

AUTOMATIC DETECTION OF BUILDINGS FROM LASER SCANNER DATA FOR MAP UPDATING

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ABSTRACT:

Automatic interpretation of laser scanner data for building detection and map updating was studied. Digital surface and terrain models (DSM and DTM) and an intensity image were created using a helicopter-borne TopEye system recording with 2–3 pulses per m². The DSM was segmented into homogeneous regions using a region-based segmentation method, and the segments were classified as 'building', 'tree' or 'ground surface'. Height differences between the DSM and DTM, textural characteristics of the DSM and intensity image, and shapes of the segments were used in classification. Building segments were compared with an old building map and further classified as 'new building', 'enlarged building' or 'old building'. Similarly, building segments derived from the old map were classified as 'detected', 'partly detected' or 'not detected'. Comparison with an up-to-date building map shows that about 80% of all buildings in the study area were detected from the laser scanner data. For buildings larger than 200 m², the detection percentage was about 90%. Pixel by pixel comparison of the classification result with the reference map shows that 90% of pixels covered with buildings in the map were correctly classified. 85% of building pixels in the classification result were buildings in the reference map. The accuracy measures of the pixel-based comparison also include errors caused by small location differences between the data sources. According to visual evaluation, the most important changes between the laser scanner data and the old map, e.g. new buildings, were detected in change detection. The most problematic buildings for automatic detection were small buildings surrounded by trees.

1. INTRODUCTION

Laser scanner data has proved to be a promising data source for various mapping and 3D modelling tasks. One of the most important application areas is extraction and modelling of buildings to create 3D city models. Several studies related to the topic have been published during recent years (e.g. Haala and Brenner, 1999a, 1999b; Maas and Vosselman, 1999; Morgan and Tempfli, 2000; Vögtle and Steinle, 2000; Vosselman and Suroveg, 2001; Fujii and Arikawa, 2002; Rotensteiner and Briese, 2002). The building extraction and modelling process can typically be divided into two steps: building detection and building reconstruction. At first, buildings have to be distinguished from the ground surface and other objects, such as trees. After this, 3D models of buildings can be created.

Methods for building detection are often based on step-wise classification of the data to eliminate objects other than buildings. Some methods use aerial images in addition to the laser scanner data (e.g. Haala and Brenner, 1999b; Vögtle and Steinle, 2000). Classification can be pixel-based, but segmentation is normally applied in some stage of the process to obtain regions. Segmentation of laser scanner data has been studied by e.g. Geibel and Stilla (2000) and Gorte (2002). The building detection stage can be avoided if an up-to-date map is available as a basis for building reconstruction (see e.g. Haala and Brenner, 1999a, 1999b; Vosselman and Suroveg, 2001).

Murakami et al. (1999) studied the use of laser scanner data in change detection of buildings. They used simple comparison between DSM data sets acquired at different occasions. Use of laser scanner data in 'upvaluation' of map information to

transfer 2D building data into 3D data was discussed by Hofmann et al. (2002).

The goal of our study is to investigate the feasibility of laser scanner data for updating of large-scale city maps and to develop automatic methods for the work. In the first stage of the updating process, which is discussed in the present article, the aim is to automatically recognize buildings from laser scanner data and to detect changes compared with an existing 2D building map. The results should provide a preliminary updated 2D building map that presents approximate building polygons associated with attribute information showing if the building has been built, removed or changed after the map was made. This preliminary updated map could then be used in further processing steps that can include verification of the changes, exact location and modelling of the buildings, updating of a map database and finally creation of a 3D city model. These further processing steps can be manual, semi-automatic or fully automatic.

Results of a previous study (Matikainen et al., 2001) showed that planimetric and height precisions high enough for large-scale mapping of buildings can be obtained with high-pulse-rate laser scanners. Promising results were also obtained in automatic building detection by using a region-based segmentation method and a simple classification procedure based on laser scanner data and an aerial colour image. The present article discusses results obtained when the study was continued in a larger study area, the building detection procedure was improved and change detection compared with an existing building map was included in the process.

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Automatic Detection Of Buildings From Laser Scanner Data:

Urban Remote Sensing Xiaojun Yang, 2011-03-23 Urban Remote Sensing is designed for upper level undergraduates graduates researchers and practitioners and has a clear focus on the development of remote sensing technology for monitoring synthesis and modeling in the urban environment It covers four major areas the use of high resolution satellite imagery or alternative sources of image data such as high resolution SAR and LIDAR for urban feature extraction the development of improved image processing algorithms and techniques for deriving accurate and consistent information on urban attributes from remote sensor data the development of analytical techniques and methods for deriving indicators of socioeconomic and environmental conditions that prevail within urban landscape and the development of remote sensing and spatial analytical techniques for urban growth simulation and predictive modeling **Proceedings of the 25th**

International Symposium on Advancement of Construction Management and Real Estate Xinhai Lu, Zuo Zhang, Weisheng Lu, Yi Peng, 2021-10-11 This proceedings book focuses on innovation cooperation and sustainable development in the fields of construction management and real estate The book provides a detailed analysis and description of the disciplinary frontiers in the field of building management and real estate and how they can be promoted in the context of the epidemic A wide variety of papers provide a reference value for both scholars and practitioners The proceedings book is the documentation of the 25th International Symposium on Advancement of Construction Management and Real Estate CRIOCM 2020 which was held at the School of Public Administration Central China Normal University Wuhan China in 2020

Topographic Laser Ranging and Scanning Jie Shan, Charles K. Toth, 2018-02-19 Topographic Laser Ranging and Scanning Second Edition provides a comprehensive discussion of topographic LiDAR principles systems data acquisition and data processing techniques This edition presents an introduction and summary of various LiDAR systems and their principles and addresses the operational principles of the different components and ranging methods of LiDAR systems It discusses the subsequent geometric processing of LiDAR data with particular attention to quality accuracy and meeting standards and addresses the theories and practices of information extraction from LiDAR data including terrain surface generation forest inventory orthoimage generation building reconstruction and road extraction Written by leaders in the field this comprehensive compilation is a must have reference book for senior undergraduate and graduate students majoring or working in diverse disciplines such as geomatics geodesy natural resources urban planning computer vision and computer graphics It is also vital resource for researchers who are interested in developing new methods and need in depth knowledge of laser scanning and data processing and other professionals may gain the same from the broad topics addressed in this book New in the Second Edition A comprehensive array of new laser ranging and scanning technologies Developments in LiDAR data format and processing techniques Regrouping of surface modeling representations and reconstruction Enhanced discussions on the principles and fundamentals beyond small footprint pulsed laser systems and new application examples

Many new examples and illustrations Automatic Extraction of Man-made Objects from Aerial and Satellite Images III E.P. Baltsavias, A. Gruen, L. VanGool, 2001-01-01 This work is a collection of papers from the world's leading research groups in the field of automatic extraction of objects especially buildings and roads from aerial and space imagery including new sensors like SAR and lidar **Geographic Information Systems: Concepts, Methodologies, Tools, and Applications**

Management Association, Information Resources, 2012-09-30 Developments in technologies have evolved in a much wider use of technology throughout science government and business resulting in the expansion of geographic information systems GIS is the academic study and practice of presenting geographical data through a system designed to capture store analyze and manage geographic information Geographic Information Systems Concepts Methodologies Tools and Applications is a collection of knowledge on the latest advancements and research of geographic information systems This book aims to be useful for academics and practitioners involved in geographical data **Ubiquitous Positioning and Mobile**

Location-Based Services in Smart Phones Chen, Ruizhi, 2012-06-30 Many smart phone users reap the benefits of location based services While tracking users positions using their smart phone is an issue of concern for some others who use Foursquare or rely on their Android GPS view location based services as a necessity Ubiquitous Positioning and Mobile Location Based Services in Smart Phones explores new research in smart phones with an emphasis on positioning solutions in smart phones smart phone based navigation applications mobile geographical information systems and related standards

Spatial Data Infrastructure for Urban Regeneration Y. Sadahiro, 2008-08-22 This book represents part of the result of a project undertaken by the Center for Sustainable Urban Regeneration cSUR The center was established in 2003 by a research fund titled the 21st Century Center of Excellence COE Program provided by the Ministry of Education Culture Sports Science and Technology of Japan The project leader was Shichiro Ohgaki a professor in the Department of Urban Engineering of the University of Tokyo cSUR integrates the four specific fields of urban planning architecture civil engineering and environmental engineering with the participation of over a hundred researchers of the university The objective of the center is to create an integrated approach to and knowledge for sustainable urban regeneration based on a global network of researchers and professionals and to coordinate an international research alliance that consists of leading academic institutions worldwide The project was carried out by four research units A Environment Management B Urban Stock Management C Social Information Management D Action Studies Each unit consisted of smaller subunits The third unit which includes the contributors to this book consisted of three smaller groups C 1 The Next Generation Geographic Information System Integrating Human and Social Information C 2 Decoding and Analysis of Historical and Cultural Information Concerning Urban Space C 3 Participatory Planning and Urban Space Management Support Systems **Laser**

Scanning Belén Riveiro, Roderik Lindenbergh, 2019-10-18 This book provides an overview on the evolution of laser scanning technology and its noticeable impact in the structural engineering domain It provides an up to date synthesis of the state of

the art of the technology for the reverse engineering of built constructions including terrestrial mobile and different portable solutions for laser scanning Data processing of large point clouds has experienced an important advance in the last years and thus an intense activity in the development of automated data processing algorithms has been noticed Thus this book aims to provide an overview of state of the art algorithms different best practices and most recent processing tools in connection to particular applications Readers will find this a comprehensive book that updates the practice of laser scanning for researchers and professionals not only from the geomatic domain but also other fields such as structural and construction engineering A set of successful applications to structural engineering are illustrated including also synergies with other technologies that can inspire professionals to adopt laser scanning in their day to day activity This cutting edge edited volume will be a valuable resource for students researchers and professional engineers with an interest in laser scanning and its applications in the structural engineering domain

Geospatial Information Technology for Emergency Response

Sisi Zlatanova,Jonathan Li,2008-01-24 Disaster management is generally understood to consist of four phases mitigation preparedness response and recovery While these phases are all important and interrelated response and recovery are often considered to be the most critical in terms of saving lives Response is the acute phase occurring after the event and includes all arrangements

Computational Engineering Günter Hofstetter,2014-05-15 The book presents state of the art works in computational engineering Focus is on mathematical modeling numerical simulation experimental validation and visualization in engineering sciences In particular the following topics are presented constitutive models and their implementation into finite element codes numerical models in nonlinear elasto dynamics including seismic excitations multiphase models in structural engineering and multiscale models of materials systems sensitivity and reliability analysis of engineering structures the application of scientific computing in urban water management and hydraulic engineering and the application of genetic algorithms for the registration of laser scanner point clouds

Urban and Regional Data Management

Massimo Rumor,Volker Coors,Elfriede M. Fendel,Sisi Zlatanova,2007-10-04 Spatial technologies like GIS CAD and spatial DBMS have proved their applicability and usability in almost every sector of urban development Urban Planning Systems Public Participation Systems and others have been continuously developed and improved contributing to better decision making communicating ideas between different actors as well as

Field and Service Robotics Peter Corke,Salah

Sukkarieh,2006-08-03 The 5th International Conference on Field and Service Robotics FSR05 was held in Port Douglas Australia on 29th 31st July 2005 and brought together the worlds leading experts in field and service automation The goal of the conference was to report and encourage the latest research and practical results towards the use of field and service robotics in the community with particular focus on proven technology The conference provided a forum for researchers professionals and robot manufacturers to exchange up to date technical knowledge and experience Field robots are robots which operate in outdoor complex and dynamic environments Service robots are those that work closely with humans with

particular applications involving indoor and structured environments There are a wide range of topics presented in this issue on field and service robots including Agricultural and Forestry Robotics Mining and Exploration Robots Robots for Construction Security Defence Robots Cleaning Robots Autonomous Underwater Vehicles and Autonomous Flying Robots This meeting was the fifth in the series and brings FSR back to Australia where it was first held FSR has been held every 2 years starting with Canberra 1997 followed by Pittsburgh 1999 Helsinki 2001 and Lake Yamanaka 2003 Intelligent Robotics and Applications Chun-Yi Su, Subhash Rakheja, Liu Honghai, 2012-09-28 The three volume set LNAI 7506 LNAI 7507 and LNAI 7508 constitutes the refereed proceedings of the 5th International Conference on Intelligent Robotics and Applications ICIRA 2012 held in Montreal Canada in October 2012 The 197 revised full papers presented were thoroughly reviewed and selected from 271 submissions They present the state of the art developments in robotics automation and mechatronics This volume covers the topics of adaptive control systems automotive systems estimation and identification intelligent visual systems application of differential geometry in robotic mechanisms unmanned systems technologies and applications new development on health management fault diagnosis and fault tolerant control biomechatronics intelligent control of mechanical and mechatronic systems Remote Sensing Based Building Extraction Mohammad Awrangjeb, Xiangyun Hu, Bisheng Yang, Jiaojiao Tian, 2020-03-27 Building extraction from remote sensing data plays an important role in urban planning disaster management navigation updating geographic databases and several other geospatial applications Even though significant research has been carried out for more than two decades the success of automatic building extraction and modeling is still largely impeded by scene complexity incomplete cue extraction and sensor dependency of data Most recently deep neural networks DNN have been widely applied for high classification accuracy in various areas including land cover and land use classification Therefore intelligent and innovative algorithms are needed for the success of automatic building extraction and modeling This Special Issue focuses on newly developed methods for classification and feature extraction from remote sensing data for automatic building extraction and 3D **Headway in Spatial Data Handling** Anne Ruas, Christopher Gold, 2008-08-09 Geographic information is a key element for our modern society Put simply it is information whose spatial and often temporal location is fundamental to its value and this distinguishes it from many other types of data and analysis For sustainable development climate change or more simply resource sharing and economic development this information helps to facilitate human activities and to foresee the impact of these activities in space as well as inversely the impact of space on our lives The International Symposium on Spatial Data Handling SDH is a primary research forum where questions related to spatial and temporal modelling and analysis data integration visual representation or semantics are raised The first symposium commenced in 1984 in Zurich and has since been organised every two years under the umbrella of the International Geographical Union Commission on Geographical Information Science <http://www.igugis.org> Over the last 28 years the Symposium has been held in st 1 Zurich 1984 nd 2 Seattle 1986 rd 3 Sydney 1988 th 4

Zurich 1990 th 5 Charleston 1992 th 6 Edinburgh 1994 th 7 Delft 1996 th 8 Vancouver 1998 th 9 Beijing 2000 th 10 Ottawa 2002 th 11 Leicester 2004 th 12 Vienna 2006 th This book is the proceedings of the 13 International Symposium on Spatial Data Handling CAA2016: Oceans of Data Mieko Matsumoto,Espen Uleberg,2018-12-31 A selection of 50 papers

presented at CAA2016 Papers are grouped under the following headings Ontologies and Standards Field and Laboratory Data Recording and Analysis Archaeological Information Systems GIS and Spatial Analysis 3D and Visualisation Complex Systems Simulation Teaching Archaeology in the Digital Age **Intelligent Autonomous Systems 13** Emanuele

Menegatti,Nathan Michael,Karsten Berns,Hiroaki Yamaguchi,2015-09-03 This book describes the latest research accomplishments innovations and visions in the field of robotics as presented at the 13th International Conference on Intelligent Autonomous Systems IAS held in Padua in July 2014 by leading researchers engineers and practitioners from across the world The contents amply confirm that robots machines and systems are rapidly achieving intelligence and autonomy mastering more and more capabilities such as mobility and manipulation sensing and perception reasoning and decision making A wide range of research results and applications are covered and particular attention is paid to the emerging role of autonomous robots and intelligent systems in industrial production which reflects their maturity and robustness The contributions have been selected through a rigorous peer review process and contain many exciting and visionary ideas that will further galvanize the research community spurring novel research directions The series of biennial IAS conferences commenced in 1986 and represents a premiere event in robotics **Proceedings of the 23rd**

International Symposium on Advancement of Construction Management and Real Estate Fenjie Long,Sheng Zheng,Yuzhe Wu,Gangying Yang,Yan Yang,2021-02-02 This book presents the proceedings of CRIOCM2018 23rd International Symposium on Advancement of Construction Management and Real Estate sharing the latest developments in real estate and construction management around the globe The conference was organized by the Chinese Research Institute of Construction Management CRIOCM working in close collaboration with Guizhou Institute of Technology GIT Written by international academics and professionals the proceedings discuss the latest achievements research findings and advances in frontier disciplines in the field of construction management and real estate Covering a wide range of topics including New type urbanization land development and land use urban planning and infrastructure construction housing market and housing policy real estate finance and investment new theories and practices on construction project management smart city BIM technologies and applications construction management in big data era green architecture and eco city rural rejuvenation and eco civilization other topics related to construction management and real estate the discussions provide valuable insights into the advancement of construction management and real estate in the new era The book is an outstanding reference resource for academics and professionals alike *Digital Image Computing: Techniques and*

Applications Changming Sun,Hugues Talbot,Sebastien Ourselin,Tony Adriaansen,2003-12-01 Digital Image Computing

Techniques and Applications is the premier biennial conference in Australia on the topics of image processing and image analysis. This seventh edition of the proceedings has seen an unprecedented level of submission on such diverse areas as Image processing, Face recognition, Segmentation, Registration, Motion analysis, Medical imaging, Object recognition, Virtual environments, Graphics, Stereo vision, and Video analysis. These two volumes contain all the 108 accepted papers and five invited talks that were presented at the conference. These two volumes provide the Australian and international imaging research community with a snapshot of current theoretical and practical developments in these areas. They are of value to any engineer, computer scientist, mathematician, statistician, or student interested in these matters.

Non-Destructive Techniques for the Evaluation of Structures and Infrastructure Belén Riveiro, Mercedes Solla, 2016-04-04. This book provides an overview and up to date synthesis of the most commonly used non destructive technologies for the reverse engineering of built infrastructure facilities. These technologies tackle both the geometric and radiometric characterization of built structures and thus validated technologies such as laser scanning, photogrammetry, and

Decoding **Automatic Detection Of Buildings From Laser Scanner Data**: Revealing the Captivating Potential of Verbal Expression

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