ABSTRACT

In remote sensing, even the high resolution images have limitations in conveying information about the landcover features due to the limitations of the sensor source. This could be overcome by multisensor image fusion, a recent image processing technique, and we can obtain more and better information about an object or an area. Fusion may be defined as a combination of multiple images to form a new image for a certain application using a certain algorithm.

The results of fusion performed using certain classical (IHS - Intensity, Hue, Saturation, Brovey, PCA - Principal Component Analysis and Multiplicative) techniques have not been satisfactory due to the distortion in the spectral content, introduction of artifacts, limited applicability of the fused images, etc. This work aims to develop and implement the wavelet transformation based image fusion, which is a superior one. The *wavelet transform* or *wavelet analysis* is probably the most recent solution to overcome the shortcomings of the Fourier transform. The objectives of this work also include: improving the interpretability of fused images, evaluating the quality of fused images and the techniques of fusion, demonstrating the different applications of fusion, and assessing the role of image fusion in aiding sub-pixel classification.

While demonstrating the quality changes that occur due to fusion of images with varying resolution ratios, it is observed that the fusion of the images with unaltered (IRS 1C LISS III=23.5m and PAN=5.8m) resolution, gives the best result. Fusion using the LISS III=20; PAN=5 ratio leads to

generation of synthetic pixels and distortion of shapes of smaller features, while the LISS III=24; PAN=6 ratio results in blurring due to down sampling, dropping out of pixels and loss of information. Hence, it is recommended that no alteration of resolution of input images be attempted before fusion.

As a contribution to the field of research in image fusion, certain new and improved parameters, namely, AOI (Area of Interest) based statistical approach, spectral separability and classification accuracy (kappa statistics) are suggested for evaluating the performance of the fusion technique. Among the conventional methods, PCA based fusion was found to be better than IHS and Brovey transformation techniques in improving visual interpretability and in preserving the original spectral information content. When compared with conventional techniques, the wavelet transformation technique proved to be a better option since it preserved most (85%) of the spectral information content and also improved visual appreciation. It is observed that fusion has increased the spectral separability of vegetation classes. This increase is the highest in the wavelet transform fused image followed by the PCA fused image. As regards the classification accuracy, it is seen that the kappa value of 0.72 is obtained for wavelet fused images, while for PCA fused images it is 0.65, thus indicating that classification accuracy can also be used to evaluate the performance of a fusion technique.

To demonstrate newer applications of multisensor fusion, images with overlapping spectral ranges (for spatial enhancement); non-overlapping spectral ranges (for spectral enhancement), and images from passive and active sensor sources were fused. Soil mapping was attempted in an agriculturally dominant area, with fusion of images acquired in the VNIR and SWIR regions by the

ASTER (Advanced Space-borne Thermal Emission and Reflection Radiometer) sensor. Optimal combinations were tried from amongst 9 bands (3 in VNIR + 6 in SWIR) using PCA and wavelet based fusion techniques. It is observed that the fused image obtained by wavelet transformation resulted in exhibition of the maximum number (7) of soil types when compared to the fused image obtained by PCA technique. Fusion using PCA technique resulted in enhancing the moist/wet soil types, while the wavelet transformation technique enhanced the saline and alkaline soils. It is believed that such enhancement is due to the complementary information provided by the VNIR and SWIR bands. The SWIR bands primarily contribute information about soil moisture and salinity, while the VNIR region provides information on landscape units and soil moisture, to aid in mapping the soil types.

While individual VNIR and SWIR images provide little information about geologic features, it is observed that fusion of images obtained in these two wavelength regions resulted in enhancement of geologic features for improved mapping of the same. Due to the characteristic reflectance of rocks and minerals in the SWIR region, fusion with higher resolution VNIR images results in better delineation and demarcation of various rock types such as Charnockite, Gabbro, Peridotite, Magnesite and Gneiss.

Fusion of optical (IRS LISS III) and SAR resulted not only in removal of cloud cover but also in restoration of landcover details in the areas where the clouds, and their shadows were present. This is due to the cloud penetration and moisture detection capabilities of active sensors and depiction of spatial details in the images obtained from passive sensors. Because of the object absorption property of Radar images when there is moisture, and because of the backscattering effect in the Radar image, the inundated areas in a part of Chennai city during the November 2002 monsoon were highlighted very well in the PCA and RGB colour composite of LISS III and SAR.

Improper choice of end-members/pure pixels (pixels with only one landcover component) will lead to erroneous estimation of sub-pixel land cover parameters. This study has demonstrated that: (i) fused images contain more pure pixels than the original coarse resolution image, (ii) wavelet fused images contain pixels that are more pure than the pixels in the images generated by other (PCA, IHS, Brovey) fusion techniques, and (iii) the soil fraction image (derived using end-members from wavelet fused image) shows excellent contrast between the soil types.

Thus, the recent and improved image fusion technique, namely, the wavelet transformation approach was implemented in this thesis. As wavelet transformation operates in the frequency domain, it is able to preserve most of the original spectral content in a better fashion than the conventional techniques, which operate in the spatial domain. Hence, it is suggested that image fusion be attempted in the frequency domain.