Forest SAFE

NEWSLETTER

No 3 June 2004

Time series and change detection

Forest owners in Sweden are obligated by law to regenerate forest stands after final felling, and it is the responsibility of the regional forest authorities to verify that regeneration is adequate. With large areas to monitor and limited resources for spot checks, the forest authorities could benefit from remote sensing tools to better focus their field verification efforts. Since satellite imagery is already being used for mapping clear cuts, it is interesting to see if the regeneration status can be determined from imagery taken several years later. To investigate this possibility, we chose a study area near Vilhelmina in Västerbotten where up to 10% of stands fail to meet the standards for successful regeneration. Approximately 225 new clear cuts between 1990 and 1992 were detected and mapped from summer Landsat TM data within a 50 x 50km area. The spectral change in these stands from 1992 to 2000 was calculated by band wise differencing of stand mean values. There was considerable variation in spectral differences, particularly in TM bad 4 and 5, and it was hoped that these would correspond well with differences in regeneration status. Specifically, the working hypothesis was that stands with the best regeneration would show the largest decrease in reflectance over the period. We decided to do stratify the spectral differences and visit the extremes in the field to confirm the hypothesis before considering a full-scale field inventory. With a quick field visit in the summer of 2003, about 28 stands were visited and a wide range from good regeneration of pine or spruce on different sites to total failure were observed. A closer look at the data revealed that within this (8-year) time span in the image data, the differences in regeneration status were not well explained by the differences in stand mean spectral values. In fact, the expected trend was even reversed in some cases. The likely explanation is that during this early stage of regeneration, the re-colonization of the background vegetation and differences in site types dominate the satellite spectral signal before the trees make a significant contribution. We expect it will be possible to detect failed regeneration after more time has passed, but it does not appear that a simple tool will be successful at this time scale. What is needed is a better understanding of the spectral-temporal dynamics of the ground vegetation for different site types, and this is currently being investigated with the help of data from the National Forest Inventory.

INSIDE THIS NO.

Project website

For further information, visit our website at www.svo.se/forestsafe or e-mail Lars Björk (project leader) at lars.bjork@svsac.svo.se

A satellite image based system for production of forest management plans

A novel system for production of forest management plans based on the analysis of satellite imagery combined with an efficient field sampling supported by satellite image based estimates of forest parameters is being developed within the ForestSAFE project. The basic concept is based on previous research efforts at SLU together with the former state-owned forest company Domänverket.

The inventory concept is based on segmentation of SPOT satellite imagery combined with a specially designed field inventory method. The t-ratio segmentation algorithm was originally developed by SLU and has now been further enhanced and implemented in the user environment by SVS-VG. The segmentation is run separately for each forest property to delineate preliminary description units or sub-compartments. The segmentation result are then briefly edited by the field surveyor and downloaded into a palmtop computer with a specially developed field-GIS application (also developed within ForestSAFE). The surveyor then visits each segment in the field (guided by GPS) and records forest parameters using a fast ocular estimation procedure. Finally the inventory data can be augmented by forest parameter estimates derived from satellite imagery and NFI-plots.

The method has been found to improve both the workflow and quality of the final result in several ways:

- Less time is spent in the field trying to get an overview of the area and searching for representative spots to measure within stands. Instead the surveyor can concentrate on going directly to each sub-compartment and take one measurement per unit in a standardized way.
- The decision of which segments to merge into final compartments is postponed until the surveyor has all the relevant information at hand i.e. after field inventory.
- The averaging and summation of attribute data from multiple sub-compartments into final mapping compartments can be done automatically and accurately with GIS-tools.
- The accuracy and consistency of forest parameter estimates can be enhanced by merging the information from both field inventory and satellite-based estimates.

A first version on the segmentation, field inventory GIS and forest parameter estimation procedures are currently being tested in under semi operational conditions by the Swedish forestry boards in Västra Götaland and Västerbotten. The new methods for combined estimation or datafusion under development in ForestSAFE are specifically designed for this application and will eventually replace the currently used kNN-based method for forest parameter estimation.

Figure 1. A forest in Västerbotten.
Photo: Kristina Rylander

Combined estimation and artificial neural networks

An integrated approach to combine the information content in different data sources based on artificial neural networks (figure) is being developed for the ForestSAFE project by the Swedish University of Agricultural Sciences. The functions derived can be used for both stand-alone production of country-wide forest parameter maps from satellite imagery and NFI plot data or as an integrated component in a system for standwise estimation of forest parameters integrating ocular field inventory data and spectral signatures from satellite imagery.

A preliminary study indicates that the normalized estimation error for five important forest parameters could be reduced from 25 to 15 percent by combining the information contained in spectral signatures with a simple ocular field inventory (table). The high accuracy achieved would be similar to that of an extensive circular plot inventory.

The current work is focused on the development of an operational set of functions that can be applied to country-wide dataset of satellite imagery within the framework of the next generation of information systems.

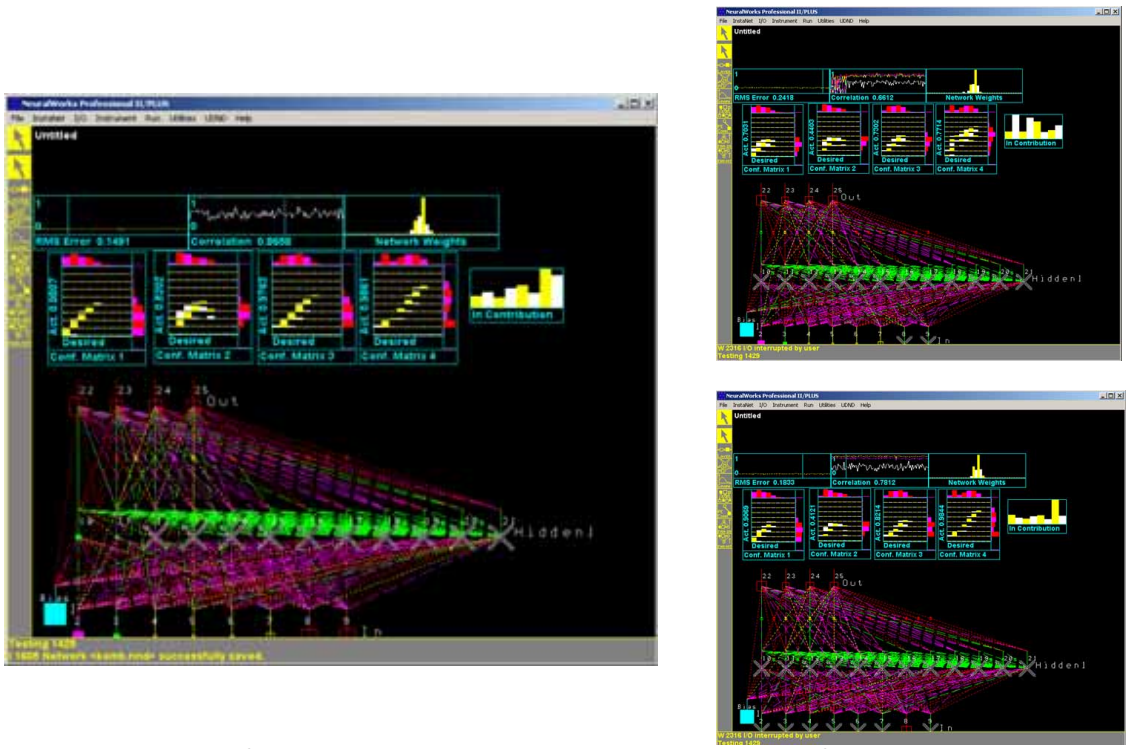

Figure 2: Prototype artificial neural network models designed to integrate the information content in satellite imagery (spectral signature) and ocular field inventory.

Indata / R%	Reflektans	Grundyta	Höjd	Grundyta + Höjd	Grundyta + Höjd + Reflektans
Volym	70	92	90	98	98
Ålder	43	32	41	41	52
Grundyta	73	97	82	97	98
Höjd	77	81	98	98	99
RMS %	24	21	18	16	15

Table 1: Estimation error (RMS%) and coefficient of correlation (R%) between predicted and actual forest parameters derived from different combinations of input data

Unmanned Aerial Vehicles (UAVs) for forest monitoring

UAVs for both military and civilian use is a rapidly expanding field driven by technological advances in microelectronics, propulsion technology, miniature cameras, sensor technology, mobile communications, and autonomous navigation and control systems. It is clear that there is a large potential for using small UAVs for forest mapping and remote sensing. Today it is possible to assemble a small aircraft that is capable of navigating along a pre-specified flight path, collecting pictures video and other data, completely from off-the-shelf components at a reasonable cost. The Remote Sensing Laboratory at the Swedish University of Agricultural sciences in Umeå, together with interested partners in the ForestSAFE project, has initiated a ”demonstration project” to follow developments in this field and promote applications in forestry. In contrast to military systems that fly fast at high altitudes and cost millions of dollars, we focus on portable low-cost systems that could perform mapping and data collection operations from a height of a few hundred meters within a single forest stand. Several different airframe designs and camera alternatives has been evaluated and an improved antenna design for the microwave downlink for live video has been developed. The current work is focused on low-cost alternatives for autonomous navigation and integration of the UAV-system in civil airspace.

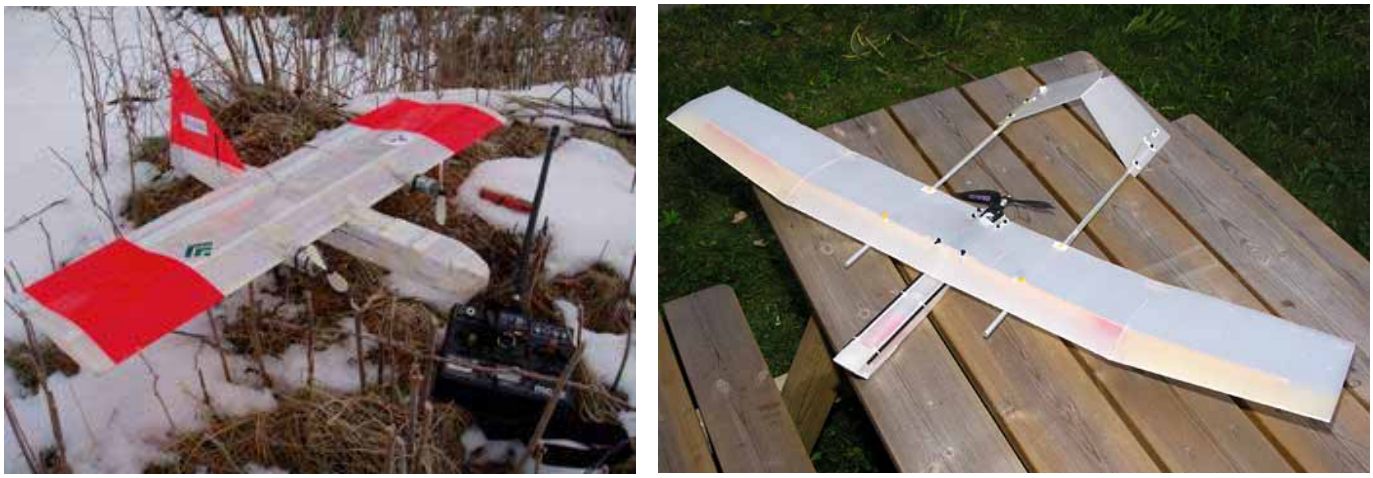

Figure 2: Two models of UAV

Two different small UAV-designs evaluated. Both systems can carry miniature color video cameras with realtime downlink or a small digital camera for high resolution photography. The flight duration with conventional NiMH batteries is 5-15 minutes. The UAVs are hand launched and designed to operate from small forest clearings.

Figure 3: photos taken by the UAV are shown.