



Object-Based Landscape Analysis

Two-day meeting
of the RSPSoc
Land Cover/Land Use SIG



7-8 April 2009
University of Nottingham
UK



The University of
Nottingham

Abstracts
and information booklet

edited by
Paul Aplin and Geoff Smith

Object-Based Landscape Analysis

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Meeting the Challenges of Environmental Decision Making with GIS

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Welcome

Earth Observation imagery is a major source of information for characterising the Earth's surface, but is conventionally analysed using pixel-based approaches that do not incorporate the concept of landscape features or real world objects. Approaches and technology that exploit landscape features to increase the accuracy and usability of EO-derived products are now becoming mainstream. These object-based methods employ spatial frameworks often aligned to the needs of scientists, policy makers and end users, but straightforward application of off-the-shelf packages is not always well-conceived.

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The aim of this meeting is to bring together practitioners in remote sensing, GIS and environmental science to identify best-practice in the development and application of object-based landscape analysis techniques.

Welcome to Nottingham and we hope you find the meeting a stimulating and enjoyable experience.

Paul Aplin and Geoff Smith
Conference organisers

Organising committee

Technical Programme

Dr Paul Aplin University of Nottingham, RSPSoc Chairman
Dr Geoff Smith Specto Natura Limited
Dr Meredith Williams Newcastle University, RSPSoc Technical Programme Committee Chairman

Administration & Registration

Mr Roger Hore RSPSoc Office
Ms Karen Laughton RSPSoc Office

Registration / Staff Helpers

Mr Somnath Ghosal University of Nottingham
Mr Nural Islam University of Nottingham

Venue

All conference sessions will be held in the Sir Clive Granger building, University Park. Technical sessions will be in Room A41 (ground floor), and refreshment breaks, exhibition and poster session will be held in Room A42 (ground floor), along with the registration desk. The RSPSoc Annual Lecture will be held in Room A48 (ground floor), and the workshop will be held in the David Ebdon Laboratory (Room B29, first floor). Internet access is available throughout the meeting in the David Ebdon Laboratory. Toilet facilities and a coffee bar are available on the ground floor.

The Tuesday evening social event – the RSPSoc Conversazione – will be held in the Long Room at Trent Bridge Cricket Ground. Transport will be arranged to and from Trent Bridge, departing from the Visitors Car Park outside the Sir Clive Granger building.

Car parking

The University's Visitors Car Park is adjacent to the meeting venue, the Sir Clive Granger building. Please be aware that parking charges will apply for visitors during daytime hours before 17:00 (free parking after this time). If you are staying in campus accommodation, it is suggested that you leave your car in the Hall car park (which is free of charge). Do not park vehicles anywhere else on the campus; otherwise your vehicle may be clamped.

Accommodation

If you have booked accommodation (single en-suite B&B), a room will be reserved for you in Ancaster Hall on campus, or Cavendish Hall if previously arranged with the RSPSoc Office. The Halls are a short walk from the Sir Clive Granger Building. The B&B rate includes a single study bedroom with en-suite bathroom facilities, full English breakfast (07:30 – 08:30 am) and coffee and tea supplies in pantries/bedrooms.

On arrival, please report to the reception desk at the Hall to collect your key. If your room is not ready when you arrive, you can leave luggage at the Hall.

Rooms must be vacated by 10:00 on the day of departure. Luggage can be left at the OBLA registration desk (Room A42, Sir Clive Granger building) throughout Wednesday.

Technical sessions

All oral presentation sessions will be held in Room A41 (ground floor, Sir Clive Granger building).

Instructions for presenters

Please liaise with the session chair in the seminar room in the break before your session to provide brief biographical details and upload your presentation.

Commercial exhibition, posters, refreshment breaks

There will be a commercial exhibition in Room A42 (ground floor, Sir Clive Granger building) throughout the OBLA meeting, featuring vendors of object-based image processing software packages. All exhibitors have provided generous sponsorship for the OBLA meeting, so please take the time to visit their stands. The poster session and all refreshment breaks will also be held in Room A42.



Workshop – registration

The Definiens workshop will take place in the David Ebdon Laboratory (Room B29, first floor, Sir Clive Granger building) on Wednesday morning.

Please note, the lab space has 28 PCs so places are limited. Please register your interest in workshop as early as possible at the OBLA registration desk in Room A42.

Internet access

Internet access is available to OBLA participants on the PCs in the David Ebdon Laboratory (Room B29, first floor Sir Clive Granger building). A temporary computer account will be required for this; please visit the registration desk for account details.

RSPSoc Annual Lecture and Conversazione

During the OBLA meeting, the RSPSoc Annual Lecture and Conversazione is taking place. The Lecture will be given by Professor John Townshend of the University of Maryland, USA on 'Challenges and Opportunities for Terrestrial Remote Sensing'. Following a drinks reception in Room A42, the Lecture will begin at 17:00 on Tuesday 7 April 2009 in Room A48.

After the Lecture, the RSPSoc Conversazione – reception and dinner – is taking place at Trent Bridge Cricket Ground. Transport to Trent Bridge will leave from the Visitors Car Park (outside the Clive Granger building) at approximately 18:15. On arrival, there will be a drinks reception and a short talk on the History of the Long Room. For those interested, there will be a short tour which will include the Long Room, a nearby net, the Library and, if there's time, the players' changing room. There will also be a short presentation of the RSPSoc President's Prize. This award is presented for the best oral presentation at RSPSoc2008 – the Society's Annual Conference in 2008. Guests should be seated by 19:40; Dinner will be served at 19:45.

A request from the Management at Trent Bridge: please note that guests are not permitted to go on the field of play (any children must be supervised at all times). Nottinghamshire County Cricket Club has a no smoking policy, apart from three designated car parks: Trent Bridge Inn, Hound Road and Dixon Gate.

***International Journal of Geographical Information Science* special issue**

Following the OBLA meeting, there are plans to publish a Special Issue on this topic in the *International Journal of Geographical Information Science*, to be edited by Paul Aplin and Geoff Smith. Presenters at the meeting are invited to submit papers for this Special Issue, though the invitation will be extended more widely around the research community.

Papers should be submitted as normal using the journal's online Manuscript Central facility (<http://mc.manuscriptcentral.com/ijgis>), though two entries should be made to identify the Special Issue. First, when choosing a 'Manuscript Type', select 'Special Issue Paper'. Second, later in the submission process the author is asked, 'Is this paper a candidate for a special issue?'. Indicate 'Yes' and then enter the title of the Special Issue, 'Object-Based Landscape Analysis'.

The **submission deadline is 31 July 2009**. However, we are keen to know as early as possible who may be interested in submitting a paper for the Special Issue, so please feel free to discuss this with Paul or Geoff during or after the meeting – paul.aplin@nottingham.ac.uk, geoffsmith@specto-natura.co.uk.

Membership of RSPSoc and the Land Cover/Land Use SIG

The OBLA meeting is organised by the Land Cover/Land Use Special Interest Group (SIG) of the Remote Sensing and Photogrammetry Society (RSPSoc). Any OBLA participants interested in becoming members of the RSPSoc and this SIG are encouraged to visit the registration desk, where the RSPSoc Office staff will provide information on membership benefits and application details. Further information is available at the RSPSoc website (<http://www.rpsoc.org/about-rpsoc/membership-and-its-benefits/>).

Programme – Tuesday 7 April 2009

09:00	Registration, coffee, exhibition	Room A42
10:30	Welcome <i>Paul Aplin & Geoff Smith – RSPSoc/University of Nottingham, UK</i>	Room A41
10:40	Keynote Address Object-based image understanding: chances and challenges for multi-scale landscape analysis <i>Stefan Lang – Salzburg University, Austria</i>	[abstract 1]
11:30	Session 1. Segmentation	
	Image segmentation using a graph theoretic approach <i>Marpu, Katrenic, Listner & Niemeyer – Freiberg University of Mining and Technology, Germany</i>	[2]
	Evaluation of multi-spectral image segmentation algorithms using the synthetic image testing framework (SITEF), including adjacency effects <i>Marçal & Rodrigues – Universidade do Porto, Portugal</i>	[3]
12:10	ENVI Fx (Feature Extraction) software demonstration <i>ITT Visual Information Systems</i>	
12:30	Lunch, exhibition	Room A42
13:30	Session 2. Optical Applications 1	Room A41
	Object-based classification of mussel beds in the Wadden Sea <i>Roupioz, Schmidt, Kramer, Fey, Cremer, Dijkman, Jansen & Dankers – Alterra, Netherlands</i>	[4]
	Orchards and vineyards classification with textures related object-based approaches by using orthophotos and quickbird images <i>Kass, Notarnicola & Zebisch – EURAC, Italy</i>	[5]
	The development of an object-based classification model for monitoring surface impermeability in urban environments <i>Kampouraki & Gitas – Aristotle University of Thessaloniki, Greece</i>	[6]
14:30	ERDAS IMAGINE Objective software demonstration <i>Infoterra Global</i>	
14:50	Session 3. Posters + coffee, exhibition	Room A42
	Assessing forest cover and land use change in the Bafut-Ngamba forest reserve, north west region of Cameroon using satellite images <i>Bienvenu, Ngala & Stanwell – UNEP-WCMC, UK</i>	[7]
	Can forest structure stages be identified using object-based methods in Aerial photography? <i>Petr & Smith – Forest Research, UK</i>	[8]
15:20	Session 4. SAR Applications	Room A41
	Object-based urban land cover classification with radarsat-2 ultra-fine-beam SAR data <i>Hu & Ban – Royal Institute of Technology, Sweden</i>	[9]
	Object-based rapid mapping of flood events with TerraSAR-X data <i>Herrera-Cruz & Koudogbo – Infoterra GmbH, Germany</i>	[10]
16:00	1Spatial software demonstration <i>1Spatial</i>	
16:20	Drinks, exhibition	Room A42
17:00	RSPSoc Annual Lecture Challenges and Opportunities for Terrestrial Remote Sensing <i>Professor John Townshend – University of Maryland, USA</i>	Room A48 [11]
18:00	Break	
18:15	Transport to Trent Bridge Cricket Ground	Visitors CP
19:00	RSPSoc Conversazione Reception, tour, President's award, dinner <i>Trent Bridge Cricket Ground</i>	
22:30	Transport to University campus	

Programme – Wednesday 8 April 2009

09:00	Invited Paper LCM2007: A pioneering land cover product built on the integration of generalised national cartography and Earth Observation data <i>Dan Morton, Clare Rowland & Geoff Smith – Centre for Ecology and Hydrology & Specto Natura Limited, UK</i>	Room A41 [12]
09:30	Session 5. Implementation	
	Automatic sample selection for object-based image analysis <i>Radoux & Defourny – University Catholique de Louvain, Belgium</i>	[13]
	An architecture based on class dependent neural networks for object-based classification <i>Marpu, Bachmann & Niemeyer – Freiberg University of Mining and Technology, Germany</i>	[14]
	Development of a transferable object-based classification model for nationwide land cover mapping in Greece <i>Polychronaki, Gitas, Galidaki & Dimitrakopoulos – Aristotle University of Thessaloniki, Greece</i>	[15]
	Thematic accuracy assessment of an object-based image classification <i>Radoux, Bogaert, Fasbender & Defourny – University Catholique de Louvain, Belgium</i>	[16]
10:50	Coffee, exhibition	Room A42
11:10	Definiens image analysis software workshop <i>Definiens</i>	Room B29
12:30	Lunch, exhibition	Room A42
13:30	Session 6. Optical Applications 2	Room A41
	Evaluation of ENVI Feature Extraction for geological mapping in arid environments <i>Tragheim & Smith – British Geological Survey, UK</i>	[17]
	Object-based classification of landforms based on their local geometry and geomorphometric context <i>Gerçek – Middle East Technical University, Turkey</i>	[18]
	The aggregation of scene components within landscape features as a way of automating the analysis of very high spatial resolution data <i>Smith, Hughes, Stroh & McWilliam – Specto Natura Limited & Anglia Ruskin University, UK</i>	[19]
14:50	Coffee, exhibition	Room A42
15:10	Keynote Address Can object-based analysis of satellite imagery replace habitat field survey? <i>Alan Brown & Katie Medcalf – Countryside Council for Wales & Environment Systems, UK</i>	Room A41 [20]
16:00	Panel Discussion <i>Vendors, invited speakers, chairs</i>	
16:20	Closing Comments <i>Paul Aplin & Geoff Smith</i>	
16:30	Close	

[Abstract 1] Keynote Address

Object-based image understanding: chances and challenges for multi-scale landscape analysis*Stefan Lang**Centre for Geoinformatics (Z_GIS), Salzburg University, Schillerstr. 30, 5020 Salzburg, Austria; stefan.lang@sbg.ac.at*

Earth's surface reveals scale-specific structures. It is neither completely unstructured nor a pertinent, ever repeating woven fabric. On views from above, shown on air photos or satellite images, we perceive scale-depending structures as statistical patterns or as distinct features with a specific arrangement. The word "perceive" pays tribute to an ambivalent appearance of structures or boundaries as functional, physical border-lines or mere mental constructions, as reflected in the discourse on *bona fide* vs. *fiat* boundaries. The advancement of image analysis techniques and increasing resolution of image data allows for better information extraction in both the thematic and geo-spatial domain. With higher resolution we can widen the scope of potential target classes and at the same time the generation of scaled representations is greatly supported. This implies opportunities and challenges. With multi-scale representations we encounter at least two challenges (1) the correspondence of scaled representations with an underlying theoretical, landscape ecological framework, and (2) the match with the given requirements from users in terms of suitability, practicability, and the fit into existing workflows and geospatial infrastructures. The new paradigm of object-based image analysis (OBIA, Lang 2008) comprising feature extraction, class modeling, scale-specific and scale-adaptive segmentation, object-based accuracy assessment and user-driven data integration provides possible answers to these challenges. This presentation will illuminate the power of OBIA from both sides, i.e. landscape ecological theory and practical use. By this it will pose a synthetic view on object-based image understanding for scientifically grounded, but policy relevant landscape analysis. To methodologically support this bridge, the *geon* concept has been introduced by Lang et al. 2008. Geons are considered generic spatial objects, homogenous in terms of varying spatial phenomena under the influence of, and partly controlled by, policy actions. The automated delineation of geons, based on continuous geospatial data sets, will lead to operational updates as a basic requirement for regular and consistent monitoring against a specific policy background. Monitoring needs expressed in international commitments, conventions and directives require these kind of methods capable of enhancing the understanding of their nature and improving the observation of the changing patterns in a spatially explicit manner. Flexible spatial units at various scales are pivotal in the process of monitoring changes and dynamics. Geons, generated by transforming continuous spatial information into discrete objects through regionalization, facilitate the transformation of singular pieces of information on specific systemic components to policy-relevant, conditioned information.

Lang, S. (2008): Object-based image analysis for remote sensing applications: modeling reality - dealing with complexity. In: Blaschke, T., S. Lang & G. Hay (eds.): Object-Based Image Analysis - Spatial concepts for knowledge-driven remote sensing applications. New York: Springer, 3-28.

Lang, S., P. Zeil, S. Kienberger & D. Tiede (2008): Geons - Policy-relevant Geo-objects for monitoring high-level indicators. In: Car, A., G. Griesebner & J. Strobl (eds.): Geospatial Crossroads @ GI_Forum '08. Proceedings of the Geoinformatics Forum Salzburg. Wichmann Verlag, Heidelberg, 180-185.

[Abstract 2] Session 1. Segmentation

Image segmentation using a graph theoretic approach*P.R. Marpu¹, J. Katrenic², C. Listner¹ & I. Niemeyer¹**¹Institute for Mine Surveying and Geodesy, Freiberg University of Mining & Technology, 09599, Freiberg, Germany; prashanthmarpu@ieee.org, irmgard.niemeyer@tu-freiberg.de**²Institute of Computer Science, Pavol Jozef Šafárik University in Košice, 040 01 Košice, Slovakia; jkatrenic@gmail.com*

Object-based classification is a rapidly developing paradigm in landscape image analysis. Unlike pixel-based techniques which only use the layer values, object-based techniques can also use shape and context information of scene texture, thereby offering more degrees of freedom in image analysis. The shape and context of the objects are very important in landscape analysis. For example, a forest object or a farm object, both have similar spectral signatures but are classified differently based on the context and shape. A forest is normally much bigger than a farm and farms have well defined boundaries. An island can be defined as a land object completely bordered by water objects. The first and important step of an object-based classification system is the segmentation of the image into primitive objects. Various segmentation algorithms have already been developed to serve this purpose each of them having its own set of limitations. In this paper, we present a new algorithm for image segmentation based on the identification of natural clusters using a graph theoretic approach. A graph resembling a minimum spanning tree is first constructed over the image and the inconsistent edges are disconnected to form image objects. The introduction of so called pseudo edges into the graph ensures that the inconsistent edges are identified properly and hence identifying the most homogenous regions in the image. These fine regions are then grouped into coarser objects based on the allowed percentage of standard deviation with respect to the mean of the object. It is often a problem to decide which two objects have to be merged first. But, the construction of the minimum spanning tree over the objects gives the order of the objects to be merged over the entire image thereby providing an easy solution to this problem. The advantage of this algorithm over other methods is that the image is segmented based on the local pixel values in the object and the fact that the standard deviation is dependent on the mean of the object is used. The algorithm can be easily programmed for tiled images to work on images of any size.

[Abstract 3] Session 1. Segmentation

Evaluation of multi-spectral image segmentation algorithms using the Synthetic Image TEsting Framework (SITEF), including adjacency effects

André R.S. Marçal & Arlete Rodrigues

Centro de Investigação em Ciências Geo-espaciais, Dep. Matemática Aplicada, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre, 687, 4169-007 Porto, Portugal; andre.marc@fc.up.pt

A common element of all object-based image analysis systems is the segmentation stage, where the image is partitioned into a number of objects (or segments). This is clearly a critical stage of the process, because if the segmentation fails to identify as an object a given element present in the image, the subsequent stages will generally be unable to recognise or to classify this element. An evaluation of the abilities and limitations of the segmentation algorithms used is therefore an important aspect of any object based image analysis system. However, there is yet no established standard procedure for the evaluation of the segmentation results produced for Earth Observation Satellites (EOS) images. The most common approaches are based on discrepancy measures between the segmentation result and a reference, but it is usually difficult to have abundant reference segmentation data.

The purpose of this work is to present the Synthetic Image TEsting Framework (SITEF), a tool to evaluate the performance of segmentation algorithms on multi-spectral images. The method is based on the production of synthetic images with the spectral characteristics of the image pixels extracted from a signature multi-spectral image. The knowledge of the exact location of objects in the synthetic image provides a reference segmentation, which allows for a quantitative evaluation of the segmentation algorithm used. This work presents an improved version of SITEF, producing more realistic synthetic images that include adjacency effects. This is achieved by considering the point spread function of the satellite sensor and the possibility of sub-pixel offsets between the sensor and expected ground grids.

Two SPOT HRG images were used as signature images, both from rural areas, one from Portugal and the other from Poland. In each image 6 land cover types were identified. A total of 60 synthetic images are initially produced, using all 5-class sub-sets of the available land cover types, and 5 sub-pixels offsets (2 images x 6 class sub-sets x 5 sub-pixels offsets). These images were then segmented using several algorithms available in Definiens 7 and ENVI software packages.

The evaluation of the segmentation results is done using the Hammoude metric and the Corrected Rand and Jaccard external similarity indices. Four distinct perspectives are considered: (1) for the various parameter settings used in the segmentation algorithms, (2) for the different parcel sizes and shapes, (3) for the different land cover types (or spectral signatures) and sets of land cover types, and (4) for different offsets between sensor and expected ground grids.

[Abstract 4] Session 2. Optical Applications 1

Object-based classification of mussel beds in the Wadden Sea

Laure Roupioz¹, Anne Schmidt¹, Henk Kramer¹, Frouke Fey², Jenny Cremer², Elze Dijkman², Jeroen Jansen² & Norbert Dankers²

¹Alterra CGI, Netherlands; laure.roupioz@wur.nl, anne.schmidt@wur.nl

²IMARES, Netherlands

As part of the Trilateral Monitoring and Assessment Program of the Wadden Sea, IMARES monitors the area and structure of intertidal mussel beds. This is an important issue for environmental policies and management concerning mussel seed fishery. The inventories are currently performed twice a year by direct field work measurements. This method is labour / intensive, time consuming and potentially dangerous. Moreover the work is restricted by meteorological and site accessibility conditions. Therefore, the use of automated object-based remote sensing methods to improve the mussels' detection and mapping (classification) is investigated. In this study, an object-based classification method is compared to a human eye interpretation method based on the same aerial photographs and field data (ground truth).

Aerial photographs with a pixel size of 0.5 by 0.5 m taken at low tide in spring are used for the analysis. Due to the fact that mussel beds are often mixed with other elements like sand and algae, it is not possible to base the classification rules on spectral parameters only. Because of their specific textural characteristics, mussel beds appear visually rougher on the image in comparison to the surrounding. This observation highlighted the necessity to apply an object-based approach combined with pixel-based approach in order to build the classification rule set. During the analysis, texture and shape parameters are used to identify mussel beds element and spectral characteristics in order to discriminate disturbing features. The obtained classification is assessed with the field survey polygon data (ground truth) and compared with the data produced manually from human eye detection. The latter comparison relies on accuracy, reliability, consistency, repeatability and time efficiency criteria.

The classification result compared to the ground truth shows that the main mussel beds are detected. The elements remaining unclassified are mostly small beds, under 2 ha. The results show also that some elements are wrongly identified as mussel bed, mainly located along canals and land areas that are transition zones between two land cover types and then present high heterogeneity in structure which is the basic characteristic used to detect mussel beds. This problem can partially be overcome by the use of masks to exclude all the surfaces where the mussel beds can not occur. The remaining mistakes correspond to elements similar to mussel beds by their structure but that are potentially recognisable by an expert.

Concerning the comparison with manual classification, more mussel beds are detected. However, the detection software is more accurate and consistent in drawing the actual boundaries. It also presents advantages concerning the time efficiency, the objectiveness and the repeatability.

Even if the automated detection of the mussel beds is possible, a difference in terms of spectral and even textural parameters among the beds is highlighted, showing the limitations of this method. To compensate, the automated object-based classification should be combined with manual correction to improve the final result. From the comparison with ground truth data, it results that the field investigation remains necessary to validate the analysis from aerial photographs. However, the latter can take place in a much smaller scale as only uncertainties have to be checked.

To conclude, it can be stated that the object-based approach might be considered as a powerful method to help the human observer with the interpretation of the aerial photographs in complement to ground truth. It offers an efficient way to detect and monitor the mussel beds by saving time and labour as well as generating a more detailed and repeatable monitoring program.

The results and the observations made during this study lead to the investigation of further use of object-based approaches for the monitoring of mussel beds. Besides the quoted advantages of using an object-based classification for the detection of mussel bed structures from aerial photographs, it is also possible to give a quantitative representation of the patterns which can be observed within mussel beds. This technique might be helpful in classification of mussel bed patterns in studies on stability of structures, as patch sizes and patch size distribution can be easily calculated.

[Abstract 5] Session 2. Optical Applications 1

Orchards and vineyards classification with textures related object-based approaches by using orthophotos and Quickbird images*Steve Kass, Claudia Notarnicola & Marc Zebisch**EURAC-Institute Applied Remote Sensing, Viale Druso 1, 39100 Bolzano, Italy;
steve.kass@eurac.edu*

Today, very high spatial resolution images offer new opportunities in land-use classification, taking account of not only spectral information but also texture and shape related attributes. In this paper we compare three different approaches (textural, object relational and hybrid) to classify and discriminate orchards and vineyards, two land-use classes which are difficult to identify with traditional spectral classifiers. The study was carried out in the valleys, surrounding Bolzano (Northern Italy), which are mainly characterized by agricultural, monoculture orchards and wine plantations. Beside orchards (apples), mainly placed in the wide valleys, a special plantation manner is dedicated to wine, which varies from cordon to pergola. This cordon style is also applied in the apple plantation with the only difference being the inter-row distance which is slightly larger in orchards. This makes the discrimination among these cultures very difficult, even in the case of simple visual interpretation. The surface covered by these monocultures is huge and therefore the plantations play an important economic impact for the region.

As data input, Quickbird and orthophotos from 2006 were considered. A multi-resolution segmentation procedure was applied to delimit individual yards used for agricultural and the mean textural information of the generated segments were considered to classify orchards, the two wine plantation practices of cordon and pergola as well as intensively used fields. The method compares three different texture related approaches to correctly classifying the given yards: (1) an zonal mean maximum of textures measurements, which considers the maximum value of the 4 directions from textures measurements related to the parcels, (2) a relational sub-object approach based on a thematically derived texture filter technique which reflects the individual row structures and finally, (3) a hybrid approach combining the two previous techniques. In order to identify relevant parameters for each approach, the data mining software See5 is used. Therefore, 350 samples were acquired through ground campaigns. Based on the given parameters from training and test samples, See5 derives hard thresholds in the form of decision trees which can be used afterwards as hard classifier. The results indicate an overall accuracy of 92% and 88% for Quickbird and orthophotos respectively. The application of the same methodology to the orthophotos results in lower accuracy but still acceptable. This offers the opportunity to consider also orthophotos for this kind of detection, especially when Quickbird data could be not available. In this sense, the developed methodology is worthy of consideration as a new object-based landscape analysis technique to deliver accurate maps to the needs of scientists, policy makers and end users.

[Abstract 6] Session 2. Optical Applications 1

The development of an object-based classification model for monitoring surface impermeability in urban environments

M. Kampouraki & I.Z. Gitas

Laboratory of Forest Management & Remote Sensing, Faculty of Forestry & Natural Environment, Aristotle University of Thessaloniki, Greece; markamp@for.auth.gr

Soil is an important non-renewable resource and its protection and allocation is critical to sustainable development goals. Urban development presents the most important driver of soil loss due to sealing over by buildings, pavements and transport infrastructures. Monitoring the percentage of sealed soils in urban environments has been of increasing interest not only for scientific research studies but also for local planning and national authorities.

Traditional air photo interpretation techniques as well as digital pixel-based classification methods have been widely used in the past but there is a need to develop more economic, less time consuming, robust and transferable automated methods. Object-based image analysis (OBIA) contains not only spectral information but also shape, texture and a whole network of relations between the image objects allowing the use of contextual information. Additionally, object-based classification can produce image objects at different resolutions and connect the levels hierarchically, similar to human interpreter.

The aim of this research is to investigate whether OBIA could be a sufficient method for monitoring surface impermeability in UK urban environments, at very large scales. The objectives of this study include:

1. the development of a transferable object-based methodology to accurately classify sealed soil and vegetated surfaces;
2. a comparison with traditional air photo interpretation (API) methods by employing different levels of thematic detail.

Orthorectified aerial photography of Cambridge, UK, acquired in June 2003, and four other sample areas were used for the development of the object-based classification methodology. After visual examination of the areas, the following classes were selected: sealed surfaces, vegetated surfaces, trees, shadow, bare soil and rail tracks. The shadow class was further reclassified into the aforementioned classes. The thematic maps produced were statistically compared with polygons derived from API and the average overall accuracy was found to be 84%. The creation of a simple binary map of sealed and green surfaces resulted in a significant increase in the accuracy (92%). In general, the object-based classification method gave promising results for identifying sealed and vegetated surfaces at very large scales.

Future investigation will explore whether the integration of elevation data will aid in the discrimination of urban features and increase the overall mapping accuracy. Finally, the application of the developed object-based model to a different study area would prove its transferability.

[Abstract 7] Session 3. Posters

Assessing forest cover and land use change in the Bafut-Ngamba forest reserve, north west region of Cameroon using satellite images*Takem Mbi B.M.^{1,3}, Humphrey Ngala N.² & Damon Stanwell-S.¹*¹UNEP-WCMC, 219 Huntingdon Road, Cambridge CB3 0DL, UK; takem.bienvenu@unep-wcmc.org²Department of Geography, Faculty of Social and Management Sciences, University of Buea, P.O. Box 63, Cameroon³National Institute of Cartography, P.O. Box 157, Yaoundé, Cameroon; takemmbi@yahoo.fr

A number of wildlife protected areas and forest reserves have been created in Cameroon with the objective of protecting biodiversity. Despite efforts invested by the Ministry of Forestry and Fauna to protect the forest and its related resources, deforestation has not ceased, leading to a continuous change in forest cover and land use in an era when the international community is struggling to significantly reduce biodiversity loss by 2010 and implement the REDD policy. The Bafut-Ngamba forest reserve in North West Cameroon is an example of a protected area that has gradually been encroached despite being closed to all unauthorised human activities. Rampant deforestation forest has occurred in this reserve. For this trend to be reversed, information on the rate and extent of change and related land use is invaluable.

The present study made use of Landsat MSS for 1978 and Aster images for 2006 to assess the change in forest cover and land use in the Bafut-Ngamba forest reserve and identify drivers of change. The satellite images were classified using MultiSpec Version 5.01 from which, four cover classes were identified (forest, shrub / grassland, farmland and water / wetland). Classified images were transferred to ArcGIS 9.3 where the various classes were digitized on screen, statistics registered on the attribute table which eventually help in calculating the area of each class. Histograms were drawn in Microsoft Excel.

The results of the assessment showed a reduction in forest cover of -34.5% for the 28 years period considered in the study with an annual decrease rate of -1.2%. During this same period, farmland and shrub / grassland increased by 0.9% and 0.3% respectively while water / wetland witnessed a minimal decrease of -0.04%. The drivers of the change observed on the reserve data were identified to be the neighboring human populations involved in farming, wood cutting for sale and use as well as charcoal burning destined for the market; the nomadic Fulani (Mbororos) with their livestock rearing activities and illegal wood exploiters.

The present study highlighted the challenges of forest and land use change in the Bafut-Ngamba Forest Reserve and the urgency for an effective management system. In addition, new and improved methods are required to both evaluate the existing situation and facilitate projection of future trends and impacts. The use of remote sensing and GIS in concert with appropriate field work proved to be effective tools in this respect.

[Abstract 8] Session 3. Posters

Can forest structure stages be identified using object-based methods in aerial photography?*Michal Petr & Mike Smith**Forest Research, Northern Research Station, Roslin, Midlothian, EH25 9SY;
Michal.Petr@forestry.gsi.gov.uk*

The concept of the Functional Forest focuses on the development of sustainable multifunctional woodlands at the landscape scale. The functional forest consists of an ecologically functionally connected network of forest units that can contribute to the economic, environmental and social functions of the forest. Woodlands are a dynamic environment consisting of various forest structure stages and these have been defined as: stand initiation, stem exclusion, understorey re-initiation and old-growth. In sustainable forest management of woodland units or stands the aim is to have all these stages in proportion so that they are in ecological balance and all forest types contributing to functionality.

There is a need to determine these structural stages for many applications such as forest planning, assessment of wind hazard and ecological spatial modelling to define habitat networks in fragmented landscapes. To identify these structural phases a fast remote sensing technique was tested using available aerial photography with 25 cm spatial resolution. Object-based image analysis (OBIA) was considered as a promising method that should help us to classify various phases of forest.

In this trial project we employed OBIA using Definiens Developer to identify and locate forest structure phases for conifers within woodlands in Angus Glens, Scotland. The method used a bottom-up principle which firstly determined small individual objects (trees) and then merged these into larger and more meaningful objects (forest stands or units). Our results so far have identified only two classes close to stages stem exclusion and understorey re-initiation. In the future more work needs to be carried out to improve our classification, methodology and test it on larger area.

[Abstract 9] Session 4. SAR Applications

Object-based Urban Land Cover Classification with RADARSAT-2 Ultra-Fine-Beam SAR Data*Hongtao Hu & Yifang Ban**Division of Geoinformatics, Department of Urban Planning and Environment,
Royal Institute of Technology, SE-10044 Stockholm, Sweden; hongtaoh@infra.kth.se,
yifang@infra.kth.se*

High spatial resolution optical satellite images have been widely used to update land cover information and monitor changes in urban areas since the launch of IKONOS which was the first satellite to collect publicly available high spatial resolution imagery. The civil space borne SAR systems like RADARSAT-2 and TerraSAR-X are now providing SAR imagery with a spatial resolution comparable to high-resolution optical systems. Although SAR data is more reliably available than optical data, it takes more effort to employ high spatial resolution SAR imagery for urban applications due to the difficulty in interpreting the complex content in SAR imagery over highly structured urban areas. The objective of this study is to develop effective object-based classification method for high spatial resolution SAR imagery over urban areas. Three RADARSAT-2 ultra-fine-beam C-HH SAR images with a pixel spacing of 1.56 m were acquired over the north part of the Greater Toronto Area (GTA) during June to September in 2008. The images are pre-processed using a structure preserving filter to reduce the speckle noise without blurring the details in the images. The images were then segmented by means of multi-resolution segmentation algorithm and two segmentation levels were created, each level representing objects at different scales. A range of spectral, geometrical and textural features were selected and calculated for all image objects on both segmentation levels. The objects on the lower level then inherit these features of their super objects on the upper level. In this way, the objects on the lower level can acquire more information about their context and neighbouring objects. Next, the image objects on the lower level are classified based on the calculated features using support vector machines (SVMs) classifier. The preliminary classification result contains confusion between some classes because of the complexity of SAR images and similarity in backscatter. In order to improve classification accuracy, expert knowledge is utilized to develop rules which are applied to the preliminary result to solve the confusion between some classes. The rules include spatial relationship, shape and location of land cover classes. The final result indicates that the proposed method can achieve a high accuracy for the classification of high spatial resolution SAR imagery over urban areas.

[Abstract 10] Session 4. SAR Applications

Object-based rapid mapping of flood events with TerraSAR-X data

V. Herrera-Cruz & F. Koudogbo

Geo-Information services, Infoterra GmbH, 88039 Friedrichshafen, Germany;
Virginia.Herrera-Cruz@astrium.eads.net

The use of Earth Observation techniques in the context of hazard management issues has received growing importance in recent years. Due to global climate change the scientific community expects an increase in the intensity and frequency of extreme weather events, such as hurricanes, floods and windstorms. Only in 2008, 156 from the 321 natural disasters registered by the Center for Research on Epidemiology of Disasters (CRED) were caused by floods.

TerraSAR-X is the new generation, high spatial resolution German radar satellite operating in the X-Band at 9.65 GHz. It was launched in June 2007 and will operate for a period of at least 5 years. The high spatial resolution, the multi-polarization and multi-incidence angle capability of TerraSAR-X open very interesting perspectives for flood mapping, assessment of damages after a hazard and landscape changes. Further, the following system capabilities make TerraSAR-X very interesting for disaster management and monitoring:

- TerraSAR-X features a quick site access time of 2.5 days to any point on Earth at 95% probability.
- Time-critical data can be downloaded within seconds after acquisition to TerraSAR-X ground stations on-scene, thus enabling near-real time data processing.
- Satellite tasking twice a day and priority settings for the ordered data takes allow for quick turnaround times in data delivery and late order changes.

Moreover natural disasters such as floods are often associated with extreme weather events resulting in a dense cloud cover. For this reason the main advantage of SAR data above optical systems is related to its nearly all-weather capacity. TerraSAR-X data, coupled with the use of optical data and other data sources allows the possibility of advancing one step further in the development of information services to better support risk management.

Within this context, the work presented in this paper focuses on the development of an object-based classification approach for operational flood extent mapping in near-real time conditions. Object-based classification methods, unlike pixel-based techniques, profit from texture, shape and context information of a scene. Additionally, the noisy effect that the natural pixel variation due to speckle of SAR images would produce in a pixel-based process is avoided without the need of a filter. A rule base approach gives flexibility and robustness to the whole process and allows setting different levels of automation in single parts of the process.

Three modules which are sequentially activated are distinguished in the developed rules system: Segmentation, Water mask extraction and Flood extraction and refinements. The initial (*Segmentation*) and final (*Flood extraction and refinements*) modules are automated, while the middle one (*Water masks extraction*) is a semi-automated process. The segmentation process focuses only on areas of interest which are automatically selected within the process. By this means, the most time consuming process of the overall flood mapping processing chain is drastically reduced.

The semi-automated water masks extraction is based on the extraction of the biophysical parameters that are characterising the backscattering from water bodies in the more adequate way. In order to develop a robust flood mask workflow, which served to

analyse not only TerraSAR-X data, but also historical data, parameters common to optical and SAR images are selected and used within a rule-based classification system. Based on those parameters, a rule-based classification system with tuneable variables and a user-friendly interface is constructed for the effective extraction of water extent. Flood extraction and refinements include the extraction of the Flood / permanent water mask as well as smoothing and minimum mapping filters.

The flood of the Mississippi river that occurred from May to August 2008 is used for illustration. Due to heavy rains it affected the States of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin. The robustness of the mapping chain is then tested against different flood events that occurred in different environmental conditions.



RSPSoc Annual Lecture

Challenges and Opportunities for Terrestrial Remote Sensing

Professor John Townshend
University of Maryland, USA; jtownshe@umd.edu

Land cover and land use dynamics are recognized as being of increasing importance to the Earth System and its human utilization. They are highly relevant to the carbon cycle and other biogeochemical cycles and as a result are now recognized as having major impacts on climate change. Their dynamics are also crucial in relation to biodiversity and conservation, natural resources management and hydrology. Even those who work in the field are unaware of the dramatic changes occurring in many parts of the world. Examples will be presented from contemporary research of changes in tropical, temperate and boreal forests.

Recent estimates using Earth Observation data often differ substantially from “official” rates of change partly because of the different methods that are used and partly because of different definitions. One of the most potent agents of change is fire and its intensity has major implications for subsequent ecological succession. The rapidity of land cover and use change also has major implications for protected areas and makes the chances of achieving Target 2010 unlikely. Rapid changes in NPP associated with land cover change can also now be directly observed. As well as land cover change *sensu stricto* we are also now able to detect rapid changes in the extent of water bodies especially in northern latitudes.

Improvements in our ability to monitor land cover should be possible but will depend on improved coordination between space agencies and much improved pre-processing of Earth Observation data and by ensuring improved access to diverse data sets.

[Abstract 12] Invited Paper

LCM2007: A pioneering land cover product built on the integration of generalised national cartography and Earth Observation data*Dan Morton¹, Clare Rowland¹ & Geoff Smith²*¹*Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK; danm@ceh.ac.uk*²*Specto Natura Limited, Bluntisham, Huntingdon PE28 3XU, UK; geoffsmith@specto-natura.co.uk*

Conventionally, land cover mapping from Earth Observation (EO) data begins with a blank canvas and the EO data is analysed using pixel-based approaches. In virtually every location on the Earth the canvas is not actually blank and there will be existing mapping of some form, much of which is now in digital format allowing further automated processing. Also, the pixel-based approach to EO data analysis does not incorporate the concept of landscape features or real world objects giving an abstract and unique world view. The incorporation of digital cartography into the analysis of EO data using the Object-Based Image Analysis (OBIA) paradigm allows the exploitation of the strengths of both data sources within a real world object context.

Unfortunately, the different data sets available which describe landscape are rarely collected for the same purpose and often to very different specifications. For instance, national digital cartography may represent features at sub-metre resolutions whereas the EO data with which it is integrated will have pixel sizes in the order of 20 – 30 m. Also, one single nationally consistent digital cartography datasets is unlikely to provide all the boundaries required to represent complex landscape structures. Some form of pre-processing is required to generalise the available digital cartography to a level of detail where integration with EO data is realistic and to finally collate the different data sources into a single object layer.

The UK Land Cover Map 2007 (LCM2007) has been developed in an attempt to exploit landscape features to improve the quality and accuracy of the derived products. It has faced and overcome the above challenges in the context of a national level semi-operational project. The spatial structure of the landscape features for LCM2007 will in the main be derived from a generalised version of Ordnance Survey MasterMap to capture the required real world objects. These objects will be supplemented by others from agricultural land parcel data sets and image segmentation.

This paper will begin by describing the generalisation process developed for the project which aligns the scale of the landscape features with the information content of EO data as the first step in the production of LCM2007. It will also describe the necessary extensions to the spatial structure to adequately describe the pattern of habitats in the UK. Results will then be compared with those from Land Cover Map 2000, a segmentation-based approach, and the Land Cover Map of Great Britain (1990), a pixel-based approach. This will demonstrate the utility of object-based approaches to landscape analysis and also the advantages to be gained by exploiting existing cartography.

[Abstract 13] Session 5. Implementation

Automatic sample selection for object-based image analysis*J. Radoux & P. Defourny**Université Catholique de Louvain, Belgium; julien.radoux@uclouvain.be*

The production of land cover maps often relies on field survey and / or remote sensing data. A lot of work has been done in order to improve the classification framework of remote sensing data, which often require a training dataset or decision rules based on expert knowledge. However, existing information from available GIS database is rarely valorized. In this study, a new methodological framework is proposed to improve the automation of map classification thanks to the input of a GIS database during the image analysis workflow. This generic workflow can be divided into four steps:

1. Automatic labelling of image-objects based on the GIS database.
2. Selection of the best characteristics to discriminate each class from the others.
3. Outlier detection to generate representative training samples.
4. Object-based classification using the representative training samples.

The aforementioned framework was applied on a Mediterranean area in a fire management context. The imagery used was a multispectral Quickbird image and the ancillary information was provided by the Corine Land Cover database, which is freely available over the European countries. After image segmentation, the image-objects were pre-labelled using a majority rule to extract information from the Corine Land Cover database. Due to land cover change and to scale difference between the image and the map, the pre-labelled objects could obviously not be used directly as training samples. After selecting the best characteristics for each class using a specificity index, outliers were therefore excluded from the training samples using a statistical iterative trimming. After this step, there is thus one set of image-objects containing the representative objects of each class, and another set of image-objects without label. The former could then be used to classify the latter, so leading to the final product with improved precision and updated regions compared with the Corine Land Cover database. In addition to the Corine land cover classes, a contextual classification was performed in order to detail the labelling conflicts occurring in the forested area, i.e. boundary delineation conflicts, recently burnt areas, new residential areas and bush clearance. At this point, only a qualitative assessment of the results was performed, but the quantitative assessment will follow.

[Abstract 14] Session 5. Implementation

An architecture based on class dependent neural networks for object-based classification*P.R. Marpu, F. Bachmann & I. Niemeyer**Institute for Mine Surveying and Geodesy, Freiberg University of Mining & Technology, 09599, Freiberg, Germany; prashanthmarpu@ieee.org, bachman1@mailserver.tu-freiberg.de, irmgard.niemeyer@tu-freiberg.de*

Object-based classification is a rapidly developing paradigm in landscape image analysis. Unlike pixel-based techniques which only use the layer values, the object-based techniques can also use shape and context information of scene texture, thereby offering more degrees of freedom in image analysis. Image objects are described by a large number of features. Normally, different landscape classes are characterized using different sets of features e.g., vegetation has a high vegetation index value, water has low pixel values, rivers have smaller width compared to lakes or sea. One way of identifying these features characterizing the classes is by calculating the distance (e.g., Bhattacharya distance measure) between the sample distributions of the classes. A tool called SEATH (Separability and Threshold) is used for this purpose. However, the classification based on these features is not trivial. SEATH provides the approximate threshold of separation between two classes for every feature. But this leads to misclassifications in the partially separable case. We propose a new architecture for object-based classification using neural networks. First, all the classes are individually separated from other classes using first level neural networks to map the characteristic features to a class probability for each of the classes. Then, a final classification decision is made using a second level neural network with inputs from the outputs of the first level neural networks. The entire architecture can be trained using a set of samples. Furthermore, the results can be improved with the boosting algorithms such as Adaboost, where a series of learning machines are employed for decision making. Owing to the fact that several segmentation algorithms provide a multi-level segmentation and the classes are classified at different levels and then combined to make a final classification, we provide a routine for sequential classification where one class can be classified at a time. This is just the first level neural network corresponding to the class of interest. The algorithms are implemented as plug-ins for the Definiens Developer software and are available for free distribution.

[Abstract 15] Session 5. Implementation

Development of a transferable object-based classification model for nationwide land cover mapping in Greece

A. Polychronaki, I.Z. Gitas, G. Galidaki & K. Dimitrakopoulos

Laboratory of Forest Management and Remote Sensing, Aristotle University of Thessaloniki, P.O. Box 248, University Campus, Greece; anpolych@for.auth.gr

National authorities and international organizations worldwide are interested in the division of the landscape according to the various classes of land cover, such as urban areas, arable land, grasslands and forests or wetlands. The creation of a land cover map emerges not only from the need to generate information that would be useful for general policy purposes, but also from the need to control development at local level as well as the need to provide essential information for environmental management and monitoring at national and international level.

Although satellite imagery and manual or computer-assisted interpretation have been used in a number of cases in the past an important issue that has recently been emphasized is the need for the use of remotely sensed data on an operational basis. It should be noted that the transition to an operational mode pre-requisites the development and validation of robust digital image analysis algorithms that can be extended through space and time. Object-based image classification, which is based on fuzzy logic, allows the integration of a broad spectrum of different object features such as spectral values, shape, and texture. Such classification techniques, incorporating contextual and semantic information, can be performed using not only image object attributes, but also the relationship among different image objects.

The aim of this work was to develop a transferable object-based classification model for mapping the basic land cover classes in Greece using Landsat TM imagery. The specific objectives were:

- to develop an object-based classification model for mapping the land cover in Chalkidiki (Northern Greece) by using a Landsat TM image, and
- to test the transferability of the classification model for mapping the land cover in Attica (Central Greece) using a second TM Landsat image.

An orthorectified Landsat TM image of Chalkidiki, acquired in the summer of 2007, was used for the development of the classification model which aimed to map the following classes: broad-leaved forest, conifer and schlerophyllous forest, shrublands, bare land, artificial areas, agricultural areas and water bodies. Apart from the TM image, a vector thematic layer containing detailed information about the agricultural areas of Greece was also included in the development of the model. A second orthorectified Landsat TM image covering the area of Attica, also acquired in the summer of 2007, was used for testing the transferability of the model. The accuracy assessment was based on data that were collected in the field during the summer of 2007.

The model proved to accurately map the pre-defined land cover classes both in the case of Chalkidiki as well as in the case of Attica. It should be noted that in the case of Attica some of the feature thresholds were calibrated before the application of the model. The application of the model on more TM images covering other parts of Greece will be investigated in the near future since there is a need to produce accurate, current and repeatable information related to the basic land cover classes in Greece due to the fact that a national land cover mapping program does not exist yet.

[Abstract 16] Session 5. Implementation

Thematic accuracy assessment of an object-based image classification*J. Radoux, P. Bogaert, D. Fasbender & P. Defourny**Université Catholique de Louvain, Belgium; julien.radoux@uclouvain.be*

Object-based image analysis is an image processing framework where groups of spatially adjacent pixels are classified as if they were behaving as a single unit. Although this approach is not new in itself, it raises concerns about the way subsequent validation studies must be conducted. Classical point-based sampling strategies based on the spatial distribution of sample points (using systematic, random or stratified random sampling) do not indeed rely on the same concept of objects and may prove to be inadequate, or at least less appropriate, than methods consistently built on the same concept of objects that was used during the prior classification step. As pixels are considered as homogeneous when they belong to the same group which defines an object at the classification stage, the same assumption should ideally be used for the validation in order to avoid consistency issues.

In this study, an original object-based sampling strategy is compared with other approaches found in the literature for the accuracy assessment of object-based classifications. New sampling unit, sampling scheme and sample analysis are proposed to accurately and precisely estimate the overall accuracy of a map. In addition to a sound theoretical framework based on few working hypotheses, the performance of the sampling strategies is quantified thanks to map simulations based on Quickbird image segmentation. Errors in the test maps were generated by randomly changing object labels. The bias (difference between average estimate and the truth) along with the variance of the overall accuracy estimates were then measured and used as indicators of the robustness of overall accuracy estimates.

Results show that pixel- and object-based sampling do not lead to the same measure of accuracy: pixel-based approach does not take object-boundaries into account while object-based accuracy ignores the heterogeneity within objects. A noticeable advantage of the proposed sampling strategies is a smaller confidence interval on the accuracy estimates for the object-based strategy. In order to reach a given confidence interval, our object-based strategy could thus significantly reduce the sampling effort.

[Abstract 17] Session 6. Optical Applications 2

Evaluation of ENVI Feature Extraction for geological mapping in arid environments

D.G. Tragheim & K.B. Smith

British Geological Survey, Keyworth NG12 5GG, UK; dgt@bgs.ac.uk

Arid environments provide ideal conditions for evaluating emerging technologies for geological mapping. This is due mainly to the lack of vegetation that otherwise covers the geological materials and prevents them from direct observation.

The most common approach to geological mapping by remote sensing involves: (i) calibration of image DN values to radiance; (ii) conversion to spectral reflectance and (iii) spectral analysis, commonly by Principal Component techniques or by comparing spectral signatures of image pixels with spectral libraries of known geological materials. Although the PC technique provides good spectral separation it is often difficult to generate suitable boundaries between the spectrally diverse units as they often become disjointed with the introduction of errors on application of region smoothing algorithms. Spectral signature analysis is often more temperamental where slight variations in spectral signatures from the reference libraries can result in small inliers of unclassified material that are clearly from the same geological unit. The ENVI Feature Extraction module enables segmentation of multi-band images into spectrally diverse components by including both spectral characteristics and surface texture in the analysis. There is also an option to include topographic information.

Multi-band spectral images have been obtained for several geological settings, mainly from arid environments: (i) Morocco, Saudi Arabia & Afghanistan, in a complex setting of sedimentary and metamorphic geology with igneous intrusions; (ii) Algeria, over a sedimentary sequence; (iii) Ethiopia, over rifting volcanic terrain, and (iv) Tristan-da-Cunha, a volcanic island in the South Atlantic Ocean. ASTER images for each of these areas have been ortho-rectified and atmospheric effects removed from the radiometrically calibrated data using the FLAASH algorithm, with the resultant reflectance images used to evaluate the ENVI Feature Extraction Module. For some of these areas, detailed geological information has recently been obtained through extensive geological mapping expeditions, thus providing good base geological data with which to compare the results of the ENVI Feature Extraction procedure.

We present results from the ENVI Feature Extraction for these different geological settings.

[Abstract 18] Session 6. Optical Applications 2

Object-based classification of landforms based on their local geometry and geomorphometric context*Deniz Gerçek**Middle East Technical University, Geodetic and Geographic Information Technologies, 06531 Ankara, Turkey; denizger@metu.edu.tr*

Terrain can be categorized into landform units that exhibit common physiological and morphological characteristics which might serve as a boundary condition for various studies such as soil mapping, vegetation mapping, landscape ecology and land resource management. This study presents an object-based classification of terrain based on local geometry and geomorphometric context characterized by topographic attributes derived from a digital elevation model of a sample area pertaining to a part of a hilly terrain.

Terrain taxonomy, divergence in conception of landforms, different definitions and labeling made by different disciplines is complicating interpretation of products and exchange of ideas in terrain analysis. Emphasizing the importance of bringing together different perceptions, concepts and definitions from different disciplines, the presented approach adopts a classification scheme that is commonsense to human insight and relevant to use and employment of various disciplines, hence regards geometric form as a basic property. Elementary forms are small and simple units, which are indivisible at the resolution considered. They are defined by geometric properties (e.g. slope, curvature) which facilitate their recognition as fundamental units in a system for terrain classification. Some landforms are single elementary forms, but some are compounded from several of them or they are defined via contextual information (e.g. positional properties). Those landforms constitute the second level of relief complexity.

The study for categorizing terrain into landforms is implemented as a two-step process: First, a segmentation procedure is run based on topographical attributes that characterize local geometry (slope, plan curvature, profile curvature). This generates first level of categorization: "landform elements". Second, these form elements are aggregated via fuzzy classification based on their statistical similarities (that is when geometric properties define the landform type) or landform types are derived by evaluating the form elements in their spatial context (when landform type is a compound of several landform elements).

The presented approach, based on geomorphometric properties and geomorphometric context, using a limited number of terrain parameters, is capable of modeling fundamental land elements that can be utilized in landscape modeling and in various applications in land resource management.

[Abstract 19] Session 6. Optical Applications 2

The aggregation of scene components within landscape features as a way of automating the analysis of very high spatial resolution data

Geoff Smith¹, Francine Hughes², Peter Stroh², Nicholas McWilliam²

¹*Specto Natura Limited, Bluntisham, Huntingdon PE28 3XU, UK; geoffsmith@specto-natura.co.uk*

²*Department of Life Sciences, Anglia Ruskin University, East Road, Cambridge, CB1 1PT, UK*

Large amounts of remotely sensed data are collected from airborne and spaceborne platforms with very high spatial resolutions (VHR) from 2 m down to 15 cm and are available easily to a broad range of end users. Data with this type of spatial resolution are used to address mapping issues in the location and identification of objects or areas on the surface. Conventionally their exploitation has tended to be limited to that of a backdrop for other data or they have been analysed by manual airphoto interpretation techniques, although this is time-consuming, subjective and expensive.

When attempting to automate the analysis of VHR data, pixel-based approaches are difficult to implement as rather than representing a land cover class of interest, for instance urban, the pixels may represent facets of buildings, cars, pavements, roads, grass, tree crowns and even people. Although the data obviously contain useful information to a human operator, the classifiers are extremely difficult to train and results difficult to interpret.

Object-Based Image Analysis (OBIA) would appear to offer a solution to the analysis of VHR data as clusters of pixels, or landscape objects, and can be identified and analysed by aggregating the pixel information within them. This works well in some cases, but where there is limited spectral information and the classes of interest may be heterogeneous (e.g. semi-natural habitats), the results can be disappointing.

This paper describes a method of analysing VHR data which represents a combination of the two approaches outlined above. First, it is necessary to classify the VHR data into a set of scene components which manifest themselves at that particular spatial resolution. A conventional pixel-based clustering algorithm can be used with sufficient clusters to capture the dominant spectral variations in the data. The scene components are then labelled from the clusters in generic terms such as bright vegetation, dark vegetation, bare ground, shadow etc. OBIA is then used to identify landscape features, either from image segmentation or by adapting existing cartography. The landscape objects allow aggregation of the scene component information within them, the consideration of context, both within the region and beyond it, and the application of knowledge-based rules at the parcel level to classify them.

This paper will give a number of case studies which highlights the problems associated with classifying fine spatial resolution images and also describe the latest developments where existing cartography and segmentation are being used to assess change.

[Abstract 20] Keynote Address

Can object-based analysis of satellite imagery replace habitat field survey?*Alan Brown¹ & Katie Medcalf²*¹*Countryside Council for Wales, UK; a.brown@ccw.gov.uk*²*Environment Systems, UK; Katie.medcalf@envsys.co.uk*

The use of satellite imagery for mapping land cover is well-established – but not for mapping the more detailed 'phase 1' habitat classes used by the nature conservation agencies, which up to now have been mapped exclusively by extensive ground survey. Work in Wales suggests that it is possible to update an existing phase 1 map from satellite data using object-based methods, and may be possible to produce completely new maps with relatively little ground truth work. In this paper, we consider the strategic requirement for this type of mapping, the form of the maps consistent with the legacy of existing surveys and how new methods are not restricted either to reproducing the output of traditional methods or to only one pre-determined habitat classification. This is possible if the maps are accurate and reproducible, with uncertainty and errors that can be followed through the processing chain and spatially expressed. The critical component is attention to detail in pre-processing (e.g. very accurate registration of image stacks), processing (e.g. the use of different levels of segmentation depending on habitat type) and accuracy assessment that incorporates an ecologically-based assessment of different types of error to optimise each context-sensitive version of a crisp map. We believe that these new approaches to habitat mapping, leading to entirely new workflows, standards and management of uncertainty, will emerge from this and other projects over the next five years.

List of participants

Surname	Firstname	Affiliation	Email
Anderson	Karen	University of Exeter, UK	Karen.Anderson@exeter.ac.uk
Aplin	Paul	University of Nottingham, UK	paul.aplin@nottingham.ac.uk
Armitage	Richard	University of Salford, UK	r.p.armitage@salford.ac.uk
Bachmann	Florian	TU Bergakademie Freiberg, Germany	bachmann1@student.tu-freiberg.de
Bienvenu	Takem	UNEP WCMC, UK	Takem.Bienvenu@unep-wcmc.org
Bock	Michael	German Aerospace Data Centre, Germany	michael.bock@dlr.de
Bogaert	Patrick	Université Catholique de Louvain, Belgium	Patrick.Bogaert@uclouvain.be
Brown	Alan	Countryside Council for Wales, UK	a.brown@ccw.gov.uk
Brown	Christine	Forest Research, UK	christine.brown@forestry.gsi.gov.uk
Cooper	Phil	Infoterra Ltd, UK	phil.cooper@infoterra-global.com
Crawford	Oliver	Environment Agency, UK	Oliver.Crawford@environment-agency.gov.uk
Crick	Mark	JNCC, UK	Mark.Crick@jncc.gov.uk
Crisford	Gareth	ITT VIS, UK	gcrisford@ittvis.com
Edwards	Adam	University of Leicester, UK	adam.edwards@ntlworld.com
Ehrhardt	Martin	Definiens, Germany	mehrhardt@definiens.com
Farquhar	Clive	ITT VIS, UK	cfarquhar@ittvis.com
Fernando	Nick	ITT VIS, UK	nick@ittvis.com
Gardiner	Andrew	Ordnance Survey, UK	andy.gardiner@ordn.co.uk
Gerçek	Deniz	Middle East Technical University, Turkey	denizger@metu.edu.tr
Ghosal	Somnath	University of Nottingham, UK	lgxsg4@nottingham.ac.uk
Gitas	Ionnis	Aristotle University of Thessaloniki, Greece	igitas@For.auth.gr
Graham	Alastair	Atkins, UK	alastair.graham@atkinsglobal.com
Gregory	Martin	1Spatial, UK	Martin.Gregory@1Spatial.com
Groom	Andrew	Infoterra Ltd, UK	Andrew.Groom@infoterra-global.com
Hambidge	Crispin	Environment Agency, UK	crispin.hambidge@environment-agency.gov.uk
Harling	Thomas	Infoterra Ltd, UK	thomas.harling@infoterra-global.com
Herrera-Cruz	Virginia	Infoterra GmbH, Germany	Virginia.Herrera-Cruz@astrium.eads.net
Hinchliffe	Graham	Infoterra Ltd, UK	graham.hinchliffe@infoterra-global.com
Hore	Roger	RSPSoc	rspsoc@rspsoc.org
Hu	Hongtao	Royal Institute of Technology, Sweden	hongtaoh@infra.kth.se
Islam	Nural	University of Nottingham, UK	lgxmni@nottingham.ac.uk

Surname	Firstname	Affiliation	Email
Jarman	Mark	Environment Systems, UK	mark.jarman@envsys.co.uk
Jordan	Colm	British Geological Survey, UK	cjj@bgs.ac.uk
Kampouraki	Mary	Aristotle University of Thessaloniki, Greece	markamp@for.auth.gr
Kass	Steve	EURAC, Italy	steve.kass@eurac.edu
Kitmitto	Kamie	University of Manchester, UK	k.kitmitto@manchester.ac.uk
Lamb	Alistair	Infoterra Ltd, UK	alistair.lamb@infoterra-global.com
Lang	Stefan	Salzburg University, Austria	Stefan.Lang@sbg.ac.at
Laughton	Karen	RSPSoc	rspsoc@rspsoc.org
Listner	Clemens	TU Bergakademie Freiberg, Germany	clemens_listner@gmx.de
Marçal	André	Universidade do Porto, Portugal	andre.marcal@fc.up.pt
Medcalf	Katie	Environment Systems, UK	katie.medcalf@envsys.co.uk
Morton	Dan	Centre for Ecology and Hydrology, UK	danm@ceh.ac.uk
Petr	Michal	Forest Research, UK	Michal.Petr@forestry.gsi.gov.uk
Radoux	Julian	Université Catholique de Louvain, Belgium	julien.radoux@uclouvain.be
Reynolds	Louisa		louisa_reynolds@yahoo.co.uk
Robinson	Paul	Joint Nature Conservation Committee, UK	Paul.Robinson@jncc.gov.uk
Rogg	Caroline	Definiens, Germany	crogg@definiens.com
Roupioz	Laure	Alterra CGI, Netherlands	laure.roupioz@wur.nl
Sanchez-Hernandez	Carolina	Ordnance Survey, UK	Carolina.Hernandez@ordnancesurvey.co.uk
Schmidt	Anne	Alterra CGI, Netherlands	anne.schmidt@wur.nl
Smith	Geoff	Specto Natura Limited, UK	geoffsmith@specto-natura.co.uk
Smith	Kay	British Geological Survey, UK	kmcm@bgs.ac.uk
Stickler	Graham	1Spatial, UK	Graham.Stickler@1Spatial.com
Tewkesbury	Andrew	Infoterra Ltd, UK	Andrew.tewkesbury@infoterra-global.com
Tragheim	Douglas	British Geological Survey, UK	dgt@bgs.ac.uk
Vancoillie	Frieke	Ghent University, Belgium	frieke.vancoillie@ugent.be
Vickers	Martin	University of Aberystwyth, UK	mjv08@aber.ac.uk
Viergever	Karin	Ecometrica, UK	Karen.Viergever@ecometrica.co.uk
Visser	Fleur	University of Worcester, UK	f.visser@worc.ac.uk
Williams	Meredith	Newcastle University, UK	meredith.williams@ncl.ac.uk