

Astronomical Images Enhancement using Kuan Filter and Local Enhancement

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Abstract: *Principle objective of Image enhancement is to process an image so that result is more suitable than original image for specific application. Digital image enhancement techniques provide a multitude of choices for improving the visual quality of images. The paper focuses on spatial domain techniques for image enhancement, with particular reference to point processing methods and histogram processing.*

Keywords: enhancement, Astronomical Images, Local Enhancement, Kuan filter

1. Introduction

Images have a finite set of digital values, called picture elements or pixels. The digital image contains a fixed number of rows and columns of pixels. Pixels are the smallest individual element in an image, holding antiquated values that represent the brightness of a given color at any specific point.

Raster images can be created by a variety of input devices and techniques, such as digital cameras, scanners, coordinate-measuring machines, seismographic profiling, airborne radar, and more. They can also be synthesized from arbitrary non-image data, such as mathematical functions or three-dimensional geometric models; the latter being a major sub-area of computer graphics. The field of digital image processing is the study of algorithms for their transformation[1].

Typically, the pixels are stored in computer memory as a raster image or raster map, a two-dimensional array of small integers. These values are often transmitted or stored in a compressed form.

In imaging science, image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Images are also processed as three-dimensional signals with the third-dimension being time or the z-axis [2].

Astro photography is a large sub discipline in amateur astronomy usually seeking aesthetically pleasing images rather than scientific data. Amateurs use a wide range of special equipment and techniques. Astro photography had an early role in sky surveys and star classification but over time it has given way to more sophisticated equipment and techniques designed for specific fields of scientific research, with image sensors becoming just one of many forms of sensor.

2. Astrophotography

Astro photography is a specialized type of photography for recording photos of astronomical objects and large areas of the night sky. The first photograph of an astronomical object (the Moon) was taken in 1840, but it was not until the late 19th century that advances in technology allowed for detailed stellar photography. Besides being able to record the details of extended objects such as the Moon, Sun, and planets, astro photography has the ability to image objects invisible to the human eye such as dim stars, nebulae, and galaxies. This is done by long time exposure since both film and digital cameras can accumulate and sum light photons over these long periods of time [3].

Photography revolutionized the field of professional astronomical research, with long time exposures recording hundreds of thousands of new stars and nebulae that were invisible to the human eye, leading to specialized and ever larger optical telescopes that were essentially big cameras designed to record light using photographic plates. Astro photography had an early role in sky surveys and star classification but over time it has given way to more sophisticated equipment and techniques designed for specific fields of scientific research, with image sensors becoming just one of many forms of sensor.

Astronomical photography is one of the earliest types of scientific photography and almost from its inception it diversified into subdisciplines that each have a specific goal including star cartography, astrometry, stellar classification, photometry, spectroscopy, polarimetry, and the discovery of astronomical objects such as asteroids, meteors, comets, variable stars, novae, and even unknown planets. These all require specialized equipment such as telescopes designed for precise imaging, for wide field of view (such as Schmidt cameras), or for work at specific wavelengths of light. Astronomical CCD cameras may use cryogenic cooling to reduce thermal noise and to allow the detector to record images in other spectra such as in infrared astronomy. Specialized filters are also used to record images in specific wavelengths. Images of astronomical objects are usually taken with electronic detectors such as a CCD (Charge Coupled Device). Similar detectors are found in normal digital cameras. Telescope images are nearly always grey

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scale, but nevertheless contain some colour information. An astronomical image may be taken through a colour filter. Different detectors and telescopes also usually have different sensitivities to different colours (wavelengths) [4].

3. Images Enhancement

Enhancement techniques are used to reduce image noise and increase the contrast of structure of interest. Enhancement techniques are generally used to provide a clearer image for human observer, but they can also form a preprocessing step for subsequent automated analysis. Fundamentally, image enhancement is the transformation or mapping of one image to another. This transformation is not necessarily one to one, so that two different input images may transform into the same or similar output images after enhancement, more commonly, one may want to generate multiple enhanced versions of a given image. This aspect also means that enhancement techniques may be irreversible [5].

Image enhancement allows the observer to see details in images that may not be immediately observable in the original image, often the image enhancement of certain features in images is accompanied by undesired effect. Valuable image information may be lost or the enhanced image may be poor representation of the original. Furthermore, enhancement algorithm cannot be expected to provide information that is not present in the original image. If the image does not contain the feature to be enhanced, noise or other unwanted image component, may be inadvertently enhanced without any benefit to the user.

The enhancement methods can broadly be divided into the following two categories: spatial domain methods and frequency domain methods. In spatial domain methods, enhancement techniques are directly deal with the image pixels. The pixel values are manipulated to achieve desired enhancement. In frequency domain methods, the image is first transferred into frequency domain. It means that, the Fourier Transform (FT) of the image is computed first. All the enhancement operations are performed on the FT of the image and then the Inverse Fourier Transform (IFT) is performed to get the resultant image. These enhancement operations are performed in order to modify the image brightness, contrast or the distribution of the grey levels [6]. The paper focuses on spatial domain techniques for image enhancement

1) Kuan filter

It was developed by Kuan and Nathan and Kurlander in 1987. The Kuan filter is a generalization of the Lee filter. It is advanced than Lee filter in a factor as it has no approximation involved. It transforms the multiplicative speckle model into the additive linear form. However, it is based on the equivalent noise looks (ENL), which is computed from an US image to determine a different weighting function. Kuan filter is defined by equation(1), [7].

$$F(x,y) = \tilde{g} + k_{xy}[g(x,y) - \tilde{g}] \quad (1)$$

Where $f(x,y)$ is the filtered output image, $g(x,y)$ corresponds to the image with noise, (\tilde{g}) is the local mean.

$$K_{xy} = \frac{1 - cn/ci}{1 + cn} \quad (2)$$

Where (cn) is the estimated noise variation coefficient, $cn = \sqrt{I/ENL}$, (ci) is the variation coefficient of image, $ci = S/\tilde{g}$, (s) is the standard deviation in the filter

2) Local Enhancement

Local enhancement is Define square or rectangular neighborhood (mask) and move the center from pixel to pixel. For each neighborhood, calculate histogram of the points in the neighborhood. Obtain histogram equalization/specification function. Map gray level of pixel centered in neighborhood. It can use new pixel values and previous histogram to calculate next histogram [8].

4. Image Quality Assessment

Image quality assessment shown that enhancement techniques improves the visual perception of the expert in the assessment of Astronomical images, the quality of the images will also be measured by the traditional distortion measurements such as RMSE and PSNR between the original images and the output images. The following metrics are calculated using the original image and the enhanced image.

1) Root mean square error (RMSE)

RMSE is an estimator in many ways to quantify the amount by which an filtered/noisy image differs from noiseless image. If the value of RMSE is low then we can say the enhancement is better. The RMSE is defined as equation(3), [2].

$$RMSE = \sqrt{MSE} \quad (3)$$

MSE is mean square error given in equation (4)

$$MSE(I_{filt}, I_{ref}) = \frac{1}{xy} \sum_{i=1}^y \sum_{j=1}^x (I_{filt}(i,j) - I_{ref}(i,j))^2 \quad (4)$$

Where (I_{ref}) is the original image of size $(x \times y)$ pixels, and (I_{fil}) is the filtered image of size $(x \times y)$ pixels.

2) Peak signal to noise ratio(PSNR)

PSNR is defined from RMSE. PSNR is a quality measurement between the original and a denoised image. The higher PSNR, the better is the quality of the compressed or reconstructed image. PSNR is defined as equation (5), [2].

$$PSNR = 20 \log_{10} \left(\frac{255}{RMSE} \right) \quad (5)$$

5. Experiment Results

In this work applied Enhancement techniques, to obtain the best quality for resultant images. The purpose of image enhancement as mention above is to reverse any defects that alter an image. Kuan filter and Local Enhancement will be applied Using image quality assessment RMSE and PSNR to analysis the performance of all filters used in this work. The original image, and enhancement image is shown in fig(1).The statistical parameters(RMSE and PSNR) are

used to analysis the performance of enhancement techniques will be shown in table (1).

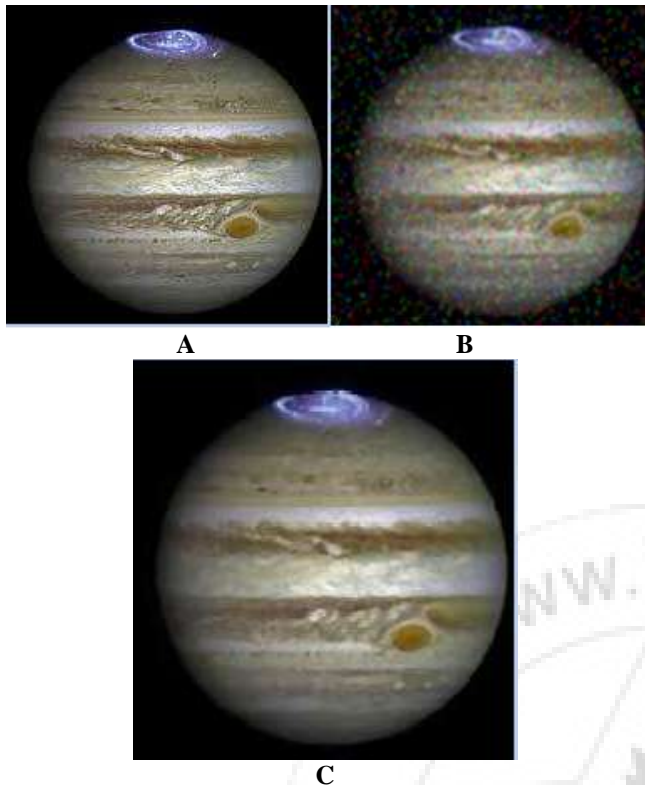


Figure 1(a): Original image b- result of using Kuan filter c- result of using Local Enhancement

Table 1: The statistical parameters (RMSE and PSNR) for two used filters

Filter	RMSE	PSNR
Kuan filter	0.0975	68.349
Local Enhancement	0.0270	79.5189

6. Conclusion

Image enhancement algorithms offer a wide variety of approaches for modifying images to achieve visually acceptable images. From the results obtained after applying Kuan filter and Local Enhancement on original Astronomical image. It is clear that the performance of Local Enhancement is better than Kuan filter to enhanced the Astronomical image. depending on the clearly of enhanced images and the values of RMSE and PSNR.

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