

# Terrain modelling in surveying and civil engineering

G Petrie and T J M Kennie\*

*This paper is a review of the application of terrain modelling to surveying and civil engineering. The first section considers the theoretical background to the subject and two distinct approaches are identified based on the use of either grid or randomly located heights data. The relative merits of each are discussed and the most frequently used algorithms for interpolation and contouring are examined. This is followed by a review of the characteristics of a selected number of terrain modelling and contouring packages. Five distinct groups of packages are identified. Finally, a review of applications is presented together with some views on the future trends in this field.*

*terrain modelling, civil engineering, landscape planning*

Surface modelling is a general term used to describe the process of representing a physical or artificially created surface by means of a mathematical expression. Terrain modelling is one particular category of surface modelling which deals with the specific problems of representing the surface of the earth.

The term 'digital terrain model' was originally coined in 1958 by Miller and Laflamme<sup>1</sup>. Since then, the subject has developed considerably and is currently an area of widespread activity in surveying, geology and geophysics, civil and mining engineering and other disciplines in the earth sciences.

The paper is divided into three distinct sections. The first section examines the theoretical background and considers the advantages and limitations of the various interpolation and contouring techniques which are used by the program packages described in the second section. The paper concludes by listing the range of projects where terrain modelling may be applied and considers the most likely trends for the future in this field.

## THEORETICAL BACKGROUND

As the review in the later part of the paper will show, a very large number of program packages have been devised and written for terrain modelling applications in surveying and civil engineering. Each program package has been written independently and usually has been optimized for a specific

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application or for use on a specific computer or uses a different programming language, or has a distinctive user interface. However, in spite of this diversity, when their characteristics are analysed, it can be seen that basically they follow one or two main approaches (see Figure 1). Either they are based on, or make use of, height data which has been collected or arranged in the form of a regular (e.g. rectangular or square) grid or they are based on a triangular network of irregular size, shape and orientation, and use randomly-located height data.

## Grid based terrain modelling

The first approach is in many ways the simplest, in that the data comprising the terrain model is measured or collected in the form of a regular grid. This is in widespread use, e.g. in the grid levelling of building sites carried out by surveyors and civil engineers and in the acquisition of profile data measured photogrammetrically in stereoplottling instruments, in the latter case, especially when derived automatically or semi-automatically during the production

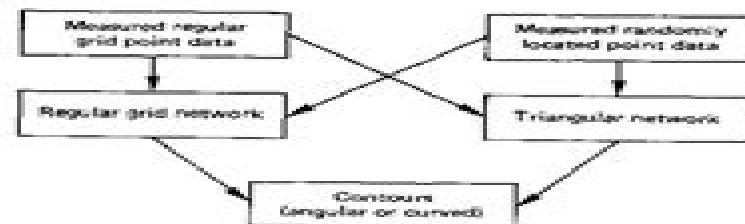


Figure 1. Overall relation between measured point data, networks and contours in terrain modelling

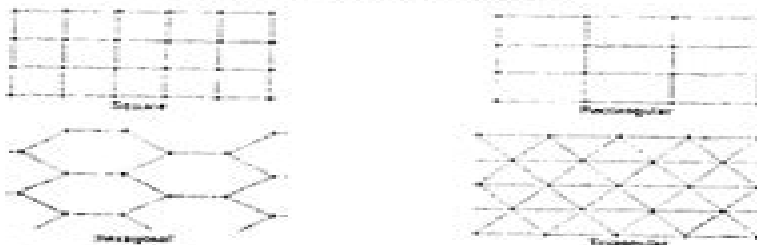


Figure 2. Regular grid patterns

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**Barnali Dixon,Venkatesh Uddameri**



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Terrain Modelling in Surveying and Civil Engineering G. Petrie, T. J. M. Kennie, 1991      Terrain Modelling in Surveying and Civil Engineering G. Petrie, 1989-12-01 An examination of current developments in terrain modelling and its application to civil engineering design land and hydrographic surveying development planning and computer visualization for civil and military applications      **Engineering Surveying Technology** T.J.M. Kennie, 2014-04-21 This book examines the major changes in the technology now used for the measurement and processing of topographic and non topographic spatial data with emphasis on the new and emerging technology and its applications Fundamental principles are introduced to explain the basic operation of different types of equipment      Short Course on Terrain Modelling in Surveying and Civil Engineering, 7-9 April, 1987, University of Surrey, Guildford, 3-5 September, University of Glasgow, Glasgow Thomas J. M. Kennie, G. Petrie, 1987      Civil Engineer's Reference Book L S Blake, 1994-03-21 After an examination of fundamental theories as applied to civil engineering authoritative coverage is included on design practice for certain materials and specific structures and applications A particular feature is the incorporation of chapters on construction and site practice including contract management and control      Geographical Information Systems and Computer Cartography Chris B. Jones, 2014-05-01 A concise text presenting the fundamental concepts in Geographical Information Systems GIS emphasising an understanding of techniques in management analysis and graphic display of spatial information Divided into five parts the first part reviews the development and application of GIS followed by a summary of the characteristics and representation of geographical information It concludes with an overview of the functions provided by typical GIS systems Part Two introduces co ordinate systems and map projections describes methods for digitising map data and gives an overview of remote sensing Part Three deals with data storage and database management as well as specialised techniques for accessing spatial data Spatial modelling and analytical techniques for decision making form the subject of Part Four while the final part is concerned with graphical representation emphasising issues of graphics technology cartographic design and map generalisation      Terrain Modelling in Surveying and Civil Engineering University of Glasgow, University of Surrey, 1987      An Introduction to Civil Engineering Surveying J. Paul Guyer, P.E., R.A., 2020-12-14 Introductory textbook for graduate and undergraduate civil engineering students studying civil engineering surveying Here is what is covered 1 TOPOGRAPHIC SURVEYS OVERVIEW 2 SURVEY METHODS AND TECHNIQUES 3 SURVEY CONTROL MONUMENTS 4 FIELD DATA COLLECTORS AND COORDINATE GEOMETRY 5 HORIZONTAL CONTROL SURVEY TECHNIQUES 6 VERTICAL CONTROL SURVEY TECHNIQUES 7 ACCURACY STANDARDS FOR LAND SURVEYS 8 GEODETIC REFERENCE SYSTEMS 9 PLANNING AND CONDUCTING CONTROL AND TOPOGRAPHIC SURVEYS      *Surveyor (Theory) - II* Mr. Rohit Manglik, 2024-05-18 EduGorilla Publication is a trusted name in the education sector committed to empowering learners with high quality study materials and resources Specializing in competitive exams and academic support EduGorilla provides

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Spatial Modelling of the Terrestrial Environment Richard E.J. Kelly, Nicholas A. Drake, Stuart L. Barr, 2004-10-22

Understanding and predicting the behaviour of natural and human environmental systems is crucial for the effective management of the Earth's limited resources. Recently great advances have been made through spatial modelling. This book provides a snapshot of the latest research in modelling technologies and methodologies within five environmental fields: the cryosphere, hydrology, geomorphology, vegetation interfaces and urban environments. *Spatial Modelling of the Terrestrial Environment* deals with the use of remote sensing, numerical models and GIS in addressing important natural and human environmental sciences issues, focusing on the theory and application of modelling remotely sensed data within the context of environmental processes. Extensive case material exemplifies the latest research and modelling paradigms presented in the book.

**Applications of Geomatics in Civil Engineering** Jayanta Kumar Ghosh, Irineu da Silva, 2019-06-19. This book comprises select proceedings of the First International Conference on Geomatics in Civil Engineering (ICGCE 2018). This book presents latest research on applications of geomatics engineering in different domains of civil engineering like structural engineering, geotechnical engineering, hydraulic and water resources engineering, environmental engineering and transportation engineering. It also covers miscellaneous applications of geomatics in a wide range of technical and societal problems, making use of geospatial information engineering principles and relational data structures involving measurement sciences. The book proves to be very useful for the scientific and engineering community working in the field of geomatics and geospatial technology.

*Geomorphometry* Tomislav Hengl, Hannes I. Reuter, 2008-09-25. Geomorphometry is the science of quantitative land surface analysis. It draws upon mathematical, statistical and image processing techniques to quantify the shape of Earth's topography at various spatial scales. The focus of geomorphometry is the calculation of surface form measures, land surface parameters and features, objects which may be used to improve the mapping and modelling of landforms to assist in the evaluation of soils, vegetation, land use, natural hazards and other information. This book provides a practical guide to preparing Digital Elevation Models (DEM) for analysis and extracting land surface parameters and objects from DEMs through a variety of software. It further offers detailed instructions on applying parameters and objects in soil, agricultural, environmental and earth sciences. This is a manual of state-of-the-art methods to serve the various researchers who use geomorphometry. Soil scientists will use this book to further learn the methods for classifying and measuring the chemical, biological and fertility properties of soils and gain a further understanding of the role of soil as a natural resource. Geologists will find value in the instruction this book provides for measuring the physical features of the soil such as elevation, porosity and structure which geologists use to predict natural disasters such as earthquakes, volcanoes and flooding. Technical details on a variety of software packages allow researchers to solve real-life mapping issues. Provides soil and agronomy researchers best practice techniques for soil data analysis to assist in enhanced land use and planning. Offers

geologists essential tactics for better environmental management by providing a comprehensive analysis of the physical features of soil Companion website includes access to the latest technological advancements previously unpublished in any other comprehensive source geomorphometry software DEM data sources and applications *GIS and Geocomputation for Water Resource Science and Engineering* Barnali Dixon,Venkatesh Uddameri,2016-02-08 GIS and Geocomputation for Water Resource Science and Engineering not only provides a comprehensive introduction to the fundamentals of geographic information systems but also demonstrates how GIS and mathematical models can be integrated to develop spatial decision support systems to support water resources planning management and engineering The book uses a hands on active learning approach to introduce fundamental concepts and numerous case studies are provided to reinforce learning and demonstrate practical aspects The benefits and challenges of using GIS in environmental and water resources fields are clearly tackled in this book demonstrating how these technologies can be used to harness increasingly available digital data to develop spatially oriented sustainable solutions In addition to providing a strong grounding on fundamentals the book also demonstrates how GIS can be combined with traditional physics based and statistical models as well as information theoretic tools like neural networks and fuzzy set theory **Manual of Aerial Survey** Roger E. Read,Ron Graham,2002

*Fundamentals of Civil Engineering: Principles, Practices, and Applications* Anasuya Mondal ,Subhankar Dey,2025-05-08

**GIS Methodologies for Developing Conservation Strategies** Basil G. Savitsky,Thomas E. Lacher, Jr.,1998-04-28

Tropical habitats may contain more than a third of the world s plant and animal species Costa Rica alone is home to one of the highest levels of biodiversity per unit area in the world and stands at center stage in worldwide conservation efforts Within such regions the use of state of the art digital mapping technologies sophisticated techniques that are relatively inexpensive and accessible represents the future of conservation planning and policy These methods which employ satellites to obtain visual data on landscapes allow environmental scientists to monitor encroachment on indigenous territories trace park boundaries through unmarked wilderness and identify wildlife habitats in regions where humans have limited access Focusing on the rich biodiversity of Costa Rica the contributors demonstrate the use of geographic information systems GIS to enhance conservation efforts They give an overview of the spatial nature of conservation and management and the current status of digital mapping in Costa Rica a review of the basic principles behind digital mapping technologies a series of case studies using these technologies at a variety of scales and for a range of conservation and management activities and the results of the Costa Rican gap analysis project GIS Methodologies for Developing Conservation Strategies provides powerful tools for those involved in decision making about the natural environment particularly in developing nations like Costa Rica where such technologies have not yet been widely adopted For specialists in such areas as geography conservation biology and wildlife and natural resource management the combination of conceptual background and case examples make the book a crucial addition to the literature Handbook of Hydrology David R. Maidment,1993-02-22 An all inclusive reference

covering all practical aspects of hydrology Twenty nine chapters in four major sections I Hydrologic Cycle II Hydrologic Transport III Hydrologic Statistics IV Hydrologic Technology 500 illustrations      **Basic Surveying** Raymond Paul, Walter Whyte, 2012-09-10 The primary aim of this book is to provide a guide to current practice and equipment for non specialist surveyors in the various professions involved in the construction industry and the environment It is suitable for students preparing for degrees and diplomas in architecture building building surveying quantity surveying estate management and town planning and environmental studies It is also of value to engineers who are not specialising in engineering surveying This book has been thoroughly revised to include new topics such as OS digital mapping standard deviation and standard error global positioning systems transition and vertical curves Walter Whyte was born in New Zealand of Scottish parents and educated in Scotland He worked on site and building surveys in Scotland He worked on site and building surveys in Scotland then on road survey and setting out in the North Nyanza and Uasin Gishu Provinces of Kenya and as a road engineer in British Southern Cameroons and Northern Nigeria De Montford University in the UK and latterly at City University Hong Kong Raymond E Paul has been professionally involved in surveying for over 40 years as a land and cartographical surveyor senior lecturer and author He has a wealth of practical experience and an awareness of the needs of the intended users of this book from all corners of the globe      **Spatial Data Modelling for 3D GIS** Alias

Abdul-Rahman, Morakot Pilouk, 2007-09-23 This book covers fundamental aspects of spatial data modelling specifically on the aspect of three dimensional 3D modelling and structuring Realisation of true 3D GIS spatial system needs a lot of effort and the process is taking place in various research centres and universities in some countries The development of spatial data modelling for 3D objects is the focus of this book      **Geomatics Applied to Civil Engineering** Irineu da Silva, Paulo C. L.

Segantine, 2025-05-13 This textbook deals jointly with theoretical and practical concepts within geomatics in civil engineering based on the global understanding of its use Written by civil engineers with professional backgrounds in geomatics the book has a number of unique characteristics including analysis of geodetic references and their coordinate systems to allow their conversions and applications taking into account the local topographic plan analysis of the measurements of directions angles and distances inserting them into the concepts of practical use of modern measuring instruments detailed description of the main components of measurement instruments used in geomatics discussion of instrumentation errors and their implications and a complete study of UTM Projection System and its variants equations and practical application in civil engineering projects For students and instructors and practitioners the subjects covered in the book are organized to cover most topics related to the disciplines of surveying or geomatics studied in civil engineering courses It is entirely based on adjustment computation for spatial data analysis including coordinate geometry and traverse computation To this end an entire chapter is devoted to adjustment computation based on matrix theory to help readers understand its applications in spatial data analysis throughout the book s chapters including chapters on modern technologies such as conventional and

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