

# **20th International Conference on Ground Penetrating Radar 2024**

Journal of Physics: Conference Series Volume 2887

Online  
23-27 June 2024

ISBN: 979-8-3313-1023-3  
ISSN: 1742-6588

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

This work is licensed under a Creative Commons Attribution 3.0 International Licence.  
Licence details: <http://creativecommons.org/licenses/by/3.0/>.

No changes have been made to the content of these proceedings. There may be changes to pagination and minor adjustments for aesthetics.

Printed with permission by Curran Associates, Inc. (2025)

For permission requests, please contact the Institute of Physics  
at the address below.

Institute of Physics  
Dirac House, Temple Back  
Bristol BS1 6BE UK

Phone: 44 1 17 929 7481  
Fax: 44 1 17 920 0979

[techtracking@iop.org](mailto:techtracking@iop.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

Preface	
Peer Review Statement	
Tunnel Quality Inspection Based on GPR and Machine Learning .....	1
<i>Shan Shan Huang, Jun Chao Wang, Dan Dan Cheng, Hong Yan Geng, Li Yong Zhang, Yu Qi Yao, Pei Wen Yao</i>	
Monitoring Technology of Urban Underground Space Infrastructure Structure Based on Fully Polarized Ground Penetrating Radar .....	6
<i>Yue Yu, Xuan Feng, Zejun Dong, Enhedelihai Alex Nilot</i>	
A Compact Ultra-Wideband Circular Bowtie Antenna for Ground Penetrating Radar .....	12
<i>Shenzhao Lv, Chunlin Huang, Xiaoji Song, Zhihua He, Tao Liu</i>	
Enhancing GPR-Based Tunnel Lining Delamination Detection: An Unsupervised Domain-Adaptive YOLO Network .....	19
<i>Yuanzheng Wang, Hui Qin, Jinbo Liu, Youjian Chen, Lipeng Wang, Hongyong Ren, Xianbiao Meng, Wenjiang Luo, Lei Gao</i>	
Three-Dimensional Random Medium Modelling for GPR Based on Soil Fractals.....	23
<i>Shilong Guo, Qi Lu, Sixin Liu, Wenjing Liang, Kexin Liu</i>	
Effects of Measuring Angles on Detection of Millimeter-Scale Fractures with Fluid Flow Using Full-Polarimetric GPR.....	29
<i>Zejun Dong, Xuan Feng, Haoqiu Zhou, Cai Liu</i>	
CNN Based Approach for Root Zone Soil Moisture Prediction by Ground Penetrating Radar .....	36
<i>Kexin Liu, Qi Lu, Shilong Guo, Wenjing Liang</i>	
Investigating the Variation of Iron-Titanium Content in Lunar Farside Regolith Along the Route of the Yutu-2 Rover with Lunar Penetrating Radar.....	41
<i>Huaqing Cao, Jing Li, Chang Zhang</i>	
Study on Wavefield Characteristics of Irregular Cavity Boundaries Based on GPR.....	45
<i>Jianyu Ling, Rongyi Qian</i>	
Deep Learning-Based Cross-Hole GPR Travel Time Tomography.....	49
<i>H Cheng, S F Hu, Y H Zhao</i>	
Ground Penetrating Radar Urban Road Underground Target Classification Algorithm Using Sequential Spectral and Time-Domain Features.....	53
<i>F R Li, W X Shi, F Yang, M X Xu, L Fang, Y J Fang, Y L Wen</i>	
A New 3D Mapping Method of Buried Pipelines from GPR B-Scans .....	59
<i>Y Li, X T Xiao, L Ge</i>	
Design of Dual-Channel Ground Penetrating Radar on Tianwen-2 Mission.....	63
<i>Shuanlao Li, Ruidong Liu', Shi Zheng, Yinguang He, Xiaoqiang Zhang, Hongxing Dang, Xiaomin Tan, Peng Liu</i>	
Study on Detection and Estimation Method of PCCP Filament Breaking .....	67
<i>Ya Li Ren, Jian Le Zhao, Shan Shan Huang, Xue Chao Sun, Yi Liu</i>	

Detection Method for Asteroid Interior Structure Verified by Scale Model .....	74
<i>Zheng Shi, Chen Gang, Li Shuanlao, Liu Tao, Dai Shun, Liu Ruidong, Dang Hongxing</i>	
GPR Image Retrieval and Localization Based on Spatial Prior Constraints .....	79
<i>Beizhen Bi, Yuwei Chen, Liang Shen, Pengyu Zhang, Xiaotao Huang, Tian Jin</i>	
Enhanced Scoring Instance Segmentation Network for Subsurface Targets Recognition from GPR B-Scans.....	83
<i>Feifei Hou, Xue Yin, Hai Liu, Boxuan Qiao</i>	
Simulation Analysis of Ground-Penetrating Radar in Seasonal Freezing Soil Area with Temperature-Varying Media.....	87
<i>Guojiang Lu, Qinghua Chen, Xianwu Zhang</i>	
Probing Multilayer Road Structures Using the GPR “Terrazond” .....	91
<i>Ilya Tseplyaev, Sergey Shipilov, Ivan Fedyanin, Vitaly Khmelev, Rail Satarov, Dmitry Romanov, Roman Eremin</i>	
A Holographic Subsurface Imaging Radar with High Plane Resolution: Principle and Application .....	97
<i>He Zhihua, Liu Tao, Song Xiaoji, Chen Cheng, Jin Guanghu, Huang Chunlin, Su Yi</i>	
Unmanned Unexploded Ordnance Detection System Based on Magnetic Method.....	107
<i>Y L Xu, Y J Zhou, K Ding, R Q Lv, M W Wu, Z Wang</i>	
Advancements and Applications of GMS3: A Surface and Subsurface Unified Database System .....	111
<i>J M S Rodrigues Neto, J Shinohara, Y Kato, K Tanida, A Okino, T Sato</i>	
Research on the Application of 3D GPR in the Detection of Road Collapse Diseases in Loess Region of Ningxia .....	115
<i>Zhaotao Yan, Zhaofa Zeng, Baizhou An, Jiayu Lu, Boyang Sun</i>	
Three-Dimensional Reverse Time Migration for Detecting Tree Trunk Defects Using Ground Penetrating Radar .....	120
<i>Y Liu, D Feng, X Wang</i>	
A GPR Layered Media Parameters Inversion Method Under Rough Surface.....	124
<i>S Zhao, X Yang, L Liao, T Lan</i>	
3D GPR Detection and Case Analysis of Collapse Hazards for an International Airport Runway .....	128
<i>Q F Hu, Z H Zhang, F Wang, H Liu, Z Su</i>	
Research on Ground Penetrating Radar and Muon Detection Method in Xixia Mausoleum .....	133
<i>Jiayu Lu, Baizhou An, Yadong Bai, Zhaofa Zeng, Xiufen Ren, Shuai Zhou, Boyang Sun, Zhaotao Yan</i>	
Deviation Aware Mask for Localizing Ground Penetrating Radar Data Alignment.....	137
<i>Pengyu Zhang, Yuwei Chen, Liang Shen, Beizhen Bi, Tian Jin, Xiaotao Huang</i>	
Modeling and Calculation of Ground Penetrating Radar Detection on Rough Interface of Soil Media.....	141
<i>Jia Yi Zhu, Ying Liu, Yao Yao Liu, Chen Wang, Ya Jing Li</i>	
Realistic Method for Numerical Characterization of GPR Responses of Cracked Drainage Pipelines in Loose-Soil Areas .....	145
<i>Weihuang Shi, Tess Luo</i>	

Adaptive Variational Mode Decomposition Denoising Scheme for Ground Penetrating Radar Data.....	149
<i>Ding Yang, Raffaele Persico, Cheng Guo, Yajie Liu, Jiamin Yang, Handing Liu, Changjin Bai, Qing Zhao</i>	
Signal Fusion of Multi-Frequency Continuous Wave Ground Penetrating Radar .....	153
<i>Jianping Xiao, Zhijing Liu, Rui Qu, Lanbo Liu</i>	
Detection of Termite Nests in Dams Using Ground Penetrating Radar Based on Deep Learning .....	159
<i>Jiao Peng, Wei Xue, Wenkai Wang, Junlei Song, Feng Zhou, Pengchun Huang, Zhixuan Zhang, Feng Zhang, Xu Zhang, Longjia Chen, Li Sun</i>	
Spatiotemporal Localization of GPR Sequence Images with 3DResNet18.....	163
<i>Yuchen Hu, Pengyu Zhang, Beizhen Bi, Yuwei Chen, Qin Xin, Xiaotao Huang</i>	
Denoising Method of Microwave Earth Exploration Test System Based on Deep-KSVD .....	167
<i>Chen Feiyu, Han Shunli, Zhang Wenzheng, Gao Tianfeng, Hao Zeyu, Li Wanrong</i>	
Comparative Analysis of the Application of Different GPR Devices in the Concealed Karst Detection of Railway Slopes .....	171
<i>Zhou Chao, Jin Junjun, Zhao Siwei</i>	
Experiment on Measuring Lake Ice Thickness Using a SFCW Ground Penetrating Radar System .....	175
<i>Hongxing Zheng, Chunlin Huang, Zhihua He, Tao Liu, Xiaoji Song</i>	
Ground-Penetrating Radar Dual-Parameter Full Waveform Inversion Based on Finite Domain Method .....	181
<i>B Li, Z Fang, D Feng, X Wang</i>	
Preliminary Results of the Interior Features Inferred from Radargrams, Ulanhada Volcano, Inner Mongolia, China .....	185
<i>S Dai, Y Su, C Y Ding, X P Xue, C Li, X Y Zhu</i>	
Design of a Linear Array Holographic Subsurface Radar System.....	190
<i>Wei Liu, Zhihua He, Tao Liu, Xiaoji Song</i>	
An Identification Method of Bonding State in ETIS Based on GPR.....	196
<i>C Wang, J Wang, M Liu, X Li, J Gong, X Yang, T Lan</i>	
Application of Ground-Penetrating Radar Based on U-Net in the Statistics on the Bonded Area of External Wall Insulation .....	201
<i>J Wang, Y Li, Z Jiang, M Liu, J Gong, X Yang, T Lan</i>	
A Compact Air-Coupled SFCW Ground Penetrating Radar and Its Application in the Earthen Sites.....	205
<i>Shengbo Ye, Xu Li, Xinhui Li, Xiaojun Liu, Guangyou Fang, Hejun Jiang, Rongqi Lyu</i>	
A Ground Penetrating Radar Array Antenna Designed for Small Targets Detection.....	209
<i>Xinghua Shi, Shaolong Li, Yuemeng Yin, Zhao Zhang</i>	
Image Enhancement Algorithm for Ground Penetrating Radar Based on Nonlinear Technology.....	216
<i>Guo Xian Wu, Ying Liu</i>	
Application of Ground Penetrating Radar in Rapid and Non Destructive Detection of Urban Tunnels .....	221
<i>Beiqiang Zhao, Zhihua He, Tao Liu, Xiaoji Song, Hongxing Zheng</i>	

Numerical Parametric Study for Ballast Assessment Using SVM Applied to GPR Data.....	226
<i>Ernest Mubia T, David Guilbert, Jérôme Tissier, Antoine Martin, Théo Dezert, Yannick Fargier, Amine Ihamouten</i>	
Calculation of the Reflected Wave from an Inclined Conducting Cylinder for the Array-Type Singlehole Borehole Radar.....	230
<i>S Ebihara, R Tsukuda, S Yamanaka</i>	
Adding the Outer Pipe to a Thin Borehole Radar Probe in a Thick Water-Filled Borehole in Rock to Reduce Direct Coupling .....	234
<i>S Ebihara, R Masui, K Koyama, Y Tsujikawa, Y Nishida</i>	
Russian RES and GPR Research in Antarctica.....	238
<i>S V Popov</i>	
Characterization of GPR Radiation Pattern in the Upper and Lower Hemisphere (theory and Experiment).....	242
<i>P Morozov, I Prokopovich, M Lazarev, A Popov, V Sakhterov, D Edemsky</i>	
A Comprehensive Detection and Evaluation Method for the Internal Health Status of Highways .....	246
<i>W Y Feng, D D Cheng, C H Wang, X Cheng, Y J Yin, H Y Geng</i>	
An Intelligent Power Management System Design of Ground Penetrating Radar .....	250
<i>Hongyan Geng, Yijun Geng, Huiying Che, Qiuyuan Chen, Shanshan Huang, Minggang Ding, Yun Liu</i>	
Accurate Real-Time ANN Classification of Cavities and Utilities Using 3D GPR Data in the MFCC Domain.....	254
<i>J N Ogunbo, S H Baek, S W Kim</i>	
The GPR and ERT Detection for Road Hazard in Loess Region .....	258
<i>Jiahe Yan, Zhaofa Zeng, Baizhou An, Boyang Sun, Zhilian Li, Haoyu Wang, Jianwei Zhao</i>	
GPR Circumferential Survey Line Radius's Effect on Shield Machine Tunnel Look-Ahead Detection .....	262
<i>W Duan, X Xie, T Zhu, Y Yang, H Wu, Y Pei</i>	
A Study on the Characteristics of Time-Lapse Full-Polarimetric GPR for Ice Fractures.....	266
<i>Yafei An, Xuan Feng, Qi Lu, Tseulam Khuut, Jiarun Yang, Zejun Dong, Haoqiu Zhou, Minghe Zhang, Yinghao Zhang, Enhedelihal</i>	
Antenna Comparison of Different Antennas in Through-Wall Radar Human Vital Signs Recognition .....	270
<i>Tieyu Liu, Jing Li, Zhaofa Zeng, Hai Liu</i>	
DL-GPRd: Deep Learning for Ground Penetrating Radar Deconvolution.....	275
<i>G. Roncoroni, E. Forte, M. Pipan</i>	
Numerical Simulation and Dispersion Inversion of Ground Penetrating Radar Waveguide .....	279
<i>Kaiwen Zhang, Jing Li, Ruizhe Sun, Tieyu Liu, Lige Bai</i>	
Analysis of Characteristics of Underground Pipeline Detection by Co-Polarization and Cross-Polarization of Ground Penetrating Radar.....	283
<i>Zeshan Xu, Min Xiao, Jie Chen</i>	
Application of Ground Penetrating Radar in Potential Hazards Detection of Levee.....	293
<i>W K Huang, S P Li, C Tan, P Y Lu</i>	

Improved Synchrosqueezing S-Transform and Its Application in Reinforcement Protection Layer Identification .....	298
<i>Hongqiang Xiong, Jing Li, Tengfei Zhang, Rong Hu, Tieyu Liu</i>	
Polarimetric Attributes of Martian Regolith at the Tianwen-1 Landing Site .....	302
<i>Jiarun Yang, Xuan Feng, Tseulam Khuut, Qi Lu, Haoqiu Zhou, Zejun Dong, Minghe Zhang, Yafei An</i>	
Time-lapse Monitoring of Soil Water Content by Full GPR Waveform Inversion with Grey Wolf Optimizer.....	306
<i>M H Zhang, M Bano, X Feng</i>	
Estimation of Soil Water Content Based on Full Waveform Inversion Technique of GPR Data with a Grey Wolf Optimizer .....	310
<i>M. H. Zhang, M. Bano, X. Feng, T. Khuut, Q. Lu</i>	
Estimation of Soil Hydraulic Properties Based on Full Waveform Inversion of Ground-Penetrating Radar Data with Grey Wolf Optimization Algorithm.....	315
<i>M. H. Zhang, M. Bano, X. Feng, T. Khuut, Q. Lu</i>	
Mapping Engineering Communications Based on Radiovision and Augmented Reality Technologies.....	319
<i>Vitaly Khmelev, Ilya Tseplyaev, Sergey Shipilov, Ivan Fedyanin, Maxim Dimov, Rail Satarov, Dmitry Romanov</i>	
Lunar Surface Permittivity Distribution Along Route of Yutu-2 Rover .....	325
<i>W Du, Y Su, S Dai, C Y Ding</i>	
Reverse Time Migration of GPR Data Based on GPU Parallel Symplectic Euler Algorithm and Total Variation Regularization.....	329
<i>Xin Gao, Jianwei Lei, Zhiqing Chen, Hongyuan Fang</i>	
Subsurface Characterization of Removable Urban Pavements (RUP) Using Ground Penetrating Radar (GPR).....	333
<i>G Andreoli, F Schmidt, A Ihamouten, A Cothenet, T Dezert, M L Nguyen, T Sedran</i>	
Multi-Frequency Electromagnetic Sensor for Detecting NaCl Concentration in Water - Experimental Study .....	337
<i>Haoyu Wang, Zhaofa Zeng, Zhilian Li</i>	
Application of Geo-Radar in the Detection of Various Adverse Geology in Tunnel Over-Advance Geological Forecasting.....	341
<i>Wenlong Zhao, Yuhao Tang, Siwei Zhao</i>	

**Author Index**