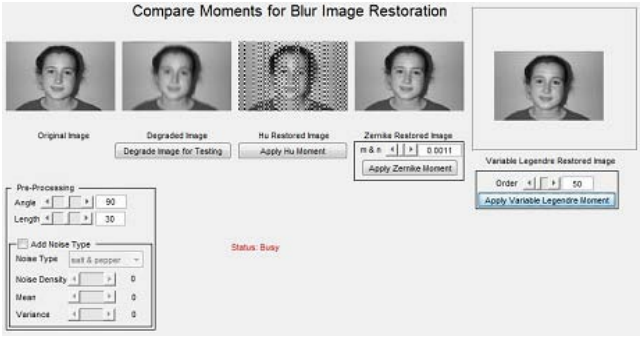

Figure 2. 9 : Restoration of Face Image using moments

The input face image is blurred with length of 30mm and been tested for restoration with Hu, Zernike and Legendre moments of 50 order [Figure – 2.9]

Henceforth we compare the initial image and restored image generated by the Hu, Zernike and Legendre moments using the following formulation:

The difference between the original image and the restored image using movements' algorithms considered as K_1 and the difference between the original image and blurred image is considered as K_2.

Hence the comparative difference between the K_1 and K_2 is considered K, demonstrating the amount of successful restoration for any given image using any given moment algorithm.

$$\left|\det(I_{ori}) - \det(I_{res(Moment)})\right| = K_1 \quad \text{...Eq 13}$$

$$\left|\det(I_{ori}) - \det(I_{blur})\right| = K_2 \quad \text{...Eq 14}$$

$$|K_1 - K_2| = K, K_1 \to 0, K \to K_2 \quad \text{...Eq 15}$$

Table II : Comparative Study of Hu, Zernike and Legendre moment based on K value in Eq. 15.

For dataset of fingerprint, bird and human face

Input Image	Blur Length	Hu Moment (In %)	Zernike Moment (In %)	Legendre Moment (In %)
Fingerprint	10 mm	78	65	53
	20 mm	80	68	58
	30 mm	83	71	68
Bird	10 mm	23	63	71
	20 mm	24	68	75
	30 mm	24	71	79
Human Face	10 mm	37	53	81
	20 mm	41	57	83
	30 mm	53	61	87

The testing results clearly demonstrate the comparative study on different data sets such as fingerprint, bird and human face for restoration using Hu, Zernike and Legendre moment. For fingerprint Hue method exhibit better results, Zernike and Legendre shows better results for bird. In the case of human face Legendre moments demonstrates better results.

VIII. Conclusion

In this paper focus on the analysis of three categories of moments such as Raw Moments, Central Moments and Scale invariant Moments and the basic mathematics functions behind those moments. In order to achieve better understanding of image restoration process, we have also understood the nature of blurred images. The understanding of the difference of lengths for normal and blurred image based on the length for various capture device types. Henceforth, this work proposes a theoretical framework using Hu, Zernike and Legendre moment to restore blurred images. The theoretical model is also validated using the image dataset and the results are also been tested. The result of image dataset is satisfactory for restoring the blurred images. The application is been tested on three types of image such as Fingerprint, bird and human face. For majority of the image restoration Legendre moments demonstrate good results.

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