Remote sensing is making an increasingly significant contribution to the mapping and monitoring of vegetation. Satellite and aircraft platforms are able to quickly gather very large amounts of data; in addition, remotely sensed data can be archived so that it is possible to track changes in the Earth's surface over long periods of time.

One of the most important advances of the last decade is the availability of multispectral and hyperspectral sensors able to measure the radiance emitted by the Earth's surface in several narrow spectral bands. An important use of remotely sensed image data is the monitoring of land coverage for diverse applications: deforestation, agriculture, fire alerting etc. Other applications include land classification and segmentation, which are useful in fields such as land-use management and the monitoring of urban areas, glacier surfaces and so on. A lot of information can be extracted from these images and applied, for example, in monitoring soil conditions, supporting cultivation management or mapping land usage.

Land classification exploits the fact that we are able to identify the type of land cover associated with a given pixel by its unique spectral signature. The use of medium- or high-resolution spectral data opens new application opportunities: coverage of a wider fraction of the electromagnetic spectrum at a better spectral resolution means a better representation of the spectral signature corresponding to each pixel and better recognition of the unique spectral features of land categories.

However, the effectiveness of standard univariate classification techniques applied to multispectral data is often hindered by redundant or irrelevant information present in the multivariate data set.

Processing a large number of bands can paradoxically result in a higher classification error than processing a subset of relevant bands without redundancy, if multispectrality is not correctly taken into account.

Image processing can also provide boundary recognition and localization. One of the most frequent steps in deriving information from images is segmentation: the image is divided into homogeneous regions that are estimated to correspond to structural units in the scene, and the edges to be detected are calculated to correspond to the contours of these units. In some cases, segmentation can be performed using multiple original images of the same scene (the most familiar example is that of colour imaging). For satellite imaging this may include several infrared bands, containing important information for selecting regions according to vegetation, mineral type and so forth.

The WAGRIT project has been developed within the framework of the Italian Space Agency funding program to support SME technology development. The main functions of WAGRIT are: authenticated access to data and services via Intranet/Internet; multi-platform client applications; raster and GIS data browsing and retrieval from centralized archives; centralized data processing on the server side; data handling and editing on the client side; and simultaneous visualization of up to four images and synchronized operations (pan, zoom etc). In particular, the project has addressed the question of supervised classification based on statistical approaches and of land segmentation based on a variational approach.

Discriminant analysis was used in the first case. It was applied in the context of vegetation detection to establish relationships between ground and spectral classes. We have extended classical discriminant analysis with (a) a linear transform of the original components into principal or independent components, and b) a univariate nonparametric estimate of the density function for each separate component. In this way we are able to...
Mathematics Makes Waves

by Arghiris I. Delis, Serafim Poulos, Nikolaos A. Kampanis and Costantin E. Synolakis

Waves represent a driving force affecting coastal and urban areas. Mathematical models and their computational counterparts can provide simulation and forecasting tools that help us study their behaviour. FORTH-IACM is participating in European projects that are working to forecast the behaviour and effects of flood waves and tsunamis. This involves both exploiting and further developing existing simulation expertise and experience in field measurements and observation methods. These are envisaged to be a necessary complement to high-fidelity mathematical models.

Waves, although a source of delight, can apply significant and sometimes destructive pressure on coastal and urban areas, since their energy can grow enormously. Mathematical models account for such phenomena and offer a way of understanding how they form and propagate. Numerical discretization of such models provides tools to simulate existing observations and to forecast that which is yet to be seen and accounted for.

Free surface-water flow models provide the mathematics necessary to simulate flood waves. The full flow field, being turbulent and of geographical size, is described by the Navier-Stokes (NS) equations in complex 3D domains, supplied with appropriate turbulence closure models. The cascade of length and time scales therefore is huge, which makes the problem expressed in the Reynolds-Averaged (RANS) form computationally very demanding. Of particular difficulty is the discretization of the equations, the handling of the air-water interface movement and the poorly described turbulence characteristics. Recently, related research has been initiated in FORTH-IACM emphasizing high-resolution numerical techniques for the NS equations, in particular compact schemes and semi-implicit time-stepping.

A simpler yet reliable model is obtained by depth-averaging the NS equations using the shallow-water approximation. The water is considered to be an incompressible fluid with depth-averaged horizontal particle velocities, some variants as regards friction, and the Coriolis force (usually neglected). In addition, pressure is assumed to be hydrostatic, vertical accelerations negligible and depth-averaged viscous and turbulent stresses are applied. These are reasonable assumptions under the shallow-water hypothesis in many practical applications. As an alternative, the Bussinesq approximation is often used when dispersion is or is assumed to be relevant in modifying the waveforms. Such models are usually referred to as depth-averaged models. They provide qualitative approximate solutions efficiently and are therefore widely used in engineering applications.

Due to the complex nature of the water motion, especially during the process of wave breaking, the numerical models used to simulate the run-up of breaking long waves must be treated meticulously. Related research at IACM-FORTH focuses on the development of finite-difference and finite-volume...