

Analecta Praehistorica Leidensia 28 / Interfacing the past : computer applications and quantitative methods in archaeology CAA95 Vol. I

Kamermans, Hans; Fennema, Kelly; et al., ; Kamermans, Hans; Fennema, Kelly

Citation

Kamermans, H., Fennema, K., & Et al., (1996). Analecta Praehistorica Leidensia 28 / Interfacing the past : computer applications and quantitative methods in archaeology CAA95 Vol. I, 272. Retrieved from https://hdl.handle.net/1887/32752

Version:	Not Applicable (or Unknown)
License:	Leiden University Non-exclusive license
Downloaded from:	https://hdl.handle.net/1887/32752

Note: To cite this publication please use the final published version (if applicable).

ANALECTA PRAEHISTORICA LEIDENSIA



PUBLICATIONS OF THE INSTITUTE OF PREHISTORY UNIVERSITY OF LEIDEN

INTERFACING THE PAST

COMPUTER APPLICATIONS AND QUANTITATIVE METHODS IN ARCHAEOLOGY CAA95 VOL. I

EDITED BY HANS KAMERMANS AND KELLY FENNEMA



UNIVERSITY OF LEIDEN 1996

contents

VOLUME I

Preface

Hans Kamermans Kelly Fennema

	Data Management
Jens Andresen Torsten Madsen	IDEA – the Integrated Database for Excavation Analysis 3
Peter Hinge	The Other Computer Interface 15
Thanasis Hadzilacos Polyxeni Myladie Stoumbou	Conceptual Data Modelling for Prehistoric Excavation Documentation 21
E. AgrestiA. Maggiolo-SchettiniR. SaccoccioM. PierobonR. Pierobon-Benoit	Handling Excavation Maps in SYSAND 31
Alaine Lamprell Anthea Salisbury Alan Chalmers Simon Stoddart	An Integrated Information System for Archaeological Evidence 37
Jon Holmen Espen Uleberg	The National Documentation Project of Norway – the Archaeological sub-project 43
Irina Oberländer-Târnoveanu	Statistical view of the Archaeological Sites Database 47
Nigel D. Clubb Neil A.R. Lang	A Strategic Appraisal of Information Systems for Archaeology and Architecture in England – Past, Present and Future 51
Nigel D. Clubb Neil A.R. Lang	Learning from the achievements of Information Systems – the role of the Post- Implementation Review in medium to large scale systems 73
Neil Beagrie	Excavations and Archives: Alternative Aspects of Cultural Resource Management 81
Mark Bell Nicola King	The MARS Project – an interface with England's past 87

ANALECTA PRAEHISTORICA LEIDENSIA 28

Archaeometry

Detecting Unusual Multivariate Data: An Archaeometric Example 95

Restoration of magnetometry data using inverse-data methods 111

Extraction and visualisation of information from ground penetrating radar surveys 103

M.J. Baxter H.E.M. Cool M.P. Heyworth

Jon Bradley Mike Fletcher

Gayle T. Allum Robert G. Aykroyd John G.B. Haigh

W. NeubauerP. MelicharA. Eder-Hinterleitner

A. Eder-HinterleitnerW. NeubauerP. Melichar

Phil Perkins

Reconstruction of archaeological structures using magnetic prospection 131

Collection, visualization and simulation of magnetic prospection data 121

An image processing technique for the suppression of traces of modern agricultural activity in aerial photographs 139

Statistics and Classification

Clive Orton Markov models for museums 149

Juan A. Barceló Heuristic classification and fuzzy sets. New tools for archaeological typologies 155

Kris Lockyear Dmax based cluster analysis and the supply of coinage to Iron Age Dacia 165

Christian C. BeardahMATLAB Routines for Kernel Density Estimation and the Graphical Representation ofMike J. BaxterArchaeological Data 179

John W.M. Peterson A computer model of Roman landscape in South Limburg 185

Time versus Ritual – Typological Structures and Mortuary Practices in Late Bronze/Early Iron Age Cemeteries of North-East Caucasia ('Koban Culture') 195

Leonardo García SanjuánPredicting the ritual? A suggested solution in archaeological forecasting throughJesús Rodríguez Lópezqualitative response models203

Simulating hunter-gatherer colonization of the Americas 223

The use of correspondence analysis for different kinds of data categories: Domestic and ritual Globular Amphorae sites in Central Germany 217

J. Steele T.J. Sluckin D.R. Denholm C.S. Gamble

Johannes Müller

Sabine Reinhold

VI

VII CONTENTS Paul M. Gibson An Archaeofaunal Ageing Comparative Study into the Performance of Human Analysis Versus Hybrid Neural Network Analysis 229 Image Processing Strategies for Artefact Classification 235 Peter Durham Paul Lewis Stephen J. Shennan Gijsbert R. Boekschoten A new tool for spatial analysis: "Rings & Sectors plus Density Analysis and Trace lines" 241 Dick Stapert Susan Holstrom Loving Estimating the age of stone artifacts using probabilities 251 Application of an object-oriented approach to the formalization of qualitative (and quan-Oleg Missikoff titative) data 263 **VOLUME II Geographic Information Systems I** Between the lines: the role of GIS-based predictive modelling in the interpretation of David Wheatley extensive survey data 275 The contribution of GIS to the study of landscape evolution in the Yorkshire Dales, Roger Martlew UK 293 Extending GIS Methods for Regional Archaeology: the Wroxeter Hinterland Project 297 Vincent Gaffney Martijn van Leusen Multi-dimensional GIS: exploratory approaches to spatial and temporal relationships Trevor M. Harris within archaeological stratigraphy 307 Gary R. Lock Philip Verhagen The use of GIS as a tool for modelling ecological change and human occupation in the Middle Aguas Valley (S.E. Spain) 317 The Romans in southwestern Spain: total conquest or partial assimilation? Can GIS Federica Massagrande answer? 325 Recent examples of geographical analysis of archaeological evidence from central Italy 331 Shen Eric Lim Simon Stoddart Andrew Harrison Alan Chalmers Satellite Imagery and GIS applications in Mediterranean Landscapes 337 Vincent Gaffney Krištof Oštir Tomaž Podobnikar Zoran Staničič The long and winding road: land routes in Aetolia (Greece) since Byzantine times 343 Yvette Bommeljé Peter Doorn

VIII	ANALECTA PRAEHISTORICA LEIDENSIA 28
Javier Baena Preysler Concepción Blasco	Application of GIS to images and their processing: the Chiribiquete Mountains Project 353
	Geographic Information Systems II: The York Applications
Julian D. Richards	From Site to Landscape: multi-level GIS applications in archaeology 361
Harold Mytum	Intrasite Patterning and the Temporal Dimension using GIS: the example of Kellington Churchyard 363
A. Paul Miller	Digging deep: GIS in the city 369
Julian D. Richards	Putting the site in its setting: GIS and the search for Anglo-Saxon settlements in Northumbria 379
Jeffrey A. Chartrand	Archaeological Resource Visibility and GIS: A case study in Yorkshire 389
	Visualisation
John Wilcock	A description of the display software for Stafford Castle Visitor Centre, UK 405
Christian Menard Robert Sablatnig	Pictorial, Three-dimensional Acquisition of Archaeological Finds as Basis for an Automatic Classification 419
Katalin T. Biró	Simple fun – Interactive computer demonstration program on the exhibition of the Szentgál-Tűzköveshegy prehistoric industrial area 433
György Csáki Ferenc Redö	Documentation and modelling of a Roman imperial villa in Central Italy 437
Maurizio Forte Antonella Guidazzoli	Archaeology, GIS and desktop virtual reality: the ARCTOS project 443
Germà Wünsch Elisabet Arasa Marta Pérez	Dissecting the palimpsest: an easy computer-graphic approach to the stratigraphic sequence of Túnel VII site (Tierra del Fuego, Argentina) 457
David Gilman Romano Osama Tolba	Remote Sensing and GIS in the Study of Roman Centuriation in the Corinthia, Greece 461
F.J. Baena F. Quesada M.C. Blasco	An application of GIS intra-site analysis to Museum Display 469
	Education and Publication
Robin B. Boast Sam J. Lucy	Teaching with objects 479

CONTENTS

Martin Belcher Alan Chalmers Andrew Harrison Simon Stoddart

Anja C. Wolle Stephen J. Shennan

G. Gyftodimos D. Rigopoulos M. Spiliopoulou

Martijn van Leusen Sara Champion Jonathan Lizee Thomas Plunkett

Mike Heyworth Seamus Ross Julian Richards

Virgil Mihailescu-Bîrliba Vasile Chirica

Kris Lockyear

Teaching the Visualisation of Landscapes – Approaches in Computer based learning for Archaeologists 487

A Tool for Multimedia Excavation Reports – a prototype 493

Exploring Archaeological Information through an Open Hypermedia System 501

Toward a European Archaeological Heritage Web 511

Internet archaeology: an international electronic journal for archaeology 521

A Survey of the Development of Computer Applications in Romanian Archaeology 529

Computer-aided publication in practice 535

IX

An image processing technique for the suppression of traces of modern agricultural activity in aerial photographs

1 The problem

Agricultural activity can make buried archaeological sites visible from the air. Ploughing creates soil marks and sowing creates crop marks. However, mechanised agriculture also creates other patterns in the soil or in crops. Ploughing leaves regular furrows and mechanised sowing leaves fine alignments of plants in the field and fertilisation or pesticide treatments can leave regular tractor tracks across fields. Traces of this agricultural activity are also visible from the air and may mask or confuse archaeological crop marks or soil marks. Archaeologists have employed image processing to aerial photographs for many reasons (Booth *et al.* 1991) and it offers some hope of enhancing this particular form of 'noise'.

A first approach in such cases where there is unwanted fine detail, such as furrows, is to convolve the image using an averaging filter. This removes fine detail in the image leaving coarse detail visible. However, the filter is indiscriminate and has the effect of blurring everything in the image equally. Certainly it removes traces of sowing and tractor tracks but it also corrupts the crop marks which are clearly visible in the data which have been removed from the image in the filtering process (fig. 1).

What is required is a filter which can discriminate between the regular traces of agriculture and the less regular traces of archaeological structures. Edge suppression filters offer some hope but in practice the edges of the archaeological features are also suppressed, reducing their legibility.

2 A solution

A solution to this problem is possible if we consider the image in the frequency domain as a sum of phase shifted sine waves. Determining which sine waves to use is the major concern of Fourier Analysis. Information about the amplitude and phase shift of the sine waves can be encoded as a Fourier transform, and since it is discrete sampled data we can use the Fast Fourier Transform. The image may now be filtered in the frequency domain as we might in the



Figure 1. Left: the original photo. Right: blurred image after applying a 3×3 averaging filter. Centre: an equalised image of the difference between the before and after images. Many of the traces of the tractor tracks and alignments of plants have been removed and so are visible in the difference between the two images, however the crop mark itself is also visible and so has been corrupted.



Figure 2. Frequency filtering applied to a data set simulating a ploughed field. Top left: simulated data. Top right: Fast Fourier Transform of simulated data. Bottom left: Fast Fourier Transform filtered by hand. Bottom right: Inverse Fast Fourier Transform of filtered simulated data.

spatial domain. Truncation of the high frequencies is equivalent to blurring the image in the spatial domain, that is the high frequencies are filtered out (the technique is fully described in theory in the context of antialiasing in Foley *et al.* 1990: 623-46). Filtering in the frequency domain allows the possibility to selectively filter the transforms of the coarseness or fineness of regular patterning along with the orientation of features in the spatial (unfiltered) domain.

2.1 SIMULATED DATA

In order to test the effects of frequency filtering and explore its impact on defined signals, a simulated data set consisting of a 256×256 pixel field of black and white diagonal lines representing furrows at 45° was created (fig. 2 top left). When transformed to the frequency domain with a Fast Fourier Transform the image appears as three bright dots aligned at 45° (fig. 2 top right). Filtering this image by hand these outlying peaks of high frequency are removed (fig. 2 bottom left). The Inverse Fast Fourier Transform applied to transform this filtered image back to the spatial domain results is a uniformly mid-grey field — the furrows have been effectively removed by filtering out their frequencies (fig. 2 bottom right). The filtering is extremely effective on such a simple image. However, add a simulated round barrow to the simulated field (fig. 3 top left) and the Fast Fourier Transform of the image appears much more complex (fig. 3 top right). Filtering out the frequencies known from the previous experiment to remove the traces of the furrows only (fig. 3 bottom left) and applying the Inverse Fast Fourier Transform (fig. 3 bottom right) effectively removes the traces of the furrows. The simulated round barrow, which was originally uniformly grey, rather than furrowed, has taken on zebra stripes due to the fact



Figure 3. Frequency filtering applied to a data set simulating a ploughed field with a circular soil mark. Top left: simulated data. Top right: Fast Fourier Transform of simulated data. Bottom left: Fast Fourier Transform filtered by hand. Bottom right: Inverse Fast Fourier Transform of filtered simulated data.



Figure 4. The simulated data of a ploughed field with a circular soil mark is shown before filtering (left) and after filtering (centre). The equalised difference between the two (right) shows, in an exaggerated way, the nature of the part of the signal that has been filtered out.



Figure 5. Frequency filtering applied to a data set simulating a ploughed field with a circular soil mark. Top left: simulated data. Top right: Fast Fourier Transform of simulated data. Bottom left: Fast Fourier Transform filtered with a band stop filter. Bottom right: Inverse Fast Fourier Transform of filtered simulated data.

that the values representing the furrows have been subtracted from it too. Around the ring there is some 'rippling' in the uniform grey of the field indicating that the technique is not perfect when more complex images are filtered. This is visualised in figure 4 where the simulated data is shown before (left) and after (centre) filtering and the equalised difference between the two (right) shows, in an exaggerated way, the nature of the part of the signal that has been filtered out.

Other filters instead of a heuristic hand filtering may also be applied to transformed images. For example a band stop filter, i.e. stopping the frequency which coincides with the peaks in frequency representing the furrows is applied in figure 5. The results are similar but the 'rippling' around the ring has a different form. The Fast Fourier Transform of a simulated complex crop mark (fig. 6 top left and right) can be seen to be more complex and less structured than the simple simulation. The filtering is still effective but the 'rippling' effects become more apparent closer to the simulated soil mark (fig. 6 bottom left and right).

Using real world data, figure 7 illustrates a variety of filtering strategies applied to the same photograph. The first column on the left shows at the top the image before filtering and below the Fast Fourier Transform of the image. The second column shows at the top a heuristic filter removing only low frequencies, in the centre is the



Figure 6. Frequency filtering applied to a data set simulating a ploughed field with a complex soil mark. Top left: simulated data. Top right: Fast Fourier Transform of simulated data. Bottom left: Fast Fourier Transform filtered by hand. Bottom right: Inverse Fast Fourier Transform of filtered simulated data.

filtered image and at the bottom an equalised image of the difference between the image before and after the filtering. Similarly the third column removes middle frequencies and the fourth only high frequencies. The fifth column on the right removes all frequencies with a particular frequency. Different filtering strategies may be adopted according to the nature of the noise to be removed from the image.

The Fourier Transform can only be applied to single band data, e.g., greyscale images only. To filter 'true' colour images it is first necessary to split the image into individual channels, in this case at Gussage All Saints red, green, blue. Each channel is then filtered separately and then the three filtered images may be recombined from the channels to produce a 'true' colour filtered image (fig. 8). Although differing parts of each band are filtered out when used carefully the technique does not impair the colour balance of the image.

3 Conclusions

This technique of filtering images of aerial photographs in the frequency domain has been found to be effective in the removal of systematic 'noise' in the images. It has been used in experiments to remove traces of ploughing thereby enhancing soil marks, traces seeding in young and mature crops, and tractor or machine tracks. It has been tested on images of regular olive groves but with limited success.



Figure 7. A variety of filtering strategies applied to the same photograph. The first column on the left shows at the top the image before filtering and below the Fast Fourier Transform of the image. The second column shows at the top a heuristic filter removing only low frequencies, in the centre is the filtered image and at the bottom an equalised image of the difference between the image before and after the filtering. Similarly the third column removes middle frequencies and the fourth only high frequencies. The fifth column on the right removes all frequencies with a particular frequency.

Such filtering has its limitations: the mathematics requires the image to be a perfect square, and large squares are computationally intensive. Most significant is that the filtering will only be effective on certain images. The 'noise' in the image, e.g. ploughing, needs to be reasonably regular in its linearity, spacing and orientation for good results to be obtained. The filtering will work on any square image, but if there is no regular 'interference' in the image, the Fourier Transform of the image becomes relatively even and offending frequencies become difficult to identify and filter out.

The technique has only been tested on aerial photographs to date but other forms of remote sensing, particularly those prone to banding due to systematic instrumentational misalignment or those that also detect agricultural phenomena might also benefit from filtering in the frequency domain.

Technical note

Large images were processed on a Sun Sparc IPX running IP an image processing suite which uses VIPS an image processing library written in C and developed as part of the VASARI Project at Birkbeck College. Smaller images were processed using a combination of Aldus PhotoStyler and ProFFT V. 1 a project developed by Marius Kjeldahl and four other students learning C++ at the Norwegian Institute of Technology, Trondheim, running on a variety of Viglen PC's.

Acknowledgments

Thanks are due to Blaise Vyner who provided many of the aerial photographs used to experiment with the technique and to Kirk Martinez who introduced me to the frequency domain.



Figure 8. To filter 'true' colour images split the image into individual channels. Each channel is then filtered separately and then the three filtered images may be recombined from the channels to produce a 'true' colour filtered image. This image is of the Iron Age enclosure at Gussage All Saints (Original © Crown Copyright).

references

1992

Booth, W. S.S. Ipson J.G.B. Haigh

J. Moffett (eds), Computer Applications and Quantitative Methods in Archaeology 1991, 197-204, BAR International Series 577, Oxford: Tempus Reparatum
Computer Graphics: Principles and Practice, (2nd ed). Reading, Massachusetts: Addison

An inexpensive PC-based imaging system for applications in archaeology. In: G. Lock/

Foley, J. A. van Dam S. Seiner J. Hughes (eds)

> Phil Perkins Department of Classical Studies The Open University Walton Hall Milton Keynes MK7 6BT United Kingdom e-mail: P.Perkins@open.ac.uk

Wesley.