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Basic Research on Three-dimensional (3-D) Electromagnetic (EM) Methods for Imaging the Flow of Organic Fluids in the Subsurface
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Physics-based Subsurface Information Extraction by Parametric Inversion
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Ground Penetrating Radar
Quantitative Integration of Multiple Near-surface Geophysical Techniques for Improved Subsurface Imaging and Reducing Uncertainty in Discrete Anomaly Detection
Ground Penetrating Radar
Introduction to Subsurface Imaging

TRISTEN VAUGHAN

Evaluation of a Ground Penetrating Radar System for Detecting Subsurface Anomalies IntechOpen
Just below our feet is an environment that supports our infrastructure, yields water, provides for agriculture, and receives our waste. Our capacity to describe, or characterize, this environment is crucial to the solution of many resource, environmental, and engineering problems. And just as medical imaging technologies have reduced the need for exploratory surgeries, a variety of technologies hold the promise for rapid, relatively inexpensive noninvasive characterization of the Earth's subsurface. Seeing into the Earth examines why noninvasive characterization is important and how improved methods can be developed and disseminated. Looking at the issues from both the commercial and public perspectives, the volume makes recommendations for linking characterization and cost savings, closing the gap between the state of science and the state of the practice, and helping practitioners make the best use of the best methods. The book provides background on: The role of noninvasive subsurface characterization in contaminant cleanup, resource management, civil engineering, and other areas. The physical, chemical, biological, and geological properties that are characterized. Methods of characterization and prospects for technological improvement. Certain to be important for earth scientists and engineers alike, this book is also accessible to interested lay readers.
Improving Ground Penetrating Radar Imaging in High Loss Environments by Coordinated System Development, Data Processing, Numerical Modeling, & Visualization ...
Cambridge University Press
Currently there is no systematic quantitative methodology in place for the integration of two or more coincident data sets collected using near-surface geophysical techniques. As the need for this type of methodology increases--particularly in the fields of archaeological prospecting, UXO detection, landmine detection, environmental site characterization/remediation monitoring, and forensics--a detailed and refined approach is necessary. The objective of this dissertation is to investigate quantitative techniques for integrating multi-tool near-surface geophysical data to improve subsurface imaging and reduce uncertainty in discrete anomaly detection. This objective is fulfilled by: (1) correlating multi-tool geophysical data with existing well-characterized "targets"; (2) developing methods for quantitatively merging different geophysical data sets; (3) implementing statistical tools within Statistical Analysis System (SAS) to evaluate the multiple integration methodologies; and (4) testing these new methods at several well-characterized sites with varied targets (i.e., case studies). Three geophysical techniques utilized in this research are: ground penetrating radar (GPR), electromagnetic (ground conductivity) methods (EM), and magnetic gradiometry. Computer simulations are developed to generate synthetic data with expected parameters such as heterogeneity of the subsurface, type of target, and spatial sampling. The synthetic data sets are integrated using the same methodologies employed on the case-study sites to (a) further develop the necessary quantitative assessment scheme, and (b) determine if these merged data sets do in fact yield improved results. A controlled setting within The University of Tennessee Geophysical Research Station permits the data (and associated anomalous bodies) to be spatially correlated with the locations of known targets. Error analysis is then conducted to guide any modifications to the data integration methodologies before transitioning to study sites of unknown subsurface features. Statistical analysis utilizing SAS is conducted to quantitatively evaluate the effectiveness of the data integration methodologies and determine if there are significant improvements in subsurface imaging, thus resulting in a reduction in the uncertainty of discrete anomaly detection.
Characterization of Subsurface Stratigraphy Using Ground Penetrating Radar at the Dover Air Force Base, Delaware
Cambridge University Press
Present applications of standoff (airborne) Ground Penetrating SAR (Synthetic Aperture Radar) allows objects near the surface to be detected but only provides an approximation for the actual location and image. When single media models are employed the lack of correction for the phase velocity and refractive changes at the air/soil interface result in object distortions. Positional errors and image distortions comparable to the size of the object are possible. Correction is possible, if the media properties are known, by modeling the scene as a two-layer medium and accounting for the propagation effects. The propagation parameters for the lower media are estimated in the migration of observable responses for surface and subsurface objects. This approach allows for corrected images to subsurface objects to be produced after data collection. Surface objects will be distorted as a result of this process. The modeling process, simulations, and results with field data will be discussed. An improvement by a factor of two would enable standoff radar to detect objects at depths of on meter or more benefiting Unexploded Ordnance (UXO) and hazardous waste site survey activities.
Stratigraphic Analyses Using GPR John Wiley & Sons
Rock glaciers are dynamic landforms and, as such, exhibit interesting and welldeveloped structural features, which translate to surface morphology in the form of ridges and furrows. These distinguishing features have led researchers to study the physics behind the movement and internal deformation of rock glaciers. For years researchers had no access to the internal makeup of rock glaciers. Thus, proposed models and discussion have been based on theoretical concepts of electromagnetic (EM) wave propogation. With the application of ground penetrating radar (GPR) to provide a view of the interior structure of a rock glacier, researchers had "real" data to verify their models. However, no comparison has been made between a GPR profile and an actual cross-section of a rock glacier. The purpose of this thesis is to validate the fidelity of GPR in showing the actual structure of a

rock glacier. A trench that was excavated through the toe of a rock glacier on Mount Mestas in south central Colorado provided a view of the actual structure of the landform. The structure in the trench was compared with GPR and EM data. The GPR study was conducted using a PulsEKKOTM 100A subsurface imaging radar with 25, 50, and 100 MHz antennas, to detect dielectric contrasts within the rock glacier. A frequency domain EM34 by Geonics LtdTM was also used to supplement the GPR data by measuring the rock glacier's conductivity at various depths. This thesis proved, by utilizing statistics, that GPR is a useful tool in visualizing the interior structure of rock glaciers. The 100 MHz antennas clearly show small scale reflection horizons caused by changes in clast orientation and subsurface material composition. These events coincide with structures seen in the trench. Individual clasts greater than 0.375 m were also recognized as point sources in the GPR profiles. Large continuous bedding layers were observed with the 25 and 50 MHz antennas, which reflect the structure seen in the trench. A large scale thrust fault was also located with the GPR. However, this was not visible in the panoramic photograph because the fault occurs below the base of the trench.

Proximal Soil Sensing John Wiley & Sons

Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band of the radio spectrum to detect reflected signals from subsurface structures. This book concisely summarizes many of the lessons learned over the past few decades working on the problem of algorithm development for landmine and IED detection in GPR data and represents an in-depth analysis of different stages of signal processing applied to GPR data.

Subsurface Imaging with Ground Penetrating Radar CRC Press

Describing and evaluating the basic principles and methods of subsurface sensing and imaging, Introduction to Subsurface Imaging is a clear and comprehensive treatment that links theory to a wide range of real-world applications in medicine, biology, security and geophysical/environmental exploration. It integrates the different sensing techniques (acoustic, electric, electromagnetic, optical, x-ray or particle beams) by unifying the underlying physical and mathematical similarities, and computational and algorithmic methods. Time-domain, spectral and multisensor methods are also covered, whilst all the necessary mathematical, statistical and linear systems tools are given in useful appendices to make the book self-contained. Featuring a logical blend of theory and applications, a wealth of color illustrations, homework problems and numerous case studies, this is suitable for use as both a course text and as a professional reference.

Advanced Ground-penetrating Radar System and Signal Analysis for High-performance Tomographic Subsurface Imaging and Identification John Wiley & Sons

The objective of this applied research and development project is to develop a system known as '3-D SISAR'. This system consists of a ground penetrating radar with software algorithms designed for the detection, location, and identification of buried objects in the underground hazardous waste environments found at DOE storage sites. Three-dimensional maps of the object locations will be produced which can assist the development of remediation strategies and the characterization of the digface during remediation operations. It is expected that the 3-D SISAR will also prove useful for monitoring hydrocarbon based contaminant migration after remediation. The underground imaging technique being developed under this contract utilizes a spotlight mode Synthetic Aperture Radar (SAR) approach which, due to its inherent stand-off capability, will permit the rapid survey of a site and achieve a high degree of productivity over large areas. When deployed from an airborne platform, the stand-off techniques is also seen as a way to overcome practical survey limitations encountered at vegetated sites.

Techniques for Real World Ground Penetrating Radar Data Analysis MDPI

The Department of Energy has identified the location and characterization of subsurface contaminants and the characterization of the subsurface as a priority need. Many DOE facilities are in need of subsurface imaging in the vadose and saturated zones. This includes (1) the detection and characterization of metal and concrete structures, (2) the characterization of waste pits (for both contents and integrity) and (3) mapping the complex geological/hydrological framework of the vadose and saturated zones. The DOE has identified ground penetrating radar (GPR) as a method that can non-invasively map transportation pathways and vadose zone heterogeneity. An advanced GPR system and advanced subsurface modeling, processing, imaging, and inversion techniques can be directly applied to several DOE science needs in more than one focus area and at many sites. Needs for enhanced subsurface imaging have been identified at Hanford, INEEL, SRS, ORNL, LLNL, SNL, LANL, and many other sites. In fact, needs for better subsurface imaging probably exist at all DOE sites. However, GPR performance is often inadequate due to increased attenuation and dispersion when soil conductivities are high. Our objective is to extend the limits of performance of GPR by improvements to both hardware and numerical computation. The key features include (1) greater dynamic range through real time digitizing, receiver gain improvements, and high output pulser, (2) modified, fully characterized antennas with sensors to allow dynamic determination of the changing radiated waveform, (3) modified deconvolution and depth migration algorithms exploiting the new antenna output information, (4) development of automatic full waveform inversion made possible by the known radiated pulse shape.

הדרכה לשמוש במלון John Wiley & Sons

In this book “Radar Technology”, the chapters are divided into four main topic areas: Topic area 1: “Radar Systems” consists of chapters which treat whole radar systems, environment and target functional chain. Topic area 2: “Radar Applications” shows various applications of radar systems, including meteorological radars, ground penetrating radars and glaciology. Topic area 3: “Radar Functional Chain and Signal Processing” describes several aspects of the radar signal processing. From parameter extraction, target detection over tracking and classification technologies. Topic area 4: “Radar Subsystems and Components” consists of design technology of radar subsystem components like antenna design or waveform design.

Introduction to Subsurface Imaging Geological Society of America

A real-world guide to practical applications of ground penetrating radar (GPR) The nondestructive nature of ground penetrating radar makes it an important and popular method of subsurface imaging, but it is a highly specialized field, requiring a deep understanding of the underlying science for successful application. Introduction to Ground Penetrating Radar: Inverse Scattering and Data Processing provides experienced professionals with the background they need to ensure precise data collection and analysis. Written to build upon the information presented in more general introductory volumes, the book discusses the fundamental mathematical, physical, and engineering principles upon which GPR is built. Real-world examples and field data provide readers an accurate view of day-to-day GPR use. Topics include: 2D scattering for dielectric and magnetic targets 3D scattering equations and migration algorithms Host medium characterization and diffraction tomography Time and frequency steps in GPR data sampling The Born approximation and the singular value decomposition The six appendices contain the mathematical proofs of all examples discussed throughout the book. Introduction to Ground Penetrating Radar: Inverse Scattering and Data Processing is a comprehensive resource that will prove invaluable in the field.

Ground Penetrating Radar Springer

This book offers an overview of modern advances in Ground Penetrating Radar (GPR) for the reader hoping to understand comprehensive electromagnetic culture, combining instrumental development of radar, signal processing, imaging, and calibration/correction of measured data. GPR has a multi-disciplinary character that can bring together a diverse and broad community. Of concern are the design and optimization of innovative radars, by virtue of the antennas and associated electronics, imaging algorithms, methodological diversity, calibration procedures, and the development of tools for the interpretation of data in mono-static or multi-static configurations within frequency or transient domains. This book provides illustrations in civil engineering for the diagnosis of transport infrastructures and buildings, archeological surveys for the appreciation of cultural heritage, detection of underground pipes and cavities, estimation of soil water content for agriculture, and mapping of root trees developing underground, and in planetology, the analysis of the internal structure of planets and other celestial bodies through electromagnetic waves.

Delineate Subsurface Structures with Ground Penetrating Radar Springer Science & Business Media

This book reports on developments in Proximal Soil Sensing (PSS) and high resolution digital soil mapping. PSS has become a multidisciplinary area of study that aims to develop field-based techniques for collecting information on the soil from close by, or within, the soil. Amongst others, PSS involves the use of optical, geophysical, electrochemical, mathematical and statistical methods. This volume, suitable for undergraduate course material and postgraduate research, brings together ideas and examples from those developing and using proximal sensors and high resolution digital soil maps for applications such as precision agriculture, soil contamination, archaeology, peri-urban design and high land-value applications, where there is a particular need for high spatial resolution information. The book in particular covers soil sensor sampling, proximal soil sensor development and use, sensor calibrations, prediction methods for large data sets, applications of proximal soil sensing, and high-resolution digital soil mapping. Key themes: soil sensor sampling – soil sensor calibrations – spatial prediction methods – reflectance spectroscopy – electromagnetic induction and electrical resistivity – radar and gamma radiometrics – multi-sensor platforms – high resolution digital soil mapping - applications Raphael A. Viscarra Rossel is a scientist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia. Alex McBratney is Pro-Dean and Professor of Soil Science in the Faculty of Agriculture Food & Natural Resources at the University of Sydney in Australia. Budiman Minasny is a Senior Research Fellow in the Faculty of Agriculture Food & Natural Resources at the University of Sydney in Australia.

Use of Surface and Borehole Ground Penetrating Radar in Geologic and Engineering Investigations of Transportation Projects Mdpi AG

High resolution ground penetrating radar (GPR) surveys were conducted at the Savannah River Site in South Carolina in late 1991 to demonstrate the radar techniques in imaging shallow utility and soil structures. Targets of interest at two selected sites, designated as H- and D-areas, were a buried backfilled trench, buried drums, geologic stratas, and water table. Multiple offset 2-D and single offset 3-D survey methods were used to acquire high resolution radar data. This digital data was processed using standard seismic processing software to enhance signal quality and improve resolution. Finally, using a graphics workstation, the 3D data was interpreted. In addition, a small 3D survey was acquired in The Woodlands, Texas, with very dense spatial sampling. This data set adequately demonstrated the potential of this technology in imaging subsurface features.

Hydrogeologic Investigation of Subsurface Stratigraphy Using Ground Penetrating Radar in Southwestern Shelby County, Tennessee John Wiley & Sons

A timely and authoritative guide to the state of the art of wave scattering Scattering of Electromagnetic Waves offers in three volumes a complete and up-to-date treatment of wave scattering by random discrete scatterers and rough surfaces. Written by leading scientists who have made important contributions to wave scattering over three decades, this new work explains the principles, methods, and applications of this rapidly expanding, interdisciplinary field. It covers both introductory and advanced material and provides students and researchers in remote sensing as well as imaging, optics, and electromagnetic theory with a one-stop reference to a wealth of current research results. Plus, Scattering of Electromagnetic Waves contains detailed discussions of both analytical and numerical methods, including cutting-edge techniques for the recovery of earth/land parametric information. The three volumes are entitled respectively Theories and Applications, Numerical Simulation, and Advanced Topics. In the first volume, Theories and Applications, Leung Tsang (University of Washington) Jin Au Kong (MIT), and Kung-Hau Ding (Air Force Research Lab) cover: * Basic theory of electromagnetic scattering * Fundamentals of random scattering * Characteristics of discrete scatterers and rough surfaces * Scattering and emission by layered media * Single scattering and applications * Radiative transfer theory and solution techniques * One-dimensional random rough surface scattering

Ground-penetrating Imaging Radar Development for Bridge Deck and Road Bed Inspection National Academies Press

Abstract Ground Penetrating Radar (GPR) Data Analysis deals with the problem of shallow subsurface imaging, which is motivated by the daily work of engineers, \eg those of municipalities.The concrete problem tackled in this thesis is motivated by the fact, that, at least in Germany, municipalities have knowledge about the existence of supply lines such as gas and water pipelines to cross and follow urban streets, while their actual position is often uncertain.The consequences are obvious: once a street undergoes maintenance works, pipes are easily broken.This also causes heavy problems to residents who are cut off from some supplies for a period of time. This thesis approaches a solution to the object detection problem in GPR data by means of (semi-)automated data analysis techniques, using Machine Learning methods.The problem is treated as a specialized problem for object detection in image data.In this application context, it is possible to integrate certain background knowledge and processing techniques in well-known Machine Learning methods. The thesis formalizes the problem first.A technical framework for the analysis of Complex Engineering Raw Data - CERD -, as a generalization of our current data at hand, will be used for all analysis methods developed.From a thorough data analysis, it becomes clear that our data labels are unsuitable for directly applying supervised Machine Learning methods.Therefore, we will be obtaining suitable ground truth data by semi-manually labeling more than 700 images by hand.The second part of the thesis presents both, supervised and unsupervised Machine Learning techniques for the detection of buried object locations.Techniques are introduced within the general context of object detection techniques within image data.The integration of geometrical background knowledge is shown to be feasible in all methods developed. This thesis will contribute in the followings: *The methodology and suitability of high-quality ground truth d

A Validation of Ground Penetrating Radar for Reconstructing the Internal Structure of a Rock Glacier Springer Science & Business Media

Ground penetrating radar (GPR) has become one of the key technologies in subsurface sensing and, in general, in non-destructive testing (NDT), since it is able to detect both metallic and nonmetallic targets. GPR for NDT has been successfully introduced in a wide range of sectors, such as mining and geology, glaciology, civil engineering and civil works, archaeology, and security and defense. In recent decades, improvements in georeferencing and positioning systems have enabled the introduction of synthetic aperture radar (SAR) techniques in GPR systems, yielding GPR-SAR systems capable of providing high-resolution microwave images. In parallel, the radiofrequency front-end of GPR systems has been optimized in terms of compactness (e.g., smaller Tx/Rx antennas) and cost. These advances, combined with improvements in autonomous platforms, such as unmanned terrestrial and aerial vehicles, have fostered new fields of application for GPR, where fast and reliable detection capabilities are demanded. In addition, processing techniques have been improved, taking advantage of the research conducted in related fields like inverse scattering and imaging. As a result, novel and robust algorithms have been developed for clutter reduction, automatic target recognition, and efficient processing of large sets of measurements to enable real-time imaging, among others. This Special Issue provides an overview of the state of the art in GPR imaging, focusing on the latest advances from both hardware and software perspectives.

Civil Engineering Applications of Ground Penetrating Radar

The Department of Energy has identified the location and characterization of subsurface contaminants and the characterization of the subsurface as a priority need. Many DOE facilities are in need of subsurface imaging in the vadose and saturated zones. This includes (1) the detection and characterization of metal and concrete structures, (2) the characterization of waste pits (for both contents and integrity) and (3) mapping the complex geological/hydrological framework of the vadose and saturated zones. The DOE has identified ground penetrating radar (GPR) as a method that can non-invasively map transportation pathways and vadose zone heterogeneity. An advanced GPR system and advanced subsurface modeling, processing, imaging, and inversion techniques can be directly applied to several DOE science needs in more than one focus area and at many sites. Needs for enhanced subsurface imaging have been identified at Hanford, INEEL, SRS, ORNL, LLNL, SNL, LANL, and many other sites. In fact, needs for better subsurface imaging probably exist at all DOE sites. However, GPR performance is often inadequate due to increased attenuation and dispersion when soil conductivities are high.

Imaging the Shallow Subsurface Using Ground Penetrating Radar at the Nyack Floodplain, Montana

Describing and evaluating the basic principles and methods of subsurface sensing and imaging, Introduction to Subsurface Imaging is a clear and comprehensive treatment that links theory to a wide range of real-world applications in medicine, biology, security and geophysical/environmental exploration. It integrates the different sensing techniques (acoustic, electric, electromagnetic, optical, x-ray or particle beams) by unifying the underlying physical and mathematical similarities, and computational and algorithmic methods. Time-domain, spectral and multisensor methods are also covered, whilst all the necessary mathematical, statistical and linear systems tools are given in useful appendices to make the book self-contained. Featuring a logical blend of theory and applications, a wealth of color illustrations, homework problems and numerous case studies, this is suitable for use as both a course text and as a professional reference.

Introduction to Ground Penetrating Radar

This book provides readers with a solid understanding of the capabilities and limitations of the techniques used for buried object detection. Presenting theory along with applications and the existing technology, it covers the most recent developments in hardware and software technologies of sensor systems with a focus on primary sensors such as Ground Penetrating Radar (GPR) and auxiliary sensors such as Nuclear Quadruple Resonance (NQR). It is essential reading for students, practitioners, specialists, and academicians involved in the design and implementation of buried object detection sensors.

Subsurface Object Position and Image Correction for Standoff Ground Penetrating Radar

Currently there are no systems available which allow for economical and accurate subsurface imaging of remediation sites. In some cases, high frequency ground penetrating radar (GPR) has been shown to be capable of accurately mapping the movement of contaminant plumes. Unfortunately, high frequency GPR has much too limited a depth of penetration in many soils to be useful for a large number of environmental problems. Lower frequencies are needed in order to obtain a reasonable depth of penetration. During this project, we conducted research on a prototype 8 MHz null field electromagnetic (EM) system to address this need. This project has been very successful in showing a promising new direction for high resolution subsurface imaging. Our tests with a prototype Electromagnetic Sensitive Null Array Probe (EM-SNAP) showed that we were able to obtain very sensitive measurements over subsurface dielectric targets. Although more basic research must be done, this approach holds great promise for imaging the flow of organic fluids in the subsurface.