Digital Image Processing

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Abstract: With the large cost involved in launching satellites, probes, sensors to keep an eye on the resources and entities of commercial value necessitates to strengthen the processing of procured data at ground stations. The emphasis is laid on enhancing the quality for easy human interpretation and reducing the quantity for easy storage and transmission. The first sine qua non involves the capturing of image and subsequent transfer to the ground stations, where the image is passed through various operations to retrieve the information of the captured area. The three pronged approach of capturing at suitable height, segmentation or edge roughening at the middle stage and retrieving the information from the base created by initial stages. With the arrival of new software's to enhance the quality, a single image serves the representative of the whole area. The processing of the images helps to get the information in shortest possible time and energy.

Keywords: Digital Image,

Introduction

A digital image is the representation of two dimensional image as a finite set of digital values, known as picture elements or pixels. The processing of the image initiates with news paper industry got necessary impetus with arrival of computers and soon entered into the domain of critical professions. Image processing serves as a technique to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts. Image Processing has become essential feature for retrieving maximum information suitable for various professions like Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Graphic arts and Printing Industry. The common steps in image processing are image scanning, enhancing, interpretation and storage. Either traditional methods or modern technological tools are used for enhancing the quality of the images. Accordingly, processing is categorized into two types: Analog Image Processing: It involves the alteration of images with the aid of electrical variation technology. The most common example is television image. The television signal is a voltage level which varies in amplitude to represent brightness through the image. By electrically varying the signal, the displayed image appearance is altered. The brightness and contrast controls on a TV set serve to adjust the amplitude and reference of the video signal resulting in the brightening, darkening and alteration of the brightness range of the displayed image. Digital Image Processing: The sine qua non of this processing involves the availability of computer for the subsequent Processing of 2-dimensional picture. It also involves subjecting numerical representations of objects to a series of operations in order to obtain a desired result. It starts with one image and produces a modified version of the same. It is, therefore, a process that takes an image into another form. Digital image is an array of real numbers represented by a finite number of bits formed by the intersection of each row i and column j in each k band (pixel). The pixels are associated with Digital Number (DN) or Brightness Value (BV). The DN value varies from 0-1063 (10 digit), 0-255(8-bit) or 0-63 (6- bit). It represents the average radiance of a relatively small area within a scene.

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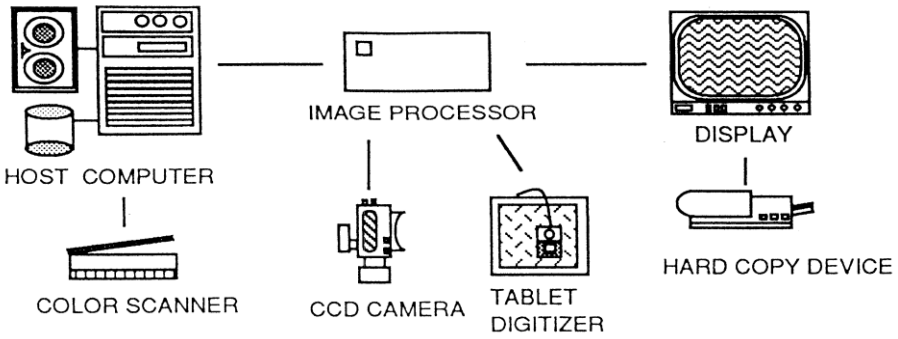


Image processing system with Image processor

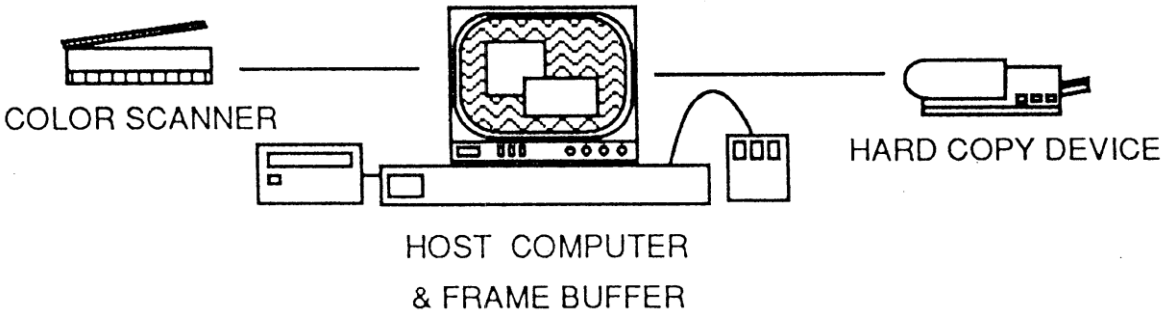
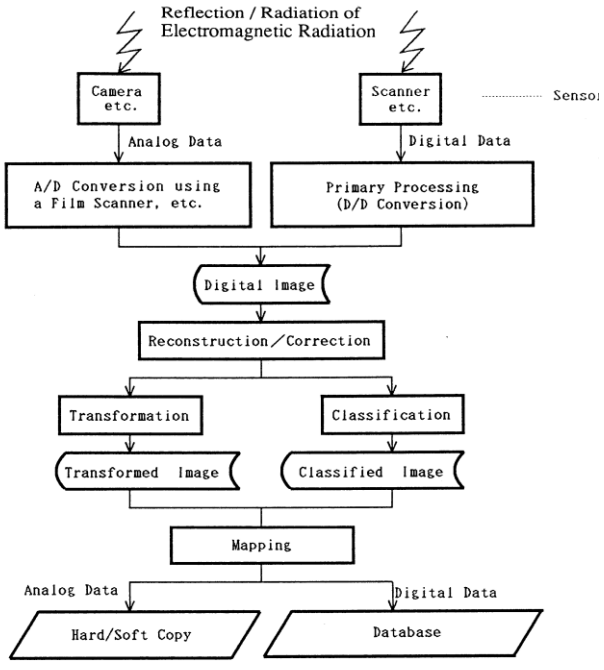


Image processing system with general purpose Computer

Process Flow: As the humans are not able to see infrared radiations, a false composite colour combination is used to represent different segments in imagery. The most commonly used being Red, Blue and Green (RGB). The camera is used to capture the image and scanners are used to produce digital imagery. Cameras mounted in light aircraft flying between 200 and 15,000 m capture images autonomously. Aerial photos provide an instant visual inventory of a portion of the earth's surface and can be used to create detailed maps. Light, portable, inexpensive video cameras and recorders can also be carried in chartered aircraft. For use in digital analysis, special graphics hardware boards known as frame grabbers can be used to freeze any frame within a continuous video sequence and convert it to digital format, usually in one of the more popular exchange formats such as TIF or TARGA. The angle at which the images are captured determines the technological superiority as images at certain angle gave larger information than others. The camera and the platform configurations are categorized into oblique and vertical. The capturing of the images at an angle occurs in the domain of obligue aerial photography. The surroundings of the camera are fully covered under such image. The oblique image is easier to interpret than vertical photographs, but it is difficult to locate and measure features for mapping purposes. The images obtained at 'nadir' is taken by pointing the camera in perpendicular direction. The images obtained by vertical camera depict the ground features clearly in plan form, ensuring its utilisation for mapping purposes. Vertical images are highly desirable for resource surveys in areas where no maps are available. The necessity of covering the whole area is ensured by capturing the images in overlapped position which varies from 60% along flight path and at least 20% between the lines. Overlapped images can be viewed with a stereoscope to create a three-dimensional view, called **stereo model.** Images are usually taken by large format cameras (23x23 cm) or small format cameras (35mm x 70 mm). The images are stored in hard/ soft form (analog form) or directly in database (digital form). A classical flow chart of data flow in remote sensing is as follows, Pic 1



Pic 1: Flow Chart: Data Flow in Remote Sensing

Data processing: The processing of the data in remote sensing following three stages as Reconstruction, Transformation and Classification, Pic 2. The individual breakup helps to enrich the quality of the captured images for easier interpretation.

I) Reconstruction/ Correction: It is subdivided into different categories

i) Restoration: Image restoration refers to removal or minimization of degradations in an image. The restoration of the image involves improving the condition for further processing. This includes de-blurring of images degraded by the limitations of a sensor or its environment, noise filtering, and correction of geometric distortion or non-linearity due to sensors. Image is restored to its original quality by inverting the physical degradation phenomenon such as defocus, linear motion, atmospheric degradation and additive noise. This is called radiometric resolution. The geometric resolution employability ensured the registration of the imagery for the mapping purposes. With satellite imagery, the very high altitude of the sensing platform results in minimal image displacements due to relief. As a result, registration can usually be achieved through the use of a systematic rubber sheet transformation process that gently warps an image (through the use of polynomial equations) based on the known positions of a set of widely dispersed control points.

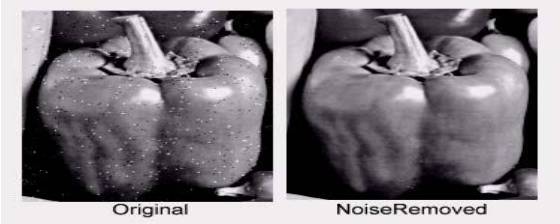
ii) Image Reconstruction: Image reconstruction from projections is utilized for special class of image restoration problems where a two or higher dimensional object is reconstructed from several one-dimensional projections. Each projection is obtained by projecting a parallel X-ray (or other penetrating radiation) beam through the object. The projection obtained are Planar, obtained by viewing the object from many different angles. Reconstruction algorithms derive an image of a thin axial slice of the object, giving an inside view otherwise unobtainable without performing extensive surgery. Such techniques are important in medical imaging (CT scanners), astronomy, radar imaging, geological exploration, and non-destructive testing of assemblies.

iii) Mosaic: Sometimes the images of particular area or object are captured in patches. Mosaic involves the combining of two or more images or patches to form a single large image without radiometric imbalance. Mosaic is required to get the synoptic view of the entire area, otherwise captured as small images.

II) Transformation: The images need to be transformed for larger retrieval of information. The images lacking proper contrast and brightness is accentuated for subsequent analysis. It is done by

i) Contrast stretching: Some images (Ex. Over water bodies, deserts, dense forests, snow, clouds and under hazy conditions over heterogeneous regions) are homogeneous i.e., they do not have much change in their levels. In terms of histogram representation, they are characterized as the occurrence of very narrow peaks. The homogeneity can also be due to the incorrect illumination of the scene. The contrast stretching methods are designed exclusively for frequently encountered situations.

ii) Noise filtering: It is used to filter the unnecessary information from an image. It is also used to remove various types of noises from the images. Various filters like low pass, high pass, mean, median etc. are available.



iii) Histogram modification: Histogram has a lot of importance in image enhancement. It reflects the characteristics of image. By modifying the histogram, image characteristics can be modified. One such example is Histogram Equalization. Histogram equalization is a nonlinear stretch that redistributes pixel values so that there is approximately the same number of pixels with each value within a range. The result approximates a flat histogram. Therefore, contrast is increased at the peaks and lessened at the tails.

iv) Data compression: The image is should be compressed so that each pixel is compressed without affecting radiometric properties. It is commonly done by DCT (discrete cosine transformation) developed by JPEG (joint photographers expert group). For higher compression ratios with minimum loss of data, Wavelet based compression technique is used.

v) Rotation: The images are rotated in order to match with the second image. It is mostly used in mosaic, restoration for joining many images together for final interpretation. Most common technique is 3-pass shear rotation where matrix is decomposed into separate matrices (developed in California) like

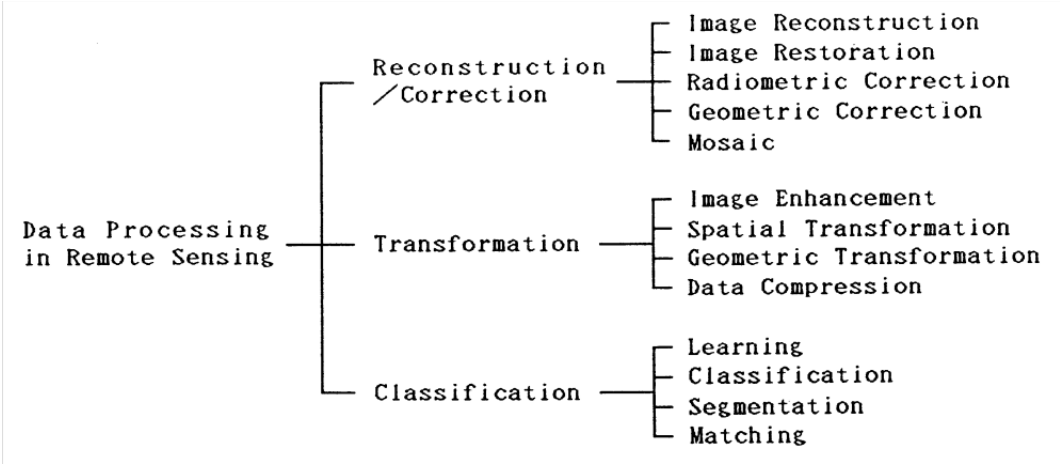
$$R=\begin{matrix}\cos\alpha & -\sin\alpha \\ \sin\alpha & \cos\alpha\end{matrix}=\begin{matrix}1 & \tan\alpha \\ 0 & 1\end{matrix}\ x\ \begin{matrix}1 & 0 \\ \sin\alpha & 1\end{matrix}\ x\ \begin{matrix}1 & -\tan\alpha \\ 0 & 1\end{matrix}$$

III) Classification: It involves the categorisation of individual components of the image that constitute the image.

i) Segmentation: It is the process that subdivides an image into its constituent parts or objects. The level to which this subdivision is carried out depends on the problem being solved, i.e., the segmentation should stop when the objects of interest in an application have been isolated e.g., in autonomous air-to-ground target acquisition, when our interest

lies in identifying vehicles on road, first step is to segment the road from the image and then segment the contents of road down to potential vehicles. Image thresholding techniques are used for image segmentation.

ii) Classification: It is the labelling of a pixel or a group of pixels based on its grey value. Classification is one of the most often used methods of information extraction. In Classification, usually multiple features are used for a set of pixels i.e., many images of a particular object are needed. In Remote Sensing area, this procedure assumes that the imagery of a specific geographic area is collected in multiple regions of the electromagnetic spectrum and that the images are in good registration. Most of the information extraction techniques rely on analysis of the spectral reflectance properties of such imagery and employ special algorithms designed to perform various types of 'spectral analysis'. The process of multispectral classification is performed by either supervised or unsupervised way. In Supervised classification, the identity and location of some of the land cover types such as urban, wetland, forest etc., are known as priori through a combination of field works and toposheets. The analyst attempts to locate specific sites in the remotely sensed data that represents homogeneous examples of these land cover types. These areas are commonly referred as TRAINING SITES because the spectral characteristics of these known areas are used to 'train' the classification algorithm for eventual land cover mapping of reminder of the image. Multivariate statistical parameters are calculated for each training site. Every pixel both within and outside these training sites is then evaluated and assigned to a class of which it has the highest likelihood of being a member. While in Unsupervised Classification the identities of land cover types has to be specified as classes within a scene which are generally not known priori because ground truth is lacking or toposheets are not available. In this case, computers are required to group pixel data into different spectral classes according to some statistically determined criteria. Example the comparison in medical area is labelling of cells based on their shape, size, colour, and texture which act as features. This method is useful for MRI images.

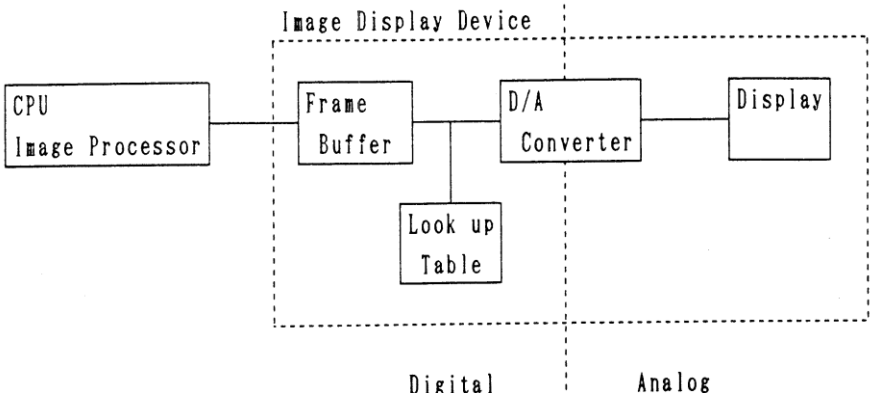


Pic 2: Data processing in remote Sensing

After processing of the image**,** Principal Components Analysis (PCA) is brought to the surface, a linear transformation technique related to Factor Analysis. Given a set of image bands, PCA produces a new set of images, known as components that are uncorrelated with one another and are ordered in terms of the amount of variance they explain from the original band set. PCA has traditionally been used in remote sensing as a means of data compaction. For a typical multispectral image band set, it is common to find that the first two or three components are able to explain virtually all of the original variability in reflectance values. Later components thus tend to be dominated by noise effects. By rejecting these later components, the volume of data is reduced with no appreciable loss of information.

Image Display Devices: The information is converted by Image input system pic 3. Image input systems are defined as the analog to digital converters of analog images. The image system provides digital data which are the converted tone or colour of a film or photograph. In case of colour image, the components of the three primary colours (Red, Blue and Green) are digitized by using three colour filters. In Mechanical Scanner, an image placed around a drum is scanned using the rotation of the drum and a shift of a light source. Though the speed of scanning is not very high, it is widely used because the spatial resolution and density resolution are very high. Recently laser beams have been used as the light source which enables a faster speed. The Electronic image tube such as TV camera is used for A/D conversion of an image. However the spatial resolution density resolution and positioning accuracy are low. The advantages are its low price and ease of use. The electronic image tube is now being replaced by CCD cameras with higher spatial resolution and positioning accuracy. These systems are compact and lightweight. In some cases, a linear array CCD with very high resolution, for example 409 pixels line is derived mechanically to

enable line, scanning on a flat table. The spatial resolution, density resolution and positioning accuracy are very high, so that desk top scanners are becoming popular. In latest methods, an illuminated spot on a CRT is projected onto a film, at a given coordinate, with high speed. The density of the film can be digitized regularly as well as randomly depending on the input coordinates known as flying spot technique. The disadvantage is that a dark room is required.



Pic 3: Organization of Image display Devices

The processed images need to be stored for their long term survivability. The digital data is stored in magnetic and streamer tapers, which are most widely used with general purpose computers and minicomputers. The data format is well standardized so that transportability is also guaranteed. The disadvantage is that the size of the magnetic tape and tapers are so big that the storage space becomes bulky. In Digital audio tape (DAT) the capacity is bigger and the price is lower and is becoming popular for PC's. The disadvantage is its low data transfer rate. Magneto optical disk (MO-disk) ensures compact size and capacity is also large, similar to an ordinary hard disk. Because rewriting is possible, exchange is available, the data transfer rate is much faster than tape media, and the price is lower, this media is very popular for Pc's. In write one and read many optical disk (WORM) rewriting is impossible, therefore, users are decreasing. However the capacity is a little larger than a MO-DISK and the storage life is longer. The large scale spread of computer technology ensures the large scale usage of Floppy discs, which are the most popular storage for Pc. The disadvantage is that the capacity is limited to a few Megabytes and the data transfer rate is low. The advantages are its low price and data exchangeability. The modern storage devices like 8 mm video tape is cheaper in price and bigger in storage capacity than DAT. The data transfer rate is not very fast but is a little faster than DAT. The optimum storage is provided by Optical tape with a capacity of about 1 terabyte. The data transfer rate is more than ten times faster than DAT, rewriting is possible and the device is exchangeable. The optical tape is expected to be the new media for the next generation. Although the price is very expensive, data capacity and the life of the tape make it economic for all large volume users since for less standard tape is used.

Advantages of DIP: The main advantages include Versatility, repeatability and preservation of original data precision. The processing of images is faster and cost-effective. Transmission of the digital images are easier as compared to normal images. The processed images can be further enriched by various available software's, thus ensures higher retrievability of information.

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