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# A Novel Radar Signal Recognition Method Based On Deep Learning

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Based On  
Deep  
Learning*      2021-04-03

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## **JAQUAN YARELI**

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Novel Radar  
Techniques and  
Applications SciTech  
Publishing

This revised and expanded second edition brings you to the cutting edge with new chapters on LPI radar design, including over-the-horizon radar, random noise radar, and netted LPI radar. You also discover critical LPI detection techniques, parameter extraction signal processing techniques, and anti-radiation missile design strategies to counter LPI radar.

**Artificial Intelligence  
in China** World  
Scientific

This book covers the latest developments in radar micro-Doppler signatures and non-cooperative recognition of moving targets, for researchers and advanced students of radar systems.

Micro-Doppler signatures is a very broad topic with applications in healthcare, security and surveillance. Edited by leading researchers in the field, the book consists of a series of chapters with contributions from different groups of authors who are international experts on their topics. The following topics are covered: multistatic radar micro-Doppler; passive radar approaches for healthcare; sparsity-driven methods for micro-Doppler

detection and classification; deep neural networks for radar micro-Doppler signature classification; classification of personnel for ground-based surveillance; multimodal sensing for assisted living using radar; micro-Doppler analysis of ballistic targets; small drones and bird signatures as emerging targets; hardware development and applications of portable FMCW radars; digital-IF CW Doppler radar and its contactless healthcare sensing; L1-norm principal component and discriminant analyses of micro-Doppler signatures for indoor human activity recognition; and micro-Doppler signature extraction and analysis for automotive application. Finally, the

editors have written a concluding short chapter that brings together an overview of the field and discusses likely future trends.

*Deep Learning Applications of Short-Range Radars* MIMO Radar Signal Processing

This 1179-page book assembles the complete contributions to the International Conference on Intelligent Computing, ICIC 2006: one volume of Lecture Notes in Computer Science (LNCS); one of Lecture Notes in Artificial Intelligence (LNAI); one of Lecture Notes in Bioinformatics (LNBI); and two volumes of Lecture Notes in Control and Information Sciences (LNCIS). Include are 149 revised full papers,

and a Special Session on Computing for Searching Strategies to Control Dynamic Processes.

Millimeter Wave Radar  
Elsevier

In past twenty years or so, information technology has influenced and changed every aspect of our lives and our cultures. Without various IT-based applications, we would find it difficult to keep information stored securely, to process information and business efficiently, and to communicate information conveniently. In the future world, ITs and information engineering will play a very important role in convergence of computing, communication, business and all other

computational sciences and application and it also will influence the future world's various areas, including science, engineering, industry, business, law, politics, culture and medicine. The International Conference on Information Engineering and Applications (IEA) 2011 is intended to foster the dissemination of state-of-the-art research in information and business areas, including their models, services, and novel applications associated with their utilization. International Conference on Information Engineering and Applications (IEA) 2011 is organized by Chongqing Normal University, Chongqing University, Shanghai

Jiao Tong University, Nanyang Technological University, University of Michigan and the Chongqing University of Arts and Sciences, and is sponsored by National Natural Science Foundation of China (NSFC). The objective of IEA 2011 is to will provide a forum for engineers and scientists in academia, industry, and government to address the most innovative research and development . Information Engineering and Applications provides a summary of this conference including contributions for key speakers on subjects such as technical challenges, social and economic issues, and ideas, results and current work on all aspects of advanced

information and business intelligence. Detecting and Classifying Low Probability of Intercept Radar SciTech Publishing  
The subject of this book is theory, principles and methods used in radar algorithm development with a special focus on automotive radar signal processing. In the automotive industry, autonomous driving is currently a hot topic that leads to numerous applications for both safety and driving comfort. It is estimated that full autonomous driving will be realized in the next twenty to thirty years and one of the enabling technologies is radar sensing. This book presents both detection and tracking topics specifically for

automotive radar processing. It provides illustrations, figures and tables for the reader to quickly grasp the concepts and start working on practical solutions. The complete and comprehensive coverage of the topic provides both professionals and newcomers with all the essential methods and tools required to successfully implement and evaluate automotive radar processing algorithms. *Wavelet Analysis and Its Applications, and Active Media Technology 2004* Springer Science & Business Media

These proceedings present technical papers selected from the 2012 International Conference on Intelligent Systems and

Knowledge Engineering (ISKE 2012), held on December 15-17 in Beijing. The aim of this conference is to bring together experts from different fields of expertise to discuss the state-of-the-art in Intelligent Systems and Knowledge Engineering, and to present new findings and perspectives on future developments. The proceedings introduce current scientific and technical advances in the fields of artificial intelligence, machine learning, pattern recognition, data mining, knowledge engineering, information retrieval, information theory, knowledge-based systems, knowledge representation and reasoning, multi-agent systems, and natural-

language processing, etc. Furthermore they include papers on new intelligent computing paradigms, which combine new computing methodologies, e.g., cloud computing, service computing and pervasive computing with traditional intelligent methods. By presenting new methodologies and practices, the proceedings will benefit both researchers and practitioners who want to utilize intelligent methods in their specific fields. Dr. Fuchun Sun is a professor at the Department of Computer Science & Technology, Tsinghua University, China. Dr. Tianrui Li is a professor at the School of Information Science &

Technology, Southwest Jiaotong University, Chengdu, China. Dr. Hongbo Li also works at the Department of Computer Science & Technology, Tsinghua University, China. The Application of Connectionist Models to Radar Signal Recognition and Fusion Artech House  
This book constitutes the refereed proceedings of the 17th Australian Conference on Artificial Intelligence, AI 2004, held in Cairns, Australia, in December 2004. The 78 revised full papers and 62 revised short papers presented were carefully reviewed and selected from 340 submissions. The papers are organized in topical sections on agents; biomedical applications; computer

vision, image processing, and pattern recognition; ontologies, knowledge discovery and data mining; natural language and speech processing; problem solving and reasoning; robotics; and soft computing.

### **AI 2004: Advances in Artificial Intelligence**

BoD – Books on Demand  
Radar Signal Processing and Its Applications brings together in one place important contributions and up-to-date research results in this fast-moving area. In twelve selected chapters, it describes the latest advances in architectures, design methods, and applications of radar signal processing. The contributors to this work were selected

from the leading researchers and practitioners in the field. This work, originally published as Volume 14, Numbers 1-3 of the journal, *Multidimensional Systems and Signal Processing*, will be valuable to anyone working or researching in the field of radar signal processing. It serves as an excellent reference, providing insight into some of the most challenging issues being examined today.

### **4th International Conference, ICCSIP 2018, Beijing, China, November 29 - December 1, 2018, Revised Selected Papers, Part II**

Elsevier  
Radar-related technology is mainly processed within the time and frequency



domains but, at the same time, is a multi-dimensional integrated system including a spatial domain for transmitting and receiving electromagnetic waves. As a result of the enormous technological advancements of the pioneers actively discussed in this book, research and development in multi-dimensional undeveloped areas is expected to continue. This book contains state-of-the-art work that should guide your research.

**(In 2 Volumes)** Artech House

Learn about the most recent theoretical and practical advances in radar signal processing using tools and techniques from compressive sensing.

Providing a broad perspective that fully demonstrates the impact of these tools, the accessible and tutorial-like chapters cover topics such as clutter rejection, CFAR detection, adaptive beamforming, random arrays for radar, space-time adaptive processing, and MIMO radar. Each chapter includes coverage of theoretical principles, a detailed review of current knowledge, and discussion of key applications, and also highlights the potential benefits of using compressed sensing algorithms. A unified notation and numerous cross-references between chapters make it easy to explore different topics side by side. Written by leading experts from both academia and

industry, this is the ideal text for researchers, graduate students and industry professionals working in signal processing and radar.

17th Australian Joint Conference on Artificial Intelligence, Cairns, Australia, December 4-6, 2004, Proceedings  
CRC Press

As well as being fully up-to-date, this book provides wider subject coverage than many other radar books. The inclusion of a chapter on Skywave Radar, and full consideration of HF / OTH issues makes this book especially relevant for communications engineers and the defence sector. \*

Explains key theory and mathematics from square one, using case studies where relevant

\* Designed so that

mathematical sections can be skipped with no loss of continuity by those needing only a qualitative understanding \*

Theoretical content, presented alongside applications, and working examples, make the book suitable to students or others new to the subject as well as a professional reference

**Chongqing, China, 29-31 August 2006**

World Scientific  
Offering radar-related software for the analysis and design of radar waveform and signal processing, Radar Signal Analysis and Processing Using MATLAB® provides a comprehensive source of theoretical and practical information on radar signals, signal analysis, and radar signal processing with

companion MATLAB® code. After an overview of radar systems operation and design, the book reviews elements of signal theory relevant to radar detection and radar signal processing, along with random variables and processes. The author then presents the unique characteristic of the matched filter and develops a general formula for the output of the matched filter that is valid for any waveform. He analyzes several analog waveforms, including the linear frequency modulation pulse and stepped frequency waveforms, as well as unmodulated pulse-train, binary, polyphase, and frequency codes. The book explores radar target detection and

pulse integration, emphasizing the constant false alarm rate. It also covers the stretch processor, the moving target indicator, radar Doppler processing, beamforming, and adaptive array processing. Using configurable MATLAB code, this book demonstrates how to apply signal processing to radar applications. It includes many examples and problems to illustrate the practical application of the theory.

### **Topics in Radar Signal Processing**

CRC Press

This authoritative resource presents a comprehensive illustration of modern Artificial Intelligence / Machine Learning (AI/ML) technology for

radio frequency (RF) data exploitation. It identifies technical challenges, benefits, and directions of deep learning (DL) based object classification using radar data, including synthetic aperture radar (SAR) and high range resolution (HRR) radar. The performance of AI/ML algorithms is provided from an overview of machine learning (ML) theory that includes history, background primer, and examples. Radar data issues of collection, application, and examples for SAR/HRR data and communication signals analysis are discussed. In addition, this book presents practical considerations of deploying such techniques, including performance

evaluation, energy-efficient computing, and the future unresolved issues.

### **MIMO Radar Signal Processing** Springer

Synthetic aperture radar and inverse synthetic aperture radar (SAR/ISAR) images have been largely used for monitoring small to large areas and more specifically for target recognition/identification. However, the technology has limitations due to the use of classical monostatic, single channel, single frequency and single polarization systems. To overcome these limitations, solutions have been proposed that show the benefit of using multiple frequencies, spatial channels, polarisations and perspective, in one

word multi-dimensional radar imaging systems when dealing with non-cooperative targets. Multidimensional Radar Imaging introduces a new framework within which to address the problem of radar imaging and target recognition as it jointly looks at optimising the use of multiple channels to significantly outperform classical radar imaging systems. It has been used in the military within NATO for the last few years and the technology is now declassified. Topics covered include three-dimensional ISAR; STAP-ISAR; wide-band multi-look passive ISAR; radar tomography; multistatic PCL-SAR; fusion of multistatic ISAR images with large angular separation;

rotor blade parameter estimation with multichannel passive radar; multistatic 3D ISAR imaging of maritime targets; challenges of semi-cooperative bi/multistatic SAR using Cosmo SkyMed as an illuminator; and lessons learnt from the NATO SET-196 RTG on multi-channel/multistatic radar imaging of non-cooperative targets. *International Conference, ICSC 2012, Shanghai, China, October 27-30, 2012. Proceedings, Part II* BoD – Books on Demand The first book to present a systematic and coherent picture of MIMO radars Due to its potential to improve target detection and discrimination capability, Multiple-

Input and Multiple-Output (MIMO) radar has generated significant attention and widespread interest in academia, industry, government labs, and funding agencies. This important new work fills the need for a comprehensive treatment of this emerging field. Edited and authored by leading researchers in the field of MIMO radar research, this book introduces recent developments in the area of MIMO radar to stimulate new concepts, theories, and applications of the topic, and to foster further cross-fertilization of ideas with MIMO communications. Topical coverage includes: Adaptive MIMO radar

Beampattern analysis and optimization for MIMO radar MIMO radar for target detection, parameter estimation, tracking, association, and recognition MIMO radar prototypes and measurements Space-time codes for MIMO radar Statistical MIMO radar Waveform design for MIMO radar Written in an easy-to-follow tutorial style, MIMO Radar Signal Processing serves as an excellent course book for graduate students and a valuable reference for researchers in academia and industry. Micro-Doppler Characteristics of Radar Targets Springer Nature  
In recent years rough set theory has attracted the attention of many researchers

and practitioners all over the world, who have contributed essentially to its development and applications. We are observing a growing research interest in the foundations of rough sets, including the various logical, mathematical and philosophical aspects of rough sets. Some relationships have already been established between rough sets and other approaches, and also with a wide range of hybrid systems. As a result, rough sets are linked with decision system modeling and analysis of complex systems, fuzzy sets, neural networks, evolutionary computing, data mining and knowledge discovery, pattern recognition, machine

learning, and approximate reasoning. In particular, rough sets are used in probabilistic reasoning, granular computing (including information granule calculi based on rough mereology), intelligent control, intelligent agent modeling, identification of autonomous systems, and process specification. Methods based on rough set theory alone or in combination with other approaches have been discovered with a wide range of applications in such areas as: acoustics, bioinformatics, business and finance, chemistry, computer engineering (e.g., data compression, digital image processing, digital signal processing, p-allele and

distributed computer systems, sensor fusion, fractal engineering), de-sion analysis and systems, economics, electrical engineering (e.g., control, signal analysis, power systems), environmental studies, informatics, medicine, molecular biology, musicology, neurology, robotics, social science, software engineering, spatial visualization, Web engineering, and Web mining.

**Radar Signal Processing and Its Applications** Springer  
The Three-Volume-Set CCIS 323, 324, 325 (AsiaSim 2012) together with the Two-Volume-Set CCIS 326, 327 (ICSC 2012) constitutes the refereed proceedings of the Asia Simulation Conference, AsiaSim

2012, and the International Conference on System Simulation, ICSC 2012, held in Shanghai, China, in October 2012. The 267 revised full papers presented were carefully reviewed and selected from 906 submissions. The papers are organized in topical sections on modeling theory and technology; modeling and simulation technology on synthesized environment and virtual reality environment; pervasive computing and simulation technology; embedded computing and simulation technology; verification, validation and accreditation technology; networked modeling and simulation technology; modeling and



simulation technology of continuous system, discrete system, hybrid system, and intelligent system; high performance computing and simulation technology; cloud simulation technology; modeling and simulation technology of complex system and open, complex, huge system; simulation based acquisition and virtual prototyping engineering technology; simulator; simulation language and intelligent simulation system; parallel and distributed software; CAD, CAE, CAM, CIMS, VP, VM, and VR; visualization; computing and simulation applications in science and engineering; computing and simulation applications

in management, society and economics; computing and simulation applications in life and biomedical engineering; computing and simulation applications in energy and environment; computing and simulation applications in education; computing and simulation applications in military field; computing and simulation applications in medical field.

**Information Processing** Control, Robotics and Sensors Micro-Doppler Characteristics of Radar Targets is a monograph on radar target's micro-Doppler effect theory and micro-Doppler feature extraction techniques. The micro-Doppler effect is presented

from two aspects, including micro-Doppler effect analysis and micro-Doppler feature extraction, with micro-Doppler effects induced by different micro-motional targets in different radar systems analyzed and several methods of micro-Doppler feature extraction and three-dimensional micro-motion feature reconstruction presented. The main contents of this book include micro-Doppler effect in narrowband radar, micro-Doppler effect in wideband radar, micro-Doppler effect in bistatic radar, micro-Doppler feature analysis and extraction, and three-dimensional micro-motion feature reconstruction, etc. This book can be used as a reference for

scientific and technical personnel engaged in radar signal processing and automatic target recognition, etc. It is especially suitable for beginners who are interested in research on micro-Doppler effect in radar. Presents new views on micro-Doppler effects, analyzing and discussing micro-Doppler effect in wideband radar rather than focusing on narrowband Provides several new methods for micro-Doppler feature extraction which are very helpful and practical for readers Includes practical cases that align with main MATLAB codes in each chapter, with detailed program annotations [International Conference on Information Engineering and](#)

Applications (IEA 2011)  
Springer  
By studying  
applications in radar,  
telecommunications  
and digital image  
restoration, this  
monograph discusses  
signal processing  
techniques based on  
bispectral methods.  
Improved robustness  
against different forms  
of noise as well as  
preservation of phase  
information render this

method a valuable  
alternative to common  
power-spectrum  
analysis used in radar  
object recognition,  
digital wireless  
communications, and  
jitter removal in  
images.

**Micro-Doppler Radar  
and its Applications**  
Cambridge University  
Press  
MIMO Radar Signal  
Processing John Wiley &  
Sons