NEWSLETTER

INSTITUT CARTOGRÀFIC DE CATALUNYA

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CONTRIBUTION OF THE ICC TO THE XIX CONGRESS OF THE ISPRS

On 16-23 July 2000 the XIX Congress of the International Society for Photogrammetry and Remote Sensing will be held in Amsterdam. As at the previous congresses, the Institut Cartogràfic de Catalunya will be a very active participant, since it will present five posters, three papers and a tutorial. Each of these contributions is included in summarized form in this edition of the ICC Newsletter, although once the Congress has been held, they will posted in greater detail at the ICC's website:

Furthermore, this Congress will be important for an additional reason: the Sociedad Española de Cartografía, Fotogrametría y Teledetección (Spanish Society of Cartography, Photogrammetry and Remote Sensing), which represents the Spanish organizations that specialize in these fields, will present its candidature for the ICC to host the XX Congress of the ISPRS, due to be held in the year 2004.

It is to be hoped that this bid will have the effect that we all desire, and that, once again, Barcelona will be selected as the venue for an international event, whose aim is to bring together the most prestigious specialists in cartography, photogrammetry and remote sensing, in order that they may exchange experiences and share the latest knowledge that is currently being developed and applied in these fields.

Airborne sensor integration and direct orientation of the CASI system

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The ICC has developed a SISA (Integrated System of Airborne Sensors). The SISA is an integrated system of airborne sensors (imagery, position, attitude, etc.) and algorithms that can be used to obtain correct georeferencing of imaging sensors. To date, the SISA has been used with the CASI sensor (Compact Airborne Spectographic Imager) and on one gravimetric flight over Catalonia.

The main objective of the SISA is to provide an imaging sensor with precise attitude and positioning. In order to fulfil this objective, the SISA integrates GPS data, IMU (Inertial Measurement Unit) data and it provides a synchronization procedure for the entire set of sensors. The current configuration of the SISA provides an interface with the attitude subsystem (based on a Litton LTN 101 FLAGSHIP INS - Inertial Navigation System), an interface with a dual frequency GPS receiver and a robust procedure for synchronizing the attitude sensor (IMU/INS) and the imaging sensor (CASI). The ICC has developed software to ensure the correct time tag of the inertial and image data, and to determine the trajectory and attitude of the airborne platform.

The discrepancies between the Image Reference System and the Inertial Reference System caused by the mounting of the sensors are determined together with certain calibration parameters of the CASI in a bundle adjustment using the GeoTeX/ACX software.

The direct orientation methods require a good (*a priori*) knowledge of the geometric relationships between the sensors involved. The stability of the SISA-CASI attachment has been studied, comparing adjusted misalignment matrix and self-calibration parameters on series of CASI flights.

In conclusion, the SISA proves its capability as a system for the absolute direct orientation of the CASI imaging sensor.

SUMMARY

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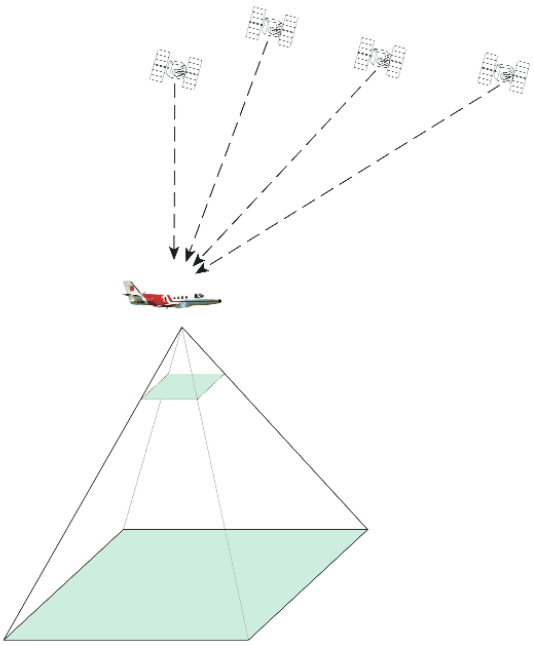

Robust GPS kinematic positioning for direct georeferencing

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The photogrammetric community is rapidly assimilating the new developments in GPS/INS integration, and therefore direct georeferencing is becoming a widely applied technique.

However, as this technique has no (or very little) external control, the robustness of GPS kinematic positioning becomes a critical issue. This paper presents a technique for determining the GPS trajectory that takes advantage of the regional GPS networks to increase the reliability of GPS derived trajectory and, as a result, of direct georeferencing.

The increasing number of regional permanent GPS networks allows for a differential kinematic positioning where instead of using a single GPS receiver as a reference station, uses the entire set of receivers as a reference network for kinematic positioning. The permanent GPS network is employed to generate small scale atmospheric models and to minimize the orbital and multipath errors of the GPS signals.

The geometric constraints of the GPS network increase the robustness of the results, and at the same time they increase the decorrelation between the ambiguity parameters and the atmospheric parameters, helping to achieve correct ambiguity determination.

The Visual Factory Suite. Facing evolving mass production in spatial data processing environments

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The construction of software systems for massive batch production ("factories" in this context) by assembling multiple components has always been a slow, difficult task, delivering rather inflexible solutions and requiring specialized personnel (software engineers) not only to create such systems but, often, to exploit them. The reasons for such difficulties may be classified as follows:

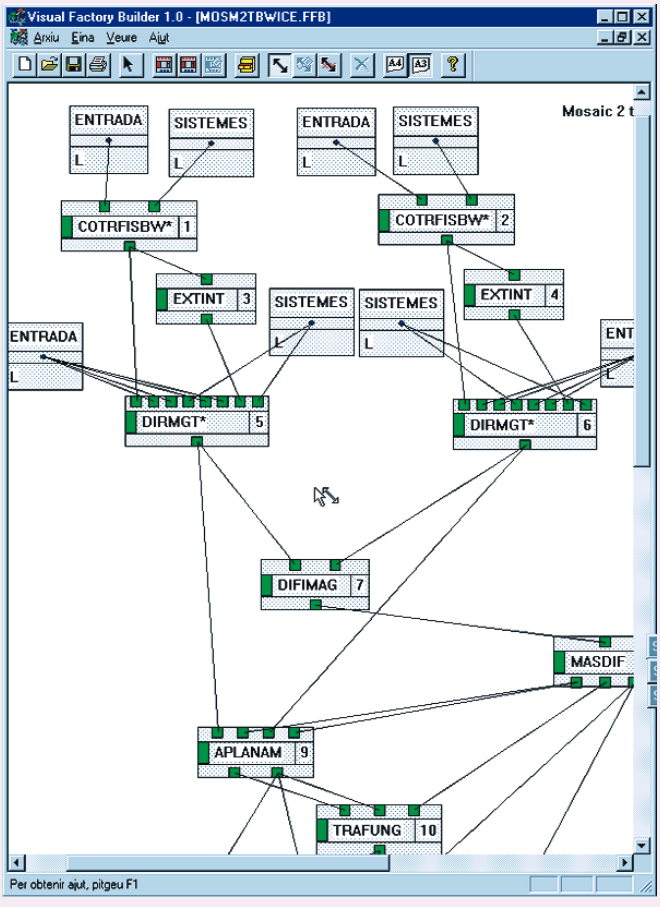
Assembly. Combining several programs to create a workflow is a task that poses technical problems.

Change. New products are requested; improved algorithms appear; new data formats have to be used; therefore, existing systems must be maintained or new ones created.

Complexity. Only experts in a particular field are capable of establishing what the correct workflow is, in order to obtain a particular product. Software engineers do not usually possess this knowledge, essential to the construction of the system aimed at.

Such difficulties lead to inflexible software systems, which are far from capable of meeting the challenge of day-to-day production. The Visual Factory Suite (VFS) for Windows NT is a set of applications and standards that has been created at the ICC with the aim of solving, or at least alleviating these problems.

The main objective of the VFS may be defined as follows: *The production (not the software) engineer must be able to create new factories by him/herself and put them into operation in a matter of minutes*. This objective has been achieved with the VFS 1.0, since this suite enables the production engineer to do the following: *1)* design factories visually, *2)* plan the deployment of these in order to exploit them in accordance with the available resources and, *3)* visually once again, monitor and control the production process.



Visual design of a factory

Agricultural field extraction from aerial images using a Region Competition algorithm

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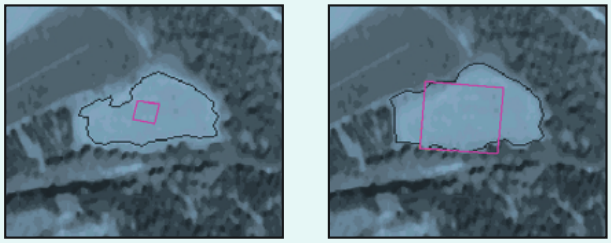
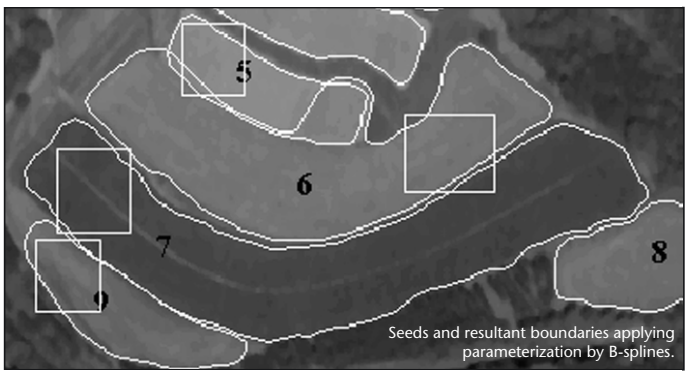
In this paper we consider the problem of segmenting agricultural fields on digital aerial images by using a generalization of Region Growing techniques combined with deformable models. This mixed approach is called Region Competition. The deformable models are a generalization of the Snakes method to dynamically adapt a vectorial contour to a region of interest by applying energy minimization techniques. At the same time, given the problem of agricultural land segmentation, our interest is use to Region Growing techniques in order to obtain the statistical distribution parameters of the regions and to divide the raster image into homogeneous parcels. Region Competition combines the best features of Snakes/Balloon models and Region Growing techniques. This algorithm is based on an energy minimization approach that actively optimizes the region contours and updates the probabilistic distribution parameters of the regions to be segmented. Using the fact that the existing techniques of Snakes/Balloon models, Region Growing and Minimum Description Language (MDL) can address the segmentation problem from different angles, through this approach they are combined within a common statistical framework in order to reap the advantages of the three methods. When applying this strategy, the preservation of topological features of the agricultural fields guides the pixel aggregation process of homogeneous regions and makes it more robust.



Seed selection effect.



Seeds and resultant boundaries applying parameterization by B-splines.

With this approach, each region is modeled by a probabilistic distribution, since some areas are qualified as belonging to the same region due to the homogeneity of their radiometric pixel values. A region is considered homogeneous if its intensity values are consistent with having been generated by a pre-specified family of probability distribution, in our case the "Normal" distribution.

A seed point, given by the operator, is taken as an initial snake defining a small circular area of image I, and it also provides the first approximation of the statistical parameters of the parcel. On the basis of these data, two regions R and S (S can be R-complementary) are created, and the corresponding probabilities P(I | R) and P(I | S) (where I is the image) are calculated. The contour motion is determined by the likelihood ratio test. The boundary selectively move on the image, deforming the region R, depending on whether the characteristics of a small area around each point of the boundary of R are closer to P(I | R) or to P(I | S). In this way adjacent regions compete for ownership of pixels along their boundaries, subject to the smoothness of shape restrictions imposed.

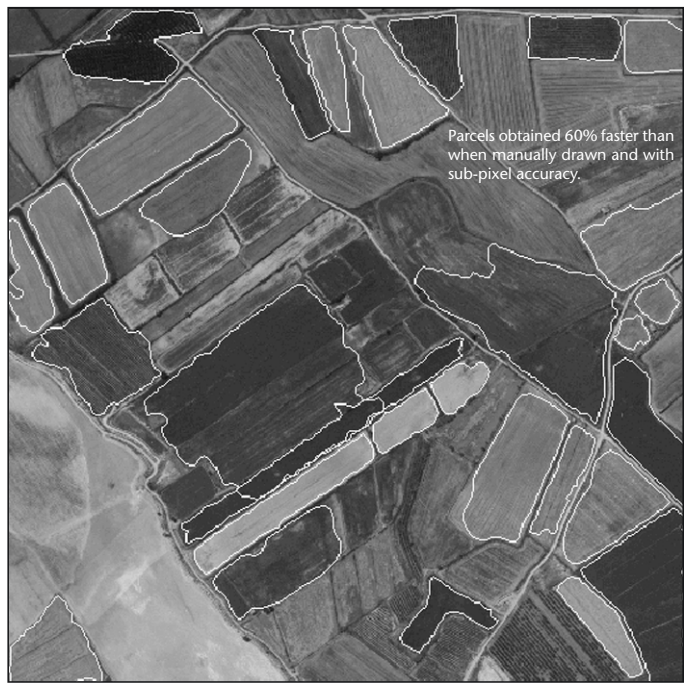
There are two types of forces acting on the contour of the region to minimize its energy: the external force that decides to include/exclude a point of the boundary of a region, as described before, and the internal force incorporating the conditions that the contour will have to meet, ensuring its smoothness in the evolution of its shape in the course of the different iterations to obtain a solution.

In order to reduce the process time and to guarantee more accurate results, the characteristics of the initial data provided by the operator have been studied. Moreover, different initializations have been compared to obtain a better estimation of the initial probabilistic parameters and to improve the performance of the process. By studying the convergence of the process in several cases, different strategies have been developed to stop the iterative process when it is considered that a solution has been obtained. One of these is based on shape correlation between two consecutive iterations of the process.

In order to adapt the Region Competition algorithm to our applications, the approach has been extended by using a parameterization of the contour that uses B-splines. One of the reasons for selecting the B-spline representation was the easy and compact way in which it can represent the regularity of the agricultural field shapes. Another advantage of the B-spline is the rapid computation of the spline derivatives, and so the internal forces, such as the curvature, can be introduced at a very low cost. Strategies have also been developed to control the appearance of loops and to help the internal force to maintain the smoothness of shape.

Our objective has been to recover the boundary of the parcels that appear on the digital aerial photographs in the simplest possible way. After weighing up the benefit of automation against the cost of error detection and edition, a decision was made to develop semi-automatic tools. With our approach the system is assisted by the operator in two ways: firstly, by giving a point inside the region to be segmented, and then by accepting, refusing or editing the result obtained.

The system has been developed in a user friendly environment and validated on numerous aerial images, and the algorithms can easily be incorporated into a GIS system.



Parcels obtained 60% faster than when manually drawn and with sub-pixel accuracy.

Land use map production through the fusion of multispectral classification of Landsat images and texture analysis of high resolution images

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One of the most frequently used methods to obtain a land cover map is the supervised classification of multispectral Landsat images, but often the result is not accurate enough for most practical remote sensing projects. Although multitemporal images are used to capture the phenological evolution of the vegetation in the course of the year, a high degree of uncertainty in some legend classes is almost always present.

In spite of this, it is very common to have several data sets obtained from a given physical geographic area, since any data acquired at different times or by different sensors can be used to obtain a land use classification by means of different techniques. Usually, different data sources are best suited to the study of different characteristics, such as urban uses, vegetation, humidity, etc.

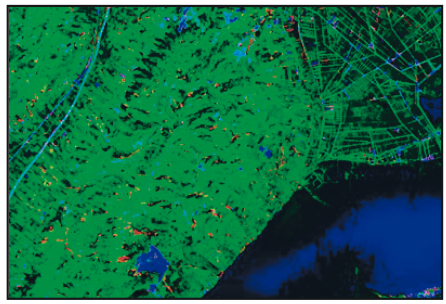
At this point it becomes necessary to devise a method that combines the different classifications, in order to obtain a new one that contains the best characteristics of each. This paper presents an algorithm based on the "Evidence Theory", which merges several land use maps obtained from different data sources and by different methods of analysis.

A supervised classification provides a likelihood distribution that indicates the probable assignment of each point/pixel for each one of the legend classes. Through the use of some test areas, an individual measurement of the classification success ratio as a percentage can also be obtained for each data source. The method presented here, that of merging two different classifications of the same geographic area, is based on the combination of those likelihoods (assignment probabilities) and the classification success ratio of each data source. By combining them, a new assignment probability distribution and therefore a new classification is obtained.

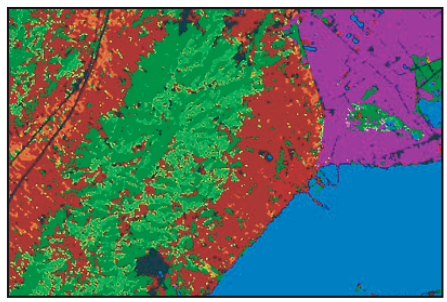
The behavior of this method and the improvements it brings to the usual classification methods are tested using two data sources, although the method could easily and immediately be extended to different sources. The first is a set of multispectral Landsat images taken in two different seasons of the year, from which a first classification is obtained. The second data source is a b/w orthophotomap with a 2.5 meter pixel resolution obtained by means of aerial photography. In order to use its higher spatial resolution compared with that of the Landsat, a texture analysis is made, and in this way a second classification is obtained from the bands derived. Both likelihood assignments are combined using a different weight depending on the original classification success, and a new likelihood is obtained.

If a new success ratio for this final combined classification is calculated in order to test its accuracy, the result is better than that obtained in the original classes. Thus it may be concluded that the "Evidence Theory" provides a good framework in which to combine individual classifications obtained from different data sources, while retaining the best of each.

Example of orthophoto obtained by panchromatic aerial photography.



False colour texture image.



Final classification obtained using the "Evidence Theory".

Accuracy potential of point measurements on MOMS images using a rigorous model and rational functions

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The study of potential accuracy in the measurement of points on MOMS images using a rigorous model and rational functions originated with the initiative of the ISPRS-WGII/7 (working group II/7 of the International Society for Photogrammetry and Remote Sensing) to establish a general purpose image-transfer standard for photogrammetric applications and remote sensing. While rigorous photogrammetric models guarantee a defined accuracy, the rational functions approach only permits more general establishment of the anticipated accuracy of the points extracted from a stereopair.

In order to select the most suitable method for a correct application, the effective point accuracy has been tested in a joint project undertaken by the Institut Cartogràfic de Catalunya and the Fachhochschule Neubrandenburg. MOMS scenes of mountainous and flat terrain have been employed in the test, which has been conducted using several software ZI-Imaging packages.

Given the orientation of images using a rigorous photogrammetric model, there are two parameters to choose the rational functions that approximate the rigorous model. The first one is the degree of the rational functions, and the second is the set of points whose coordinates are known through the rigorous model and used in the computation of the coefficients of the rational functions.

The results have been compared using the rational functions (changing the parameters to determine them) and the rigorous model, and there has been discussion of the dependence of the rational functions on the terrain and the calibration parameters.

Map production in Venezuela using airborne InSAR

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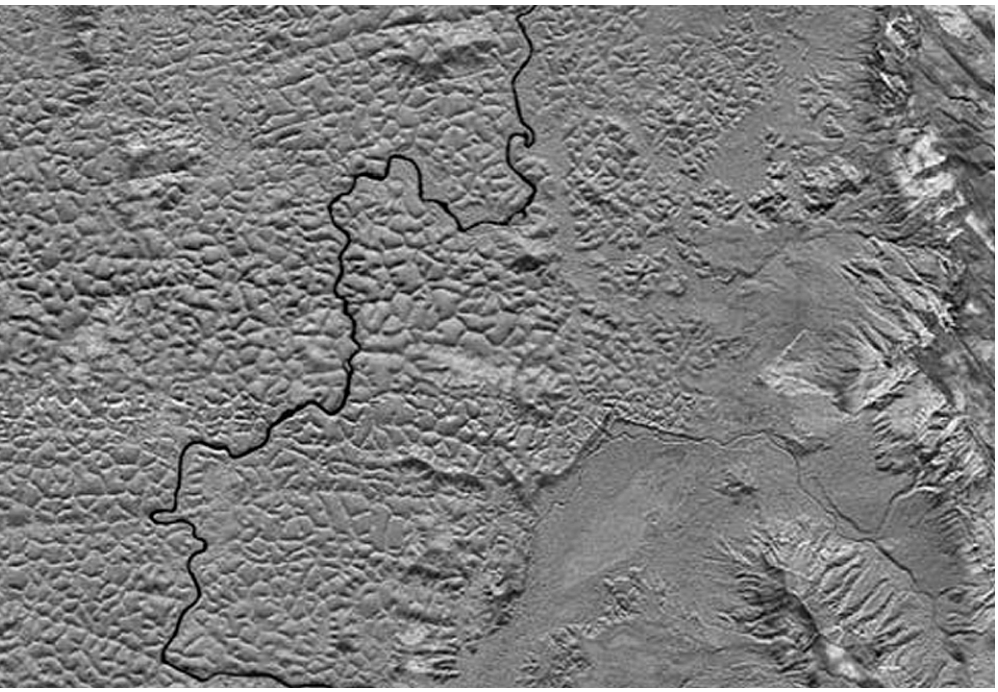

Geocoded image after radiometric correction.

The Servicio Autónomo de Geografía y Cartografía Nacional (National Mapping Service) of Venezuela has risen to the challenge of mapping the region between the Orinoco River and the Brazilian border. This remote region of Venezuela has a warm and humid climate, with almost permanent cloud cover. The topography is hilly, with few flat areas and very abrupt elevations emerging from the plain. The land is mostly covered by rainforest, with trees of up to 40 meters in height.

The project involved the production of 5 meter pixel digital orthoimages and orthoimage maps at 1:50,000 scale, with 40 meter contours derived from a very dense digital elevation model over a region of 266,616 km^2. The total number of map sheets covering the area is 536.

The Institut Cartogràfic de Catalunya submitted a technical proposal based on interferometric SAR technology to ensure that the products would be obtained and delivered in a foreseeable period of time. The accuracy and pixel size specifications excluded the use of satellite radar, and therefore the AeS-1 single pass airborne interferometric radar of AeroSensing Radarsysteme, GmbH was proposed and selected for the project.

The AeS-1 system relies on GPS and INS data for georeferencing, so ground control is used for checking purposes only. The checkpoints can be made visible on the radar image by installing radar reflectors (corner reflectors) at known positions. Finally, 35 corner reflectors were measured on the ground and on the image.

The flight campaign lasted from 28 October 1998 to 3 February 1999. There were 66 effective flying days.

The first stage of the process consists of the reconstruction of the two complex images (intensity and phase) from the raw data of the two antennas. The interferogram is then obtained by multiplying the first image with the complex conjugate of the second. The interferogram represents the phase difference due to the elevation of the terrain and is expressed ("wrapped") in module 2π. The "phase unwrapping" process computes the absolute phase difference by adding 2π if discontinuities of 2π are detected in the interferogram.

The elevations are then computed from the absolute phase after phase calibration. Once the elevations are known, flight tracks are geocorrected and assembled in a mosaicking process.

An almost cloud-free Landsat coverage is used for estimating the height of the trees and converting the Digital Surface Model (DSM) into the Digital Terrain Model (DTM). After co-registering with the radar images, the Landsat scenes are classified using unsupervised clustering techniques. Height differences between adjacent classes are obtained by drawing profiles across them and then extracting the heights from the DSM. The output is a table with the average differences in height for each type of transition between classes. The bare soil class is used as a reference, and then the heights are subtracted from the DSM to obtain the DTM. The classes are derived from the texture of the radar images in places where the Landsat scenes are covered by clouds. Interpolating from the neighboring heights eliminates local minima and maxima.

Contour lines are then computed automatically and very small closed contours are deleted. Geographical names are extracted from existing maps and positioned on the map. Finally, frames, legends and marginalia are placed on the map, plotted on film and printed.

Perhaps the most important conclusion is that single pass airborne interferometry is a reliable operational tool for mapping missions in areas with severe cloud cover. On the other hand, a lengthy period of time is required to process the radar data. Comparatively, the amount of hardware needed and the time spent are several times greater than for an equivalent optical mission.

BRIEF NOTES

MAPS IN THE HISTORY OF CARTOGRAPHY IN THE 20TH CENTURY

The ICC's project on the study of the development and influence of map collections in the history of cartography in the 20th century has been incorporated into a three-year research program financed by the National Science Foundation of the USA.

The proposal forms part of the work undertaken to prepare volume 6 of the *History of Cartography*, published by the University of Chicago under the directorship of Professor David Woodward. This volume specifically deals with cartography in the 20th century and is co-edited by Professor Mark Monmonier.

AWARD FOR THE BEST PAPER

At the 12th International Technical Meeting of The Satellite Division of the Nashville Institute of Navigation (Tennessee), held in September 1999, the award for the best paper presented at the Carrier-Phase Positioning & Ambiguity Resolution Session was awarded to the paper entitled "Resolving Carrier-Phase Ambiguities On-The-Fly, At More Than 100 km From Nearest Reference Site, With Help From Ionospheric Tomography", whose authors were O. L. Colombo (USRA/NASA GSFC), M. Hernandez-Pajares, J. M. Juan and J. Sanz (Universitat Politècnica de Catalunya) and Julià Talaya (Institut Cartogràfic de Catalunya).

Congratulations!

"JORDI VIÑAS I FOLCH" AWARD

During the course of every Barcelona Geomatic Week, held every two years, the ICC calls for contestants for the "Jordi Viñas i Folch" award, which is awarded to an individual and hitherto unpublished piece of research work in the field of geomatics.

During the 4th Geomatic Week, held on 3-6 April 2000 and organized by the Institut de Geomàtica, the Institut Cartogràfic de Catalunya, the Col·legi Oficial d'Enginyers Tècnics en Topografia (Catalonia division) and the Escola Universitària Politècnica de Barcelona, the jury awarded the award to the research work: "New technologies for the establishment of GPS differential correction services", by Ernest Bosch (ICC).

Congratulations!

A countrywide TIN elevations database

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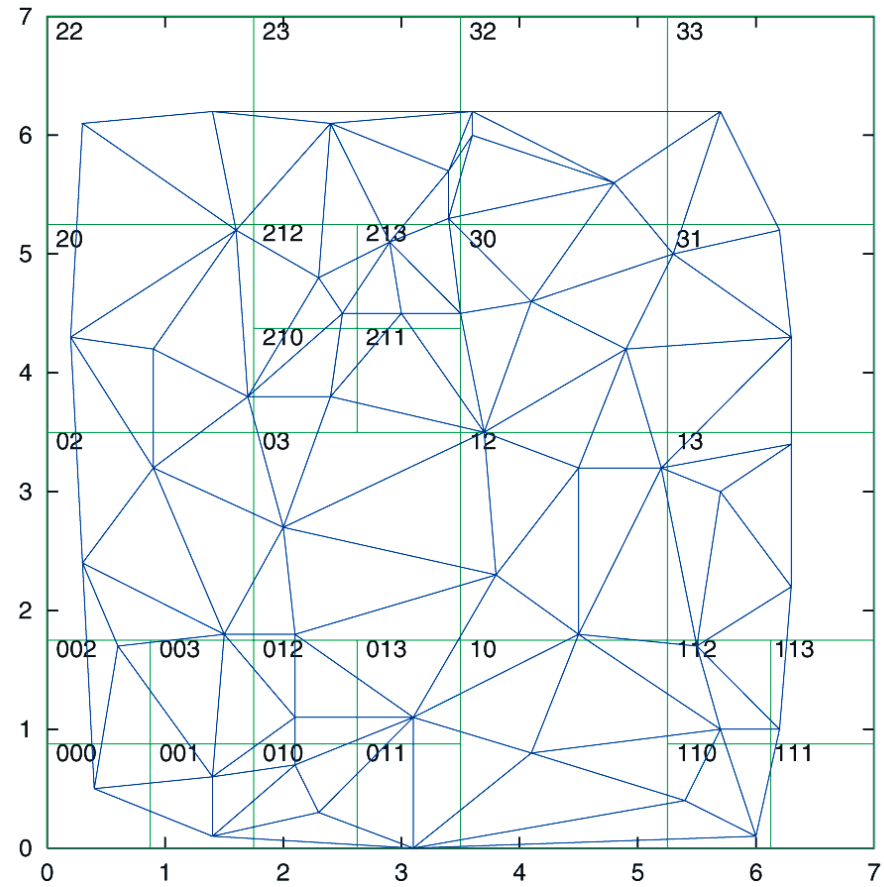
The regular grid elevations database that the Institut Cartogràfic de Catalunya has been using since 1987 is insufficient for certain applications. For this reason, development was begun of a new database, with the aim of building a one piece TIN model with sufficient precision to generate cartographic quality contours at 1:5,000 scale and smaller for the whole of Catalonia (32,000 km^2). It is anticipated that approximately 300 million points will be entered. The model must be dynamic in order to support insertion and deletion, the surface model needs to be refinable, algorithms have to be robust and data integrity must be preserved.

The chosen triangulation is constrained Delaunay triangulation (CDT) and the incremental construction algorithm is used. Its performance is good when the input data are well distributed, and it is fully dynamic.

The main difficulty is how to deal with a triangulation in external memory. Common triangulation programs hold all the information in core memory and cannot triangulate very large data sets (a few million vertices), because the system degrades very quickly due to the page faults. We use a bucket point region quadtree to help point location and to reduce page faults by bucketing.

The surface model is a polyhedral TIN terrain by default, but it can be extended in different ways. The use of object-oriented technology means that these extensions can be programmed easily and gives the design great flexibility.



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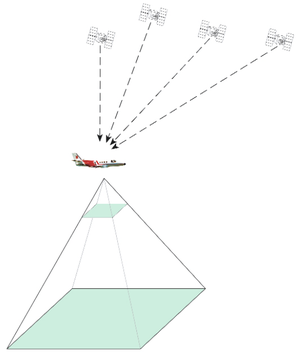

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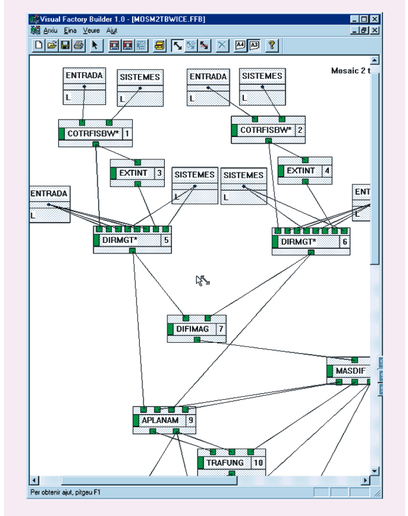

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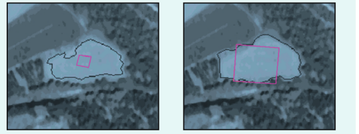
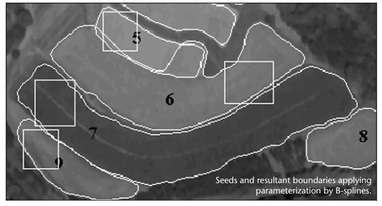


Seed selection effect.



Seeds and resultant boundaries applying parameterization by B-splines.

With this approach, each region is modeled by a probabilistic distribution, since some areas are qualified as belonging to the same region due to the homogeneity of their radiometric pixel values. A region is considered homogeneous if its intensity values are consistent with having been generated by a pre-specified family of probability distribution, in our case the "Normal" distribution.

A seed point, given by the operator, is taken as an initial snake defining a small circular area of image I, and it also provides the first approximation of the statistical parameters of the parcel. On the basis of these data, two regions R and S (S can be R-complementary) are created, and the corresponding probabilities P(I | R) and P(I | S) (where I is the image) are calculated. The contour motion is determined by the likelihood ratio test. The boundary selectively move on the image, deforming the region R, depending on whether the characteristics of a small area around each point of the boundary of R are closer to P(I | R) or to P(I | S). In this way adjacent regions compete for ownership of pixels along their boundaries, subject to the smoothness of shape restrictions imposed.

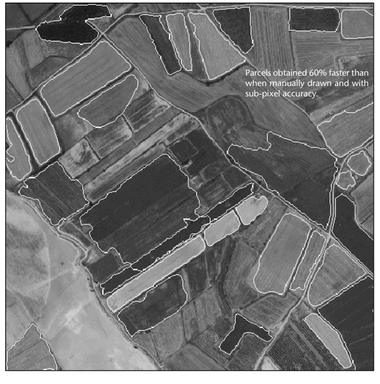
There are two types of forces acting on the contour of the region to minimize its energy: the external force that decides to include/exclude a point of the boundary of a region, as described before, and the internal force incorporating the conditions that the contour will have to meet, ensuring its smoothness in the evolution of its shape in the course of the different iterations to obtain a solution.

In order to reduce the process time and to guarantee more accurate results, the characteristics of the initial data provided by the operator have been studied. Moreover, different initializations have been compared to obtain a better estimation of the initial probabilistic parameters and to improve the performance of the process. By studying the convergence of the process in several cases, different strategies have been developed to stop the iterative process when it is considered that a solution has been obtained. One of these is based on shape correlation between two consecutive iterations of the process.

In order to adapt the Region Competition algorithm to our applications, the approach has been extended by using a parameterization of the contour that uses B-splines. One of the reasons for selecting the B-spline representation was the easy and compact way in which it can represent the regularity of the agricultural field shapes. Another advantage of the B-spline is the rapid computation of the spline derivatives, and so the internal forces, such as the curvature, can be introduced at a very low cost. Strategies have also been developed to control the appearance of loops and to help the internal force to maintain the smoothness of shape.

Our objective has been to recover the boundary of the parcels that appear on the digital aerial photographs in the simplest possible way. After weighing up the benefit of automation against the cost of error detection and edition, a decision was made to develop semi-automatic tools. With our approach the system is assisted by the operator in two ways: firstly, by giving a point inside the region to be segmented, and then by accepting, refusing or editing the result obtained.

The system has been developed in a user friendly environment and validated on numerous aerial images, and the algorithms can easily be incorporated into a GIS system.



Parcels obtained 60% faster than when manually drawn and with sub-pixel accuracy.

Land use map production through the fusion of multispectral classification of Landsat images and texture analysis of high resolution images

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One of the most frequently used methods to obtain a land cover map is the supervised classification of multispectral Landsat images, but often the result is not accurate enough for most practical remote sensing projects. Although multitemporal images are used to capture the phenological evolution of the vegetation in the course of the year, a high degree of uncertainty in some legend classes is almost always present.

In spite of this, it is very common to have several data sets obtained from a given physical geographic area, since any data acquired at different times or by different sensors can be used to obtain a land use classification by means of different techniques. Usually, different data sources are best suited to the study of different characteristics, such as urban uses, vegetation, humidity, etc.

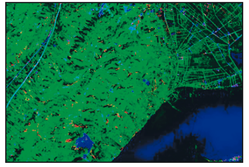
At this point it becomes necessary to devise a method that combines the different classifications, in order to obtain a new one that contains the best characteristics of each. This paper presents an algorithm based on the "Evidence Theory", which merges several land use maps obtained from different data sources and by different methods of analysis.

A supervised classification provides a likelihood distribution that indicates the probable assignment of each point/pixel for each one of the legend classes. Through the use of some test areas, an individual measurement of the classification success ratio as a percentage can also be obtained for each data source. The method presented here, that of merging two different classifications of the same geographic area, is based on the combination of those likelihoods (assignment probabilities) and the classification success ratio of each data source. By combining them, a new assignment probability distribution and therefore a new classification is obtained.

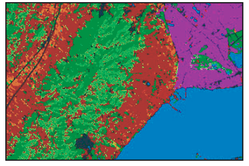
The behavior of this method and the improvements it brings to the usual classification methods are tested using two data sources, although the method could easily and immediately be extended to different sources. The first is a set of multispectral Landsat images taken in two different seasons of the year, from which a first classification is obtained. The second data source is a b/w orthophotomap with a 2.5 meter pixel resolution obtained by means of aerial photography. In order to use its higher spatial resolution compared with that of the Landsat, a texture analysis is made, and in this way a second classification is obtained from the bands derived. Both likelihood assignments are combined using a different weight depending on the original classification success, and a new likelihood is obtained.

If a new success ratio for this final combined classification is calculated in order to test its accuracy, the result is better than that obtained in the original classes. Thus it may be concluded that the "Evidence Theory" provides a good framework in which to combine individual classifications obtained from different data sources, while retaining the best of each.

Example of orthophoto obtained by panchromatic aerial photography.



False colour texture image.



Final classification obtained using the "Evidence Theory".

Accuracy potential of point measurements on MOMS images using a rigorous model and rational functions

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The study of potential accuracy in the measurement of points on MOMS images using a rigorous model and rational functions originated with the initiative of the ISPRS-WGII/7 (working group II/7 of the International Society for Photogrammetry and Remote Sensing) to establish a general purpose image-transfer standard for photogrammetric applications and remote sensing. While rigorous photogrammetric models guarantee a defined accuracy, the rational functions approach only permits more general establishment of the anticipated accuracy of the points extracted from a stereopair.

In order to select the most suitable method for a correct application, the effective point accuracy has been tested in a joint project undertaken by the Institut Cartogràfic de Catalunya and the Fachhochschule Neubrandenburg. MOMS scenes of mountainous and flat terrain have been employed in the test, which has been conducted using several software ZI-Imaging packages.

Given the orientation of images using a rigorous photogrammetric model, there are two parameters to choose the rational functions that approximate the rigorous model. The first one is the degree of the rational functions, and the second is the set of points whose coordinates are known through the rigorous model and used in the computation of the coefficients of the rational functions.

The results have been compared using the rational functions (changing the parameters to determine them) and the rigorous model, and there has been discussion of the dependence of the rational functions on the terrain and the calibration parameters.