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***Research Article***

# VISIBLE AND IR SPECTRAL IMAGES OF IN SAT SATELLITE FFT ANALYSIS AND ITS SIGNIFICANCE IN WEATHER FORECASTING OF CYCLONES IN INDIAN SEAS

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## ABSTRACT
With rapid progress in remote sensing programs occurring in India and elsewhere, these techniques are becoming the pivotal component of global observing systems for both research and operational environmental monitoring. In the coming years, remote sensors will provide an unprecedented volume of data that present real challenges to engineers and scientists. Satellite imaging techniques use the principle of molecular spectroscopy to sense and understand the earth and the atmosphere above it. This amalgamates the interests of different disciplines in modeling, algorithm, processing, information distribution and application. This way institutional and personal collaboration and interaction advances our optical remote sensing knowledge and skill to meet increasing demands for understanding and management of our environment. Tropical cyclones or hurricanes are extremely dangerous to mankind. Early detection of these systems by traditional methods was inaccurate and had less range. Authors in this paper have focused on the latest accomplishments and future advances of the remote sensing techniques to optimize 'the use of the satellite (both Infra-red and Visible imagery) data. The results obtained by using the satellite imagery data embedded in pseudo colors, are more impressive. The use of fast Fourier transform algorithm in image analysis provides almost noise free and optimal information.

***Keywords:*** *Fast Fourier transform , tropical cyclone and remote sensing*

## INTRODUCTION
Remote sensing is the acquisition of physical data of an object without touch or contact. It concerns with the collection of information related in some way to the Earth' natural resources or environment. Data is collected by satellite involving measurements of the electromagnetic spectrum that can be used to characterize or infer properties of it in conjunction with localized ground-based surveys and measurement. The data are then processed by digital computer or optical techniques to extract information of value of interest. Different sensors can provide unique information about the properties of the surface or shallow layers of the earth. The electromagnetic spectrum is the basis for all-remote sensing. Remote sensing takes advantages of the unique interaction of radiation from the specific regions in the spectrum and the Earth (Barrett, 1983). Their four basic components of a radiation-based remote sensing system are radiation source, transmission path, target and sensors (Slater, 1980; Curran, 1985). The type of sensor is perhaps the only characteristic of remote sensing over which the user can has some control. Based on the above properties the satellite imageries are used for providing the idea of Tropical cyclones (TC) over Indian Ocean.

## MATERIALS AND METHODS
A digital image is a two-dimensional array of small square regions known as pixels. In the case of a monochrome or color image it is not free from distortions. The presence of necessary information can be extracted by pixel based spectral assessments. To extract correct information radiance difference can be taken as a proxy for thresholding. This type of thresholding is very useful to filter out the unwanted noise. The spatial frequency spectrum of any satellite image can be analysed with the help of Fast Fourier

Transform Methods. The Fast Fourier Transform (FFT), like most computer algorithms, generates an Exponential Fourier Series, instead of a Trigonometric Fourier Series. The two series are identical except that the magnitudes generated by the exponential series are half the value of the trigonometric series. Most application software automatically compensates for this and presents the magnitude spectrum as a Trigonometric series. This is done by several common approaches like optimal, Neighborhood-averaging and Mode filtering etc. In high pass filtering we use the approaches like histogram equalization and density slicing etc. This image enhancement using pseudo look up tables (luts) with the help of FFT technique is highlight the important meteorological features.

***FFT Principle***

FFT is an algorithm to rapidly compute the Discrete Fourier Transform (DFT) and DFT is the digital tool to analyze the frequency content of the signal. For this present study we have taken INSAT IR and VISIBLE imagery digital data and reprocess the data by applying the FFT to set the optimal brightness and contrast. Initially did the histogram analysis of the digital imagery data and then made matrices of 1X1 grid box of the entire image and calculate the DFT for each box and finally normalize the maximum frequency content of the pixels under consideration. To remove the vagueness of the boundary pixels we have used the averaging of the pixel followed by mode filtering to remove the signal or pixels of unwanted frequency. By doing so the smoothed satellite image of relevant features is reproduced. After getting the final noise free image it is anlysed for cyclone analysis. The FFT reproduce image helps to identify the bending or central dense overcast features. The fundamental equation of FFT is given below:

$$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-i\omega t} dt \qquad F(k\Delta\omega) = \sum_{n-0}^{N-1} f(n\Delta t) e^{-ik\Delta\omega - n\Delta t} \qquad \omega = 2\pi f$$

$f(t) =$ an a log *signal*, $f(n\Delta t)$ = digitized signal

$t =$ time $f =$ frequency (Hz) $\omega =$ angular frequency (radians/sec)

$F(\omega) =$ Fourier transform

$F(k\Delta\omega) =$ Discrete Fourier Transform

$\Rightarrow$ Magnitude & Phase Spectrum

$N =$ total number of discrete samples

$T =$ total sampling time (not the period)

$\Delta t = \dfrac{T}{N} =$ time increment between samples

$f_s = \dfrac{1}{\Delta t} =$ sampling frequency

**RESULTS AND DISCUSSION**

The satellite imagery used in this study is taken after applying FFT technique. To illustrate the technique few cases of tropical cyclones have been taken. As we know Tropical cyclones are special classes of large whirling wind systems, which occur over a sizable portion of the global tropical and subtropical oceans. A typically mature tropical cyclone is warm core (relatively warm) than the environments at the same pressure level vortex in the atmosphere with circulation extending horizontally to some 1000 km from the center and vertically to about 15km above sea level. There is an eye at the center of radius 5 to 50km. The Eye is rain free with light winds. It is surrounded by a wall made up to a tall cumulonimbus clouds (Cb) clouds rising up to an altitude of ~15km the wall clouds thickness being about 10-15 km radially. Beyond

wall cloud surface winds speeds decreases gradually with radial distance from the center. Classification of tropical disturbances on the basis of wind intensity is shown in table 1.
Satellite picture of tropical cyclone indeed show both inward spiraling (anticlockwise) low level clouds &the outward moving (clockwise) cirrus clouds at the upper levels in the N.H. The mechanism for tropical cyclone intensification is conditional instability of the second kind (CISK) (Craig et al, 1996).
The reprocessed of INSAT 1-D images for the October, 1999 (Orissa super cyclone), May, 2001 and September, 2001 cyclones are shown in Figures (1, 2), (3a, 3b) and (4a, 4b) respectively.

**Table 1: Classification of tropical disturbances on the basis of wind speed**

| System (Intensity in T Number) | | Mean wind Speed in (Knots) |
|---|---|---|
| Low | (1.0) | <17 |
| Depression | (1.5) | 25 |
| Deep depression | (2.0) | 30 |
| Cyclone | (2.5) | 35 |
| Cyclone | (3.0) | 45 |
| " | (3.5) | 55 |
| " | (4.0) | 65 |
| " | (4.5) | 77 |
| Very SC | (5.0) | 90 |
| " | (5.5) | 102 |
| " | (6.0) | 115 |
| " | (6.5) | 127 |
| " | (7.0) | 140 |
| " | (7.5) | 155 |
| " | (8.0) | 170 |

*Where,*
*I = Current intensity.*
*SC = Super cyclone.*
*1 Knots = 0.5 m/sec.*

Accurate estimation of the eye of the cyclone and assignment of intensity is of prime importance to predict its future direction of movement and hazardous capability. Using satellite imagery Dvorak (1975) developed a technique to estimate tropical cyclone intensity. This approach is further evaluated and refined for IR images and evolved into a "digital IR" Technique (Dvorak, 1984). T number shown in the table 1 above measures the intensity of a tropical cyclone.
The Data 'T' Number (DT) defined as determines eye pattern:
DT =CF + BF
Where,
CF = Central feature (central dense overcast (CDO))
BF = Bending feature (curvature, spiral bending)
However the Dvorak techniques is subjective but provide an additional input to traditional synoptic techniques .To further accurately estimate the eye position and the bands of heavy rain bearing clouds the FFT technique provide realistic image enhancement to highlight the particular area over the image. In FFT low pass filtering to remove the noise from the digital image does smoothing. After application of FFT technique the quality of the image for interpretation purposes improves dramatically as shown in the satellite pictures above. The FFT enhanced image brings out clearly the rain bearing bands and the eye of the cyclone. In this way it can help to forecast clearly the future track of cyclone and the region of

maximum rainfall. When this estimate is obtained near the coast the region affected by the cyclone is clearly delineated and the economic damage can be minimized.

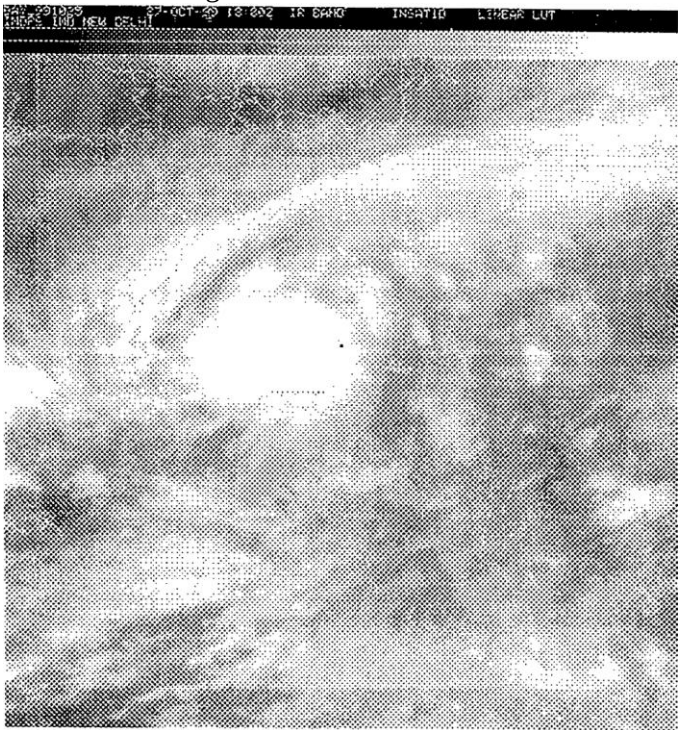

**Figure 1: INSAT Infrared image 1800UTC 27 October, 1999 (T 4, 0)**

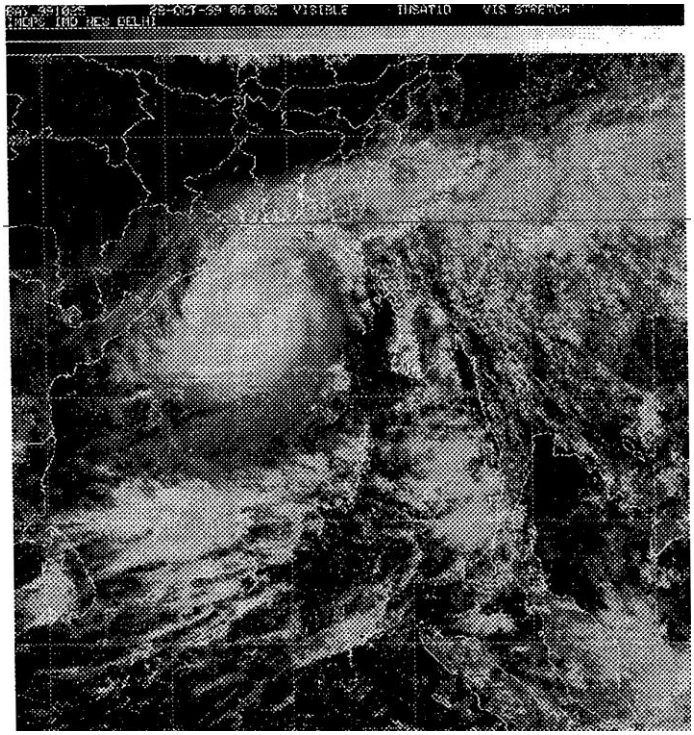

**Figure 2: INSAT visible image 0600UTC 28 October, 1999 (T 55)**

T2.5

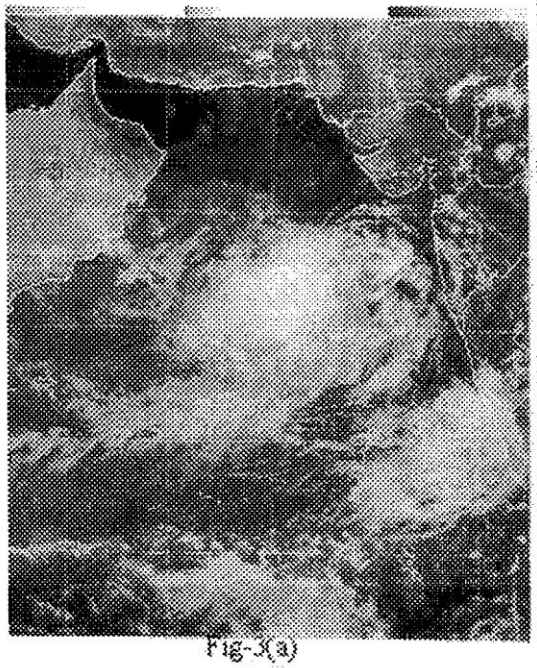


Fig-3(a)

T2.5

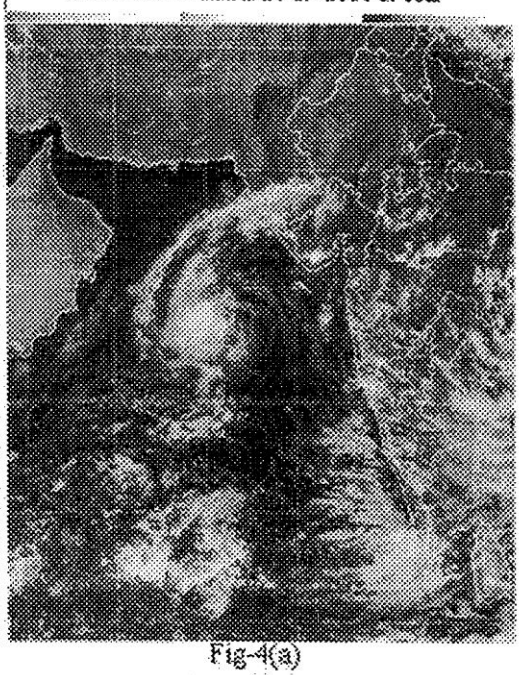


Fig-4(a)

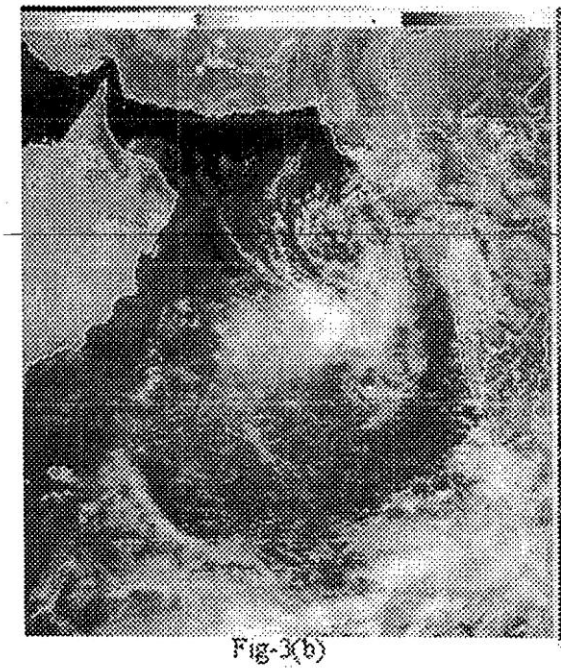


Fig-3(b)

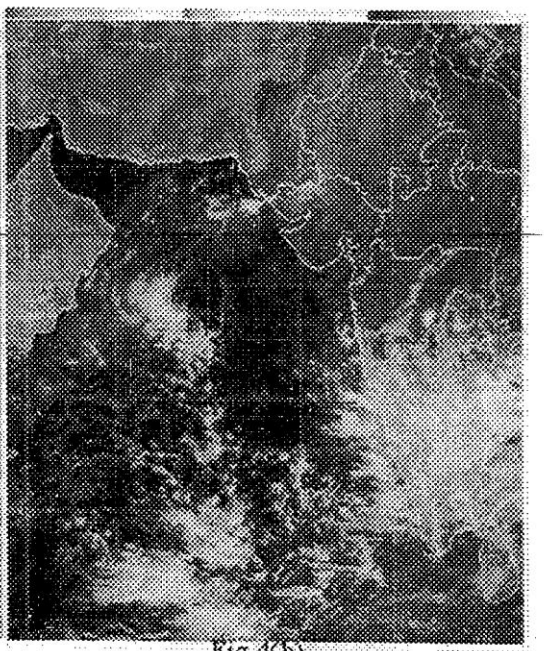


Fig-4(b)

T (1.5)

T (1.5)

## CONCLUSIONS

The FFT image analysis improved the art and science of image interpretation compared to traditional image systems in remote sensing. This improves the texture of image data and a large variability of spectral and morphological appearance of Tropical cyclone imagery. In the future we will have better imaging and sounding capabilities in both Geostationary and Polar orbiting satellite. This will get provide the satellite imagery with better resolution. So more sophisticated image analysis will help to better visualize the main features in the INSAT satellite imagery.

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