STUDY THE CHROMATIC ABERRATION IN LENS

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ABSTRACT

Sharpness, focus, magnification, distortion, colour are the main areas of image, on which the image quality are measured. Chromatic aberration is the physical defect present in lenses. It is produced by refraction of light having different wavelength with the slight angles shift. Due to this defect the lens failed to produce sharp focus on object. This paper main concept is to study the chromatic aberration effect on the lens, which the result into bad image quality, search for different ways to eliminate and avoid it from the image and improve quality of image.

KEYWORDS: Lens, Chromatic Aberration, Refraction etc

INTRODUCTION

Lenses have history from china and Greece independently. Whether lenses are plane or curved, convex or concave in nature. The famous burning mirror concept takes us almost to the start of history. In century of BC, Indian, Egyptian, Greek philosopher thought that the light travels from eye to object rather than object to eye. This idea is known as Pythagorean idea of light. Euclid, a mathematician, supports the Pythagorean idea and added that angle of reflected light rays from a mirror equals angle of incident light ray from the object to the mirror. This click the idea to Epicurus, another philosopher that direction of light is not from the eye, it is from some other source. Finally the Pythagorean idea was rejected and Arabian mathematician and physicist Alhazen stated that ray of light travels from object to eye. He use spherical and parabolic mirrors and aware of aberration.

EXPLANATION

A lens forms point charge image when the aperture is small and incident ray is nearly parallel to axis. In paraxial optic calculation, theoretically, all the rays comes out from the single object point and converge to single image point but in practical non paraxial rays also take part in image formation. This non paraxial rays leads to the phenomenon of Aberration. If the polychromatic source is used to image formation this phenomenon of aberration is known as Chromatic Aberration. When ray of light passes from one medium to another, its velocity will change, and if, the interface of medium is at some angle then change of direction also take place. There are two concept that happened at interface of two medium, one is reflection another is refraction [1].

CHROMATIC ABERRATION

Lens is, theoretically, thought of a part or section of prism placed one above another. The angle of deviation increases as move away from the axis. Due to this the light ray dispersed red to violet. Angle of deviation is maximum for violet colour and minimum for red colours as shown in figure 1. The dispersive power of lens is given by

$$-\frac{df}{f} = 2\frac{f_r - f_v}{f_r + f_r}$$

Where f_r , f_v are focal length of red and violet colours[3]

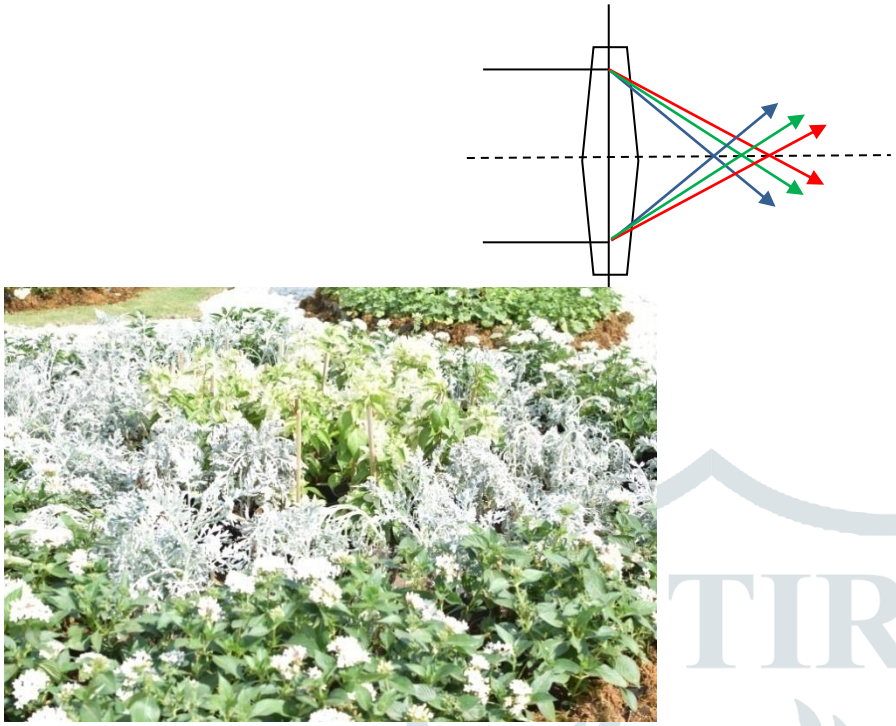

Fig 1. Chromatic Aberration

Chromatic aberration can be divided in two namely longitudinal or axial and lateral or transverse.

Longitudinal Aberration: this aberration occurs when focus of lens shifted, when different wavelength of light focused at different distance from the lens. This aberration seen at long focal lengths and can affect throughout the whole image. In digital sensor, the image will more focused green colour, red and blue colour will be defocused. It is relatively difficult to eliminate in post processing of image.

Technique to reduce: firstly, increase the depth of field so that object is still in acceptable focus. Secondly, achromatic doublet, it uses two different types of glass material with different refracting and dispersing properties as shown in figure 2. Two different wavelengths of light hit the sensor at the same point [2].

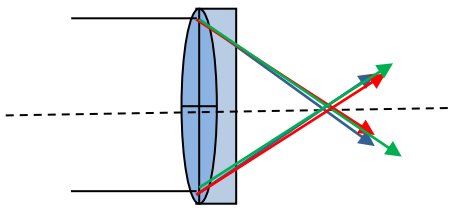

Fig 2. Achromatic Doublet

Fig 3. Longitudinal Chromatic Aberration

Lateral Chromatic Aberration: Lateral aberration follows the same principal as longitudinal one but it is due to bending of off the axis light rays. This defect is shown on edge not in the centre of the image. This defect softens the image edge and corners.

Fig 4: Lateral Chromatic Aberration

Technique to reduce: best way is to symmetrically stop (aperture ring).In 1866, Rapid Rectilinear lens use these designs first time and continued till today in lenses [4]. It is possible to reduce the aberration in the post processing software. In realistic image, it results in permanent loss of some part of image details.

This technique is to reduce the aberration but apart from it there are the ways to avoid this aberration at first place, while producing image.

1. High Contrast: Colour fringes more pronounce, when image has been recorded on high contrast scenes. If the back light or light from the intense source with including source in background of the image, Chromatic aberration occurrences probability will be very high.
2. Adjustment with focal length: Now days, lenses are available with different focal length. If we avoid using zoom lenses pr using mid range of focal length then also we can avoid chromatic aberration. The best result will produce with single focal length lenses, commonly known as prime lenses.
3. Reducing the aperture: reducing less light to pass through the lens is also produce the best result. Controlling aperture setting also exclude chromatic aberration
4. Keeping Object on Principle axis: as we know that aberration will eliminate, if the ray coming from object is paraxial. If the object is not in centre and rather toward the corner of the lens then aberration occurs due to the curvature of the lens

CONCLUSION

The study shows the if we avoid high contrast and learn simple adjustment of focal length, aperture, keep focus on object then chromatic aberration can avoid at starting itself. Even though there are ways to reduce it by achromatic doublet and post processing technique. Measurement of good quality image is very sharp details of object.

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