



Innovative landslide disaster monitoring: unmanned aerial vehicle-deployed GNSS technology

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ABSTRACT

Real-time monitoring technologies of surface deformation represented by the global navigation satellite system (GNSS) are essential for landslides early warning. Monitoring methods such as GNSS require on-site manual installation. Therefore, it becomes nearly impossible to deploy surface monitoring equipment when landslides are located in high mountain valleys that are challenging for personnel to access, and/or in hazardous situations. We propose an intelligent real-time monitoring and early-warning technology that employs an unmanned aerial vehicle (UAV) as a carrier to deploy GNSS equipment. A system was initially designed with five components: an adaptive sampling GNSS receiver, an intelligent cooperative network transmission module, UAV-dropped GNSS equipment, special delivery UAV, and an intelligent monitoring and early warning cloud platform. This new technology was applied to a real landslide in Gansu Province, China, in 2020. The mean absolute error of 30 days in the east, north, and upward directions were 1.2, 1.3, and 2.9 mm/d, respectively, comparing the deformation velocity between the traditional monitoring station and the UAV-dropped monitoring station. This observation facilitated the successful prediction of a landslide hazard on 27 January 2021, allowing for a timely alert to be issued. Collectively, the results of this study established that UAV-deployed GNSS technology can accomplish unmanned deployment of GNSS equipment for landslide monitoring to ensure early warning issuance in inaccessible and/or high-risk areas.

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1. Introduction

Landslide disasters are widespread and recurring global disasters posing significant obstacles to infrastructure development and operations while also causing substantial casualties and economic losses. In China, approximately two-thirds of the land

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Unmanned Aerial Vehicles in Smart Cities Fadi Al-Turjman, 2020-04-20 This book addresses the major challenges in realizing unmanned aerial vehicles UAVs in IoT based Smart Cities The challenges tackled vary from cost and energy efficiency to availability and service quality The aim of this book is to focus on both the design and implementation aspects of the UAV based approaches in IoT enabled smart cities applications that are enabled and supported by wireless sensor networks 5G and beyond The contributors mainly focus on data delivery approaches and their performability aspects This book is meant for readers of varying disciplines who are interested in implementing the smart planet environments vision via wireless wired enabling technologies Involves the most up to date unmanned aerial vehicles UAV assessment and evaluation approaches Includes innovative operational ideas in agriculture surveillance rescue etc Pertains researchers scientists engineers and practitioners in the field of smart cities IoT and communications Fadi Al Turjman received his Ph D from Queen s University Canada He is a full professor and a research center director at Near East University Nicosia He is a leading authority in the area of IoT and intelligent systems His publication history spans over 250 publications in addition to his editorialship in top journals such as the IEEE Communication Surveys and Tutorials and the Elsevier Sustainable Cities and Society

Geological Disaster Monitoring Based on Sensor Networks Tariq S. Durrani, Wei Wang, Sheila M Forbes, 2018-08-09 This book presents the outcomes of the workshop sponsored by the National Natural Sciences Foundation of China and the UK Newton Fund British Council Researcher Links The Workshop was held in Harbin China from 14 to 17 July 2017 and brought together some thirty young postdoctoral researchers from China and the UK specializing in geosciences sensor signal networks and their applications to natural disaster recovery The Workshop presentations covered the state of the art in the area of disaster recovery and blended wireless sensor systems that act as early warning systems to mitigate the consequences of disasters and function as post disaster recovery vehicles This book promotes knowledge transfer and helps readers explore and identify research opportunities by highlighting research outcomes in the internationally relevant area of disaster recovery and mitigation

Unmanned Aerial Systems Anis Koubaa, Ahmad Taher Azar, 2021-01-21 Unmanned Aerial Systems Theoretical Foundation and Applications presents some of the latest innovative approaches to drones from the point of view of dynamic modeling system analysis optimization control communications 3D mapping search and rescue surveillance farmland and construction monitoring and more With the emergence of low cost UAS a vast array of research works in academia and products in the industrial sectors have evolved The book covers the safe operation of UAS including but not limited to fundamental design mission and path planning control theory computer vision artificial intelligence applications requirements and more This book provides a unique reference of the state of the art research and development of unmanned aerial systems making it an essential resource for researchers instructors and practitioners Covers some of the most innovative approaches to drones Provides the latest state of the art research and

development surrounding unmanned aerial systems Presents a comprehensive reference on unmanned aerial systems with a focus on cutting edge technologies and recent research trends in the area

Remote Sensing P. Garg,2024-06-17 This book explores the world of remote sensing technology offering comprehensive insights into its principles data acquisition methods advanced processing techniques and diverse applications It covers the basics of remote sensing such as the foundational principles and data acquisition techniques image pre processing such as noise removal radiometric corrections and image fusion and advanced classification techniques like machine learning algorithms including neural networks and support vector machines Finally it discusses disaster management and agriculture demonstrating how remote sensing methods are revolutionizing fields such as disaster response and agricultural monitoring Professionals researchers and students involved in environmental sciences geography urban planning and disaster management will benefit from these topics

5th World Congress on Disaster Management: Volume I S. Ananda Babu,2022-09-21 World Congress on Disaster Management WCDM brings researchers policy makers and practitioners from around the world in the same platform to discuss various challenging issues of disaster risk management enhance understanding of risks and advance actions for reducing risks and building resilience to disasters The fifth WCDM deliberates on three critical issues that pose the most serious challenges as well as hold the best possible promise of building resilience to disasters These are Technology Finance and Capacity WCDM has emerged as the largest global conference on disaster management outside the UN system The fifth WCDM was attended by more than 2500 scientists professionals policy makers and practitioners all around the world despite the prevalence of pandemic

Advances in Disaster Management, Volume 2 Nihal Anwar Siddiqui,Mohammad Moizuddin,Anil Kumar Gupta,Akbar Ziauddin,Prasenjit Mondal,2025-06-16 This book presents cutting edge research and forward looking strategies from the International Conference on Advances in Health Safety Fire Environment Allied Sciences and Sustainability HSFEAS 2023 This volume captures the collective expertise of global thought leaders and practitioners addressing the complex challenges of disaster risk reduction and resilience building in today s uncertain world Covering diverse topics including disaster preparedness response systems climate induced risks and community resilience this compilation provides actionable insights and scientific advancements that are vital for policymakers emergency professionals urban planners and academic researchers alike

UAV or Drones for Remote Sensing Applications Felipe Gonzalez Toro,Antonios Tsourdos,2018-11-23 This book is a printed edition of the Special Issue UAV or Drones for Remote Sensing Applications that was published in Sensors

Nanotechnology-Based Smart Remote Sensing Networks for Disaster Prevention Adil Denizli,Marcelo S. Alencar,Tuan Anh Nguyen,David Motaung,2022-05-29 Nanotechnology Based Smart Remote Sensing Networks for Disaster Prevention outlines how nanotechnology and space technology could be applied for the detection of disaster risks in early stages using cheap sensors cheap constellations of low Earth orbit LEO satellites and smart wireless networks with artificial intelligence AI tools Nanomaterial based sensors nanosensors can offer several

advantages over their micro counterparts such as lower power or self powered consumption high sensitivity lower concentration of analytes and smaller interaction distances between the object and the sensor Besides this with the support of AI tools such as fuzzy logic genetic algorithms neural networks and ambient intelligence sensor systems are becoming smarter when a large number of sensors are used This book is an important reference source for materials scientists engineers and environmental scientists who are seeking to understand how nanotechnology based solutions can help mitigate natural disasters Shows how nanotechnology based solutions can be combined with space technology to provide more effective disaster management solutions Explores the best materials for manufacturing different types of nanotechnology based remote sensing devices Assesses the challenges of creating a nanotechnology based disaster mitigation system in a cost effective way *Landslides: Detection, Prediction and Monitoring* P. Thambidurai, T. N. Singh, 2023-03-02 This book intends to decipher the knowledge in the advancement of understanding detecting predicting and monitoring landslides The number of massive landslides and the damages they cause has increased across the globe in recent times It is one of the most devastating natural hazards that cause widespread damage to habitat on a local regional and global scale International experts provide their experience in landslide research and practice to help stakeholders mitigate and predict potential landslides The book comprises chapters on Dynamics mechanisms and processes of landslides Geological geotechnical hydrological and geophysical modelling for landslides Mapping and assessment of hazard vulnerability and risk associated with landslides Monitoring and early warning of landslides Application of remote sensing and GIS techniques in monitoring and assessment of landslides The book will be of interest to researchers practitioners and decision makers in adapting suitable modern techniques for landslide study *Innovations and Developments in Unmanned Aerial Vehicles* Mellal, Mohamed Arezk, 2025-04-09 Unmanned Aerial Vehicles UAVs are transforming industries by enhancing efficiency safety and accessibility in sectors such as agriculture logistics defense and disaster response Innovations in UAV design propulsion and autonomy are driving new possibilities from precision farming and infrastructure inspection to environmental monitoring and emergency aid delivery As these technologies evolve they are reshaping how businesses operate improving data collection and enabling cost effective solutions in previously inaccessible areas Understanding the latest advancements in UAVs is crucial for harnessing their full potential and addressing regulatory ethical and technical challenges in their widespread adoption *Innovations and Developments in Unmanned Aerial Vehicles* offers a comprehensive exploration of the latest developments and emerging trends in the field of UAV technology From advancements in design and propulsion systems to breakthroughs in autonomy and applications this book provides an in depth analysis of the rapidly evolving UAV landscape Covering topics such as fault detections aerodynamic principles and control optimization this book is an excellent resource for engineers technologists industry stakeholders policymakers industry leaders manufacturers professionals researchers scholars academicians and more Proceedings of UASG 2021:

Wings 4 Sustainability Kamal Jain, Vishal Mishra, Biswajeet Pradhan, 2023-03-15 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 2nd International Conference on Unmanned Aerial System in Geomatics UASG held in Roorkee India on April 2 4 2021 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

Drone Technology Sachi Nandan Mohanty, J. V. R. Ravindra, G. Surya Narayana, Chinmaya Ranjan Pattnaik, Y. Mohamed Sirajudeen, 2023-05-15 DRONE TECHNOLOGY This book provides a holistic and valuable insight into the revolutionary world of unmanned aerial vehicles UAV The book elucidates the revolutionary and riveting research in the ultramodern domain of drone technologies drone enabled IoT applications and artificial intelligence based smart surveillance The book explains the most recent developments in the field challenges and future scope of drone technologies Beyond that it discusses the importance of a wide range of design applications drone UAV development and drone enabled smart healthcare systems for smart cities It describes pioneering work on mitigating cyber security threats by employing intelligent machine learning models in the designing of IoT aided drones The book also has a fascinating chapter on application intrusion detection by drones using recurrent neural networks Other chapters address interdisciplinary fields like artificial intelligence deep learning the role of drones in healthcare in smart cities and the importance of drone technology in agriculture Audience The book will be read and consulted by a range of industry engineers involved with introducing drone technology to their daily operations

Nonlinear Control of Fixed-Wing UAVs with Time-Varying and Unstructured Uncertainties Michail G. Michailidis, Kimon P. Valavanis, Matthew J. Rutherford, 2020-02-21 This book introduces a comprehensive and mathematically rigorous controller design for families of nonlinear systems with time varying parameters and unstructured uncertainties Although the presented methodology is general the specific family of systems considered is the latest NextGen unconventional fixed wing unmanned aircraft with circulation control or morphing wings or a combination of both The approach considers various sources of model and parameter uncertainty while the controller design depends not on a nominal plant model but instead on a family of admissible plants In contrast to existing controller designs that consider multiple models and multiple controllers the proposed approach is based on the one controller fits all models within the unstructured uncertainty interval The book presents a modeling based analysis and synthesis approach with additive uncertainty weighting functions for accurate realization of the candidate systems This differs significantly from existing designs in that it is capable of handling time varying characteristics This research monograph is suitable for scientists engineers researchers and graduate students with

a background in control system theory who are interested in complex engineering nonlinear systems **Unmanned Aerial Vehicles for Internet of Things (IoT)** Vandana Mohindru, Yashwant Singh, Ravindara Bhatt, Anuj Kumar Gupta, 2021-08-03

UNMANNED AERIAL VEHICLES FOR INTERNET OF THINGS This comprehensive book deeply discusses the theoretical and technical issues of unmanned aerial vehicles for deployment by industries and civil authorities in Internet of Things IoT systems Unmanned aerial vehicles UAVs has become one of the rapidly growing areas of technology with widespread applications covering various domains UAVs play a very important role in delivering Internet of Things IoT services in small and low power devices such as sensors cameras GPS receivers etc These devices are energy constrained and are unable to communicate over long distances The UAVs work dynamically for IoT applications in which they collect data and transmit it to other devices that are out of communication range Furthermore the benefits of the UAV include deployment at remote locations the ability to carry flexible payloads reprogrammability during tasks and the ability to sense for anything from anywhere Using IoT technologies a UAV may be observed as a terminal device connected with the ubiquitous network where many other UAVs are communicating navigating controlling and surveilling in real time and beyond line of sight The aim of the 15 chapters in this book help to realize the full potential of UAVs for the IoT by addressing its numerous concepts issues and challenges and develops conceptual and technological solutions for handling them Applications include such fields as disaster management structural inspection goods delivery transportation localization mapping pollution and radiation monitoring search and rescue farming etc In addition the book covers Efficient energy management systems in UAV based IoT networks IoE enabled UAVs Mind controlled UAV using Brain Computer Interface BCI The importance of AI in realizing autonomous and intelligent flying IoT Blockchain based solutions for various security issues in UAV enabled IoT The challenges and threats of UAVs such as hijacking privacy cyber security and physical safety Audience Researchers in computer science Internet of Things IoT electronics engineering as well as industries that use and deploy drones and other unmanned aerial vehicles *Unmanned Aerial Vehicles: Breakthroughs in Research and Practice* Management Association, Information Resources, 2019-05-03 First used in military applications unmanned aerial vehicles are becoming an integral aspect of modern society and are expanding into the commercial scientific recreational agricultural and surveillance sectors With the increasing use of these drones by government officials business professionals and civilians more research is needed to understand their complexity both in design and function Unmanned Aerial Vehicles Breakthroughs in Research and Practice is a critical source of academic knowledge on the design construction and maintenance of drones as well as their applications across all aspects of society Highlighting a range of pertinent topics such as intelligent systems artificial intelligence and situation awareness this publication is an ideal reference source for military consultants military personnel business professionals operation managers surveillance companies agriculturalists policymakers government officials law enforcement IT professionals academicians researchers and graduate level students **Pattern Recognition. ICPR**

International Workshops and Challenges Alberto Del Bimbo, Rita Cucchiara, Stan Sclaroff, Giovanni Maria Farinella, Tao Mei, Marco Bertini, Hugo Jair Escalante, Roberto Vezzani, 2021-02-24 This 8 volumes set constitutes the refereed of the 25th International Conference on Pattern Recognition Workshops ICPR 2020 held virtually in Milan Italy and rescheduled to January 10 11 2021 due to Covid 19 pandemic The 416 full papers presented in these 8 volumes were carefully reviewed and selected from about 700 submissions The 46 workshops cover a wide range of areas including machine learning pattern analysis healthcare human behavior environment surveillance forensics and biometrics robotics and egovision cultural heritage and document analysis retrieval and women at ICPR2020

Drone Applications for Industry 5.0 Singh, Chandra, Gatti, Rathishchandra Ramachandra, 2024-06-24 The fusion of drones and Industry 5 0 has emerged as a transformative force redefining the landscape of industrial progress Drone Applications for Industry 5 0 reveals the strong connection between drones and Industry 5 0 exploring how they come together to blend human skills with automated precision As we stand on the horizon of the fifth industrial revolution Industry 5 0 uniquely celebrates the return of the human touch harmonizing the strengths of machines with human intuition and empathy Drones play a pivotal role in shaping this evolutionary transition The narrative unfolds against the backdrop of historical industrial revolutions each marked by radical transformations Unlike its predecessors Industry 5 0 places humans at the center emphasizing collaboration with machines Drones have matured into invaluable instruments with applications spanning manufacturing agriculture transportation and emergency services Drone Applications for Industry 5 0 embarks on a journey guiding scholars researchers and students through the foundations of Industry 5 0 and the mechanics of drones It explores practical uses in various fields offering both theory and practical insights which empowers professionals to fully utilize drones

The Distributed Functions of Emergency Management and Homeland Security David A. McEntire, 2023-07-19 The Distributed Functions of Emergency Management and Homeland Security outlines the roles and responsibilities of various individuals and agencies involved in homeland security and all aspects of emergency management Each chapter focuses on the practical and applied aspects of a range of public servants in various departments and the organizations that they represent Rather than presenting a theoretical exploration alone the book examines the practical knowledge and hands on skills related to various functions and how their decisions and actions play into the larger framework of safety and security in the public private and nonprofit sectors Every professional has a unique and integral part to play in fulfilling their roles and obligations whether it be in relation to prevention mitigation preparedness response or recovery operations Personnel that frequently come to mind in such scenarios include emergency managers geographers and land use planners EMTs and paramedics fire fighters police officers public health officials nurses public administrators and public information officers And while these individuals are integral to homeland security and emergency management there are other professionals that also perform essential duties that while they aren't first to mind are vital to efforts relating to terrorism and disasters this includes pilots

in the aviation sector the military attorneys psychologists and forensic professionals serving in pathology DNA and dentistry roles Chapters provide a holistic rendering of the homeland security and emergency management landscape to present all these various professional capabilities and contributions This includes how current functions are coordinated as well as how future efforts might change relative to a more proactive all hazards and holistic approach As such the book will be a useful resource for students and practitioners to understand the dynamic professions and various disciplines and fields that impact disaster and terrorism preparedness and response capabilities

AI, Cybersecurity and Data Science for Drone and Unmanned Aerial Vehicles Shishir Kumar Shandilya, Fernando Ortiz-Rodriguez, Smita Shandilya, Gerardo

Romero, 2025-09-09 This book explores the transformative impact of drone technology and unmanned aerial systems UAS across diverse industries from precision agriculture and logistics to disaster response and forensic investigations It highlights how the integration of Artificial Intelligence AI into UAVs is addressing contemporary challenges optimizing operations and shaping the future of aerial systems It offers technical methodologies case studies and a detailed roadmap for integrated drone forensics making it an essential resource for understanding the dynamic sector of Intelligent Aerial Systems Examines the integration of AI in drones and UAS enhancing operational efficiency and investigative processes Covers the evolving landscape of drone technology including swarms autonomous systems and forensic methodologies Focuses on specific sectors such as agriculture logistics and disaster response offering practical insights real life examples and future scenarios Explores the role of drones in delivery and logistics transforming transportation systems by improving efficiency and reducing costs Explains the use of drones for public safety smart city disaster response and forensic investigations providing critical insights for emergency operations This reference book serves as a comprehensive guide for professionals researchers and scholars interested in the rapidly advancing world of drone technology

Intelligent Electrical Systems: Satyajit

Chakrabarti, Ayan Kumar Panja, Amartya Mukherjee, Arun Kr. Bar, 2021-04-15 The conference aims to provide a premier platform for Engineers researchers scientists and academicians to present their work in the emerging areas such as Renewable Energy Energy storage Power Electronics drives Smart devices and communication systems Artificial Intelligence Robotics Networks an IoT Control and automation etc

Disaster Monitoring And Management By The Unmanned Aerial: Bestsellers in 2023 The year 2023 has witnessed a remarkable surge in literary brilliance, with numerous captivating novels captivating the hearts of readers worldwide. Lets delve into the realm of bestselling books, exploring the fascinating narratives that have enthralled audiences this year. The Must-Read : Colleen Hoover's "It Ends with Us" This heartfelt tale of love, loss, and resilience has gripped readers with its raw and emotional exploration of domestic abuse. Hoover expertly weaves a story of hope and healing, reminding us that even in the darkest of times, the human spirit can prevail. Uncover the Best : Taylor Jenkins Reid's "The Seven Husbands of Evelyn Hugo" This intriguing historical fiction novel unravels the life of Evelyn Hugo, a Hollywood icon who defies expectations and societal norms to pursue her dreams. Reid's captivating storytelling and compelling characters transport readers to a bygone era, immersing them in a world of glamour, ambition, and self-discovery. Disaster Monitoring And Management By The Unmanned Aerial : Delia Owens' "Where the Crawdads Sing" This captivating coming-of-age story follows Kya Clark, a young woman who grows up alone in the marshes of North Carolina. Owens spins a tale of resilience, survival, and the transformative power of nature, captivating readers with its evocative prose and mesmerizing setting. These bestselling novels represent just a fraction of the literary treasures that have emerged in 2023. Whether you seek tales of romance, adventure, or personal growth, the world of literature offers an abundance of captivating stories waiting to be discovered. The novel begins with Richard Papen, a bright but troubled young man, arriving at Hampden College. Richard is immediately drawn to the group of students who call themselves the Classics Club. The club is led by Henry Winter, a brilliant and charismatic young man. Henry is obsessed with Greek mythology and philosophy, and he quickly draws Richard into his world. The other members of the Classics Club are equally as fascinating. Bunny Corcoran is a wealthy and spoiled young man who is always looking for a good time. Charles Tavis is a quiet and reserved young man who is deeply in love with Henry. Camilla Macaulay is a beautiful and intelligent young woman who is drawn to the power and danger of the Classics Club. The students are all deeply in love with Morrow, and they are willing to do anything to please him. Morrow is a complex and mysterious figure, and he seems to be manipulating the students for his own purposes. As the students become more involved with Morrow, they begin to commit increasingly dangerous acts. The Secret History is a brilliant and thrilling novel that will keep you wondering until the very end. The novel is a warning tale about the dangers of obsession and the power of evil.

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