

2010 International Conference on Computational Intelligence and Vehicular System (CIVS2010)

Cheju, Korea (South), November 22-23, 2010

Edited by
Li Jian

Co-Sponsored by
**Intelligent Information Technology Application Research Association, Hong
Kong**

Technical Co-Sponsored by
IEEE Seoul Section VT Chapter

2010 International Conference on Computational Intelligence and Vehicular System Proceedings

Copyright and Reprint Permission: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limit of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923. For other copying, reprint or republication permission, write to IEEE Copyrights Manager, IEEE Operations Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331. All rights reserved. Copyright 2010 by the Institute of Electrical and Electronics Engineers

© 2010 IEEE. Personal use of this material is permitted. However, permission to reprint/republish this material for advertising or promotional purposes or for creating new collective works for resale or redistribution to servers or lists, or to reuse any copyrighted component of this work in other works must be obtained from the IEEE.

Print Version

IEEE Catalog Number: CFP1036L-PRT

ISBN: 978-1-4244-8717-2

Conference CD-ROM Version

IEEE Catalog Number: CFP1036L-CDR

ISBN: 978-1-4244-8718-9

Compliant PDF Files

IEEE Catalog Number: CFP1036L-ART

ISBN: 978-1-4244-8720-2

Publisher: Institute of Electrical and Electronics Engineers, Inc.

Message from the CIVS 2010 Conference Chairs

We are pleased to announce that 2010 International Conference on Computational Intelligence and Vehicular System (CIVS2010) will be held in Cheju, Korea (South), November 22-23, 2010. The CIVS2010 will provide opportunities for the delegates to exchange new ideas and application experiences face to face, to establish business or research relations and to find global partners for future collaboration. With a great number of famous scientists around the world attending this Congress, we are sure there will be many useful and significant conclusion and agreements on Computer-aided Manufacturing and Design.

CIVS 2010 is a leading conference on Computational Intelligence and Vehicular System. The goal of this conference is to provide a forum for participants from industry, academic, and non-profit organizations to exchange innovative ideas on intelligent vehicles, their systems, and related manufacturing processes. We welcome papers from all areas of computational intelligence demonstrating applications of theoretical advances to modern and future vehicles and vehicular systems (engine, transmissions, actuators, sensors, networks, communications, interfaces, etc.) and related manufacturing technologies. Although the focus of the symposium is on the application aspects of CI, papers describing simulation-only results are also solicited.

The conference will include invited talks, workshops, tutorials, and other events dedicated to this theme. Welcome to CIVS 2010 Conference. Welcome to Cheju, Korea (South). 2010 International Conference on Computational Intelligence and Vehicular System (CIVS2010) is co-sponsored by Intelligent Information Technology Application Research Association, Hong Kong.

We hope that CIVS 2010 will be successful and enjoyable to all participants. We look forward to seeing all of you next year at the CIVS 2011.

Li Jian, Hubei University of Education, China

CIVS 2010 Organizing Committee

Honorary Conference Chairs:

Chris Price, Aberystwyth University, United Kingdom
ChinChen Chang, National Chung Hsing University, Taiwan
Luo Wujin, Hubei University of Education, China
Lu Xiaocheng, Hubei University of Education, China
Gong Yijian, Hubei University of Education, China

Program Committee Chairs

Qihai Zhou, Southwestern University of Finance and Economics, China
Junwu Zhu, Yangzhou University, China

Organizing Chair

Honghua Tan, Wuhan Institute of Technology, China

Publication Chairs

Li Jian, Hubei University of Education, China
Feng Xiong, Intelligent Information Technology Application Research Association, Hong Kong

International Committees

Shao Xi, Nanjing University of Posts and Telecommunication, China
Xueming Zhang, Beijing Normal University, China
Peide Liu, Shangdong Economic University, China
Dariusz Krol, Wroclaw University of Technology, Poland
Jason J. Jung, Yeungnam University, Republic of Korea.
Paul Davidsson, Blekinge Institute of Technology, Sweden
Cao Longbing, University of Technology Sydney, Australia
Huaifeng Zhang, University of Technology Sydney, Australia
Qian Yin, Beijing Normal University, China General Chairs

CIVS 2010 Reviewers

Qihai Zhou, Southwestern University of Finance and Economics, China.
Yongjun Chen, Guangdong University of Business Studies, China.
Luo Qi, Wuhan Institute of Technology, China
Zhihua Zhang, Wuhan Institute of Physical Education China
Yong Ma, Wuhan Institute of Physical Education China
Zhenghong Wu, East China Normal University, China
Chen Jing, Wuhan University of Technology, China
Xiang Kui, Wuhan University of Technology, China
Li Zhijun, Wuhan University of Technology, China
Zhang Suwen, Wuhan University of Technology, China
Shufang Li, Beijing University, China
Tianshu Zhou, George Mason University, USA
Bing Wu, Loughborough University, UK
Huawen Wang, Wuhan University, China
Zhihai Wang, Beijing Jiaotong University, China
Ronghuai Huang, Beijing Normal University, China
Xiaogong Yin, Wuhan University, China
Jiaqing Wu, Guangdong University of Business Studies, China
Xiaochun Cheng, Middlesex University, UK
Jia Luo, Wuhan University of Science and Technology Zhongnan Branch, China
Toshio Okamoto, University of Electro-Communications, Japan
Kurt Squire, University of Wisconsin-Madison, USA
Xianzhi Tian, Wuhan University of Science and Technology Zhongnan Branch, China
Alfredo Tirado-Ramos, University of Amsterdam, Amsterdam
Bing Wu, Loughborough University, UK.
Yanwen Wu, Central China Normal University, China
Harrison Hao Yang, State University of New York at Oswego, USA
Dehuai Zeng, Shenzhen University, China
Weitao Zheng, Wuhan University of Technology, China.
Qihai Zhou, Southwestern University of Finance and Economics, China
Tianshu Zhou, George Mason University, USA
Shao Xi, Nanjing University of Posts and Telecommunication, China
Xueming Zhang, Beijing Normal University, China
Peide Liu, Shandong Economic University, China
Qian Yin, Beijing Normal University, China
Zhigang Chen, Central South University, China
Hoi-Jun Yoo, Korea Advanced Institute of Science and Technology
Chin-Chen Chang, Feng Chia University, Taiwan.
Jun Wang, the Chinese University of Hong Kong, Hong Kong

CIVS 2010 Contents

A Genetic algorithm to solve the container storage space allocation problem I. Ayachi,R. Kammarti,M. Ksouri,P. Borne	1
Robust Outdoor Tracking by Fusion of Laser Scanner and Image Processing Data Stefan Thamke,Matthias Langer,Lars Kuhnert,Klaus-Dieter Kuhnert	5
Critical Knock Diagnosis for Gasoline Engines Based on Neural Network with Wavelet Transform and Fuzzy Clustering Yang Jianguo,Wang Yanyan,Lin Bo	9
Objects Handoff Between Un-Calibrated Views Based on DS Theory Chunhui Zhao,James Orwell,Tim Ellis,Alberto Colombo	13
Simulation-based analysis of articulated steer grader with six motor-driven wheels Shen Yanhua,Zhang Taohua,Jin Chun	18
Research on Influential Factors of the Satisfaction of Railway Passengers Based on Rough Set MA Ning,DING Jia-qi,XIE Fei-fei,LI Xue-mei	22
Semi-physical Simulation of Signal Processing in IMU Aided GPS Receiver Lin ZHAO,Shuaihe GAO,Jicheng DING,Yingfei Li	27
A New Subspace-based Algorithm for Clustering Highdimensional Categorical Data Streams Jun Dong,Weiwei Zhou, Jiadong Ren, Yujie Xie	30
Study on Time Domain Numerical Simulation Method of Track Irregularity Based on IFFT Hongmei Shi,Jialiang Zhou	35
Model Test and Finite Element Analysis for the Pylon of the Jointed Pylon Cable-Stayed Bridge Zhouyuan Xu,Renda Zhao	39
Complexity of Generating Multi-collisions for MD4 and MD5 Wei Gong,Yang Liu,Lei Pan	44
Free Space Management and I/O Communication Based Placement Algorithm in Reconfigurable Systems Mohammad Esmaeildoust,Mahmood Fazlali,Keivan Navi,Ali Zakerolhosseini	47
The Study on Generic Cabling Standard Index System Min Li,Gang Li,HuoMin Dong,XiaoYan Bi	52
Status and System Study on Generic Cabling System Standard HuoMin Dong,Min Li,MingLe Zhou,XiaoYan Bi	56

Applying Time Granularity in Multimedia Data Management M Nordin A Rahman, Farham Mohamed, Suhailan Safei, Sufian Mat Deris, M Kamir Yusof.....	60
Learning Control of State Time-delayed Nonlinear System Based on Spectral Theory of Operator Wang Cong, Wei Cao, Jin Li, Yuan Guo	65
Overlay Routing based Application-Layer Transmission Mechanism for Multimedia Communications Xiaohong Huang, Fang Wei, Zheng He, Yan Ma.....	69
Designing a class of $2n$ -point p -ary Interpolatory Subdivision Schemes Based on Variation of Constants Hongchan Zheng, Feng Xu, Lulu Pan, Min Zhou	73
Research on Group Decision Making Cases based Utility Reasoning with Fuzzy Preference Relation Structure Xinqiao Yu	77
Research on the Optimal Generation of Test Sequence for CTCS-3 On-board Equipment Yong Zhang, Chaoqi Wang.....	81
Fuzzy Comprehensive Evaluation of Performance of the Natural Gas Driven Vuilleumier Cycle Heat Pump Yingbai Xie, Bing Li, Shaoheng Wang, Yun Liu	86
Pulse-Coupled Neural Networks Learning Through STDP Liqiang Zhu.....	90
Image Mosaic based on Simplified SIFT Jin Li, Yanwei Wang, Lei Wang	94
ID-based Ring Signature Scheme with Revocable Anonymity and Its Application in VANETs Shangping Wang, Lijun Liu, Yaling Zhang.....	98
Numerical analysis for stochastic delay neural networks with Poisson jump Hongge Yue, Qimin Zhang.....	103
Exponential Stability of Numerical Solutions to a Stochastic Navier-Stokes Equation Qimin Zhang	107
Performance Analysis of Intra-vehicle 60 GHz Binary THPPM Systems over Multipath Fading Channels Na Li, Hao Zhang, Jingjing Wang, Xuerong Cui, T. Aaron Gulliver	111
BMFLC based Time-Frequency Decomposition of EEG for Event-Related Desynchronization Detection Kalyana C. Veluvolu, Yubo Wang, S. Kavuri	117
Motor Vehicle Driving Skill Evaluation System on Location Service and Vibration Transducer Xuguang Zhu, Lingdao Sha, Yi Yang, Nan Chen, Yang Ji.....	121

On Stability of Markovian Jumping Neural Networks with both unknown and uncertain transition probabilities Ye Zhao,Lixian Zhang,Yong Chen	125
Compact Genetic Algorithm with CUDA Nugool Sataporn,Worasait Suwannik	129
Generation the 3D Image of the Free Viewpoint by Combination of Partial Image Sequences Fei Gu,Yue Bao,Takayuki Nakata	134
Direction-Of-Arrival Estimation using Special Phase Pattern Antenna Elements in Uniform Circular Array T.T.T.Quynh,P.P.Hung,P.Anh,P.T.Hong,T.M.Tuan	138
Edge Enhancement and Generalized Parameter Scheduling in Statistical Smoothing Inverse Halftone Filter Yohei Saika,Ken Okamoto,Masahiro Nakagawa.....	142
Moving Object Tracking with Integration of Algorithms and PTZ Camera Controlling Strategy Chen Chen,Wenqiang Zhang,Defeng Zhang,Zhenzhong Song	146
Derivation of a Relation Formula to Develop an Overload Limiter for a Movable Crane Dong-Seop Han,Geun-Jo Han, Ji-Hye Park.....	150
Experimental Study of ARIB T-75 Coverage Range for Installing Neighbor Road Side Units S. Poochaya,P. Uthansakul,M. Uthansakul	155
A Real-time Vibration Monitoring for Vehicle Based on 3-DOF MEMS Accelerometer Tran Duc Tan,Luu Manh Ha,Nguyen Tien Anh.....	160
Practical Inverse Model of a Magnetorheological Damper for Vehicle Suspension Applications Saber M. Fallah,Rama Bhat,Wen-Fang Xie.....	165
Submarine Operation Tool and Intelligent Device He Jin Meng,Qing Xing.....	170
The Generation of Test Cases Based on UML Activity Diagram and Colored Petri Nets Youbing ZHANG,Tao TANG	174
The research and implementation of three stages traffic stations intelligent monitor systems based on GIS Chen Hong-ying,Xiao Ting,WangTao,He Jin-yi	178
Using UDP Datagram to Realize a Distributed Control Mode At High-Speed Data Communication Lindi Zhao.....	182
The Design and Implementation of Network Teaching Platform Basing on .NET Ren Yanna.....	186

Research on design scheme of WLAN communication adapter based on 802.11 protocols CHEN Xiang,ZHAN Guo-hua.....	190
The research of highway toll collection system based on image processing technology Cheng-jie Zhu,Ming-san OuYang	194
An Integrated Tourism Information System based on GIS-T Data Warehouse for Telematics Applications Chi-Chung Tao,Wu-Tung Lee,Jo-Chieh Wu,Chia-Chi Hung,Ray-Her Tsaur,Yu-Fen Ho	198
Feasible Study of Fire-resisting Wood Material in Habitability Design of Large Surface Vessels Wenbo Zhang,Fenghu Wang,Bing Liu	202
Estimating of Timing and Carrier Phase for Multi-h CPM in Walsh Signal Space Kai Zhong,Lindong Ge,Kexian Gong	206
A Measurement of Vehicle Attitude Using Single Tri-axial Acceleration Transducer Based on ANN Liming Wu,Likai Zhang,Yang Wang	210
Credibility dominance method for multi-attribute decision making under fuzzy environment Shaowen Yao	214
Optimization of sensor Deployment for Mobile Wireless Sensor Networks Zhongnan Chen,Guofang Nan	218
Dynamic Characteristics of High Speed Vehicle Passing over Railway Turnout on Bridge Chen Rong,Wang Ping	222
Strategy of Triangulating Surface of the Hollow Cylinder Hongliang Li,Jingui Lu,Zhaoxin Xuan,Jiande Zhang	227
Symmetry Intelligent Nesting with Shifted Graph ZHANG Yuping,DENG Zhaori,YANG Caijun	231
License Plate Location Based on Immune Clonal Selection Xiaoying Pan,Hao Chen	235
Reliability intending on the control circuit of vehicle Zhuting Yao,Hongxia Pan	239
ECC-based Distributed Trust Security System for VANET Chao Wang,ZhenHua Zhang,Qiang Lin	243
A Novel Botnet Detection Model Based on Sequential Analysis Yiyan Fan,Xiaoyong Mei	247
A Robust Tracking Algorithm for Vehicle Navigation Systems with Stochastic Uncertainties Zhenliang Ma,Jianping Xing,Yanbo Zhu,Jun Zhang	251

Two-Stage PID Control Using a Limiter to Consider an Initial Value of Integrator Kazusa Matsumoto,Manato Ono,Naohiro Ban,Kazuhiro Sasaki,Hiroki Shibasaki,Yoshihisa Ishida	257
Antiwindup Control Scheme with Discrete Modified Internal Model Control Naohiro Ban,Manato Ono,Kazuhiro Sasaki,Kazusa Matsumoto,Hiroki Shibasaki,Yoshihisa Ishida	261
Multiple Pitch Estimation Using Non-Negative Matrix Factorization with Harmonic Constraint Yuta Otani,Ryo Tanaka,Masaru Fujieda,Yoshihisa Ishida.....	265
PID Parameters Optimization of Maglev Controller Based on CLPSO Algorithm with Stagnation Detection Liu Zhongli,Zhuang Shengxian	269
A Qualitative Self Modeling Algorithm of Reconfiguration for Model-based Autonomous Systems Zhen-yun Hu,He-xuan Hu	273
Comparison Study of Engine Mounts YAN Wen-bing,WANG Jie,JIANG Shao-zhong.....	277
Dynamic Properties of Engine Main Components YAN Wen-bing,PAN Hong-xia,JIANG Shao-zhong.....	280
Analysis of Impact of Tire Tread Groove Depth on Hydroplaning Risk Level Liu Tangzhi,Tang Boming,Dong Bin , Gao Jianping,Li Haiying	283
Analysis of Traffic Accidents on Highways in Urban-Rural Linking Areas and the Countermeasures Liu Tangzhi,Tang Boming,Shang Ting	289
Comparative Analysis of Three Types of Shoulder Rumble Strips Tangzhi Liu,Boming Tang,Jiang Tang,Kunhua Tan	295
Study on Speed Control Methods in Intersections of First-grade Highways Ting Shang,Tangzhi Liu,Boming Tang,Minglei Chen	302
Still Image Partition Scheme Based on IAM Zhaohui Cui, Jiwei Liu,Zhiliang Wang,Xiaoliang Gao.....	307
Identification of green tea (Camellia sinensis (L.)) quality level using computer vision and pattern recognition Han Zhiyi,Chen Quansheng,Cai Jianrong	311
Data Acquisition System for Electric Vehicle's Driving Motor Test Bench Based on VC++ Song Qiang,Lv Chenguang	316
Research on Chord Searching Algorithm Base on Cache Strategy GUO Jun,CHEN Chen.....	320

Vehicle Speed Detection based on video image processing Xianbo Xiao	323
The Network Monitoring System of Flexible Production Line Based on Bus Technology Na Wang,Hui Zhang,Quancheng Dong	326
Research on CPA's Civil Responsibility for the False Audit Reports without Operational Mistakes Rong Li,Shunliang Cao,Huali Liu,Jiajiang Hu	330
Modeling the Glass Transition Temperature of Polymers via Multipole Moments Using Support Vector Regression J.F. Pei, C.Z. Cai, X.J. Zhu, G.L. Wang, B. Yan	334
Prediction of Glass Transition Temperature of Polymer by Support Vector Regression J.F. Pei , C.Z. Cai, X.J. Zhu, G.L. Wang , B. Yan	338
Intelligent Speed Adaption System Based on GPS/GIS and Rain Sensor Shao-Bin Wu,Xue-Wei Wang,Ruo-Nan Geng,Li Gao	342
Prediction Study on Anti-Slide Control of Railway Vehicle Based on RBF Neural Networks Lijun Yang,Jimin Zhang.....	346
Reliability analysis of intersection safety under traffic conflict Changjiang Zheng,Zhangxiao Yu.....	350
Optimal QoS Mapping from the IP Service to the variable Rate wireless Network Juling Zeng,Junde Song.....	354
Parametric and controllable shape model of the waterlubricated rubber journal bearing Xiaoping Pang,Jin Chen,Jiaxu Wang,Yi Hou	358
Traffic Information Fusion Based on the Urban Traffic Ontology Wang-Dong YANG,Tao WANG	362
Damage Identification of Beam Structures Based on Genetic Algorithm and Sensitivity Analysis Tian-li Huang,Wei-xin Ren	366
The effect of centrifugal force and Coriolis force on vehicle-flexible bridge vertical vibration Xiao Xiang,Ren Wei-Xin,He Wen-Yu.....	370
Research and Application for Third-party Software Testing Methodology Integrated with Defects Prevention Technology Yan Meng,Lei Wang,XiaoGeng Liu,Jing Zhao.....	374
Application of BP neural network to the prediction of Liuhe water quality in Fuxin Zhi-bin LIU,Xu LIN,Ying-wei TONG	379

Research on design methods and aerodynamics performance of CQU-DTU-B21 airfoil Chen Jin,Cheng Jiangtao,WenZhong Shen	384
Design method of the parameters of tools for clinching technology Baijun Shi,Yeqing Wang,Songlin Liu,Hengyu Tian	388
Analysis of Vehicle's Kinetic Characteristic after Tire Blow-out Yinglin Wang,Konghui Guo	392
Random fuzzy demand newsboy problem Yuanji Xu,Jinsong Hu	396
Probe into Necessity of Active Suspension Based on LQG Control Shian Chen,Ren He,Hongguang Liu,Ming Yao	400
Optimization of Process Parameters of U-shape sheet metal Based on Compensation of Geometric Springback Value Xiangwu JIA,Shugen HU	405
Automatic Military One-point Located Symbols Placement Based on the Genetic Algorithm CAO Ze-Wen,CHEN Wen-Kai,ZHOU Yao	409
Realization of Large-Scale Civil Engineering Wireless Health Monitoring System Gang Li,PengChang ZHANG	413
Modeling and Predicting Tensile Strength of Tungsten Alloy by Using PSO-SVR J.L. Tang,C.Z. Cai,X.J. Zhu,G.L. Wang,D.F. Cao	416
Integrated Control of AFS and ESC for Vehicle Handling and Stability Using Inverse Nyquist Array Method Zhu Bing,Zhao Jian,Li Jing,Li Youde	420
Road Background Generation and Update Method Based on Segment Statistics LI jing LIU,Huai-yu,HONG Liu-rong	424
Effect of Vehicle Speed and Vehicle Load on Damage of Pavement Zhongliang Kang,Dawei Liu,Rongchao Jiang,Yuedong Yang	428
Construction of Response Surface Based on Projection Pursuit Regression and Genetic Algorithm Qin Boying,Lin Xiankun	432
Punching Teeth Layout on Steel Belt of the Box Based on Optimized Simulated Annealing Algorithm Wenqi Tian,Jiping Bai	436
Design of Improvement for Heavy Dump Truck Frame without Assistant Frame Dawei Liu,Huanming Chen,Wei Liu	439

A Structure Optimization for Hooklift Arm Device Based on the Genetic Algorithm Huanming Chen,Dawei Liu	443
Traffic Flow Distribution in Road Based on FEM Jian-ming CUI,Ya LI	446
Research of Temperature Rise Model for Drum Brake Yingshi Guo,Rui Fu Wei Yuan,Wang Chang.....	449
A Qualitative Multi-faults Diagnosis Algorithm: Theory and Detection Zhen-yun Hu,He-xuan Hu	452
A Qualitative Multi-faults Diagnosis Algorithm: Process Zhen-yun Hu,He-xuan Hu	456
Adaptive Control of Synchromesh Shifting Process for Automated Manual Transmission Peng Gong,Jianmin Meng,Junqiang Xi.....	460
Theoretical Study of the Optical Properties of the Derivatives of 4-Phenylethynyl-1,8-naphthalimide Ruifa Jin	463
A Hybrid Real-Coded Genetic Algorithm for Arterial Signal Timings Optimization Xiaofeng Chen,Zhongke Shi	467
Modeling and Simulation of Electrically Powered Hydraulic Steering System Based on Fuzzy Control Shaoxin Luo,Weijun Zhao,Jinbiao Chang	471
Study on a Pneumatic Automatic-extendable Crash Energy Absorption System Libo Cao,Hongbao Wang,Jun Wu,Huiqin Chen.....	475
An Evaluation of Feature Selection Methods for Text Categorization Xu Lijun,Zhang Guiping,Ji Duo	479
Detecting Object by Affine Transform Using Line LIU Huai-yu,HONG Liu-rong,LI jing.....	483
Intelligent Multi-objective Optimization for High Strength Sheet Metal Forming Process of Body Part Zhiguo An,Yu Zhang	487
How the Highway Alignment Design Parameters Affect its Capacity on a Two-lane Highway in China Jiang Liu	491
Initial Research on Relationship between Drivers' Temperament and Travel Speed Jiang Liu	497
Simulation Testing Research on Ride Comfort of Vehicle with Global-coupling Torsion-elimination Suspension W. Tong,K. H. Guo.....	501

A New Fuzzy Transit Signal Priority Control System Design Based on ZigBee Wireless Communication	
Wang Yang,Cao Kun	505
Author Index.....	509

Direction-Of-Arrival Estimation using Special Phase Pattern Antenna Elements in Uniform Circular Array*

T.T.T.Quynh, P.P.Hung and P.Anh

Faculty of Electronics and
Telecommunications

University of Engineering and
Technology

Hanoi, Vietnam

{quynhhtt & hungpp & anhph}@vnu.edu.vn

P.T.Hong

School of Electrical Engineering

Korea University

Seoul, Korea

hongpt@korea.ac.kr

T.M.Tuan

National Institute of Information and
Communications Strategy

Ministry of Information and
Communications

Hanoi, Vietnam

tm_tuan@mic.gov.vn

Abstract - A theory model in which Uniform Circular Array (UCA) using special antenna elements for Direction of Arrival (DOA) estimation is presented. Simulation results show that although the number of incident sources is larger than the number of antenna elements, DOA spectrum using the proposed antenna model is still better than one using UCA with traditional antenna elements.

Index Terms - Direction of Arrival (DOA), Uniform Linear Array (ULA), Uniform Circular Array (UCA), Multiple Signal Classification (MUSIC).

I. INTRODUCTION

DOA estimation is very important in smart antenna designing and direction finding. In most of the research papers and real systems, the popular antenna array structures in DOA systems are ULA and UCA with simple antenna elements, such as dipoles.

The accuracy of DOA estimation in 360° range with ULA and UCA structures is usually dependent on the number of elements in array and elements arrangement. The more element number is large, the more accuracy is high. With UCA structure, unique disadvantage is: the algorithm can not detect sources if the number of antenna elements is not large enough (smaller or little larger than the number of incident sources).

To increase accuracy and overcome the disadvantage in DOA estimation using UCA with traditional elements, we introduce a theory model using new antenna element structure for UCA. It will be described in next sections in details.

In this paper, we used well-known Multiple Signal Classification (MUSIC) algorithm [1] to estimate DOA for UCA in traditional elements case and proposed elements case. After that, different spatial spectrum results of these structures will be compared and discussed.

The paper is organized as follows. Section II presents an overview description of system, proposed element structure and detailed data model analysis. Simulation results and discussion are given in section III. Section IV is a short conclusion. MUSIC algorithm is given in Appendix in detail.

II. SYSTEM DESCRIPTION, THEORY MODEL OF PROPOSED ANTENNA ARRAY STRUCTURE AND DATA MODEL

A. Overview System Description

Fig. 1 shows the model of DOA estimation system with general antenna array structure.

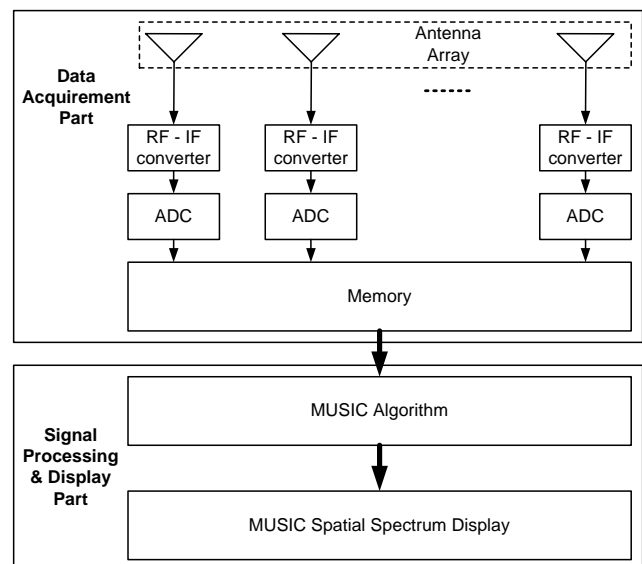


Fig. 1 DOA estimation system with general antenna structure

The system has two parts: Data Acquisition part and Signal Processing & Display part. The former includes antenna array, RF-IF converter and ADC. The later includes MUSIC algorithm and result display.

B. Theory model of Proposed Antenna Element for UCA

Model and phase pattern of a traditional element (dipole) is showed in Fig 2.

* This work is supported by UET, VNUH. The content of this work was partly supported by the research project QC.07.21 and QC.08.15.

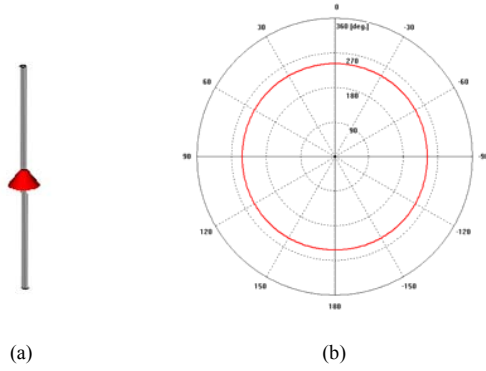


Fig. 2 Model (a) and phase pattern (b) of traditional element

According to [2], special phase patterns can be created by dipoles combine. One of them is showed in Fig. 3

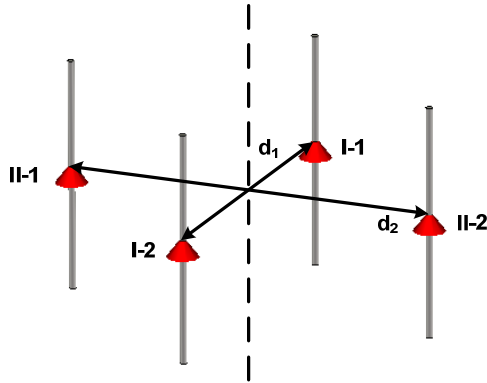


Fig. 3 One of structures which has special phase pattern

where: d_1 is the distance between I-1 and I-2 dipoles and d_2 is the distance between II-1 and II-2 dipoles.

TABLE 1
PARAMETERS OF ANTENNA ELEMENTS IN FIG.3

I-1 Dipole amp/phase excitation	I-2 Dipole amp/phase excitation	II-1 Dipole amp/phase excitation	II-2 Dipole amp/phase excitation	d_1	d_2
$1/90^\circ$	$1/270^\circ$	$1/0^\circ$	$1/180^\circ$	0.5λ	λ

where λ is the operation wavelength.

With parameters in Table 1, the special phase pattern is presented in Fig.4

Compare with traditional element, proposed element has phase pattern is very specially different from traditional element. It has nonlinear form and can be expressed by [2]:

$$\Phi(\theta) = \arctg \left[\frac{\sin\left(\frac{k\lambda}{2} \sin \theta\right)}{\sin\left(\frac{k0.5\lambda}{2} \cos \theta\right)} \right] \quad (1)$$

where θ is the direction of propagation, k is the wave number.

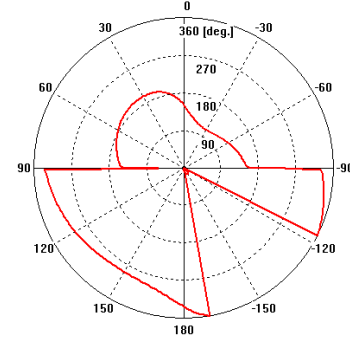


Fig. 4 Phase Pattern of the Proposed Element

C. UCA with Proposed Elements

Proposed antenna element which includes 4 dipoles in Fig.3 can be considered as one element with phase pattern likes in Fig.4.

Then, UCA with proposed elements is shown in Fig.5.

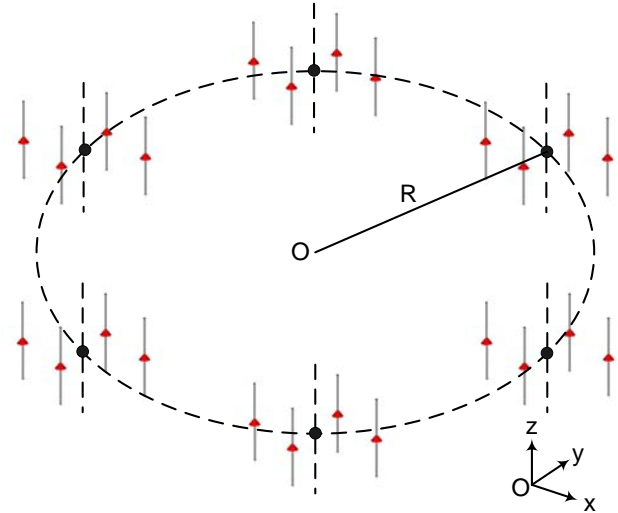


Fig. 5 UCA with 6 Proposed Antenna Elements

where R is the radius of circular.

D. Data model Analysis

Assume that amplitude pattern of each proposed element is constant; the number of elements in UCA is N . Data model can be described as follows:

The antenna array receives signals from L narrowband sources, which are randomly distributed in the xy -plane in the far field of antenna array. Phase patterns of proposed elements are rotated step by step by electrically control system. Each step is considered as N elements in general antenna array. The array steering vector of θ_i direction is expressed as:

$$\mathbf{a}(\theta_i) = [\mathbf{a}_1(\theta_i) \ \mathbf{a}_2(\theta_i) \ \dots \ \mathbf{a}_M(\theta_i)]^T \quad (2)$$

where

$$\mathbf{a}_1(\theta_i) = \begin{bmatrix} e^{j\Phi(\theta_i)} & e^{j\left[\Phi(\theta_i) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{I}{N}\right)\right]} & \dots & e^{j\left[\Phi(\theta_i) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{N-I}{N}\right)\right]} \end{bmatrix}$$

$$\mathbf{a}_2(\theta_i) = \begin{bmatrix} e^{j\Phi(\theta_i + \Delta\theta)} & e^{j\left[\Phi(\theta_i + \Delta\theta) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{I}{N}\right)\right]} & \dots & e^{j\left[\Phi(\theta_i + \Delta\theta) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{N-I}{N}\right)\right]} \end{bmatrix}$$

$$\mathbf{a}_M(\theta_i) = \begin{bmatrix} e^{j\Phi(\theta_i + (M-1)\Delta\theta)} & e^{j\left[\Phi(\theta_i + (M-1)\Delta\theta) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{I}{N}\right)\right]} & \dots & e^{j\left[\Phi(\theta_i + (M-1)\Delta\theta) + \frac{2\pi}{\lambda} R \cos\left(\theta_i - 2\pi \frac{N-I}{N}\right)\right]} \end{bmatrix}$$

$M-1$ is the number of rotated steps, $\Delta\theta$ is rotated angle.

The acquired data after $(M-1)^{\text{th}}$ step is given by:

$$\mathbf{x}(t) = \sum_{i=1}^L \mathbf{a}(\theta_i) s_i(t) + \mathbf{n}(t) \quad (3)$$

where $s_i(t)$ is source at θ_i direction which is assumed that uncorrelated with the others, $\mathbf{n}(t)$ is noise vector which is modeled as temporally Additive White Gaussian Noise (AWGN).

After that, MUSIC algorithm is used to estimate DOAs as follows:

The covariance matrix of \mathbf{x} (temporal averaging over K snapshots) [4] is given by:

$$\hat{\mathbf{R}}_{\mathbf{xx}} = \frac{1}{K} \sum_{k=0}^{K-1} \mathbf{x}_k \mathbf{x}_k^H \quad (4)$$

where $(.)^H$ denotes complex conjugate transpose.

The idea of MUSIC algorithm bases on eigenvectors and eigenvalues of $\hat{\mathbf{R}}_{\mathbf{xx}}$: the eigenvectors corresponding to the smallest eigenvalues form the noise subspace and also orthogonal to the steering vectors [3]. Therefore, MUSIC spatial spectrum is expressed as:

$$\mathbf{P}_{\text{MUSIC}}(\theta) = \frac{\mathbf{a}^H(\theta) \mathbf{a}(\theta)}{\mathbf{a}^H(\theta) \mathbf{U}_n \mathbf{U}_n^H \mathbf{a}(\theta)} \quad (5)$$

where \mathbf{U}_n is the matrix which includes eigenvectors of noise subspace. Orthogonality between steering vectors and \mathbf{U}_n will minimize the denominator of (5) and hence it will make up peaks in MUSIC spectrum. These peaks will correspond to the DOAs of the sources [3].

III. SIMULATION RESULTS AND DISCUSSION

The simulation is carried out for UCA with traditional elements and UCA with proposed elements over 1000 snapshots. After that, performance of MUSIC algorithm using these antenna array structures will be compared each other. Some discussion will be presented at the end of this section.

A. Simulation Results

Simulation Parameters are described in table 2.

Fig. 6 illustrates the spatial spectrum for UCA with traditional elements and UCA with proposed elements. As shown, the former estimated 16 peaks with 1 desired peak, 15 undesired peaks and all peaks are not sharp. Meanwhile, the latter estimated 24 desired peaks with 5° resolution and all peaks are sharp.

TABLE 2
SIMULATION PARAMETERS

Parameters	UCA with traditional elements	UCA with proposed elements
Element Number	24 elements = 24 dipoles	6 elements = 24 dipoles (Rotated Step number: 100; Rotated Angle: 2°)
Element Distance	$\lambda/2$ (no mutual coupling between arbitrary two dipoles)	App. 2λ (no mutual coupling between arbitrary two dipoles)
UCA Radius	$24 \frac{\lambda}{2} \frac{1}{2\pi}$	$24 \frac{\lambda}{2} \frac{1}{2\pi}$
Source Number	24	24
Source SNR (dB)	20	20
DOA (degree)	[5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120]	[5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120]

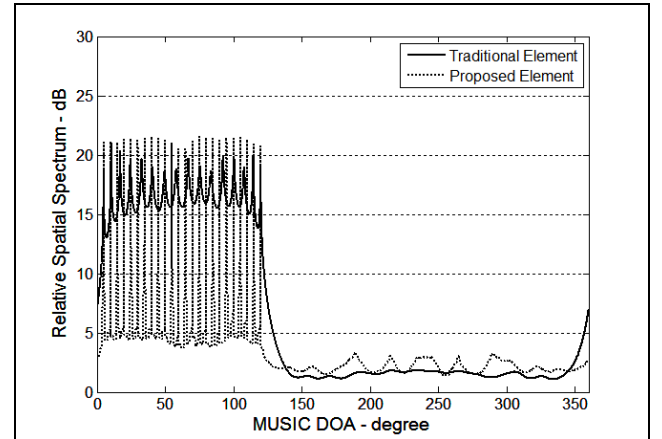


Fig. 6 MUSIC spatial spectrum

B. Discussion

According to introduction section, MUSIC algorithm using UCA with proposed elements can estimate DOAs in spatial spectrum exactly although the number of incident sources is approximate or larger than the number of antenna elements. The simulation result in Fig. 6 illustrated this idea.

The reason of the results can be explained as follows: Theory DOA estimation of proposed structure is similar to UCA with traditional elements. To increase accuracy and can detect sources in case the number of antenna elements is not large enough, the proposed method made increase the number

of elements by rotation phase pattern of proposed elements. Each phase pattern rotated step of proposed elements is corresponding to making up N traditional elements in UCA. Therefore, after M-1 rotated steps, proposed structure makes up MxN elements.

A limitation of this DOA method is amplitude pattern of proposed element has not been considered in detail yet. (In II.D part, we assumed that it is constant).

However, UCA using nonlinear phase pattern antenna elements still has meaning in looking for a DOA estimation method which has the number and accuracy of DOA peaks in spatial spectrum do not depend on the number of real antenna elements.

IV. CONCLUSION

DOA estimation algorithm (MUSIC) using UCA with new antenna element structure was investigated and compared with traditional UCA structure. Investigation results assert once again that: proposed antenna structure can be used to estimate DOAs exactly in case the number of antenna elements is not large enough. In the future work, we will consider impact of amplitude pattern on accuracy of DOA spectrum and look for a real antenna element model which has the most optimal amplitude and phase pattern.

APPENDIX

A. MUSIC algorithm with general antenna model [5]

Assume that: in 2D spatial coordinates, there is a narrowband signal impinges on the 1th antenna element like in Fig. 7.

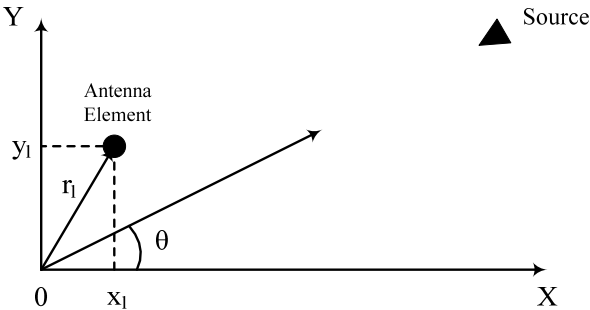


Fig. 7 General antenna model

The output is modeled by:

$$\begin{aligned} x_1(t) &= g_1(\theta) e^{-jk(x_1 \cos \theta + y_1 \sin \theta)} s(t) + n(t) \\ &= a(\theta) s(t) + n(t) \end{aligned} \quad (6)$$

with $g_1(\theta)$ is radiation pattern of 1th antenna element.

If M signals impinge on L sensors in the presence of an additive noise $\mathbf{n}(t)$ and assume that $g_l(\theta)$ is constant then the outputs of antenna elements are:

$$\mathbf{x}(t) = \mathbf{A}(\theta) \mathbf{s}(t) + \mathbf{n}(t) \quad (7)$$

where:

$\mathbf{x}(t) = [x_1(t), x_2(t), \dots, x_L(t)]^T$ is signal vector at antenna elements.

$\mathbf{A}(\theta) = [\mathbf{a}(\theta_1), \mathbf{a}(\theta_2), \dots, \mathbf{a}(\theta_M)]$ is steering matrix

$\mathbf{a}(\theta) = [a_1(\theta), a_2(\theta), \dots, a_L(\theta)]^T$ is steering vector

$\mathbf{s}(t) = [s_1(t), s_2(t), \dots, s_M(t)]^T$ is source vector

$\mathbf{n}(t) = [n_1(t), n_2(t), \dots, n_L(t)]^T$ is noise vector

MUSIC algorithm is expressed as follows:

Step1: Calculate Spatial Covariance Matrix

$$\begin{aligned} \mathbf{R} &= E\{\mathbf{x}(t)\mathbf{x}^H(t)\} = \mathbf{A} E\{\mathbf{s}(t)\mathbf{s}^H(t)\} \mathbf{A}^H + E\{\mathbf{n}(t)\mathbf{n}^H(t)\} \\ &= \mathbf{A} \mathbf{P} \mathbf{A}^H + \sigma^2 \mathbf{I} \end{aligned} \quad (8)$$

with

$$E\{\mathbf{s}(t)\mathbf{s}^H(t)\} = \mathbf{P} \quad (9)$$

$$E\{\mathbf{n}(t)\mathbf{n}^H(t)\} = \sigma^2 \mathbf{I} \quad (10)$$

Step2: Decomposition Spatial Covariance Matrix

$$\mathbf{R} = \mathbf{A} \mathbf{P} \mathbf{A}^H + \sigma^2 \mathbf{I} = \mathbf{U} \mathbf{\Lambda} \mathbf{U}^H \quad (11)$$

with \mathbf{U} is unitary and $\mathbf{\Lambda} = \text{diag}\{\lambda_1, \lambda_2, \dots, \lambda_L\}$ which $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_L > 0$.

Depend on eigenvalues with $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_M > \sigma^2$, $\lambda_{M+1} \approx \lambda_{M+2} \approx \dots \approx \lambda_L \approx \sigma^2$, we can partition the eigenvalue/eigenvector pairs into signal and noise subspaces.

So, we can write (11) into:

$$\mathbf{R} = \mathbf{U}_s \mathbf{\Lambda}_s \mathbf{U}_s^H + \mathbf{U}_n \mathbf{\Lambda}_n \mathbf{U}_n^H \quad (12)$$

From (11) and (12) we have:

$$\mathbf{R} = \mathbf{A} \mathbf{P} \mathbf{A}^H + \sigma^2 \mathbf{I} = \mathbf{U}_s \mathbf{\Lambda}_s \mathbf{U}_s^H + \mathbf{U}_n \sigma^2 \mathbf{U}_n^H \quad (13)$$

From (13), if $\mathbf{A} \mathbf{P} \mathbf{A}^H$ is full rank then eigenvectors \mathbf{U}_n in noise subspace are orthogonal to \mathbf{A} . So we can write:

$$\mathbf{U}_n^H \mathbf{a}(\theta) = 0 \quad (14)$$

with $\theta \in \{\theta_1, \theta_2, \dots, \theta_M\}$

Step3: Calculate MUSIC spatial spectrum

$$\mathbf{P}_{\text{MUSIC}}(\theta) = \frac{\mathbf{a}^H(\theta) \mathbf{a}(\theta)}{\mathbf{a}^H(\theta) \mathbf{U}_n \mathbf{U}_n^H \mathbf{a}(\theta)} \quad (15)$$

REFERENCES

- [1] R. O. Schmidt, "Multiple emitter location and signal parameter estimation", IEEE Trans. Antennas and Propagation, vol AP-34, pp.271-280, Mar. 1986
- [2] Phan Anh, *Antenna without Phase Center and Their Applications in Radio Engineering*, Series: Monograph, No.23, Wroclaw, Poland, 1986, ISSN 0324-9328.
- [3] Liu Jin, Li li, Huazhi Wang, "Investigation of Difference Types of Array Structures for Smart Antennas", Proceedings of ICMMT 2008.
- [4] Joseph C. Liberti, Jr. & Theodore S.Rappaport, *Smart Antenna for Wireless Communications IS-95 and Third Generation CDMA Applications*, Prentice Hall PTR.
- [5] Hamid Krim and Mats Viberg, "Two Decades of Array Signal Processing Research", IEEE Signal Processing Magazine, July 1996, pp 67-94.