



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

Qin Zhang^a, Zhengwei Bai^a , Guanwen Huang^{a,b}, Jiaxu Kong^a, Yuan Du^a, Duo Wang^{a,c}, Ce Jing^a and Wei Xie^a

^aCollege of Geological Engineering and Geomatics, Chang'an University, Xi'an, China; ^bKey Laboratory of Ecological Geology and Disaster Prevention, Ministry of Natural Resources, Xi'an, China; ^cDepartment of Geomatics Engineering, University of Calgary, Calgary, Canada

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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Global navigation satellite system; landslide; real-time monitoring; unmanned deployment; unmanned aerial vehicle

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 *AI and IoT for Proactive Disaster Management* Ouaisa, Mariyam,Ouaisa, Mariya,Boulouard, Zakaria,Iwendi, Celestine,Krichen, Moez,2024-05-06 In our rapidly evolving digital landscape the threat of natural disasters looms large necessitating innovative solutions for effective disaster management Integrating Artificial Intelligence AI and the Internet of Things IoT presents a transformative approach to addressing these challenges However despite the potential benefits the field needs more comprehensive resources that explore the full extent of AI and IoT applications in disaster management AI and IoT for Proactive Disaster Management fills that gap by examining how AI and IoT can revolutionize disaster preparedness response and recovery It offers a deep dive into AI frameworks IoT infrastructures and the synergy of these technologies in predicting and managing natural disasters Ideal for undergraduate and postgraduate students academicians research scholars industry professionals and technology enthusiasts this book serves as a comprehensive guide to understanding the intersection of AI IoT and disaster management By showcasing cutting edge research and practical applications this book equips readers with the knowledge and tools to harness AI and IoT for more efficient and effective disaster management strategies *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

Internet of Things and AI for Natural Disaster Management and Prediction

Satishkumar, D.,Sivaraja, M.,2024-03-07 In a world where natural disasters wreak havoc with increasing frequency and severity the need for accurate prediction and effective management has never been more critical From earthquakes shattering communities to floods submerging vast regions these events endanger lives and strain resources and infrastructure to their limits Yet amidst this turmoil traditional forecasting methods often need to catch up leaving us vulnerable and reactive rather than proactive This comprehensive academic collection provides a beacon of hope in uncertain circumstances Internet of Things and AI for Natural Disaster Management and Prediction By bridging the gap between theory and practice this book empowers academics policymakers and practitioners alike to harness the full potential of machine learning in safeguarding lives and livelihoods

Unmanned Aerial Vehicles in Civilian Logistics and Supply Chain Management

Kille, Tarryn,Bates, Paul R.,Lee, Seung Yong,2019-05-31 Many industries have begun to recognize the potential support that unmanned aerial vehicles UAVs offer and this is no less true for the commercial sector Current research on this field is narrowly focused on technological development to improve the functionality of delivery and endurance of the drone delivery in logistics as well as on regulatory challenges posed by such operations There is a need for further attention to be applied to operational and integration challenges associated with UAVs Unmanned Aerial Vehicles in Civilian Logistics and Supply Chain Management is a collection of innovative research that investigates the opportunities and challenges for the use of UAVs in logistics and supply chain management with a specific aim to focus on the multifaceted impact of drone delivery While highlighting topics including non military operations public management and safety culture this book is ideally designed for government administrators managers industry professionals researchers and 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 *Bio-Inspired Computing* Anu Bajaj,Ajith Abraham,K. Reddy Madhavi,Dalia Kriksciuniene,2025-05-28 This book presents 53 selected papers focused on Machine Learning and Applications from the 14th International Conference on Innovations in Bio Inspired Computing and Applications IBICA 2023 and 13th World Congress on Information and Communication Technologies WICT 2023 which was held in five different cities namely Olten Switzerland Porto Portugal Kaunas Lithuania Greater Noida India Kochi India and in online mode IBICA WICT 2023 had contributions by authors from 36 countries This book offers a valuable reference guide for all scientists academicians researchers students and practitioners focused on real world applications of modern ICT and bio inspired computing **Advancing Disaster Management Through Federated Learning** C Kishor Kumar Reddy,Anindya Nag,2025-01-30 Effective disaster management in an age of more frequent and devastating calamities requires creative solutions This book explores the revolutionary possibilities of Federated Learning FL in crisis management providing an all inclusive manual that connects theory with practice Learn how FL can change the game for disaster response and recovery decision making resource allocation predictive modeling and information sharing Readers in the fields of emergency response governance research and technology will find this book s wealth of real world case studies and examples to be an important resource It shows how FL improves catastrophe readiness and response by letting strong models be built while data privacy is maintained across decentralized sources With a comprehensive roadmap that includes enhancing early warning systems optimizing resource distribution and integrating cutting edge technologies like IoT blockchain and advanced AI this book provides a clear explanation of how to use FL to protect communities infrastructure and lives during disasters Intelligent Electrical Systems: Satyajit Chakrabarti,Ayan Kumar Panja,Amartya Mukherjee,Arun Kr. Bar,2021-01-10 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 *Road to a More Intelligent World* Pengfei Sun,2025-05-31 This book provides an in depth look at the current development of the fifth generation mobile communication technology 5G and artificial intelligence AI their technological advantages application and critical role in science and technology as well as their future development trends This book is divided into three parts The first part details the current development of 5G around the globe and the evolution from 5G to 5.5G The second part explores the significant developments in AI technologies including typical AI technologies such as machine learning ML natural language processing NLP and computer vision CV and the popular foundation model technologies The

third part looks at the impacts of 5G AI on the digitalization and intelligent development of industries and showcases some of the applications in government meteorology education and healthcare etc This book can serve as a reference for a diverse range of readers such as people in the public sector and the mobile communications industry and faculty and students in this field

Integrating Disaster Science and Management Pijush Samui,Dookie Kim,Chandan Ghosh,2018-05-04 Integrated Disaster Science and Management Global Case Studies in Mitigation and Recovery bridges the gap between scientific research on natural disasters and the practice of disaster management It examines natural hazards including earthquakes landslides and tsunamis and uses integrated disaster management techniques quantitative methods and big data analytics to create early warning models to mitigate impacts of these hazards and reduce the risk of disaster It also looks at mitigation as part of the recovery process after a disaster as in the case of the Nepal earthquake Edited by global experts in disaster management and engineering the book offers case studies that focus on the critical phases of disaster management Identifies advanced techniques and models based on natural disaster science for forecasting disasters and analyzing risk Offers a holistic approach to the problem of disaster management including preparation recovery and resilience Includes coverage of social economic and environmental impacts on disasters

Drones for Transportation Logistics and Disaster Management A. Prasanth,Rajesh Kumar Dhanaraj,Munish Sabharwal,Vandana Sharma,Seifedine Kadry,2025-10-29 Explore the future of logistics and disaster management with this essential guide to the design applications and challenges of integrating advanced drone technology into intelligent transportation systems Drones are quickly becoming an essential technology for navigating inaccessible areas especially during emergency situations However the implementation of these drones requires strict standards policies and procedures Currently drones are being used in several industrial and service sectors extending the possibilities of handling transportation and logistics The future of transportation is based on unmanned vehicles and it is important to identify their challenges and futuristic applications Drones for Transportation Logistics and Disaster Management introduces the essential aspects of the technological advancement of drones the challenges faced in current practices and their advanced applications The book describes future intelligent and resilient transportation systems backed by the Internet of Vehicle Things the problems of big data analytics and optimization techniques for in house supply chain management Using a global multi sector perspective this volume will comprehensively cover essential components of drone systems including their modeling design and maintenance making it an essential guide for anyone looking to the future of disaster management

Artificial Intelligence in Remote Sensing for Disaster Management Neelam Dahiya,Gurwinder Singh,Sartajvir Singh,Apoorva Sharma,2025-07-09 Invest in Artificial Intelligence in Remote Sensing for Disaster Management to gain invaluable insights into cutting edge AI technologies and their transformative role in effectively monitoring and managing natural disasters Artificial Intelligence in Remote Sensing for Disaster Management examines the involvement of advanced tools and technologies such as Artificial Intelligence in disaster management with remote sensing

Remote sensing offers cost effective quick assessments and responses to natural disasters In the past few years many advances have been made in the monitoring and mapping of natural disasters with the integration of AI in remote sensing This volume focuses on AI driven observations of various natural disasters including landslides snow avalanches flash floods glacial lake outburst floods and earthquakes There is currently a need for sustainable development near real time monitoring forecasting prediction and management of natural resources flash floods sea ice melt cyclones forestry and climate changes This book will provide essential guidance regarding AI driven algorithms specifically developed for disaster management to meet the requirements of emerging applications **Handbook for Management of Threats** Konstantinos P.

Balomenos, Antonios Fytopoulos, Panos M. Pardalos, 2023-12-26 In answer to the unprecedented challenges and threats that face today's globalized world the primary goal of this Handbook is to identify the most probable threats that have affected humanity in recent years and our world in years to come The Handbook comprises mostly expository chapters that discuss tested methods algorithms case studies as well as policy decision making techniques surrounding threats and unnatural disasters to evaluate their effects on people and to propose ways to mitigate these effects In several chapters new approaches and suggested policies supplement algorithms that are already in practice The curated content brings together key experts from the academic and policy worlds to formulate a guide of principal techniques employed to gain better control over selected types of threats This Handbook explores a wide range of technologies and theories and their impact on countering threats These include artificial intelligence machine learning variational inequality theory game theory data envelopment analysis and data driven risk analysis These tools play a vital role in decision making processes and aid in finding optimal solutions Additionally a variety of optimization techniques are employed These include mixed integer linear programming models for identifying critical nodes in complex systems heuristics approximation algorithms and bilevel mixed integer programming for determining the most impactful links in dynamic networks Furthermore simulation tools are described that enable the quantification of societal resilience These techniques collectively provide a mathematical framework capable of quantifying fundamental aspects of threats They equip policymakers with the necessary tools and knowledge to minimize the impact of unnatural threats The expected readership is wide and includes officials working in technical and policy roles in various ministries such as the Ministry of Defense Civil Protection Ministry of Public Order and Citizen Protection United Nations European Institutions for Threat Management NATO Intelligence Agencies Centers of Excellence for Countering Threats Think Tanks Centers for Policy Studies Political Leaders the European Commission National Institutes International Organizations Strategic Consulting Experts Policymakers and Foreign Affairs personnel Some of these national or international organizations employ algorithms to measure resilience and enhance security Quantification is challenging but crucial in the scenarios discussed in the book This Handbook will also prove valuable to various universities non practitioners studying systems engineering leadership management strategy foreign affairs politics

and related disciplines Chapter Risk Assessment and Identification Methodology for the Defense Industry in Times of Crisis Decision Making is available open access under a Creative Commons Attribution 4.0 International License via Springerlink

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 **Inaugural Section Special Issue** Deodato Tapete, 2021-02-22 This book collects selected high quality papers published in 2018-2020 to inaugurate the Natural Hazards Section of the Geosciences journal The topics encompass trends in publications at international level in the field of natural hazards research the role of Big Data in natural disaster management assessment of seismic risk through the understanding and quantification of its different components climatic hydro meteorological hazards and finally the scientific analysis and disaster forensics of recent natural hazard events The target audience includes not only specialists but also graduate students who wish to approach the challenging but also fascinating

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