Digital Image Processing of Remotely Sensed Satellite Images for Information Extraction

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Abstract

Remote Sensing (RS) refers to the science of identification of earth surface features by measuring portion of reflected or emitted electromagnetic radiation from earth's surface by sensors onboard manmade satellites orbiting around the earth. The output of a remote sensing system is usually an image representing the scene being observed. Many further steps of digital image processing and modelling are required in order to extract useful information from the image. Suitable techniques are adopted for a given theme, depending on the requirements of the specific problem. Multi-spectral classification is an information extraction process that analyses these spectral signatures and assigns the pixels to classes based on similar signatures. The paper reviews the digital image processing techniques for information extraction from high resolution satellite images.

Keywords : Digital Image processing, Multispectral classification, Remote Sensing, Spectral Signature

1. **Introduction**

Remote sensing usually refers to the technology of acquiring information about the earth's surface (land and ocean) and atmosphere, using sensors onboard airborne (aircraft, balloons) or space-borne (satellites, space shuttles) platforms. The electromagnetic radiation is normally used as an information carrier in RS. Remote sensing employs passive and/or active sensors. Passive sensors are those which sense natural radiations, either reflected or emitted from the earth. On the other hand, the sensors which produce their own electromagnetic radiation, are called active sensors (e.g. LIDAR, RADAR). Remote sensing can also be broadly classified as optical and microwave. In optical remote sensing, sensors detect solar radiation in the visible, near-, middle- and thermal-infrared wavelength regions, reflected/scattered or emitted from the earth, forming images resembling photographs taken by a camera/ sensor located high up in space. RS data, with its ability for a synoptic view, repetitive coverage with calibrated sensors to detect changes, observations at different resolutions, provides a better alternative for natural resources management as compared to traditional methods. Different land cover features, such as water, soil, vegetation, cloud and snow reflect visible and infrared light in different ways. Interpretation of optical images requires the knowledge of the spectral reflectance patterns of various materials (natural or man-made) covering the surface of the earth. The visual interpretation of such images employ different elements of interpretation viz. shape, size, tone or hue , texture , pattern , shadow, location/ association. Manual interpretation and analysis dates back to the early beginnings of remote sensing for air photo interpretation. Manual interpretation is often limited to analyzing only a single channel of data or a single image at a time due to the difficulty in performing visual interpretation with multiple images. Manual interpretation is a subjective process, meaning that the results will vary with different interpreters. The time required for visual classification depends heavily on interpreter experience, image quality and details to identify . Due to these reasons during the last decades, visual interpretation became less popular compared to automatic processing as digital analysis is useful for simultaneous analysis of many spectral bands and can process large data sets much faster than a human interpreter.. Digital analysis is based on the manipulation of digital numbers in a computer and is thus more objective, generally resulting in more consistent results.

2. Digital image processing

It comprises the following four basic steps: (a) *Image correction/restoration*: Image data recorded by sensors on a satellite or aircraft contain errors related to geometry and brightness values of the pixels. These errors are corrected using suitable mathematical models, which are either definite or statistical models. (b) *Image enhancement:* Image enhancement is the modification of image, by changing the pixel brightness values, to improve its visual impact. Image enhancement techniques are performed by deriving the new brightness value for a pixel either from its existing value or from the brightness values of a set of surrounding pixels. (c) *Image transformation*: The multi-spectral character of image data allows it to be spectrally transformed to a new set of image components or bands with a purpose to get some information more evident or to preserve the essential information content of the image (for a given application), with a reduced number of transformed dimensions. The pixel values of the new components are related to the original set of spectral bands via a linear operation.(d) *Image classification:* The overall objective of image classification procedures is to automatically categorize all pixels in an image into land cover classes or themes. A pixel is characterized by its spectral signature, which is determined by the relative reflectance in different wavelength bands. Multi-spectral classification is an information extraction process that analyses these spectral signatures and assigns the pixels to classes based on similar signatures.

There are two major approaches to multi-spectral classification: unsupervised and supervised. The unsupervised classification is the identification of natural groups, or structures, within multi-spectral data. The supervised classification is the process of using samples of known identity (ground truth sites) to classify pixels of unknown identity (i.e. to assign unclassified pixels to one of several informational classes). There are many classifiers used for supervised classification. One of the most common is maximum likelihood classifier. The maximum likelihood classifier relies upon the assumption that the populations from which the training samples are drawn are multivariate-normal in their distribution Clearly this is not the case in remote sensing, for the image pixel values are non-negative, discrete and have an upper bound of 255, 1023 or some other value depending upon the characteristics of the instrument, which acquired the data, whereas the normal distribution relates to continuously measured and unbounded data.

To overcome the problem of normality, the currently favoured alternatives are non-parametric classifiers. A nonparametric classifier uses a set of nonparametric signatures to assign pixels to a class based on their location, either inside or outside the area in the feature space image. To overcome difficulties in conventional digital classification, new approaches like context classifiers, decision tree classifiers, neural network algorithms, etc., are being developed. Another technique is fuzzy classification in which, each pixel is assigned a number for each class, ranging from 0 to 1, which indicates the proportions of the different classes, which have contributed to the observed spectral signature. These classifiers are mainly used, when the spectral reflectance of different features do not follow normal distribution.

3. Discussion

Conventional spectral classifiers have been widely used for image classification and have given good results for a wide variety of low to medium resolution images. Usually conventional spectral classifiers perform well over limited areas where spectral signatures do not vary greatly from those captured in the training data. However, as the size of area to be classified increases, the classification accuracy typically decreases *(Carlotto, 1998)*. In many real applications, the thematic (class) maps generated by conventional spectral classifiers are often found to be very "noisy", with a considerable portion of image pixels being misclassified Limited sensor radiometric and spatial resolution. Limitations in radiometric resolution reduce the distances of classes in the feature space making it difficult to discriminate between classes. The limitation in geometric resolution leads to class mixture with one cell (mixed pixel) and since the cell boundaries in the image does not correspond with the boundaries of terrain features, this more eminent on the transition zones between land covers. A detailed discussion on causes of mixed pixels can be found in *Fisher (1997)*.

(ii.) The definition of information or land use classes is vague; there is no distinct boundary between different land uses (for example urban/rural, forest/grassland). Therefore, the boundaries that are set by image analysts are just limited idealisations of the real world which makes it difficult for automatic classification results to replicate.

(iii.) The relationship between land cover and land use is based on vague knowledge and is therefore only modelled, which limits the performance of algorithms based on it.

(iv.) The diverse composition of urban scenes (different objects with similar spectral values and same objects with different spectral values e.g building and roads) coupled with high resolution RS imagery (less than 10 m) cannot be sufficiently handled by conventional multispectral classifiers that rely on spectral information only.

In conventional multispectral classifiers a particular pixel can only be assigned to one classirrespective of the proportion of spatial and spectral similarity of a pixel to several classes. Therefore, such classifiers are known as hard classifiers. This type of decision rule results in areas of categories with spatial extents smaller than a pixel being overestimated or underestimated. Some application like extraction of urban features require information at subpixel level for clear definition of boundaries

4.Conclusion

High resolution imagery offers a new quality of detailed information. As smaller and smaller objects are now available, as well as precise contours of larger objects, automatic methods for extracting these objects are required. Consequently, this has given rise to a growing interest on image processing tools. However, the high resolution images show great heterogeneity, standard techniques for analyzing, segmenting and classifying the data are faced with increasingly difficult hurdles. When the resolution increases, the spectral variability also increases, which can affect the accuracy of further classification. Most of the current classification techniques like ML classifier operate per-pixel basis in isolation from other pertinent information. Various errors are involved in the classification performed in per-pixel basis. The mixed pixels, the simplicity of the basic assumptions made for the classification algorithms, the sensor and the atmospheric effects, and the spectral overlaps between land cover types reduces the classification accuracy. Hence, efficient object based feature extraction method is required to classify the high resolution multi-spectral imagery.

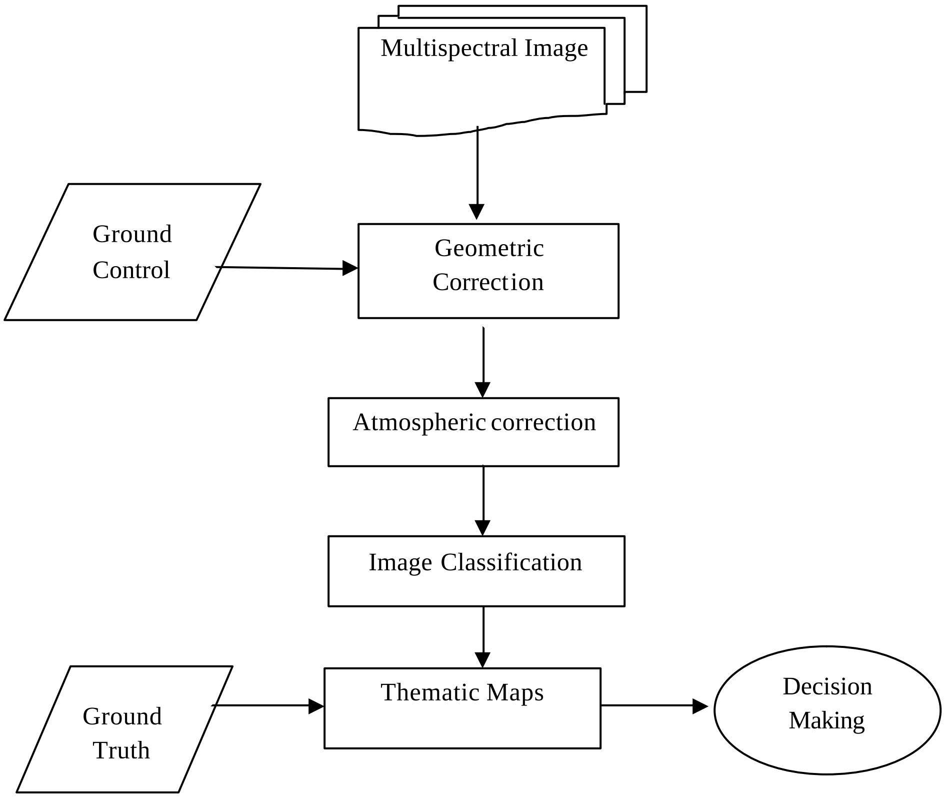

Figure 1 : Schematic of Image processing procedures for Remote Sensing satellite data

Figure 2 : False Colour Composite

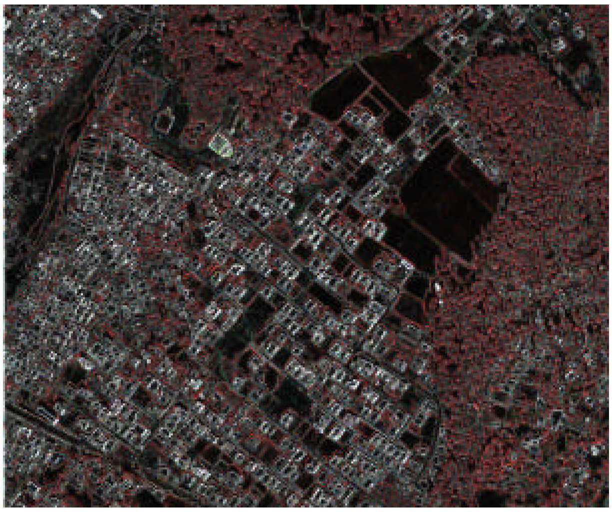

Figure 3: Sobel Filtered Image

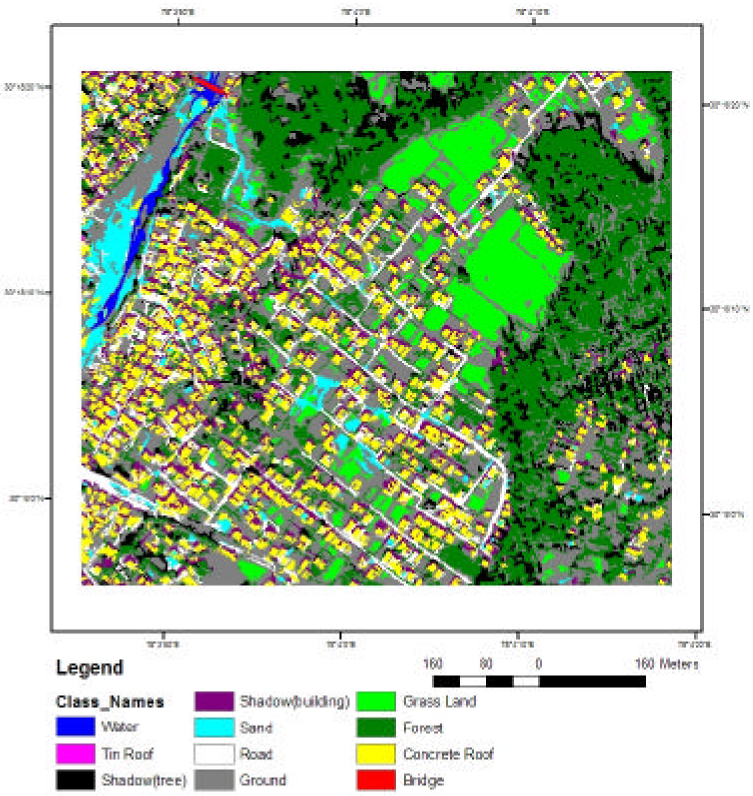

Figure 4: Classified Image (Land cover Map)

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