

4. IMAGE PROCESSING TECHNIQUES FOR REMOTE SENSING DATA

M. R. RAMESH KUMAR

National Institute of Oceanography,
Dona Paula, Goa-403 004.

Digital image processing is used for improvement of pictorial information for human interpretation and for processing of scene data for autonomous machine perception. The technique of digital image processing are used for automatic character/pattern recognition, industrial robots for product assembly and inspection, military recognizance, automatic processing of fingerprints, screening of X-ray and blood samples, machine processing of aerial and satellite imagery for weather prediction and crop assessment and in many other similar applications.

A digital image is considered as a matrix whose row and column indices identify a point in the image and the corresponding matrix element value identifies the gray level at that point. The elements of such a digital array are called image elements, picture elements, pixels or pels. The components of a basic, general purpose digital image processing system are shown in figure 1. The three important steps are digitization, processing and display.

A digitizer converts an image into a numerical representation suitable for input into a digital computer.

Some of the commonly used devices for this purpose are micro-densitometers, TV camera digitizers and photodiode/CCD scanner array chips. The systems used for image processing range from microprocessor devices for special purpose applications to large computer systems capable of performing a variety of functions on high-resolution image arrays.

In general, magnetic tapes are used for archival storage and discs are used during image processing for improving the data transfer speed between the computer memory and bulk storage media. The minicomputer generally has 64K to 128K of core memory, two disc drives, one magnetic tape unit and peripherals like VDU units, cassette recorders, line printer or some other hardcopy output devices. The function of display unit in an image processing system is to convert the numerical arrays stored in the computer into a form suitable for human interpretation. The principal display media are the VDU's, CRT's, TV systems and printing devices.

The image processing techniques are divided into four major categories: (i) image digitization, (ii) image enhancement and restoration, (iii) image encoding, and (iv) image segmentation and representation. The digitization problem is one of converting continuous brightness and spatial co-ordinates into discrete components. The mathematical concepts involved are the sampling and transform theory. Two dimensional transforms are used for image

enhancement, restoration, encoding and description too.

The main objective of the image enhancement is to process a given image so that the result is more suitable than the original image for a specific area of application. Figure 2 gives the conceptual basis of theme oriented enhancements. The curve OA represents the one to one linear mapping between actual input count and the output count (the transformed count as displayed in the image). Here the slope OA is unity. The curve OBB' refers to segment OB where the slope is greater than unity in the segment OB and the slope is zero in the segment BB' implying the masking of information gradient in the input count range corresponding to segment BB'. The curve O-C-D-E-F-G involves assigning of a particular output count to a range of input counts (thus masking the gradient) and represents step function enhancement. All these enhancements are to improve representation of small temperature gradients.

The steep linear (slope greater than one) enhancing technique provides excellent details in the data. With multiple linear enhancements (curve O-H-I-J-K-L-M) one could obtain increased contrast for the resulting introduction of multiple grey scales may mask meteorologically significant cloud edges. The step function enhancements are useful for bringing out the vertical structure of clouds.

Improved interpreting for the enhanced images demand the following:

- (a) Number of features to be enhanced in an image should be limited.
- (b) Only necessary details in the data should be studied without making the display overlay confusing.

Each image contains informations on a variety of features related to oceans, landmasses including snow and clouds. All these features cannot be enhanced simultaneously by a single enhancement curve. In other words one can enhance the features of one's interest by suppressing other features. Thus one has to trade off between the number of features to be enhanced and the easiness in assimilation.

Based on their goals, the existing techniques can be grouped into (a) noise cleaning, (b) feature enhancement, and (c) noise cleaning plus feature enhancement. It is well known that a picture can be degraded by additive noise, and be smeared by point spread functions. The noise-cleaning operator aims at the removal of random noise; in other words, it disregards irrelavant information. The feature-enhancement operator aims to decrease the blurring, and to reveal the features of interest. These two operators deal with different degradation phenomena; in practice, however, many operators are a combination of both.

According to the technical methods involved, the published techniques can be organised into four groups.

They are:

- (a) Spatial smoothing of regions, which employs linear or non-linear spatial-domain low-pass filters;
- (b) Gray-level rescaling, which manipulates or requantizes gray levels for contrast enhancement;
- (c) Edge-enhancement, which involves linear or non-linear spatial-domain high-pass filters.
- (d) Frequency-domain filtering, which utilizes low or high-pass filters in the frequency domain where fourier transformation is required.

An object when imaged through an optical system can go through various types of degradations like, diffraction limits of the optical imaging system, defocus, motion of the object in its plane during exposure, atmospheric turbulence, film grain or sensor noise etc. The mechanism of degradation is very complex. Therefore, the degradation effect is modelled in some way and then used to reconstruct the image for human or machine perception. The modelling, analytic or statistic of the degradation phenomenon is based on some apriori or aposteriori knowledge of it. Image restoration is different from image enhancement techniques which are designated to manipulate an image taking advantage of the psychophysical aspects of the human visual system. A number of techniques have been suggested for restoration

of degraded images like inverse filter, wiener filter and constrained least square filter etc.

The primary objective of scene analysis is to deduce from a single two dimensional image the organisation of the scene which it depicts, in terms of objects and their inter-relationships. In order to identify the objects which are of interest as well as to establish inter-relationships among them. The scene analysis techniques generally partition the image into elementary regions consisting of individual pieces, or perhaps groups of adjacent pixels with identical attributes. There has been a great deal of work on segmenting images. Thus regions have been classified on the basis of brightness, hue, saturation, texture, size, shape, orientation and contrast of their boundaries.

For identifying the region boundaries several edge detection techniques have been proposed. The edge detection technique assumes special importance in the context of oceanography, since locating a feature we must be able to identify its boundary. In fact much of the important information is contained in the edges. Edges in images/pictures are usually detected by the use of operators which examine and compare intensity values within a small region of the gradient, the derivative in the direction of maximum change of intensity. Some of the common operators are the Robert cross operator, Laplacian operator....etc.

The development most useful to oceanography which have occurred in image processing are those which enable

quantitative measurements to be made of the spatial features which are apparent in imagery. Simple processing to emphasize spatial patterns on an image can be of some use, but it is scientifically more valuable to be able to measure the spatial length scales on an image. Thus, if gyres or eddies are present in a visible or infra-red image, it would be of value to the development of dynamical theories to be able to extract the gyre radius.

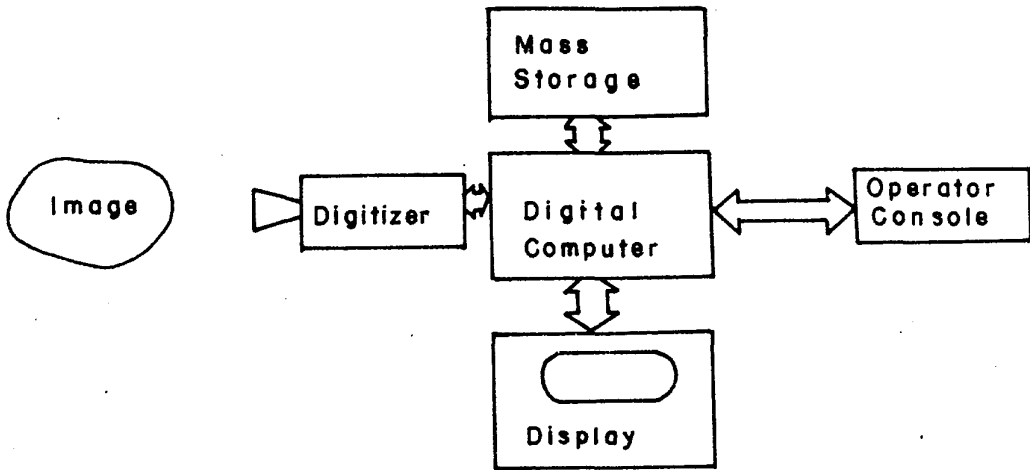


Fig. 1 : Elements of a digital image processing System.

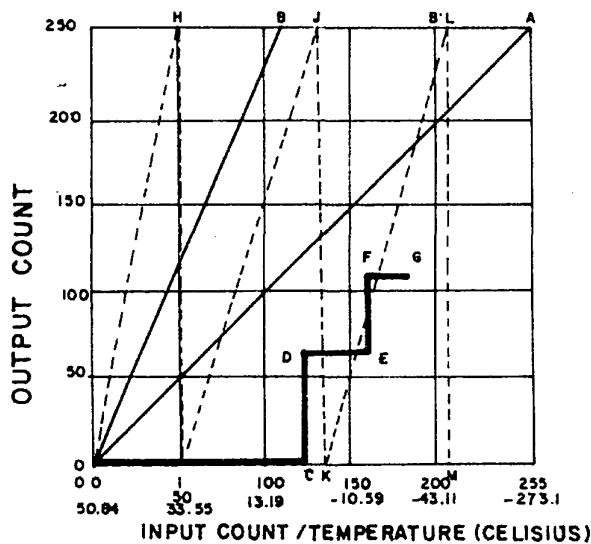


Fig. 2 Conceptual representation of the theme oriented enhancement technique for thermal infrared data