Geospatial Technology for Prediction and Management of Natural Hazard and Disaster

Manisha Chaple

Abstract- Geospatial technology for prediction and management of natural hazards and disasters The assessment of the forest fire and degradation is one of the important factors to be considered for better management of the forest resources Spatial analysis is a vital part of GIS and can be used for many applications like site suitability, natural resource monitoring, environmental disaster management and many more. Vector, raster based analysis functions and arithmetic, logical and conditional operations are used based on the r ecovered derivations. Digital Elevation Model process is one of the satellite remote sensing applications, which requires large chunk of data and computational resources.

—————————— ◆ ——————————

I. INTRODUCTION

The handling of spatial data usually involves processes of data acquisition, storage and maintenance, analysis and output. For many years, this has been done using analogue data sources, manual processing and the production of paper maps. The introduction of modern technologies has led to an increased use of computers and information technology in all aspects of spatial data handling. The software technology used in this domain is geographic information systems (GIS). A general motivation for the use of GIS can be illustrated with the following example. For a planning task usually different maps and other data sources are needed. The first problem we encounter is that the maps and data have to be collected from different sources at different locations (e.g., mapping agency, geological survey, soil survey, forest survey, census bureau, etc.), and that they are in different scales and projections. In order to combine data from maps they have to be converted into working documents of the same scale and projection. With the help of a GIS, the maps can be stored in digital form in a database in world co-ordinates (meters or feet). This makes scale transformations unnecessary, and the conversion between map projections can be done easily with the software. The spatial analysis functions of the GIS are then applied to perform the planning tasks. This can speed up the process and allows for easy modifications to the analysis approach.

II. SPATIAL FILTERING

A characteristic of remotely sensed images is a parameter called spatial frequency defined as number of changes in Brightness Value per unit distance for any particular part of an image. Spatial filtering is the process of dividing the image into its constituent spatial frequencies, and selectively altering certain spatial frequencies to emphasize some image features. This technique increases the analyst's ability to discriminate detail. The three types of spatial filters used in remote sensor data processing are: Low pass filters, Band pass filters and High pass filters. For many remote sensing earth science applications, the most valuable information that may be derived from an image is contained in the edges surrounding various objects of interest. The edges may be enhanced using either linear or nonlinear edge enhancement techniques.

A. Image Classification

Image classification is to automatically categorize all pixels in an image into land cover classes or themes. Normally, multispectral data are used to perform the classification, and the spectral pattern present within the data for each pixel is used as numerical basis for categorization. That is, different feature types manifest different combination of DNs based on their inherent spectral reflectance and remittance properties.

B. Supervised classification

It is defined normally as the process of samples of known identity to classify pixels of unknown identity. Samples of known identity are those pixels located within training areas. Pixels located within these areas term the training samples used to guide the classification algorithm to assigning specific spectral values to appropriate informational class. The basic steps involved in a typical supervised classification procedure are illustrated on Fig.. The training stage Feature selection of appropriate classification algorithm

Post classification smoothening Accuracy assessment

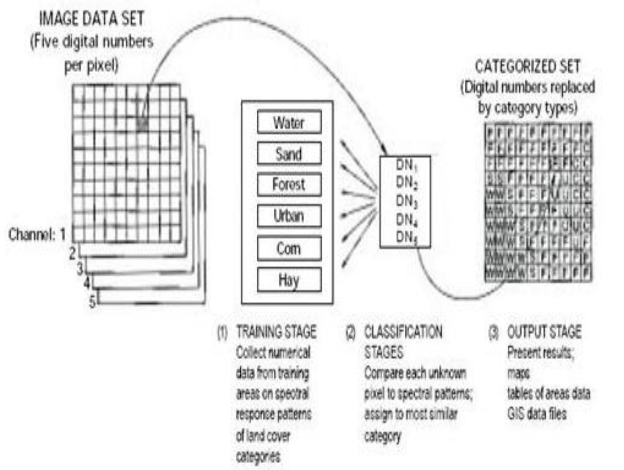


Fig. 1. Basic Steps in Supervised classification

C. Classification Error Matrix

Error matrices compare on a category by category basis, the relationship between known reference data (ground truth) and the corresponding results of an automated classification Table 1 is an error matrix that an image analyst has prepared to determine how well a Classification has categorized a representative subset of pixels used in the training process of a supervised classification. This matrix stems from classifying the training set pixels and listing the known cover types used for training (columns) versus the Pixels actually classified into each land cover category by the classifier (rows).

Table1: Error Matrix resulting from classifying training set pixels

	W	S	F	U	C	H	Row Total
W	480	0	5	0	0	0	485
S	0	52	0	20	0	0	72
F	0	0	313	40	0	0	353
U	0	16	0	126	0	0	142
C	0	0	0	38	342	79	459
H	0	0	38	24	60	359	481
Column Total	480	68	356	248	402	438	1992

III. NATURAL HAZARD: FOREST FIRE

A combination of edaphic, climatic and human activities account for the wild land fires. High terrain steepness along with high summer temperature supplemented with high wind velocity and the availability of high flammable material in the forest floor accounts for the major damage and wide wild spread of the forest fire. Fig. 2 shows triangle of forest fire. The vast majority of wild fires are intentional for timber harvesting, land conversion, slash and burn agriculture, and socio-economic conflicts over question of property and land use rights.

A. Ground fires occur in the humus and peaty layers beneath the litter of under composed portion of forest floor with intense heat but practically no flame. Such fires have been recorded in Himalayan fir and spruce forests.

B. Surface fires occurring on or near the ground in the litter, ground cover, scrub and regeneration, are the most common type in all fire-prone forests of the country.

C. Crown fires occur in the crowns of trees, consuming foliage and usually killing the trees, are in low level coniferous in the Siwaliks and Himalayas.

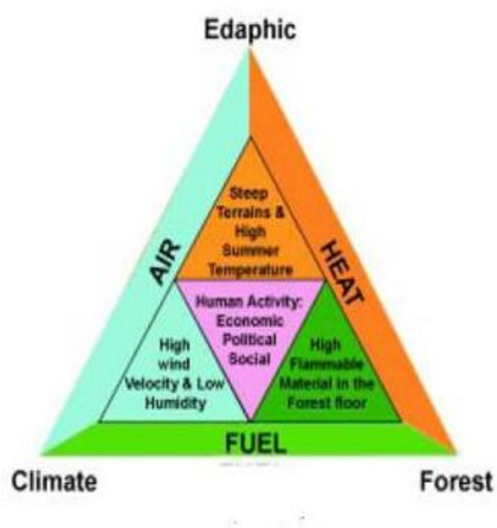


Fig. 2. Triangle of Forest Fire

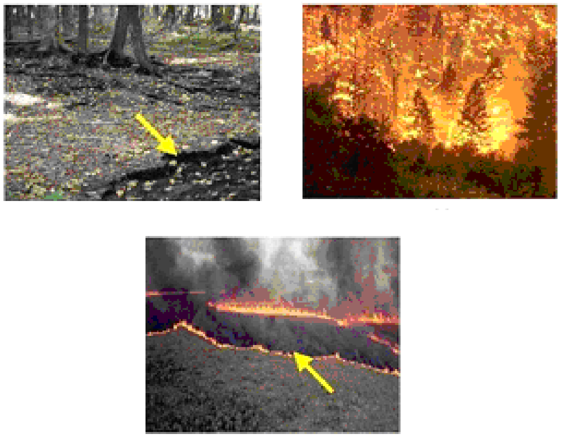
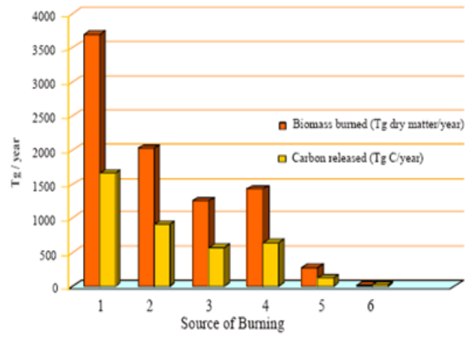


Fig. 3. Ground Fire, Surface Fire and Crown Fire

D. Impact of the Forest Fire on the Global Environment

Forest fires controlled or uncontrolled have profound impacts on the physical environment including: Landover, landuse, biodiversity, climate change and forest ecosystem. Biomass burning is global source of emission contributing Carbon dioxide and troposphere ozone. Biomass burning is uniquely tropical phenomenon because its geographical and temporal distribution is based on the observation of the tropics.

Source of burning (Tg dry matter/year)	Biomass burned	Carbon released (TgC/year)
Savannas	3690	1660
Agricultural waste	2020	910
Tropical forests	1260	570
Fuel wood	1430	640
Temperate and boreal forests	280	130
Charcoal	20	30
World total	8700	3940



E. Remote Sensing & Geographic Information System

Satellite observations providing a global survey of the composition of biomass burning plumes and their dispersal in the global atmosphere. Global mapping of CO and O3 columns can be achieved by the Global Ozone Monitoring Experiment (GOME) and Scanning Imaging. Global mapping CO is available on the EOS-A platform using the MOPPITT (Measurement of Pollution in The Troposphere). The sensor TES, planned for launching on the EOS-B platform, will provide horizontal and vertical mapping of a number of trace species including CO, O3, NOX and HNO3. Providing an effective response to wild land fires requires four stages of analysis and assessment:

F. Fire Potential

Fire potential depends on the amount of dead and live vegetation and moisture contents in each. The amount of dead and live vegetation is estimated from a high quality land cover map derived from (ideally) a high resolution sensor, such as the IRS, Landsat TM or SPOT multispectral scanner or from lower resolution sensor such as NOAA-AVHRR or NASA Moderate Resolution Imaging Spectrometer (MODIS). These satellites can be used to monitor changes in the vegetation vigor, which is correlated with the moisture of the live vegetation. The research project FIRE in global Resource and Environmental monitoring (FIRE) was initiated in order to address issues such as baseline land cover map and immediate estimate of vegetation condition. Fire monitoring system relies on remote sensing techniques as the main source of information. The AVHRR on the NOAA satellites is the main source of data for the studies done by the FIRE project.

G. Fire Detection

Satellite-borne sensors can detect fires in the visible, thermal and mid infrared bands. Active fires can be detected by their thermal or mid-infrared signature during the day or by the light from the fires at night. Satellite systems that have been evaluated for fire detection include AVHRR, which has a thermal sensor and makes daily over flights, the Defense Meteorological Satellite Program DMSP) Optical Line scan System (OLS) sensor, which makes daily over flights and routinely collects visible images during its nighttime pass, and the NOAA Geostationary Operational Environmental Satellite (GOES) sensor, which provides visible and thermal images Therefore AVHRR has been used most extensively for detecting and monitoring wildfires.

H. Fire Monitoring

Fire monitoring differs from fire detection in timing and emphasis rather than in the methods used to process the satellite image information. Satellite sensors typically provide coarse resolution fire maps which show the general location and extent of wild land fires. Detailed fire suppression mapping requires the use of higher resolution airborne thermal infrared sensors to accurately map small fire hot-spots and active fire perimeters. Higher-resolution fire maps are needed to deploy fire suppression crews and aerial water or retardant drops.

I. Fire Assessment

A combination of low resolution images (AVHRR) and higher-resolution images (SPOT, Landsat and Radar) can be used to assess the extent and impact of the fire. Radar has proved effective in monitoring and assessing the extent and severity of fire scars in the boreal forests Low resolution visible and infrared sensors such as AVHRR have proved useful for automated fire mapping (Fernandes et al., 1997) and for evaluating the impact of fire on long-term land cover change (Ehrlich et al., 1997).

IV. DIGITAL ELEVATION MODEL

A Digital Elevation Model is a digital representation of ground surface topography or terrain DEM generation from digital photos is a well-known and solved problem. Stereo matching [12] is a digital photogrammetric method to generate match points of two images taken at different angle/ time over a same area. Image matching is performed at regular grid interval. The correlation process involves searching for a reference window from left image in a larger search window that is taken on the right image. Correlation value is obtained at every position in the search window and the maximum correlation position is chosen as the match point (upper threshold). If the correlation value is below a minimum value (lower threshold), the point is immediately rejected. If the correlation value falls between minimum and maximum value, the window is expanded and again correlation values are found.

A. Requirement Analysis

A typical satellite pass of 1000 X 30 kilometer will generate 19.2GB of data volume. We need to find a large number of correlation points to generate a fairly accurate DEM, which makes 'cross correlation' algorithms more compute intensive. On a standard Intel Xeon based processor, it takes almost 50 hours of processing time. To add to the problems often the request for DEM generation is for bigger extents, which falls in multiple data sets (stereo pairs) stored at different ground stations.

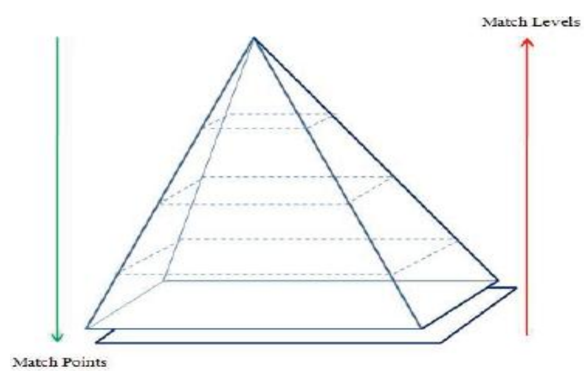


Fig. 4. Hierarchical Matching of image

B. Communication Infrastructure

Satellites have the inherent advantage of instant and easy setup at remote places where connectivity is not possible with high speed broadcast capability. Point-to-point mode is used to collect the partial results (products) from various data processing centers.

ISSN 2229-5518

C. Architecture of Proposed Grid

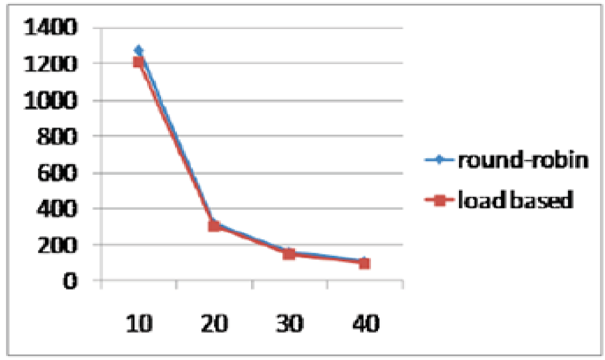
Remote sensing applications to generate large area DEMs is setup on the Grid computing environment discussed in the previous section. The architecture of DEM generation application is designed based on SOA to enable service interoperability and easy integration. It is built, based on a modular strategy and composed of many cooperating 'utility services'. DEM. Figure 3 shows the layered diagram of the proposed system. DEM request originates from DEM client in the form of geographic extents.DEM client is the user interface for product request/ visualization. Requests are submitted for in the form of 'Region of Interests. Grid Scheduler is setup on the VO node and performs three main tasks: Schedule generation, Matching & DEM generation, Aggregation of partial product.

Table 2: Schedule generated from load based cluster scheduler

DEM Inter (meters)	Total Scan Lines	Cluster									
		Node-1(SMP)				Node-2 (SMP)				Node-3	
		Job-1		Job-2		Job-3		Job-4		Job-5	
		Load	Job (Lines)	Load	Job (Lines)	Load	Job (Lines)	Load	Job (Lines)	Load	Job (Lines)
40	11095	0.197	2229	0.131	2412	0.225	2150	0.190	2246	0.258	2058
30	11095	0.176	2286	0.162	2324	0.310	1913	0.172	2297	0.180	2275
20	11095	0.219	2167	0.114	2456	0.129	2415	0.393	1684	0.144	2373
10	11095	0.248	2087	0.109	2472	0.361	1773	0.135	2400	0.148	2359

Table 3 : Stereo matching results generated from proposed load based scheduler

DEM Inter (meters)	Workstation		Cluster					
			Node-1 (SMP		Node-2 (SMP)		Node-3	
	Number of Points	Time (seconds)	Number of Points	Time (seconds)	Number of Points	Time (seconds)	Number of Points	Time (seconds)
40	304285	<u>303</u>	146047	93	146362	<u>96</u>	8024	17
30	537786	<u>547</u>	258459	142	259039	<u>147</u>	14892	18
20	1195296	<u>1164</u>	573983	301	575292	<u>304</u>	33711	35
10	4575516	<u>4955</u>	2178922	1185	2183544	<u>1206</u>	111096	124



D. Utility Services

Utility services are deployed on the GT4 web container and accessed by authorized grid application. The grid scheduler uses the following utility grid services to generate large area DEMs.

a) Data publication service : On the grid VO Data publication service is implemented as persistent grid services at all the data processing centers. Stereo pair Meta data information like sensor, extents, resolution, date of acquisition etc is published as WSResource properties. The proposed grid scheduler collects stereo information from VO to generate.

b) Utility match service: The match service generates match points for the scheduled stereo pair. These points are saved in a ASCII file, which is latter on used for DEM generation.

c) DEM generation service: DEM generation service generates the partial DEMs by interpolating height values at each match point. It is saved as image file with height values represents pixel.

d) Data transfer service: Data transfer service transfer data from one grid node to other. This service is used to transfer stereo pair, if required and to accumulate all the partial DEMs.

ISSN 2229-5518

V. CONCLUSION

Digital Elevation Model process is one of the satellite remote sensing applications, which requires large chunk of data and computational resources. this application on the grid computing platform and generated results of stereo matching process on the cluster using a load based scheduler.

REFERENCES

[1] D. Zhou and V. Lo. "Cluster Computing on the Fly: Resource Discovery in a Cycle Sharing Peer-to-Peer System", IEEE, 2004.

[2] I. Foster, C. Kesselman, S. Tuecke: "The Anatomy of the Grid: Enabling Scalable Virtual Organization",IJOSA,, 15(3), 2001, pp. 200-222.

[3] K.A Hawick, and H.A James, "A Web-based Interface for On-Demand Processing of Satellite Imagery Archives". ACSC'98,Perth, Australia, 1998.

[4] K.A Hawick, and H.A James, "Distributed High Performance Computation for Remote Sensing", Supercomputing '97, San Jose, USA, 1997.

[5] T.L Sterling, J Salmon, D.J Backer, and D.F Savarese, "HOW TO BUILD A BEOWULF: A Guide to the Implementation and Application of PC Clusters. 2nd Printing", MIT Press, Cambridge, Massachusetts, USA, 1999.

[6] C.T Yang, "Using a Beowulf Cluster for a Remote Sensing Application", Proceedings of the Asian Conference on Remote Sensing (ACRS) 2001, Singapore, 2001.