Lecture Notes in Networks and Systems 848

Phung Trung Nghia · Vu Duc Thai ·
Nguyen Thanh Thuy · Le Hoang Son ·
Van-Nam Huynh *Editors*

# Advances in Information and Communication Technology

## Proceedings of the 2nd International Conference ICTA 2023, Volume 2

Springer

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Phung Trung Nghia · Vu Duc Thai ·
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Van-Nam Huynh
Editors

# Advances in Information and Communication Technology

## Proceedings of the 2nd International Conference ICTA 2023
## Volume 2

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# Keynotes

# Exploitation of Electronic Medical Records

Ho Tu Bao
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**Abstract** Exploitation of electronic medical records (EMR) is a new, important, but challenging issue in healthcare in every country. It was started in Vietnam nearly 10 years ago, attracting and requiring much effort from the ICT community. This talk is about the story of EMR exploitation in Vietnam. It has been a long road in which our project has tried to identify the key issues to pursue and to develop the initial solutions along the way. I also point out that mathematics and informatics are essential in those solutions.

# Advancing Slope Land Disaster Monitoring and Alert Systems through Synergistic IoT and AI Integration

Tien-Yin Chou
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**Abstract** The escalating global vulnerabilities to natural disasters driven by climate change and geological instabilities have heightened the susceptibility of numerous nations. This presentation expounds upon the deployment of a comprehensive Internet of Things (IoT) framework seamlessly augmented with artificial intelligence (AI) capabilities to revolutionize slope land disaster monitoring and alerting. Within this framework, an assortment of sensor devices facilitates real-time data transmission to a centralized backend infrastructure. Through meticulous integration, an intelligent decision-making model is synthesized, empowering governmental bodies with a robust foundation for informed monitoring and dissemination, distinguished by green, yellow, and red alert levels. The adoption of these sophisticated disaster mitigation technologies adheres to internationally recognized geospatial standards. The incorporation of AI-driven disaster prevention systems refines the precision of essential information conveyance, empowering policy makers to promptly comprehend real-time disaster dynamics. This, in turn, facilitates the timely delivery of preemptive notifications to the populace, consequently mitigating the impact of impending disasters. The convergence of AI and IoT emerges as an indispensable paradigm, meticulously poised to fortify contemporary disaster management strategies.

# Audio/Speech Information Hiding Based on Human Auditory Characteristics

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**Abstract** Audio information hiding (AIH) has recently been focused on as a state-of-the-art technique enabling copyrights to be protected and defended against attacks and tampering of audio/speech content. This technique has aimed at embedding codes as watermarks to protect copyrights in audio/speech content, which are inaudible to and inseparable by users, and at detecting embedded codes from watermarked signals. It has also aimed at verifying whether it can robustly detect embedded codes from watermarked signals (robust or fragile), whether it can blindly detect embedded codes from watermarked signals (blind or non-blind), whether it can completely restore watermarked signals to the originals by removing embedded codes from them (reversible or irreversible), and whether it can be secure against the publicity of algorithms employed in public or private methods. AIH methods, therefore, must satisfy some of the five following requirements to provide a useful and reliable form of watermarking: (a) inaudibility (inaudible to humans with no sound distortion caused by the embedded data), (b) robustness (not affected when subjected to techniques such as data compression and malicious attacks), (c) blind detectability (high possibility of detecting the embedded data without using the original or reference signal), (d) confidentiality (secure and undetectable concealment of embedded data), and (e) reversibility (removable embedded data from the watermarked signal and/or enable watermarking to be re-edited). In this talk, historical and typical AIH methods (including speech information hiding) are introduced and their drawbacks are pointed out. Then our proposed methods based on human auditory characteristics (cochlear delay, adaptive phase modulation, singular spectrum analysis with psychoacoustic model, formant enhancement, spread-spectrum with LP residue) are introduced. In addition, current research issues such as speech spoofing and deepfake detection will also be introduced.

# Research on Intrusion Detection on Host Devices

Ren-Hung Hwang
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**Abstract** As networking applications prevail, network security threats also become worsen. Although deep learning-based intrusion detection systems (IDSs) are very promising, there are still unsolved issues: (1) Most of the IDSs are network-based IDSs; (2) Most of the IDSs are based on a single data source (mostly are network traffic); (3) Most of the IDSs do not differentiate different attack stages; (4) Training and testing data sets used by most of the deep learning-based IDSs are offline data sets that are from the public domain or collected by researchers through private experiments. Most IDSs do not consider decentralized learning by exploring the trust relationship between hosts. Our research aims to resolve these issues by developing a deep learning host-based intrusion detection system utilizing multiple data sources. A host-based IDS can be deployed on a personal computer, an application server, or a gateway of IoT devices. Compared to a network-based IDS, a host-based IDS can collect more critical security information, such as system logs and host statistics. These multiple data sources collected at a host benefit the intrusion detection process and preserve privacy. This talk will include three parts. The first part aims to develop a deep learning host-based intrusion detection system utilizing multiple data sources. It also aims to detect different stages of network attacks. In the second part, the trust relationship between hosts is utilized to develop a decentralized learning mechanism such that unknown attacks can be learned through decentralized learning. In the last part, semi-supervised mechanisms will be developed to conduct online learning, which could continuously re-train the deep-learning-based model to detect new network attacks.

# Acknowledgements

We would like to express our appreciation to all the members of ICTA 2023' Program Committee for their support and cooperation in this publication. We would like to thank Prof. Prasanna Kumar (Production Editor) and Dr. Thomas Ditzinger (Executive Editor, Interdisciplinary and Applied Science, Engineering, Springer) for their support and cooperation in this publication. We also wish to thank all the authors and participants for their contributions and fruitful discussions that made this conference a success.

# About This Book

Technological changes and digital transformation that have taken place over the past decade have had significant impacts on all economic and social sectors. Information and Communication Technology (ICT) in general and artificial intelligence (AI) in particular have driven socio-economic growth.

This book contains four keynote abstracts and 83 best peer-reviewed papers selected from the 179 submissions at the 2nd International Conference on Advances in ICT (ICTA 2023), which share research results and practical applications in ICT research and education. The topics cover all ICT-related areas and their contributions to socio-economic development, focusing on the most advanced technologies, such as AI. Researchers and practitioners in academia and industry can use the books as a valuable reference for their research activities, teaching, learning and advancing current technologies.

The Conference is hosted by Thai Nguyen University of Information and Communication Technology (ICTU).

December 2023

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## Electronics

# About the Editors

**Assoc. Prof. Phung Trung Nghia** received his Engineering degree in Electronics and Telecommunications from Hanoi University of Science and Technology (HUST) in 2002. He completed his Master of Science in Telecommunications from Vietnam National University, Hanoi (VNUH) in 2007 and his Ph.D. degree in Information Science from Japan Advanced Institute of Science and Technology (JAIST) in 2013. He was Dean of the Faculty of Electronics and Telecommunications and Head of Academic Affairs. He has been ICTU's Rector. He has been the Vice President of Vietnam Club of Faculties-Institutes-Schools-Universities of ICT (FISU) and President of the FISU Branch in the Northern Midlands, Mountains and Coastal Region of Vietnam. He received the Award for Excellent Young Researcher (Golden Globe Award) from Vietnam's Ministry of Science and Technology (MOST) in 2008. His main research interest lies in the interaction between signal processing and machine learning, and he has published more than 70 research papers related to this field. He serves as a technical committee program member, organizing co-chair, program co-chair, track chair, section chair, editorial board member and reviewer of several conferences, journals and books. He is an Associate Editor of Thai Nguyen University Journal of Science and Technology (ICT section).

**Dr. Vu Duc Thai** got a Master of Science in Computer Science from Thai Nguyen University and a Ph.D. degree in Mathematical Foundations for Computers and Computing Systems from the Institute of Information Technology—Vietnam Academy of Science and Technology in 2012. He has been the ICTU's Vice Rector. His research relates to databases, information systems, and embedded systems (Cellular Neural Networks, FPGA). He has published more than 40 articles, books and book chapters. He works as an editor and reviewer for some international journals.

**Prof. Nguyen Thanh Thuy** received an Engineering degree in Computing in 1982 and a Ph.D. degree in Computer Science from HUST in 1987. He was a professor of computer science at HUST until 2011 and then at the VNU University of Engineering and Technology. Prof. Nguyen Thanh Thuy is now Head of the key laboratory for AI at the Faculty of Information Technology under VNU University of Engineering and Technology. His AI research interests are mainly in knowledge systems, soft computing, data mining, deep learning, hybrid intelligent systems, general AI, and responsible AI. Prof. Nguyen Thanh Thuy is now the President of the National Committee for Professorships of Vietnam in Computer Science (upon Ministry of Education and Training), period 2018–2023. He is also the Vice Director General of the National R&D Program KC-4.0/2019–2025 (upon MOST). He serves as Deputy Chief of Vietnam's National AI Strategy Council in 2020–2030 (established by MOST and other ministries). He keeps the role of the President of the Vietnam Union of AI Institutions and Industry (VINA3I) and the President of FISU, terms 2023–2028.

**Assoc. Prof. Le Hoang Son** is the Vice Director of VNU Information Technology Institute under Vietnam National University, Hanoi. His main research areas include soft computing foundation, knowledge-based systems, integrated machine learning for multimedia intelligence, and multi-modal and environmental AI, with an interest in healthcare and telecommunications network applications. Some applications have been deployed recently with software copyrights, such as a medical imaging support system with a deep learning model and knowledge graph, semi-supervised systems in object detection on remote sensing images, large recommender system (Mega RS) with techniques to extract information on electronic medical records, the software analyzes facial expressions and supports dynamic decision-making. Dr. Son is an Associate Editor of Soft Computing (SCIE), Journal of Intelligent & Fuzzy Systems (SCIE), IEEE Access (SCIE), Data Technologies and Applications (SCIE), Neutrosophic Sets and Systems (ESCI), Vietnam Journal of Computer Science and Cybernetics, and Vietnam Research and Development on Information and Communication Technology (2018–2020), VNU Journal of Science: Computer Science and Communication Engineering, Frontiers in Artificial Intelligence. He serves on the Editorial Board of Applied Soft Computing (SCIE), PLOS ONE (SCIE), International Journal of Data Warehousing and Mining (SCIE), International Journal of Web and Grid Services (SCIE), International Journal of Ambient Computing and Intelligence (ESCI). Dr. Son has been a Vietnam Government Office Consultant (http://vpcp.chinhphu.vn/) since 2019. He received "VNU Young Scientific Research Award 2014", "VNU Annual Research Award 2015", "Vietnam Mathematics Award 2015", and a Certificate of Merit from the President of VNU for outstanding achievements in international publications and intellectual property in 2019 and 2020. He is on the list of 03 Vietnamese scientists in the list of the top 100,000 leading scientists in the world with the most significant influence of the five consecutive years 2019, 2020, 2021, 2022 and 2023.

**Prof. Dr. Van-Nam Huynh** received a Ph.D. degree in Mathematics from Vietnam Academy of Science and Technology in 1999. He is a Professor at the School of Knowledge Science, JAIST. Also, he serves as a Research Fellow at The University of Economics in Ho Chi Minh City, Vietnam. He was a visiting professor at the National Electronics and Computer Technology Center (NECTEC), Thailand, in 2019, an adjunct professor at Chiang Mai University, Thailand, from 2015 to 2017, and a part-time lecturer at Tsukuba University, Japan, from 2011 to 2015. His research interests include AI and machine learning, decision analysis and management science, modelling and reasoning with uncertain knowledge, argumentation and multi-agent systems, and Kansei information processing and applications. He serves as an Area Editor of the International Journal of Approximate Reasoning, Editor-in-chief of the International Journal of Knowledge and Systems Science, and an Area Editor of the journal Array.

# Electronics

# A Closely Spaced Multi-element Self-Isolated MIMO Antenna Array

Tan Dao-Duc[1], Nguyen Sy Hiep[2], Duc-Nguyen Tran Viet[3], and Huy-Hung Tran[1](✉)

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**Abstract.** A novel decoupling technique for multiple-input multiple-output (MIMO) antenna array is presented in this paper. Unlike the conventional method of using additional circuits for mutual coupling suppression, a self-decoupling method is employed. The proposed method makes use of the fundamental $TM_{01}$ mode on the excited element and the orthogonal $TM_{20}$ mode on the non-excited element. This can be achieved by extending the radiating edge of the patch using a meander-line structure. The feasibility of this decoupling method has been demonstrated in an H-plane coupled $1 \times 3$ array with an edge-to-edge element spacing of 0.016 $\lambda$ at the center operating frequency. Good operation characteristics in terms of impedance matching, isolation, as well as MIMO diversity performance are obtained.

**Keywords:** Microstrip patch antenna · MIMO · Self-decoupling

## 1 Introduction

Owning the low profile, planar structure, and ease of integration with large-scale integrated circuits, microstrip patch antenna has been widely used in multiple-input multiple-output (MIMO) antenna systems. Various MIMO arrays have been reported in the open literature. It is found that mutual coupling reduction is one of the most challenging tasks in designing a MIMO antenna [1].

The conventional methods are to employ additional decoupling circuits to suppress the mutual coupling between the MIMO elements. They could be electromagnetic bandgap [2], neutralization lines [3–5], parasitic elements [6, 7], and defected ground structures [8]. Alternatively, metamaterials are also employed to decouple, such as near-field resonator [9], capacitively loaded loop [10], etc. The principle of such decoupling methods is to suppress or counteract the original coupled field. Although a low mutual coupling level can be obtained, most of the decoupling structures significantly increase


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the design complexity and dimensions. Besides, they also cause some adverse effects on the radiation performance of the antenna. In recent years, a self-decoupling method has been extensively researched as an effective way to overcome the drawbacks of the current techniques [11–14]. The self-isolated antenna works as not only the radiated element but also the isolation element. Thus, there is no need for additional decoupling networks. However, the critical drawback of such designs is that large element spacing is required to achieve high isolation.

In this paper, a novel self-decoupling method is presented. Unlike the conventional microstrip patch antenna, the radiating edge of the patch is modified from a straight line to a meander-line structure. By doing this, the operation modes on the radiating and non-radiating elements are $TM_{01}$ and $TM_{20}$, respectively. Consequently, the high mutual coupling can be considerably suppressed. The proposed method is applied to a $1 \times 3$ H-plane coupled MIMO array. The simulated results have demonstrated the efficiency of the proposed concept.

## 2 Antenna Design

### 2.1 Decoupling Mechanism

It is well-known that when positioning two microstrip patches in close proximity, very high mutual coupling is attained if both antennas have similar operating modes. However, the isolation will significantly improve if they work in orthogonal modes. Based on this theory, the Characteristic Mode Analysis (CMA) on a conventional half-wavelength microstrip patch is implemented. Figure 1 shows the dominant modes of the microstrip patch with dimensions of $15.8 \times 24$ mm and printed on a Taconic RF-35 substrate with a thickness of 1.5 mm. According to the CMA, the dominant modes have a high modal significance of approximately 1 [15]. In the observed frequency from 4 to 8 GHz, there are three dominant modes at 4.8, 6.0, and 6.6 GHz, which are respectively fundamental mode ($TM_{01}$) and higher order modes of $TM_{11}$ and $TM_{20}$. It can be seen that the $TM_{01}$ and $TM_{20}$ modes are in orthogonal arrangement.

In the MIMO system, the radiating element will work in the fundamental mode. Meanwhile, the coupling mode on the non-radiating element can be controlled and when the operating mode is $TM_{20}$, high isolation can be achieved. The question is how to control the $TM_{20}$ mode so that it has a similar operating frequency to the fundamental $TM_{01}$ mode. The current distribution of the $TM_{20}$ mode reveals that the resonant frequency will shift downwards when increasing the radiating edge of the patch.

### 2.2 Antenna Structure

Figure 2 shows the configuration in terms of the top-and side-view of the proposed self-isolated MIMO antenna. Three microstrip patches are closely positioned in the H-plane arrangement with an edge-to-edge distance of $s = 1$ mm, equivalent to $0.016\ \lambda$. The radiating edge of the patch is a meander-line structure formed by inserting multiple slots into the patch. This does not have a significant effect on the resonant length of the patch ($l$). The overall substrate sizes are 100 mm $\times$ 40 mm. The antenna is characterized

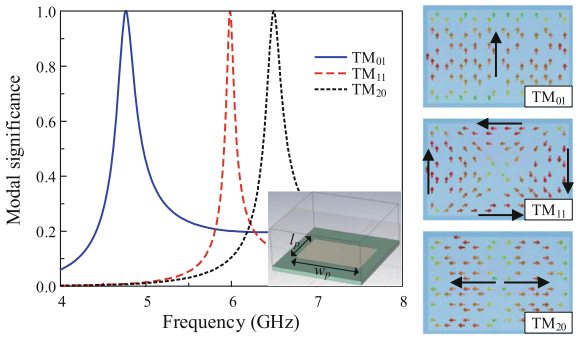


**Fig. 1.** CMA on the conventional microstrip patch antenna.

and optimized in the commercial High Frequency Structure Simulator (HFSS). The optimized antenna parameters are as follows: $l = 15.5$, $w = 20$, $l_f = 4.5$, $l_s = 6.8$, $w_s = 1.5$, $s = 1$, $h = 1.5$ (unit: mm).

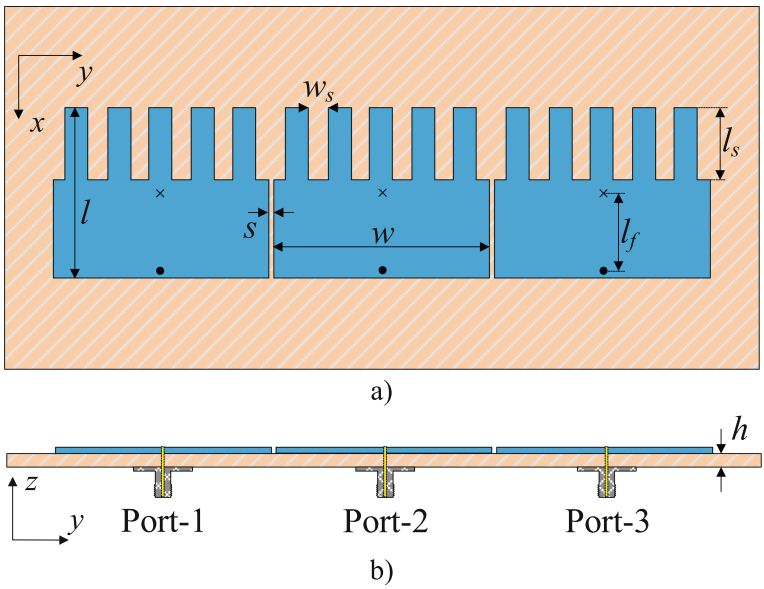


**Fig. 2.** (a) Top view and (b) side view of the proposed self-decoupled MIMO antenna. $L_s = 70$, $W_s = 40$, $l_p = 15.8$, $w_p = 24$, $l_f = 7.5$, $d = 1.0$, $l_s = 6.2$, $w_s = 3.0$, $w = 4.2$ (unit: mm).

## 3 Antenna Operation Characteristics

The S-parameter results of the self-isolated MIMO antenna are illustrated in Fig. 3. They are also compared with the coupled MIMO design. As seen, both antennas have good impedance-matching performance at 4.8 GHz. However, the coupled MIMO suffers

from significant poor isolation, which is around 6 dB at 4.8 GHz for adjacent elements. In contrast, the self-decoupled MIMO array exhibits very high isolation of better than 25 dB.

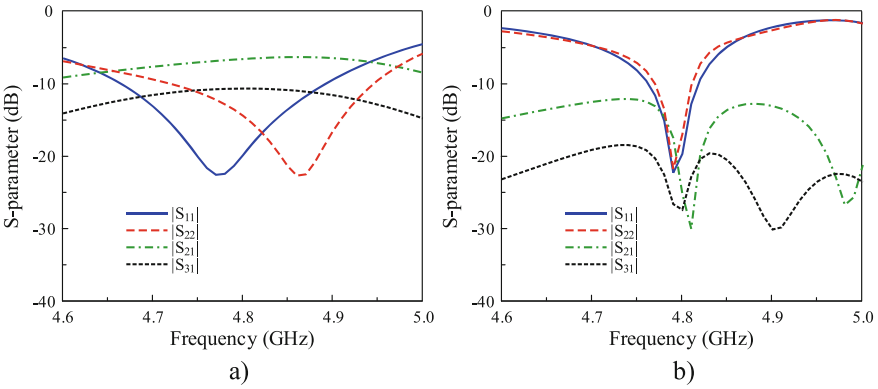


**Fig. 3.** Simulated S-parameter of (a) coupled and (b) self-decoupled MIMO antennas.

The radiation patterns in two principal planes of E- and H-plane with different excitations are plotted in Fig. 4. Overall, good radiation patterns and symmetric patterns are achieved. The gain value in the broadside direction is higher than 5 dB with Port-1 excitation and 3 dB with Port-2 excitation. Meanwhile, the cross-polarization level is lower than –16 dB and the back radiation is smaller than –9 dB.

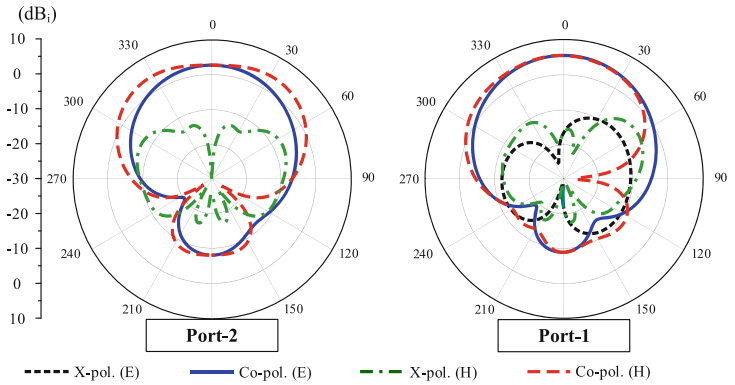


**Fig. 4.** Simulated radiation patterns of the proposed self-isolated MIMO antenna.

Next, the decoupling mechanism shown in Sect. 2.1 can be verified by observing the current distribution on the proposed MIMO antenna. The surface current $J_s$ at 4.8 GHz is illustrated in Fig. 5. It can be seen obviously that the operating mode on the excited patch is the fundamental $TM_{01}$ mode. Meanwhile, the current flowing on the non-excited elements is in the orthogonal direction. Note that this distribution is identical to the $TM_{20}$ mode shown in Fig. 1.