Concept of Remote Sensing

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Abstract: *Remote sensing is the science of making inferences about objects from measurements, made at a distance, without coming into physical contact with the objects under study. This article gives a basic introduction to remote sensing and its recent advancements and its applications.*

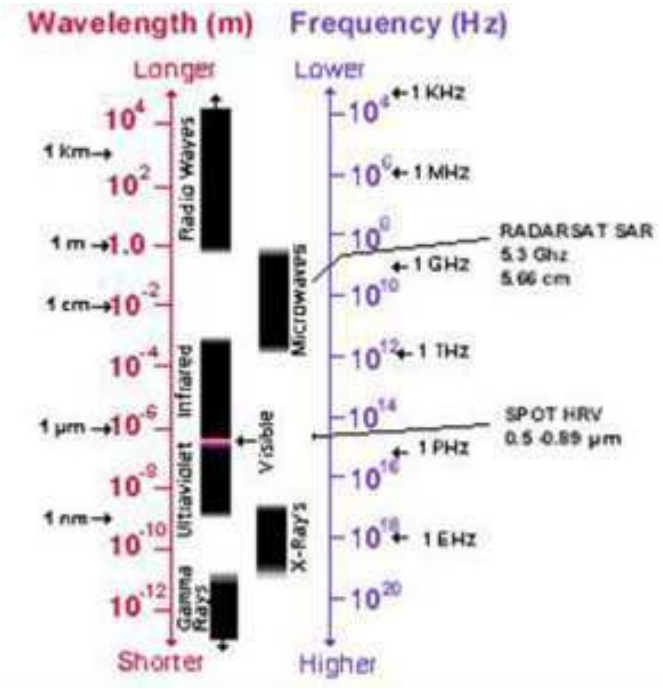
Key Words: *Remote Sensing, Electromagnetic Spectrum, Digital Image Processing, Image Enhancement, GPS, GIS, ERDAS.*

Introduction

Remote sensing is the science of acquiring information about the earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing and applying that information. Exploration of earth's natural resources is vital for the socio-economic development of any country. The various studies carried out in India and elsewhere in the world proves beyond doubt that remote sensing is a powerful tool for mapping inventorying, monitoring and managing of natural resources due to the inherent advantages of synoptic viewing, repetitive imaging, capability to study inaccessible areas, relatively at low cost and real time/near real time availability of data. Satellite remote sensing, in conjunction with geographic information systems, has been widely applied and recognized as a powerful and effective tool in analyzing land cover/use categories.

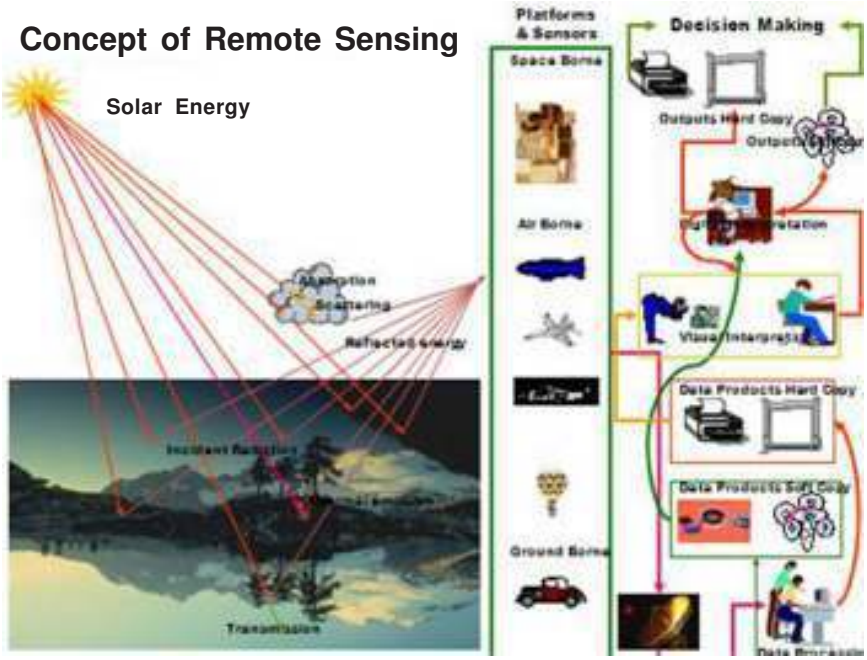
Remote sensing is mainly concerned with the measurement or acquisition of information about an object without being in physical contact with the object under study. The term remote sensing is restricted to methods, which employ electromagnetic energy (fig.1) as the means for collection of information about the object. Remote Sensing provides spatial coverage by measurement of reflected, emitted and backscattered radiation, across a wide range of wavebands, from the earth surface and surrounding atmosphere. Remote sensing based spatial coverage can be measured by reflected and emitted electromagnetic radiations emitted from the earth surface and surrounding atmosphere.

Figure 1: Electromagnetic Spectrum



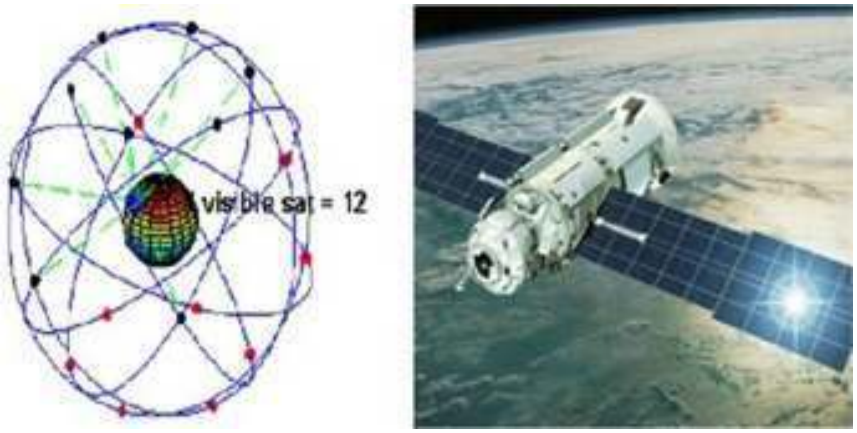
Remotely sensed data of the land surface is possible across a wide range of wavebands, from the ultra-violet (UV), visible (VIS), near infrared (NIR), short wave infrared (SWIR), mid-infrared (MIR), thermal infrared (TIR), and microwave (MV) regions of the electromagnetic spectrum. Depending on its physical features and properties, the earth surface reflects or reradiates or emits electromagnetic waves of different frequency and intensity. The measurement of reflected or radiated or emitted electromagnetic radiations form the basis for the understanding the characteristic of earth surface features [1-3]. Only selected wavelength of the electromagnetic spectrum that can pass through the earth atmosphere with little attenuation is used for remote sensing purposes. Each object of the earth surface features reflects, radiates or emits or emits electromagnetic waves of different frequency and intensity. These typical responses are used to distinguish the objects from one another. The essence of remote sensing process is shown in figure 2.

Figure 2: Process of Remote Sensing



Ground data are generally required for a full and accurate characterization from remotely sensed data. Primarily due to environmental and atmospheric variation through time and space, it is necessary to measure the property at several places and obtain a site specific statistical model of the relation between the remote and ground data. The model so obtained can be applied to the reminder of the image pixels to estimate the property of interest over the area covered by the image. The satellite based navigation system provides autonomous geospatial positioning with global coverage. A constellation of 24 earth-orbiting satellites in six orbital planes, (figure 3) which is maintained by the United States Government for the purpose of defining geographic positions which are used in GPS as space segment. The control system in the ground tracks the satellite and provides correct orbital and clock information. A user system called the GPS receiver is used to determine the location (longitude, latitude and altitude) by using time signals transmitted from a satellite.

Figure 3: GPS Satellites and Its Six Orbital Planes



1. Image Processing Techniques

Accuracy of input and source of input are more important for any kind of critical analysis. Satellite images are the sources of data used in the present study. The digital image processing techniques offer various tools to enhance the digital satellite imagery. The digital image processing is largely concerned with four basic operations: image restoration, image enhancement, image classification, and image transformation [4]. The image restoration is concerned with the correction and calibration of images in order to achieve a faithful representation of the earth surface as far as possible. The operation of image restoration is to correct the distorted image data to create a more faithful representation of the original scene. This normally involves the initial processing of raw image data to correct geometric distortions, to calibrate the data radiometrically and to eliminate the noise present in the data. Image rectification and restoration are also termed as pre-processing operations.

1.1 Image Enhancement is predominantly concerned with the modification of images to optimize their appearance to the visual system. The enhancement is concerned with the modification of images to make them more suited to the capabilities of human vision. Regardless of the extent of digital intervention, visual analysis invariably plays a very strong role in all aspects of remote

sensing. Enhancement of the imagery can be done by the histogram equalization method or linear saturation method before analysis.

The image transformation refers to the derivation of new imagery as a result of some mathematical treatment of the raw image bands. To highlight the geological, geomorphologic and land use/land cover units, various image transformation techniques like contrast enhancement, edge enhancement, band rationing and image fusion can be applied to the satellite imagery to derive new images which are more suitable for the purpose of human visual perception or computer processing tasks.

1.2 Image Classification refers to the computer-assisted interpretation of images that is vital to GIS. Digital image classification is the process of assigning a pixel (or groups of pixels) of remote sensing image to a land cover or land use class. The objective of image classification is to classify each pixel into one class (crisp or hard classification) or to associate the pixel with many classes (fuzzy or soft classification). The classification techniques are categorized based on the training process - supervised and unsupervised classification.

2 The Geographic Information System (GIS)

GIS provides a consistent framework for integrating spatial and other kinds of information within a single system (ideal for inter disciplinary work) which permits manipulation and display of geographical (digital) data in new ways. In broader sense, a GIS binds two distinct disciplines namely 'Geography' and 'Information system' where a computer based information system is used for systematically capture, store, manipulate, analyze, manage and present the geo-spatial data and geographical data.

The GIS have been used to create, manage and analyze spatially referenced data in highly structured ways. The GIS have the ability to map a city and include a substantial amount of geographic and spatial data in the system. The GIS provides benefits for urban and environmental planners because of their ability to integrate diverse data sets under a common spatial theme. This is not surprising since the organization and management of urban and environmental data often has a strong spatial element to it. Furthermore, GIS are the only technologies that offer computerized spatial query and spatial analysis in an effective manner and the GIS would be required to integrate diverse data sets. The urban information and environmental problems have an inherently spatial nature. Hence, it is no surprise that GIS plays a key role for building UIS.

The superiority of GIS technology lies in its data synthesis, the geography simulation and spatial analysis ability. Therefore through GIS technology, the system engineer can think of establishing the urban information system which has become an inevitable choice for the regional urban planning departments to realize the office automation, the management modernization and the policy-making identification. Urban planning needs to access and consume a large amount of data. Planning related information consists of 2D map, 3D urban model, thematic information, historical data, national statistics, local survey, and various policy and regulations etc. The GIS can provide two distinct views of information system.

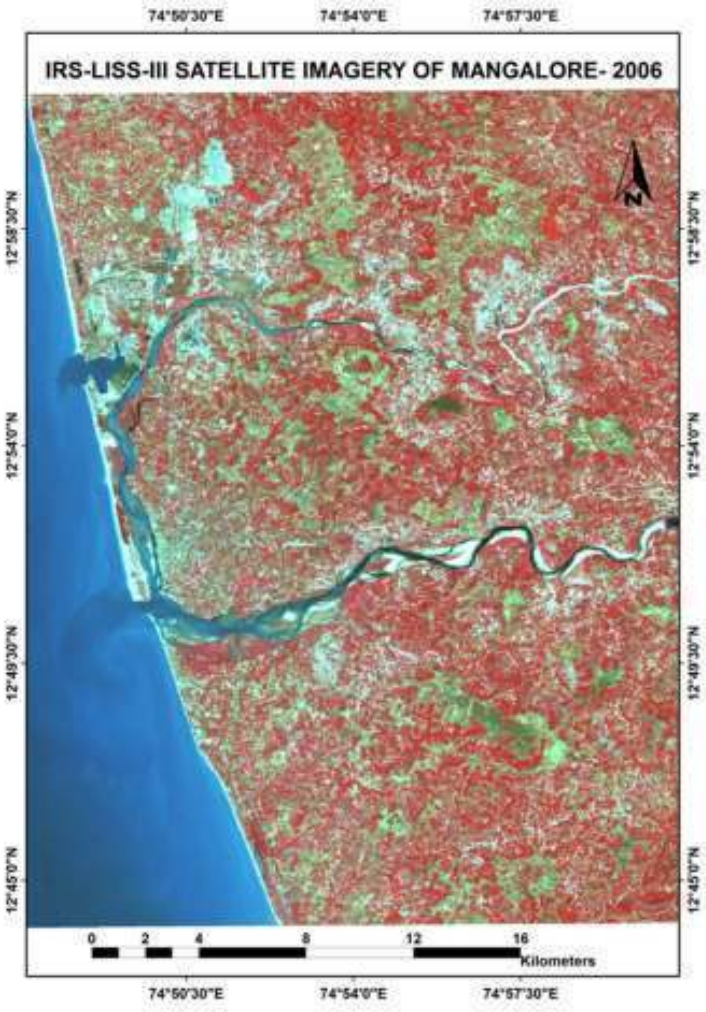
1. Database (or table) View
2. Map View
3. Model View

2.1 Satellite Data

The remote sensing surveys carried out till date use data from remote sensing satellites such as Landsat, IRS and SPOT etc. Sometimes information may be supplemented by aerial photos/airborne sensors. The resolutions of these satellites broadly fall into four categories: low, medium, high and very high. The low resolution (70-80m pixel size) is offered by Landsat MSS and IRS- LISS I sensors. Medium resolution (20-40m) is offered by Landsat: TM, IRS-LISS II, LISS III and SPOT HRV MLA sensors, high resolution (5-10m) is available from SPOT-HRV-PLA, IRS-1C/1D-PAN and Resourcesat-LISS-IV sensors. IKONOS, Quick Bird and Worldviewsatellites offer very high resolution of 4m, 1m and 2.4m & 0.61m images [2].

ISRO remote sensing program provides a constellation of polar satellites at various resolutions to map the globe. IRS - 1C/1D launched in 1995/1997 have sensors such as LISS-III (with spatial resolution of 23.5m in Green, Red and NIR and SWIR-Short Wave Infrared band), PAN (Panchromatic band with 5.8m spatial resolution). A synoptic view of IRS-1D, LISS-III multispectral satellite image is shown in figure 4.

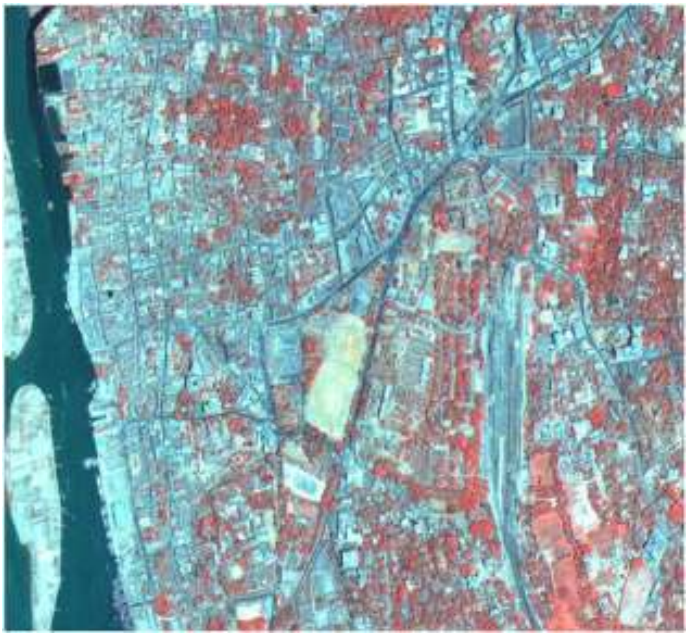
Figure 4: Synoptic View of Mangalore, a View from IRS-1D LISS-III Satellite Image.



IKONOS series of satellites are developed by Space Imaging. The IKONOS-2, employs a linear array technology which collects the data in

four multispectral bands at spatial resolution of 4m. These bands include Blue (0.45 μm to 0.52 μm), Green (0.52 μm to 0.60 μm), Red (0.63 μm to 0.69 μm) and near Infrared (0.76μm to 0.90 μm). A synoptic view of Mangalore city which is defined as the CBD (Central Business District) (figure 5). The high resolution image can provide better view and can be used to extract meaningful information of various features.

Figure 5: Synoptic View of Mangalore city, a View from IKONOS Satellite (2003)



Digital globe world view satellites provide a high resolution panchromatic band and 8 multispectral bands. The multispectral bands include coastal band (400-450 nm) supports vegetation and bathymetric studies, Yellow band (585-625 nm) supports vegetation applications, new red band (705-745 nm) supports the analysis of vegetative condition, two bands of near infrared (860-1040 nm) supports vegetation and biomass studies. Other 4 bands (blue, green, red and infrared) are similar to that of a LISS-III image. Because of

higher resolution and availability of 8 bands, it facilitates a better view and provides a good means to extract maximum information about the study area using image processing techniques.

2.2 GPS Instrument

The Global Positioning System (GPS) is a space-based satellite navigation system. Though it started primarily as a navigating system, it has wide range of geodetic, geophysical, navigational and marine applications. It provides location and time, anywhere on or near the earth, if there is no obstruction to the line of sight to four or more GPS satellites. It is maintained by the United States of America and is freely accessible. The new fully rugged PS535F is shown in figure 2.5 from GETAC with a high sensitivity GPS receiver, E-Compass, altimeter and a 3M pixels auto-focus camera, is used for field survey in the study. In the current study, GPS is used for finding the ground control points (GCP) of the study area and these GCPs are used for geo-correcting the satellite images.

Figure 6: GETAC GPS Instrument

3. Software Tools

Various software tools are used for the analysis of the data. A brief overview of these is given below.

3.1 ERDAS IMAGINE 8.5

ERDAS stands for Earth Resource Data Analysis System and is developed by Geo Atlanta of USA. ERDAS imagine is a complete image processing and GIS package which employs a graphical user interface. ERDAS imagine is a raster-based software package designed specifically to extract information from aerial/satellite images. The major advantage of ERDAS image is its ability to show each band that can be viewed as a separate image. ERDAS imagine includes a comprehensive set of tools to create accurate base imagery for inclusion into a GIS and its database. It is widely used for GIS integration, geometric correction, image ortho rectification, multispectral classification, image interpretation, image analysis, image mosaicking map production. In the current study ERDAS imagine is used for image geo correction, image enhancement, supervised classification and change detection.

3.2 SuperGeo Desktop 3.0

SuperGEO software is a GIS tool that helps in solving spatial problem. It allows the user to visualize the spatial data and to show the original landforms and its spatial features. SuperGIS desktop is software which is a powerful GIS tool to identify, measure, calculate geographic data. In the current study it is used for geo-correction, image vectorization and land use classification.

3.3 Matlab 7.0

MATLAB (matrix laboratory) is a numerical computing environment and fourth-generation programming language. Developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C,, C++, Java, and Fortran**.** One of the main applications of MATLAB is in the field digital image processing. In the current research work, MATLAB is extensively used for image fusion and stitching.

3.4 Origin

Origin is a proprietary computer program for interactive scientific graphing and data analysis. It is produced by Origin Lab Corporation, and runs on Microsoft Windows**.** In our work we haveused Origin soft ware for plotting and for interpolation.

4 Digital Image Processing Techniques

Digital image processing is the application of algorithms on digital images to perform processing, analysis, and information extraction. Remotely sensed data are usually available in digital format. Therefore, data processing in remote sensing is treated as digital image processing. Digital image processing is the computer manipulation of the digital image. The raw data received, from the imaging sensors of the satellite platforms contains flaws and deficiencies, which can be overcome by undergoing several steps of processing in order to obtain the originality of the data and to extract the required information from the images. This varies from image to image depending on the type of image format, initial condition of the image, the information of interest, and the composition of the image scene.

Remotely sensed data corresponds to different earth features collected by the sensors and stored in cartridge/CD-ROM in the form of raster or tiny equal areas or picture elements or pixels and are arranged in regular lines/ rows and columns. The pixels represent brightness value having a specific Digital Number (DN) value, which depends on the energy reflected by the earth surface in a specific wavelength or band or channel. Most of the sensors in the satellites operate in different discrete wavelengths. Hence, the earth features are sensed by the sensors simultaneously and provides a set of DN values. The DN value of each pixel ranges from zero for black to some higher value for white, based on the radiometric resolution (e.g. 7 bit data represents 0-127 grey levels and 8 bits represents 0-255). The availability of remotely sensed data in digital form helps in carrying out digital image processing with the aid of computers. The digital image processing techniques provide flexibility in data handling due to the fact that the digital data can be numerically manipulated by using an equation or set of equations to get the desired details in the graphic display monitor or pictorial form for further interpretation. In the present study, ERDAS - Imagine 8.7 and MATLAB software have been used for digital image processing. There are a number of procedures/methods available for image data manipulation [2-3]. However, they can be broadly grouped into five categories namely (i) image rectification and restoration (ii) image stitching, (iii) image enhancement, (iv) image fusion

and (v) image classification. Image rectification and restoration/pre-processing operations are intended to eliminate or correct the distortions or errors caused due to geometric distortions, radiometric distortions, presence of noise in the data, etc. If the images are not properly co-registered, the change detection algorithm will produce incorrect results around the boundaries of homogeneous regions.

Image stitching is a technique to merge a sequence of an image with limited overlap area into one blended image. The single image will enhance visual interpretation analysis [5-6]. Different methods used for image stitching are SIFT (Scale Invariant Feature transform) and homography calculation. Images obtained from satellites may lack in contrast and brightness because of the limitations of imaging sub systems and illumination conditions while capturing image. The goal of image enhancement is to accentuate certain image features for subsequent analysis. Enhancement process itself does not increase the inherent information content in the data. It simply emphasizes certain specified image characteristics. Few of the image enhancement operations such as contrast stretching, band subtraction, brightness index, vegetation index, band ratioing, principal component analysis (PCA), filtering, intensity-hue-saturation (IHS), image fusion are being applied to image data to get the enhanced output for subsequent visual interpretations. Contrast generally refers to the difference in luminance or grey level values in an image which is an important characteristic feature. It can be defined as the ratio of the maximum intensity to the minimum intensity over an image. Contrast enhancement techniques expand the range of brightness values in an image. The features of details that were obscure on the original image will be clear in the contrast stretched image. When an area having different terrain classes is linearly stretched, it will enhance some features and saturate or degrade some others [7]. Contrast stretched IRS data products have been used for preparing geological map; landform map, drainage map, and land use/land cover map and shoreline change studies. Edge enhanced image are generated using linear and non-linear edge enhancement techniques. Linear enhancement can be used to highlight points, lines and edges in the image. Edge enhanced image has been used to refine the lineaments map.

The remote sensing data contain various geometric and radiometric distortions, the rectification of which is a prerequisite to ensure compatibility of data on pixel-by- pixel basis for pixel-based image fusion. Random geometric distortions and unknown systematic geometric distortions are corrected by approximating the polynomials using well distributed ground control points (GCPs), occurring in the given data set of images.

Image fusion is the technique by which images of high spatial resolutions are fused with multi-spectral (MS) images, so that the resultant output has enhanced textural information and spatial resolution, while preserving the spectral information of MS images (Veenadevi et al., 2011). Image fusion techniques, improves geometric corrections, improves classification accuracy and hence it allows the extraction of maximum image information from the given image data set. The few fusions techniques are based on Brovey Transform, Integration of substitution (IHS), discrete wavelet transform (DWT) using additive Wavelet (WT). The fusion of images is the process of combining two or more images into a single image retaining important features from each. Otherwise it can be defined as the process by which several images or some of their features are combined together to form a single image. Image fusion can be performed at different levels of the information representation. Four different levels can be distinguished according to signal, Pixel, feature and symbolic levels. Several approaches to image fusion can be distinguished, depending on whether the images are fused in the spatial domain or they are transformed into another domain, and their transforms fused.

The fusion technique requires the input images to be registered with high accuracy of less than half a pixel, since mis-registration can cause artificial colors in features of data, thereby leading to falsifying of interpretation. The image fusion techniques can be categorized into three types, color-related, numerical/ statistical-related and a combination of the three approaches. All color related techniques employ slicing of original data into their respective layers, which can be basic Red (R),Green (G) and Blue (B). This is followed by substitution by a high resolution image in place of one of these channels and a back-transformation of this combination into the original RGB domain. The application specified decides on the choice of image channel to be substituted. The statistical method, as indicated by its name, uses a

mathematical approach for data integration. It involves addition, multiplication, differencing, and ratioing of low and high resolution data prior to their integration. Inclusion of weights and scaling factors helps in preservation of the original values. The basic purpose is to imbibe the spatial information of high-resolution data in the spectral realm of low-resolution multi-spectral data, keeping in mind the requirement of minimum loss of original information from either of the two data sets.

Conclusion

An attempt has been made to explain the concept remote sensing and GIS. Remote Sensing provides spatial coverage by measurement of reflected, emitted and back scattered radiation, across a wide range of wavebands, from the earth surface and surrounding atmosphere. The GIS can be used to create, manage and analyze spatially referenced data in highly ordered way. The GIS has the ability to map a city and include a substantial amount of geographic and spatial data in the system. The GIS provide benefits for urban and environmental planners because of its ability to integrate the diverse data sets under a common spatial theme. Remote sensing can provide an important source of data for environmental monitoring. Due to the raise in built-up area, Industrial and vehicular pollution and the reduction in agriculture land, urban temperature has been increased. The solid and liquid waste management in the city is not proportionate to serve the need of urban population. The field of remote sensing is a continuously growing field with applications in different fields like vegetation mapping, urban studies and observation of the environment. To cater the demand for higher classification accuracy and to improve the quality of the image for better interpretation, image enhancement is required, so that one can extract meaningful information from the satellite images. These requirements can be either fulfilled by the utilization of image fusion techniques which is having the benefit of lower expenses.The superiority of Geo information system (GIS) technology lies in data synthesis and geographic simulation and spatial analysis ability. It is because of its synoptic view and repetitive coverage, the satellite images are being considered as one of the best tools for urban studies. Integrated approach of combining remote sensing and GIS is best suited for analyzing the various urban related issues and urban management.

References

Colwell (1983). *Remote sensing for the Earth sciences*, *Manual of Remote sensing,* 3rd Edition, (ISBN: 0471-29405-5, John Wiley and Sons).

Eastman, J. (1993). Sequence time series evaluation using standardized principle components. *Photogrammetric Engineering and Remote Sensing*. 59(8): 991-996.

Lillesand, T. M., Kiefer R. W.,Chipman, J. (2003). *Remote sensing and image interpretation*, 5th ed., J. Wiley & Sons, New York; Lillesand, T. M. and Kiefer R.W. (2000). *Remote Sensing and Image Interpretation*, 4th ed. John Wiley and Sons, New York.

Murali Krishna, I. V. (1992). *Remote sensing approach & GIS: Recent Trends*,Tata McGrew hill publications company Ltd, New Delhi.

Sabins, F. (1997). *Remote Sensing Principles and Interpretation,* 3rd edition, Freeman press, New York.

Veena Devi, V. S. and Gangadhara Bhat, H. (2011). The critical analysis of various image fusion techniques for enhanced image features interpretation in remote sensing applications. *Archives of Applied Science Research*. 3(4): 206-21.

Veena Devi, V. S., Prasad, S. M., Gangadhara Bhat, H. (2013). An efficient algorithm for image stitching based on scale-invariant feature transform. *International Journal of Engineering and Applied Sciences*. 2(2).