

## Automatic Road Extraction from Airborne LiDAR : A Review

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### ABSTRACT

LiDAR is the powerful Remote Sensing Technology for the acquisition of 3D information from terrain surface. This paper surveys the state of the art on automated road feature extraction from airborne Light Detection and Ranging (LiDAR) data. It presents a bibliography of nearly 50 references related to this topic. This includes work related to various main approaches used for extracting road from LiDAR data, Feature extraction based on classification and filtering.

**Keywords** – LiDAR, Road Extraction, Classification, Filtering, Digital Elevation Model

### I. INTRODUCTION

Road Extraction from remotely sensed data is very challenging issue and has been approached in many different ways by photogrammetric and digital image processor. [1] Roads have long been important for development and prosperity and are essential for many applications such as urban and rural planning, transportation, management, vehicle navigation, emergency response, etc. Often, road database is generated through field surveys with the help of GPS (Global Positioning System) enabled instruments. This approach of road extraction, however, is time consuming and labour intensive. With increase in availability of satellite imagery both in high and low resolutions, automatic road network extraction from satellite imagery has received considerable attention and has been studied extensively since 1970s. Since road region appear as linear segment in low resolution images, earlier research on road extraction focused on extracting road center-line from low resolution images. On the other hand, high resolution satellite images provide an opportunity to extract entire road area, which are particularly useful for vehicle navigation, along with road network. LiDAR (Light Detection and Ranging) has become reliable technique for collection of terrain and non-terrain features from the earth surface. LiDAR system consist of laser scanner, Direct Georeferencing(Direct measurement of the sensor positions X,Y,Z and orientation with respect to ground) ,GPS(Global Positioning System) [2]. Characteristics of LiDAR data include Discrete LiDAR returns, Full waveform LiDAR and LiDAR intensity. Data collection vendors deliver LiDAR data according to user specification (ASCII text file, LAS binary file etc.) [3]. Using this technology we can obtain 3D information very quickly. This paper only focuses on various methods related to road extraction from airborne LiDAR point clouds, and general approaches

used for processing of LiDAR data for Road extraction

Paper is divided into 4 sections. Section 2 discusses general algorithms used for road extraction from LiDAR data. Section 3 discusses feature extraction based on classification. Section 4 and 5 shows survey based on filtering and finally section 6 shows summary on surveyed techniques and how road detection works for LiDAR data.

### II. RELATED SURVEY BASED ON GENERAL ALGORITHM OF ROAD EXTRACTION.

The road network is an essential geographic information system (GIS) layer in applications such as urban and rural planning, transportation management, vehicle navigation, emergency response, etc. Extraction of curvilinear features, linear features has been a popular research topic in Computer vision and Remote Sensing communities. There are several recent algorithms available that makes the use of Airborne LiDAR data for road feature extraction.

Existing airborne LiDAR technology needs a large amount of work in post processing stage. Most of the existing algorithms use some basic methods, but some of which have no definitive boundaries until they are not used in specific processing procedures. [4] Hu X. et al. (2014) [5] proposed a method which detects road centrelines from airborne LiDAR data which consist of three steps spatial clustering based on multiple features using an adaptive mean shift method to detect center point of roads, Stick Tensor Voting to enhance salient linear features and weighted Hough Transform to extract the are primitives of road centrelines. They denote their as Mean Shift, Tensor Voting, Hough Transform. They applied their method on two different datasets.

Yuan Wang et al. (2013) [6] developed a method using morphological operation which extracts road from airborne LiDAR data. Firstly, they segmented

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Laser Scanning Systems in Highway and Safety Assessment Biswajeet Pradhan, Maher Ibrahim Sameen, 2019-04-02 This book aims to promote the core understanding of a proper modelling of road traffic accidents by deep learning methods using traffic information and road geometry delineated from laser scanning data The first two chapters of the book introduce the reader to laser scanning technology with creative explanation and graphical illustrations review and recent methods of extracting geometric road parameters The next three chapters present different machine learning and statistical techniques applied to extract road geometry information from laser scanning data Chapters 6 and 7 present methods for modelling roadside features and automatic road geometry identification in vector data After that this book goes on reviewing methods used for road traffic accident modelling including accident frequency and injury severity of the traffic accident Chapter 8 Then the next chapter explores the details of neural networks and their performance in predicting the traffic accidents along with a comparison with common data mining models Chapter 10 presents a novel hybrid model combining extreme gradient boosting and deep neural networks for predicting injury severity of road traffic accidents This chapter is followed by deep learning applications in modelling accident data using feed forward convolutional recurrent neural network models Chapter 11 The final chapter Chapter 12 presents a procedure for modelling traffic accident with little data based on the concept of transfer learning This book aims to help graduate students professionals decision makers and road planners in developing better traffic accident prediction models using advanced neural networks

*Remote Sensing of Natural Resources* Guangxing Wang, Qihao Weng, 2013-07-12 Highlighting new technologies Remote Sensing of Natural Resources explores advanced remote sensing systems and algorithms for image processing enhancement feature extraction data fusion image classification image based modeling image based sampling design map accuracy assessment and quality control It also discusses their applications for evaluation of natural resources including sampling design land use and land cover classification natural landscape and ecosystem assessment forestry agriculture biomass and carbon cycle modeling wetland classification and dynamics monitoring and soils and minerals mapping The book combines review articles with case studies that demonstrate recent advances and developments of methods techniques and applications of remote sensing with each chapter on a specific area of natural resources Through a comprehensive examination of the wide range of applications of remote sensing technologies to natural resources the book provides insight into advanced remote sensing systems technologies and algorithms for researchers scientists engineers and decision makers

**Handbook on Advances in Remote Sensing and Geographic Information Systems** Margarita N. Favorskaya, Lakhmi C. Jain, 2017-02-24 This book presents the latest advances in remote sensing and geographic information systems and applications It is divided into four parts focusing on Airborne Light Detection and Ranging LiDAR and Optical Measurements of Forests Individual Tree Modelling Landscape Scene Modelling and Forest Eco system Modelling Given the scope of its coverage the book offers a

valuable resource for students researchers practitioners and educators interested in remote sensing and geographic information systems and applications

**Proceedings of 4th 2024 International Conference on Autonomous Unmanned Systems (4th ICAUS 2024)** Lianqing Liu,Yifeng Niu,Wenxing Fu,Yi Qu,2025-04-24 This book includes original peer reviewed research papers from the 4th ICAUS 2024 which provides a unique and engaging platform for scientists engineers and practitioners from all over the world to present and share their most recent research results and innovative ideas The 4th ICAUS 2024 aims to stimulate researchers working in areas relevant to intelligent unmanned systems Topics covered include but are not limited to Unmanned Aerial Ground Surface Underwater Systems Robotic Autonomous Control Navigation and Positioning Architecture Energy and Task Planning and Effectiveness Evaluation Technologies Artificial Intelligence Algorithm Bionic Technology and their Application in Unmanned Systems The papers presented here share the latest findings in unmanned systems robotics automation intelligent systems control systems integrated networks modelling and simulation This makes the book a valuable resource for researchers engineers and students alike

*Remote Sensing* Boris Escalante,2012-06-13 This dual conception of remote sensing brought us to the idea of preparing two different books in addition to the first book which displays recent advances in remote sensing applications this book is devoted to new techniques for data processing sensors and platforms We do not intend this book to cover all aspects of remote sensing techniques and platforms since it would be an impossible task for a single volume Instead we have collected a number of high quality original and representative contributions in those areas

**Transportation Research Record** ,1974

*Neural Information Processing* Tom Gedeon,Kok Wai Wong,Minho Lee,2019-12-10 The three volume set of LNCS 11953 11954 and 11955 constitutes the proceedings of the 26th International Conference on Neural Information Processing ICONIP 2019 held in Sydney Australia in December 2019 The 173 full papers presented were carefully reviewed and selected from 645 submissions The papers address the emerging topics of theoretical research empirical studies and applications of neural information processing techniques across different domains The second volume LNCS 11954 is organized in topical sections on image processing by neural techniques learning from incomplete data model compression and optimisation neural learning models neural network applications and social network computing

**Remote Sensing of Hydrometeorological Hazards** George P. Petropoulos,Tanvir Islam,2017-11-02 Extreme weather and climate change aggravate the frequency and magnitude of disasters Facing atypical and more severe events existing early warning and response systems become inadequate both in scale and scope Earth Observation EO provides today information at global regional and even basin scales related to agrometeorological hazards This book focuses on drought flood frost landslides and storms cyclones and covers different applications of EO data used from prediction to mapping damages as well as recovery for each category It explains the added value of EO technology in comparison with conventional techniques applied today through many case studies

**Laser Focus World** ,2001 Global electro optic technology and markets Photonics technologies solutions for technical

professionals worldwide      **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      **Online Engineering & Internet of Things** Michael E. Auer,Danilo G. Zutin,2017-09-14 This book discusses online engineering and virtual instrumentation typical working areas for today's engineers and inseparably connected with areas such as Internet of Things cyber physical systems collaborative networks and grids cyber cloud technologies and service architectures to name just a few It presents the outcomes of the 14th International Conference on Remote Engineering and Virtual Instrumentation REV2017 held at Columbia University in New York from 15 to 17 March 2017 The conference addressed fundamentals applications and experiences in the field of online engineering and virtual instrumentation in the light of growing interest in and need for teleworking remote services and collaborative working environments as a result of the globalization of education The book also discusses guidelines for education in university level courses for these topics      Proceedings of UASG 2019 Kamal Jain,Kourosh Khoshelham,Xuan Zhu,Anuj Tiwari,2020-02-22 This volume gathers the latest advances innovations and applications in the field of geographic information systems and unmanned aerial vehicle UAV technologies as presented by leading researchers and engineers at the 1st International Conference on Unmanned Aerial System in Geomatics UASG held in Roorkee India on April 6 7 2019 It covers highly diverse topics including photogrammetry and remote sensing surveying UAV manufacturing geospatial data sensing UAV processing visualization and management UAV applications and regulations geo informatics and geomatics The contributions which were selected by means of a rigorous international peer review process highlight numerous exciting ideas that will spur novel research directions and foster multidisciplinary collaboration among different specialists      **Green and Intelligent Technologies for Sustainable and Smart Asphalt Pavements** Xueyan Liu,Kumar Anupam,Sandra Erkens,Lijun Sun,Jianming Ling,2021-12-24 Green and Intelligent Technologies for Sustainable and Smart Asphalt Pavements contains 124 papers from 14 different countries which were presented at the 5th International Symposium on Frontiers of Road and Airport Engineering IFRAE 2021 Delft the Netherlands 12 14 July 2021 The contributions focus on research in the areas of Circular Sustainable and Smart Airport and Highway Pavement and collects the state of the art and state of practice areas of long life and circular materials for sustainable cost effective smart airport and highway pavement design and construction The main areas covered by the book include Green and sustainable pavement materials Recycling technology

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**Advances in Computer Vision** Kohei Arai, Supriya Kapoor, 2019-04-23 This book presents a remarkable collection of chapters covering a wide range of topics in the areas of Computer Vision both from theoretical and application perspectives It gathers the proceedings of the Computer Vision Conference CVC 2019 held in Las Vegas USA from May 2 to 3 2019 The conference attracted a total of 371 submissions from pioneering researchers scientists industrial engineers and students all around the world These submissions underwent a double blind peer review process after which 120 including 7 poster papers were selected for inclusion in these proceedings The book's goal is to reflect the intellectual breadth and depth of current research on computer vision from classical to intelligent scope Accordingly its respective chapters address state of the art intelligent methods and techniques for solving real world problems while also outlining future research directions Topic areas covered include Machine Vision and Learning Data Science Image Processing Deep Learning and Computer Vision Applications

**Initiatives in Information Technology and Geospatial Science for Transportation** National Research Council (U.S.). Transportation Research Board, 2003

**Scientific and Technical Aerospace Reports**, 1995-05 *Proceedings of the 8th International Conference on Sciences of Electronics, Technologies of Information and Telecommunications (SETIT'18), Vol.1* Med Salim Bouhlel, Stefano Rovetta, 2019-07-10 This two volume book presents an unusually diverse selection of research papers covering all major topics in the fields of information and communication technologies and related sciences It provides a wide angle snapshot of current themes in information and power engineering pursuing a cross disciplinary approach to do so The book gathers revised contributions that were presented at the 2018 International Conference Sciences of Electronics Technologies of Information and Telecommunication SETIT 18 held on 20-22 December 2018 in Hammamet Tunisia This eighth installment of the event attracted a wealth of submissions and the papers presented here were selected by a committee of experts and underwent additional painstaking revision Topics covered include Information Processing Human Machine Interaction Computer Science Telecommunications and Networks Signal Processing Electronics Image and Video This broad scoped approach is becoming increasingly popular in scientific publishing Its aim is to encourage scholars and professionals to overcome disciplinary barriers as demanded by current trends in the industry and in the consumer market which are rapidly leading toward a convergence of data driven applications computation telecommunication and energy awareness Given its coverage the book will benefit graduate students researchers and

practitioners who need to keep up with the latest technological advances

**Abstract Bulletin** United States. Environmental Protection Agency, 1999-07

**EPA Publications Bibliography Quarterly**

Commerce Business Daily, 1997-12-31

*Learning to Understand Remote Sensing Images* Qi Wang, 2019-09-30 With the recent advances in remote sensing technologies for Earth observation many different remote sensors are collecting data with distinctive properties The obtained data are so large and complex that analyzing them manually becomes impractical or even impossible Therefore understanding remote sensing images effectively in connection with physics has been the primary concern of the remote sensing research community in recent years For this purpose machine learning is thought to be a promising technique because it can make the system learn to improve itself With this distinctive characteristic the algorithms will be more adaptive automatic and intelligent This book introduces some of the most challenging issues of machine learning in the field of remote sensing and the latest advanced technologies developed for different applications It integrates with multi source multi temporal multi scale data and mainly focuses on learning to understand remote sensing images Particularly it presents many more effective techniques based on the popular concepts of deep learning and big data to reach new heights of data understanding Through reporting recent advances in the machine learning approaches towards analyzing and understanding remote sensing images this book can help readers become more familiar with knowledge frontier and foster an increased interest in this field

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