Deep Learning For Remote Sensing Data Wuhan University

This book reviews the state of the art in algorithmic approaches addressing the practical challenges that arise with hyperspectral image analysis tasks, with a focus on emerging trends in machine learning and image processing/understanding. It presents advances in deep learning, multiple instance learning, sparse representation based learning, low-dimensional manifold models, anomalous change detection, target recognition, sensor fusion and super-resolution for robust multispectral and hyperspectral image understanding. It presents research from leading international experts who have made foundational contributions in these areas. The book covers a diverse array of applications of multispectral/hyperspectral imagery in the context of these algorithms, including remote sensing, face recognition and biomedicine. This book would be particularly beneficial to graduate students and researchers who are taking advanced courses in (or are working in) the areas of image analysis, machine learning and remote sensing with multi-channel optical imagery. Researchers and professionals in academia and industry working in areas such as electrical engineering, civil and environmental engineering, geosciences and biomedical image processing, who work with multi-channel optical data will find this book useful.

This book covers the state-of-art image classification methods for discrimination of earth objects from remote sensing satellite data with an emphasis on fuzzy machine learning and deep learning algorithms. Both types of algorithms are described in such details that these can be implemented directly for thematic mapping of multiple-class or specific-class landcover from multispectral optical remote sensing data. These algorithms along with multi-date, multi-sensor remote sensing are capable to monitor specific stage (for e.g., phenology of growing crop) of a particular class also included. With these capabilities fuzzy machine learning algorithms have strong applications in areas like crop insurance, forest fire mapping, stubble burning, post disaster damage mapping etc. It also provides details about the temporal indices database using proposed Class Based Sensor Independent (CBSI) approach supported by practical examples. As well, this book addresses other related algorithms based on distance, kernel based as well as spatial information through Markov Random Field (MRF)/Local convolution methods to handle mixed pixels, non-linearity and noisy pixels. Further, this book covers about techniques for quantiative assessment of soft classified fraction outputs from soft classification and supported by in-house developed tool called sub-pixel multi-spectral image classifier (SMIC). It is aimed at graduate, postgraduate, research scholars and working professionals of different branches such as Geoinformation sciences, Geography, Electrical, Electronics and Computer Sciences etc., working in the fields of earth observation and satellite image processing. Learning algorithms discussed in this book may also be useful in other related fields, for example, in medical imaging. Overall, this book aims to: exclusive focus on using large range of fuzzy classification algorithms for remote sensing images; discuss ANN, CNN, RNN, and hybrid learning classifiers application on remote sensing images; describe sub-pixel multi-spectral image classifier tool (SMIC) to support discussed fuzzy and learning algorithms; explain how to assess soft classified outputs as fraction images using fuzzy error matrix (FERM) and its advance versions with FERM tool, Entropy, Correlation Coefficient, Root Mean Square Error and Receiver Operating Characteristic (ROC) methods and; combines explanation of the algorithms with case studies and practical applications.

The text is focused on the development and implementation of statistically motivated, data-driven techniques for digital image analysis of remotely sensed imagery and features a tight interweaving of statistical and machine learning theory with algorithms with computer codes. It develops statistical methods for the analysis of optical/infrared and synthetic aperture radar (SAR) imagery, including wavelet transformations, kernel methods for nonlinear classification, as well as an introduction to deep learning in the context of feed forward neural networks. The material is self-contained and illustrated with many programming examples, all of which can be conveniently run in a web browser. Each chapter concludes with exercises complementing or extending the material in the text. Numerous examples of programming the Google Earth Engine and TensorFlow APIs are given. New in the fourth edition is an in-depth treatment of a recent sequential change detection algorithm for polarimetric SAR image time series. The accompanying software consists of Python (open source) versions of all of the main image analysis algorithms, thus accessible to all readers with a computer and an Internet connection. Features Includes open source software and tools Presents easy, platform-independent software installation methods (Docker containerization) Concepts and algorithms are illustrated in Jupyter notebooks Utilizes freely accessible imagery via the Google Earth Engine Examines deep learning examples including a sound introduction to neural networks Provides many examples of cloud programming (Google Earth Engine API) SAR image time series. The accompanying software consists of Python (open source) versions of all of the main image analysis algorithms, thus accessible to all readers with a computer and an Internet connection. Features Includes open source software and tools Presents easy, platform-independent software installation methods (Docker containerization) Concepts and algorithms are illustrated in Jupyter notebooks Utilizes freely accessible imagery via the Google Earth Engine Examines deep learning examples including a sound introduction to neural networks Provides many examples of cloud programming (Google Earth Engine API)

Kernel methods have long been established as effective techniques in the framework of machine learning and pattern recognition, and have now become the standard approach to many remote sensing applications. With algorithms that combine statistics and geometry, kernel methods have proven successful across many different domains related to the analysis of images of the Earth acquired from airborne and satellite sensors, including natural resource control, detection and monitoring of anthropic infrastructures (e.g. urban areas), agriculture inventorying, disaster prevention and damage assessment, and anomaly and target detection. Presenting the theoretical foundations of kernel methods (KMs) relevant to the remote sensing domain, this book serves as a practical guide to the design and implementation of these methods. Five distinct parts present state-of-the-art research related to remote sensing based on the recent advances in kernel methods, analysing the related methodological and practical challenges: Part I introduces the key concepts of machine learning for remote sensing, and the theoretical and practical foundations of kernel methods. Part II explores supervised image classification including Super Vector Machines (SVMs), kernel discriminant analysis, multi-temporal image classification, target detection with kernels, and Support Vector Data Description (SVDD) algorithms for anomaly detection. Part III looks at semi-supervised classification with transductive SVM approaches for hyperspectral image classification and kernel mean data classification. Part IV examines regression and model inversion, including the concept of a kernel unmixing algorithm for hyperspectral imagery, the theory and methods for quantitative remote sensing inverse problems with kernel-based equations, kernel-based BRDF (Bidirectional Reflectance Distribution Function), and temperature retrieval KMs. Part V deals with kernel-based feature extraction and provides a review of the principles of several multivariate analysis methods and their kernel extensions. This book is aimed at engineers, scientists and researchers involved in remote sensing data processing, and also those working within machine learning and pattern recognition.

The second edition of Urban Remote Sensing is a state-of-the-art review of the latest progress in the subject. The text examines how evolving innovations in remote sensing allow to deliver the critical information on cities in a timely and cost-effective way to support various urban management activities and the scientific research on urban morphology, socio-environmental dynamics, and sustainability. Chapters are written by leading scholars from a variety of disciplines including remote sensing, GIS, geography, urban planning, environmental science, and sustainability science, with case studies predominately drawn from North America and Europe. A review of the essential and emerging research areas in urban remote sensing including sensors, techniques, and applications, especially some critical issues that are shifting the directions in urban remote sensing research. Illustrated in full color throughout, including numerous relevant case studies and extensive discussions of important concepts and cutting-edge technologies to enable clearer understanding for non-technical audiences. Urban Remote Sensing, Second Edition will be of particular interest to upper-division undergraduate and graduate students, researchers and

professionals working in the fields of remote sensing, geospatial information, and urban & environmental planning.
This book offers an introduction to remotely sensed image processing and classification in R using machine learning algorithms. It also provides a concise and practical reference tutorial, which equips readers to immediately start using the software platform and R packages for image processing and classification. This book is divided into five chapters. Chapter 1 introduces remote sensing digital image processing in R, while chapter 2 covers pre-processing. Chapter 3 focuses on image transformation, and chapter 4 addresses image classification. Lastly, chapter 5 deals with improving image classification. R is advantageous in that it is open source software, available free of charge and includes several useful features that are not available in commercial software packages. This book benefits all undergraduate and graduate students, researchers, university teachers and other remote- sensing practitioners interested in the practical implementation of remote sensing in R.
The multi-volume set LNAI 12975 until 12979 constitutes the refereed proceedings of the European Conference on Machine Learning and Knowledge Discovery in Databases, ECML PKDD 2021, which was held during September 13-17, 2021. The conference was originally planned to take place in Bilbao, Spain, but changed to an online event due to the COVID-19 pandemic. The 210 full papers presented in these proceedings were carefully reviewed and selected from a total of 869 submissions. The volumes are organized in topical sections as follows: Research Track: Part I: Online learning; reinforcement learning; time series, streams, and sequence models; transfer and multi-task learning; semi-supervised and few-shot learning; learning algorithms and applications. Part II: Generative models; algorithms and learning theory; graphs and networks; interpretation, explainability, transparency, safety. Part III: Generative models; search and optimization; supervised learning; text mining and natural language processing; image processing, computer vision and visual analytics. Applied Data Science Track: Part IV: Anomaly detection and malware; spatio-temporal data; e-commerce and finance; healthcare and medical applications (including Covid); mobility and transportation. Part V: Automating machine learning, optimization, and feature engineering; machine learning based simulations and knowledge discovery; recommender systems and behavior modeling; natural language processing; remote sensing, image and video processing; social media.
Artificial neural networks (ANNs) and evolutionary computation methods have been successfully applied in remote sensing applications since they offer unique advantages for the analysis of remotely-sensed images. ANNs are effective in finding underlying relationships and structures within multidimensional datasets. Thanks to new sensors, we have images with more spectral bands at higher spatial resolutions, which clearly recall big data problems. For this purpose, evolutionary algorithms become the best solution for analysis. This book includes eleven high-quality papers, selected after a careful reviewing process, addressing current remote sensing problems. In the chapters of the book, superstructural optimization was suggested for the optimal design of feedforward neural networks, CNN networks were deployed for a nanosatellite payload to select images eligible for transmission to ground, a new weight feature value convolutional neural network (WFCNN) was applied for fine remote sensing image segmentation and extracting improved land-use information, mask regional-convolutional neural networks (Mask R-CNN) was employed for extracting valley fill faces, state-of-the-art convolutional neural network (CNN)-based object detection models were applied to automatically detect airplanes and ships in VHR satellite images, a coarse-to-fine detection strategy was employed to detect ships at different sizes, and a deep quadruplet network (DQN) was proposed for hyperspectral image classification.
Target object detection and identification are among the primary uses for a remote sensing system. This is crucial in several fields, including environmental and urban monitoring, hazard and disaster management, and defense and military. In recent years, these analyses have used the tremendous amount of data acquired by sensors mounted on satellite, airborne, and unmanned aerial vehicle (UAV) platforms. This book promotes papers exploiting different remote sensing data for target object detection and identification, such as synthetic aperture radar (SAR) imaging and multispectral and hyperspectral imaging. Several cutting-edge contributions, which provide examples of how to select of a technology or another depending on the specific application, will be detailed.
The rapid growth of the world population has resulted in an exponential expansion of both urban and agricultural areas. Identifying and managing such earthly changes in an automatic way poses a worth-addressing challenge, in which remote sensing technology can have a fundamental role to answer—at least partially—such demands. The recent advent of cutting-edge processing facilities has fostered the adoption of deep learning architectures owing to their generalization capabilities. In this respect, it seems evident that the pace of deep learning in the remote sensing domain remains somewhat lagging behind that of its computer vision counterpart. This is due to the scarce availability of ground truth information in comparison with other computer vision domains. In this book, we aim at advancing the state of the art in linking deep learning methodologies with remote sensing image processing by collecting 20 contributions from different worldwide scientists and laboratories. The book presents a wide range of methodological advancements in the deep learning field that come with different applications in the remote sensing landscape such as wildfire and postdisaster damage detection, urban forest mapping, vine disease and pavement marking detection, desert road mapping, road and building outline extraction, vehicle and vessel detection, water identification, and text-to-image matching.
Roughly inspired by the human brain, deep neural networks trained with large amounts of data can solve complex tasks with unprecedented accuracy. This practical book provides an end-to-end guide to TensorFlow, the leading open source software library that helps you build and train neural networks for computer vision, natural language processing (NLP), speech recognition, and general predictive analytics. Authors Tom Hope, Yehezkel Resheff, and Itay Lieder provide a hands-on approach to TensorFlow fundamentals for a broad technical audience—from data scientists and engineers to students and researchers. You’ll begin by working through some basic examples in TensorFlow before diving deeper into topics such as neural network architectures, TensorBoard visualization, TensorFlow abstraction libraries, and multithreaded input pipelines. Once you finish this book, you’ll know how to build and deploy production-ready deep learning systems in TensorFlow. Get up and running with TensorFlow, rapidly and painlessly Learn how to use TensorFlow to build deep learning models from the ground up Train popular deep learning models for computer vision and NLP Use extensive abstraction libraries to make development easier and faster Learn how to scale TensorFlow, and use clusters to distribute model training Deploy TensorFlow in a production setting
Earth observation is the field of science concerned with the problem of monitoring and modeling the processes on the Earth surface and their interaction with the atmosphere. The Earth is continuously monitored with advanced optical and radar sensors. The images are analyzed and processed to deliver useful products to individual users, agencies and public administrations. To deal with these problems, remote sensing image processing is nowadays a mature research area, and the techniques developed in the field allow many real-life applications with great societal value. For instance, urban monitoring, fire detection or flood prediction can have a great impact on economical and environmental issues. To attain such objectives, the remote sensing community has turned into a multidisciplinary field of science that embraces physics, signal theory, computer science, electronics and communications. From a machine learning and signal/image processing point of view, all the applications are tackled under specific formalisms, such as classification and clustering, regression and function approximation, data coding, restoration and enhancement, source unmixing, data fusion or feature selection and extraction. This book covers some of the fields in a comprehensive way. Table of Contents: Remote Sensing from Earth Observation Satellites / The Statistics of Remote Sensing Images / Remote Sensing Feature Selection and Extraction / {Classification / Spectral Mixture Analysis / Estimation of Physical Parameters
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This book is a collection of best selected research papers presented at the Conference on Machine Learning, Deep Learning and Computational Intelligence for Wireless Communication (MDCWC 2020) held during October 22nd to 24th 2020, at the Department of

Electronics and Communication Engineering, National Institute of Technology Tiruchirappalli, India. The presented papers are grouped under the following topics (a) Machine Learning, Deep learning and Computational intelligence algorithms (b)Wireless communication systems and (c) Mobile data applications and are included in the book. The topics include the latest research and results in the areas of network prediction, traffic classification, call detail record mining, mobile health care, mobile pattern recognition, natural language processing, automatic speech processing, mobility analysis, indoor localization, wireless sensor networks (WSN), energy minimization, routing, scheduling, resource allocation, multiple access, power control, malware detection, cyber security, flooding attacks detection, mobile apps sniffing, MIMO detection, signal detection in MIMO-OFDM, modulation recognition, channel estimation, MIMO nonlinear equalization, super-resolution channel and direction-of-arrival estimation. The book is a rich reference material for academia and industry.

This book rests upon a smooth integration between image fusion and data mining for information retrieval and content-based mapping in the context of different environmental applications, and it focuses on environmental application issues at global and regional scale, while using local scale ground-truth data for calibration and validation.

As computer and space technologies have been developed, geoscience information systems (GIS) and remote sensing (RS) technologies, which deal with the geospatial information, have been rapidly maturing. Moreover, over the last few decades, machine learning techniques including artificial neural network (ANN), deep learning, decision tree, and support vector machine (SVM) have been successfully applied to geospatial science and engineering research fields. The machine learning techniques have been widely applied to GIS and RS research fields and have recently produced valuable results in the areas of geoscience, environment, natural hazards, and natural resources. This book is a collection representing novel contributions detailing machine learning techniques as applied to geoscience information systems and remote sensing.

This practical resource provides an overview of machine learning (ML) approaches as applied to electromagnetics and antenna array processing. Detailed coverage of the main trends in ML, including uniform and random array processing (beamforming and detection of angle of arrival), antenna optimization, wave propagation, remote sensing, radar, and other aspects of electromagnetic design are explored. An introduction to machine learning principles and the most common machine learning architectures and algorithms used today in electromagnetics and other applications is presented, including basic neural networks, gaussian processes, support vector machines, kernel methods, deep learning, convolutional neural networks, and generative adversarial networks. Applications in electromagnetics and antenna array processing that are solved using machine learning are discussed, including antennas, remote sensing, and target classification.

Image fusion in remote sensing or pansharpening involves fusing spatial (panchromatic) and spectral (multispectral) images that are captured by different sensors on satellites. This book addresses image fusion approaches for remote sensing applications. Both conventional and deep learning approaches are covered. First, the conventional approaches to image fusion in remote sensing are discussed. These approaches include component substitution, multi-resolution, and model-based algorithms. Then, the recently developed deep learning approaches involving single-objective and multi-objective loss functions are discussed. Experimental results are provided comparing conventional and deep learning approaches in terms of both low-resolution and full-resolution objective metrics that are commonly used in remote sensing. The book is concluded by stating anticipated future trends in pansharpening or image fusion in remote sensing.

Deep Learning has achieved great success in many challenging research areas, such as image recognition and natural language processing. The key merit of deep learning is to automatically learn good feature representation from massive data conceptually. In this book, we will show that the deep learning technology can be a very good candidate for improving sensing capabilities.In this edited volume, we aim to narrow the gap between humans and machines by showcasing various deep learning applications in the area of sensing. The book will cover the fundamentals of deep learning techniques and their applications in real-world problems including activity sensing, remote sensing and medical sensing. It will demonstrate how different deep learning techniques help to improve the sensing capabilities and enable scientists and practitioners to make insightful observations and generate invaluable discoveries from different types of data.

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.

DEEP LEARNING FOR THE EARTH SCIENCES Explore this insightful treatment of deep learning in the field of earth sciences, from four leading voices Deep learning is a fundamental technique in modern Artificial Intelligence and is being applied to disciplines across the scientific spectrum; earth science is no exception. Yet, the link between deep learning and Earth sciences has only recently entered academic curricula and thus has not yet proliferated. Deep Learning for the Earth Sciences delivers a unique perspective and treatment of the concepts, skills, and practices necessary to quickly become familiar with the application of deep learning techniques to the Earth sciences. The book prepares readers to be ready to use the technologies and principles described in their own research. The distinguished editors have also included resources that explain and provide new ideas and recommendations for new research especially useful to those involved in advanced research education or those seeking PhD thesis orientations. Readers will also benefit from the inclusion of: An introduction to deep learning for classification purposes, including advances in image segmentation and encoding priors, anomaly detection and target detection, and domain adaptation An exploration of learning representations and unsupervised deep learning, including deep learning image fusion, image retrieval, and matching and co-registration Practical discussions of regression, fitting, parameter retrieval, forecasting and interpolation An examination of physics-aware deep learning models, including emulation of complex codes and model parametrizations

Perfect for PhD students and researchers in the fields of geosciences, image processing, remote sensing, electrical engineering and computer science, and machine learning, Deep Learning for the Earth Sciences will also earn a place in the libraries of machine learning and pattern recognition researchers, engineers, and scientists.

This book focuses on deep learning-based methods for hyperspectral image (HSI) analysis. Unsupervised spectral-spatial adaptive band-noise factor-based formulation is devised for HSI noise detection and band categorization. The method to characterize the bands along with the noise estimation of HSIs will benefit subsequent remote sensing techniques significantly. This book develops on two fronts: On the one hand, it is aimed at domain professionals who want to have an updated overview of how hyperspectral acquisition techniques can combine with deep learning architectures to solve specific tasks in different application fields. On the other hand, the authors want to target the machine learning and computer vision experts by giving them a picture of how deep learning technologies are applied to hyperspectral data from a multidisciplinary perspective. The presence of these two viewpoints and the inclusion of application fields of remote sensing by deep learning are the original contributions of this review, which also highlights some potentialities and critical issues related to the observed development trends.

This book presents the original articles that have been accepted in the 2019 INNS Big Data and Deep Learning (INNS BDDL) international conference, a major event for researchers in the field of artificial neural networks, big data and related topics, organized by the International Neural Network Society and hosted by the University of Genoa. In 2019 INNS BDDL has been held in Sestri Levante (Italy) from April 16 to April 18. More than 80 researchers from 20 countries participated in the INNS BDDL in April 2019. In addition to regular sessions, INNS BDDL welcomed around 40 oral communications, 6 tutorials have been presented together with 4 invited plenary speakers. This book covers a broad range of topics in big data and deep learning, from theoretical aspects to state-of-the-art applications. This book is directed to both Ph.D. students and Researchers in the field in order to provide a general picture of the state-of-the-art on the topics addressed by the conference.

Traditional machine learning (ML) techniques are often employed to perform complex pattern recognition tasks for remote sensing images, such as land-use classification. In order to obtain acceptable classification results, these techniques require sufficient training data to be available for every particular image. Obtaining training samples is challenging, particularly for near real-time applications. Therefore, past knowledge must be utilized to overcome the lack of training data in the current regime. This challenge is known as domain adaptation (DA), in which the training data (source) and the test data (target) are sampled from different domains. DA is a challenging problem and the performance of the proposed techniques can be significantly affected by the type of problem, the nature of the data, and the type of data shift associated with the domains. Even though more data can be obtained from different sources, adapting these sources to obtain acceptable results is also a challenging task. This is especially true when the different domains contain a severely imbalanced class distribution. In this study, different techniques based on deep neural networks (DNNs) were developed and evaluated to solve the DA problem for remote sensing image classification in different settings. First, the single-source DA problem was addressed by finding invariant representations for both the source and the target. Denoising autoencoders (DAE) and domain-adversarial neural networks (DANN) were adopted to find these invariant representations. Results showed that both techniques were able to outperform traditional approaches, such as principal component analysis (PCA) and kernel PCA. Second, the multi-source domain adaptation for large-scale applications was addressed. A novel, efficient, scalable, yet simple, adaptive multi-source domain adaptation (AMDA) was developed to address this problem. AMDA was also capable of dealing more effectively with the imbalanced data distribution among the sources. Two techniques originally proposed for domain expansion were also extended to the task of multi-source domain adaptation. AMDA and the extended domain expansion techniques were implemented and evaluated on the LCZ classification problem. Despite its simplicity, AMDA was able to achieve more than a 12% improvement over the baseline.

At the dawn of the 4th Industrial Revolution, the field of Deep Learning (a sub-field of Artificial Intelligence and Machine Learning) is growing continuously and rapidly, developing both theoretically and towards applications in increasingly many and diverse other disciplines. The book at hand aims at exposing its reader to some of the most significant recent advances in deep learning-based technological applications and consists of an editorial note and an additional fifteen (15) chapters. All chapters in the book were invited from authors who work in the corresponding chapter theme and are recognized for their significant research contributions. In more detail, the chapters in the book are organized into six parts, namely (1) Deep Learning in Sensing, (2) Deep Learning in Social Media and IOT, (3) Deep Learning in the Medical Field, (4) Deep Learning in Systems Control, (5) Deep Learning in Feature Vector Processing, and (6) Evaluation of Algorithm Performance. This research book is directed towards professors, researchers, scientists, engineers and students in computer science-related disciplines. It is also directed towards readers who come from other disciplines and are interested in becoming versed in some of the most recent deep learning-based technological applications. An extensive list of bibliographic references at the end of each chapter guides the readers to probe deeper into their application areas of interest.

Native palms, such as the Sabal palmetto, play an important role in maintaining the ecological balance in Florida. As a side-effect of modern globalization, new phytopathogens like Texas Phoenix Palm Decline have been introduced into forest systems that threaten native palms. This presents new challenges for forestry managers and geographers. Advances in remote sensing has assisted the practice of forestry by providing spatial metrics regarding the type, quantity, location, and the state of heath for trees for many years. This study provides spatial details regarding the general palm decline in Florida by taking advantage of the new developments in deep learning constructs coupled with high resolution WorldView-2 multispectral/temporal satellite imagery and LiDAR point cloud data. A novel approach using TensorFlow deep learning classification, multiband spatial statistics and indices, data reduction, and step-wise refinement masking yielded a significant improvement over Random Forest classification in a comparison analysis. The results from the TensorFlow deep learning were then used to develop an Empirical Bayesian Kriging continuous raster as an informative map regarding palm decline zones using Normalized Difference Vegetation Index Change. The significance from this research showed a large portion of the study area exhibiting palm decline and provides a new methodology for deploying TensorFlow learning for multispectral satellite imagery.

In today's world, deep learning source codes and a plethora of open access geospatial images are readily available and easily accessible.

However, most people are missing the educational tools to make use of this resource. Deep Learning for Remote Sensing Images with Open Source Software is the first practical book to introduce deep learning techniques using free open source tools for processing real world remote sensing images. The approaches detailed in this book are generic and can be adapted to suit many different applications for remote sensing image processing, including landcover mapping, forestry, urban studies, disaster mapping, image restoration, etc. Written with practitioners and students in mind, this book helps link together the theory and practical use of existing tools and data to apply deep learning techniques on remote sensing images and data. Specific Features of this Book: The first book that explains how to apply deep learning techniques to public, free available data (Spot-7 and Sentinel-2 images, OpenStreetMap vector data), using open source software (QGIS, Orfeo ToolBox, TensorFlow) Presents approaches suited for real world images and data targeting large scale processing and GIS applications Introduces state of the art deep learning architecture families that can be applied to remote sensing world, mainly for landcover mapping, but also for generic approaches (e.g. image restoration) Suited for deep learning beginners and readers with some GIS knowledge. No coding knowledge is required to learn practical skills. Includes deep learning techniques through many step by step remote sensing data processing exercises.

Developing methods to automatically extract objects from high spatial resolution (HSR) remotely sensed imagery on a large scale is crucial for supporting land user and land cover (LULC) mapping with HSR imagery. However, this task is notoriously challenging. Deep learning, a recent breakthrough in machine learning, has shed light on this problem. The goal of this thesis is to develop a deep insight into the use of deep learning to develop reliable automated object extraction methods for applications with HSR imagery. The thesis starts by re-examining the knowledge the remote sensing community has achieved on the problem, but in the context of deep learning. Attention is given to object-based image analysis (OBIA) methods, which are currently considered to be the prevailing framework for this problem and have had a far-reaching impact on the history of remote sensing. In contrast to common beliefs, experiments show that object-based methods suffer seriously from ill-defined image segmentation. They are less effective at leveraging the power of the features learned by deep convolutional neural networks (CNNs) than conventionally patch-based methods. This thesis then studies ways to further improve the accuracy of object extraction with deep CNNs. Given that vector maps are required as the final format in many applications, the focus is on addressing the issues of generating high-quality vector maps with deep CNNs. A method combining bottom-up deep CNN prediction with top-down object modeling is proposed for building extraction. This method also exhibits the potential to extend to other objects of interest. Experiments show that implementing the proposed method on a single GPU results in the capability of processing 756 km2 of 12 cm aerial images in about 30 hours. By post-editing on top of the resulting automated extraction, high-quality building vector maps can be produced about 4-times faster than conventional manual digitization methods.