Final Program & Digest

ICROS
Institute of Control, Robotics and Systems

ICCAS 2012

2012 12th International Conference on Control, Automation and Systems

October 17(Wed) ~ 21(Sun), 2012
ICC Jeju, Korea

ICROS
Institute of Control, Robotics and Systems

ICCAS 2012

2012 12th International Conference on Control, Automation and Systems

PROCEEDINGS

October 17~21, 2012
ICC Jeju, Korea

IEEE Catalog Number: CFP1210D-CDR
ISBN: 978-89-93215-04-5 95560
ISSN: 2093-7121

Conference Website: http://2012.iccas.org

Welcome Message
Conference Organization
Reviewers
Conference Information
Plenary Lecture
Table of Contents
Author Index
Financial Contribution
E-proceeding Search

Exit

Table of Contents

WC01 : Network-Based Control Systems

WC01-1 New Results on Synchronization for Complex Dynamical Networks with Time-Varying Coupling Delay and Sampled-Data 1
J.H. Park and Tae-Hee Lee

WC01-2 Decentralized guaranteed cost dynamic control for synchronization of a complex dynamical network 7
J.H. Park and Tae-Hee Lee

WC01-3 Efficient Use of Bluetooth in Networked Control Systems 13
Ulugbek Umirov and Jung-Il Park

WC01-4 CoNeT Mobile Laboratory for Ethernet Based I/O Systems in Industrial Applications 18
Galip Cansever, Levent Ucun and Onur Akbatı

WC01-5 Practical Consensus for Heterogeneous Linear Time-Varying Multi-Agent Systems 23
Jaeyong Kim, Jongwook Yang, Jungsu Kim and Hyungbo Shim

WC01-6 A Method for Determining Classroom Seating Arrangements by Using a Genetic Algorithm 29
Kazuhiro Shinike

WC02 : Sliding Mode Control

WC02-1 Super-twisting algorithm-based sliding mode controller for a refrigeration system 34
Sangchul Won, Baeyoung Koo and Youngjun Yoo

WC02-2 Sliding mode control for uncertain discrete-time system using robust model predictive control in reaching mode 39
Wookyong Kwon, Seongcheol Jeong and Sangchul Won

WC02-3 Fault Tolerant Sliding Mode Control for a Nanosatellite 44
Miri Shin, Chul Woo Kang, Junkyu Lim and Chan Gook Park

WC02-4 Robust Control for Seeker Scan Loop using Sliding Modes 49
Dharmveer Singh, Shailaja Kurode, Prasad Parkhi and Bhagyashri Tamhane

WC02-5 Terminal Sliding Mode Control System with Minimum Convergence Time for DC Motor Systems 55
Seong-Kyun Jeong, Bo-Ram Kim and Kang-Bak Park

WC03 : [OS] Intelligent Mechatronic Systems Ⅰ

WC03-1 On-line change detection and condition-based maintenance for a gradually deteriorating system 59
Mitra Fouladirad and Antoine Grall

WC03-2 A Study on Wave Energy Conversion Using Direct Linear Generator 64
Cong Binh Phan and Kyoung Kwan Ahn

WC03-3 An Investigation of Energy Saving by a Pressure Coupling Hydrostatic Transmission 70
Hoang Thinh DO and Kyoung Kwan Ahn

WC03-4 DC Motor Parameters Identification and Sensorless Torque Estimation Using Fuzzy PID 76
Thanh Liem Dao and Kyoung Kwan Ahn

WC03-5 Semi-Active Operation Assist Control Device for Manual Conveyance of Flexible Parts - Control System Design via Bilinear Optimal Control Theory - 82
Kensuke Yamaguchi, Michihiro Takeshige, Yoshifumi Morita, Noritaka Sato, Hiroyuki Ukai and Susumu Hara

WC04 : [OS] Intelligent Systems Ⅰ

WC04-1 Observer-based decentralized fuzzy controller for discrete-time large-scale fuzzy systems with packet losses 87
Geun Bum Koo, Jin Bae Park and Young Hoon Joo

WC04-2 S-Curve Profile Switching Method using Fuzzy System for Position Control of DC motor under Uncertain Load 91
Chang-Ho Hyun and Sang-Yun Lee

WC04-3 Output Feedback Stabilization Condition for Nonlinear Systems Using Artificial T-S Fuzzy Model 96
Dae Young Kim, Jin Bae Park and Young Hoon Joo

WC04-4 Neural Network Controller for Two-Degree-Freedom Helicopter Control System 101
Ribhan Zafira Abdul Rahman and Nusrat Jahan Shoumy

WC04-5 Robust stabilization condition for a polynomial fuzzy system with parametric uncertainties 107
Han Sol Kim, Jin Bae Park and Young Hoon Joo

WC05 : [OS] Running Technology of Rolling Stocks

WC05-1 Fatigue analysis of railway wheels according to UIC standards 112
Manh-Tuan Ha and Chul-Goo Kang

WC05-2 Roller Rig Tests of a Semi-Active Suspension System for a Railway Vehicle 117
Nam-Jin Lee, Chul-Goo Kang, Won-Sang Lee and Ton van Dongen

WC05-3 Implementation of a hydraulic actuation for tilting of the Hanvit200 train 123
Ho-Yeon Kim, Jun-Ho Lee, Haeng-Seob Lee, Sung-Ho Han, Bong-Tak Kim and Chul-Goo Kang

WC05-4 A Study on a Configuration of the Hydraulic Tilting Actuator and its Experimental Evaluations 127
Jun-Ho Lee and Seong-Ho Han

WC05-5 Estimation on the ride comport and running stability for tilting train on the Gyeongbu line in the Korean rail Network 130
Seong-ho Han, Su-Gil LEE and Hag-Lae RHO

WC06 : Service and Field Robots Ⅰ

WC06-1 Giving Robots a Flexible Persona: The five factor model of Artificial Personality in Action 133
Kiwon Sohn, Saravanakrishnan Krishnamoorthy, Paul Oh and M. Anthony Lewis

WC06-2 Cooperative control of differential wheeled mobile robots for box pushing problem 140
Moon Sungwon

WC06-3 Vibration Reduction Algorithm of the Walking-will Recognition Sensor on Irregular Terrain 145
Dongkwang Lee, Min-Soo Goh, Jung-Shik Kong and Eung-Huyk Lee

WC06-4 New In-Pipe Robot Capable of Coping with Various Diameters 151
Sari Yabe, Hiroyuki Masuta and Hun-ok Lim

WC07 : Unmanned Vehicle Systems Ⅰ

WC07-1 Disturbance Observer based Trajectory Tracking Controller for Quadrotor 157
KOOKSUN LEE, Juhoon Back and Ick Choy

WC07-2 Hovering Control of a Quadrotor 162
Keun Uk Lee, Han Sol Kim, Jin Bae Park and Yoon Ho Choi

WC07-3 Systematization of Flight Instruction and Control for Autonomous Helicopter 168
Yuto Matsuzawa, Yuta Tozaki, Yuji Kameda, Masuhiro Nitta and Kiyotaka Kato

WC07-4 Stereo Vision Based Collision Avoidance of Quadrotor UAV 173
Jongho Park and Youdan Kim

WC07-5 Monitoring for Intrusion Behaviors with a Small UAV 179

Josiah Yoder, Hyukseong Kwon, Rajnikant Sharma and Daniel Pack

WC07-6 Cross-Track control of UAVs during circular and straight path following using sliding mode approach 185
M. Zamurad Shah, Raza Samar and Aamer Iqbal Bhatti

WC08 : Robot Vision

WC08-1 Implementation of Vision-based Real Time Helipad Detection System 191
Sewon Lee

WC08-2 Geometrical measurement about welding shape using dual laser vision system 195
joonkil kim, Jinil Hong, Jaewoo Kim, Doojin Choi and Siyoul Rhee

WC08-3 Hardware Architecture for Detecting Laser Point Using FPGA 199
ByungMoo Jeon, Duc Dung Ngyuen, SangJun Lee, Jung Dong Jin and Jae Wook Jeon

WC08-4 FPGA Design and Implementation of a Real-Time Vehicle Detection System 204
Jungdong Jin, Vinh Dinh Nguyen, Sang Jun Lee and Jae Wook Jae

WC08-5 Gesture-based Teleoperation using a Holonomic Robot 208
Alvaro Uribe, Byron Perez-Gutierrez and Silas Alves

WC08-6 Object Recognition and Pose Estimation Using KLT 214
Hye-Jin Kim

WC09 : Industrial Applications of Control

WC09-1 Optimized Recuperation Strategy for (Hybrid) Electric Vehicles based on Intelligent Sensors 218
Stefan Koehler, Alexander Viehl, Oliver Bringmann and Wolfgang Rosenstiel

WC09-2 Charging and discharging cycle design for performance evaluation of HV batteries 224
Kouhei Komatsuzaki, Seiichi Shin and Kenji Sawada

WC09-3 Modeling and Control of a Continuously Variable Transmission in a Constant Speed Power Take-Off Application 229
Irmak Aladagli, Theo Hofman, Maarten Steinbuch and Bas Vroemen

WC09-4 Feasibility Test of Tracking Control to Moving Target in Dual-state Trolley Control System 235
Dongho Kim, Youngjin Park and Youn-sik Park

WC09-5 Automatic Welding Robot System for the Horizontal Position in the Shipyard 240
Sunghoon Ko, Hyeong Soon Moon and Jeom Goo Kim

WC09-6 Multi-Objective Design for Half-Car Active Suspensions 246
Semiha Turkay and Huseyin Akcay

WC10 : Sensors and Signal Processing

WC10-1 Energy based Memory Regulating System 252
JeongYon Shim

WC10-2 Fault accommodation in systems described by finite automaton models 255
Alexey Zhirabok, Alexey Shumsky and Yevgeny Bobko

WC10-3 A Energy-aware Clustering Algorithm via Game Theory for Wireless Sensor Networks 261
Yiping Yang, Chuan Lai, Lin Wang and Xiaofan Wang

WC10-4 Satellite Attitude Determination in Post-processing Based on URTS Optimal Smoother 267
Jing Yang and Xuan Lei

WC10-5 A Three-Stage CMOS OP Amplifier with a Dynamic Switching Bias Circuit 273
Hiroo Wakaumi

WD01 : Real-Time and Embedded Systems

WD01-1 An Implementation of the Enhanced-CAN BUS Network Connection in CAR Real-Time Embedded Software System 277
Chun-Shian Tsai

WD01-2 Benchmarking Java Application using JNI and Native C Application on Android 284
Yeongjun Kim, Seunghyun Yoon, Seongjin Cho, Kiljae Kim, Eunhye Hwang, Jaewook Jeon and Seunghyun Yoon

WD01-3 A recovery algorithm for PE files in a multi-core system 289
EunHye Hwang, Seong Jin Cho, Kil Jae Kim, Yeong Jun Kim, Seung Hyun Yoon and Jae Wook Jeon

WD01-4 A Gateway for Multi-device Communication between Mechatrolink-III and RS-485 294
Tuan Thanh Dang, Jin Ho Kim, Dung Duc Nguyen and Jae Wook Jeon

WD01-5 Development of High Performance Space Processor Emulator based on QEMU - Open Source Dynamic Translator 300
Jong-Wook Choi and Byeong-Gyu Nam

WD01-6 Real-time optical flow measurement based on GPU architecture 305
Shogo Minami and Teruo YAMAGUCHI

WD02 : Adaptive Control

WD02-1 Fault diagnosis with adjustment of input distribution and controller reconfiguration for over-actuated feedback control system 308
Sungho Park, Youngjin Park and Seonjin Yim

WD02-2 A Design of a Gain-Scheduling Controller by Convex optimization Satisfying Robust Performance Condition on the Nyquist Diagram 312
Yoshitaka Nishiguchi, Kazuhiro Yubai and Junji Hirai

WD02-3 Robust Shape Control of Two SMA Actuators Attached to a Flexible Beam Based on DK Iteration 316
Farshid Alambeigi, Ali Zamani, Gholamreza Vossoughi and Mohammad Reza Zakerzadeh

WD02-4 Adaptive Trajectory Tracking of Quantum Systems 322
Jianxiu Liu, Shuang Cong and Yaping Zhu

WD02-5 Control and synchronization of Lorenz systems via robust backstepping technique 328
YEASEOK PARK, Pyung-Hun Chang, Kyung-Soo Kim and Soohyun Kim

WD02-6 Comparison of VRFT, NCbT and VRFT with Spline Fitting 333
Keisuke Kubota, Nobuhiko Koyama, Ichiro Kitamuki, Masuhiro Nitta and Kiyotaka Kato

WD03 : [OS] Intelligent Mechatronic Systems Ⅱ

WD03-1 Control of mixing process in a novel micro-mixer 337
Behzad Otrodi, Mohammad Eghtesad, Mojtaba Mahzoon and Saeid Movahed

WD03-2 Design and Implementation of LQR controller for Inverted Pendulum by use of REX Control System 343
Stepan Ozana, Martin Pies, Zdenek Slanina and Radovan Hajovsky

WD03-3 Identification of Dielectric Electro Active Polymer actuator by Fuzzy NARX model and Particle swarm optimization 348
Truong B.N.M. and Kyoung Kwan Ahn

WD03-4 Application of Grey predictor in controlling 5 DOF power assistant robot 354
Khoa Le and Kyoung Kwan AHN

WD03-5 A novel design technique for IPMC diaphragm in micropump application 360
NAM DOAN NGOC CHI and Kyoung Kwan Ahn

WD04 : [OS] Intelligent Systems Ⅱ

WD04-1 Evolving Internal Memory Strategies for the Woods Problems 366
Hyungu Yim and DaeEun Kim

WD04-2 New delay-dependent stability criteria for T--S fuzzy systems with interval delay 370
Song Min Kook, Joo Young Hoon and Park Jin Bae

WD04-3 Fuzzy Logic Model for Deodorizer Troubleshooting in Palm Oil Refining 374
Intan Salleh, Khairiyah Mohd-Yusof and Gholamreza Zahedi

WD04-4 Stabilization of Fuzzy Descriptor Systems with Imperfect Premise Matching 379
Hojun Kim, Jinbae Park and Younghoon Joo

WD04-5 Robust Model Free Fuzzy Adaptive Controller with fuzzy and crisp Feedback Error Learning schemes 384
Muhammad Bilal Kadri

WD05 : [OS] Micro-Fluidic System for Industrial Printing

WD05-1 Morphologies of Ag Dots Printed by Electrohydrodynamic (EHD) Jet Printing on a Silicon Wafer 389
Fariza Dian Prasetyo, Hadi Teguh Yudistira, VuDat Nguyen and DoYoung Byun

WD05-2 Stabilizing Meniscus Shape to Improve Pattern Uniformity in Drop-On-Demand EHD Inkjet Printing Using Visual Feedback 392
Jungkeun Park, Trung Kien Nguyen, Doyoung Byun and Vu Dat Nguyen

WD05-3 Fine Metal Line Patterning of ITO Ink Based On Electrohydrodynamic Printing 395
JAEYONG CHOI and sukhan lee

WD05-4 A STUDY ON CONTROL OF JET PERFORMANCE FROM ELECTROSTATIC NOZZLE USING ORGANIC SOLVENTS 398
Soo-Hong Lee, XuanHung Nuyen and HanSeo Ko

WD05-5 Analysis of Droplet Formation and Ejection from Electrohydrodynamic Nozzle Using Three-dimensional Tomography Method 401
XuanHugn Nguyen, Soo-Hong Lee and HanSeo Ko

WD06 : Service and Field Robots Ⅱ

WD06-1 A Compact Wall-Climbing and Surface Adaptation Robot for Non-Destructive Testing 404
Hernando Leon Rodriguez, Tariq Sattar and Salman Hussain

WD06-2 DESIGN AND DEVELOPMENT OF OBSTACLE DETECTION AND WARNING DEVICE FOR ABOVE ABDOMEN LEVEL 410
Anuar bin Mohamed Kassim

WD06-3 Servo State Feedback Control of the Self Balancing Robot using MATLAB 414
Viriya Kongratana and Permpong Huantham

WD06-4 Development of Wheeled Inverted Pendulum Type Personal Mobility with Pedal: Design of prototype platform and verification of basic driving function 418
Seonghee Jeong and Yuji Masuda

WD06-5 Development of Koala Robot Capable of Expressing Various Kinds of Feelings 424
Fuminori Souma, Hiroyuki Masuta and Hun-ok Lim

WD07 : Unmanned Vehicle Systems Ⅱ

WD07-1 Dynamics and Control of a Single Tilt-wing UAV 430
Sung-Tae Hong, Seung-Keun Kim, Jin-Young Suk, Moon-Kyou Lee, Keuk-Hee Bang and Do-Myung Kim

WD07-2 Airdata system calibration using GPS velocity information 433
Am Cho, Young-shin Kang, Bum-jin Park, Chang-sun Yoo and Sam-ok Koo

WD07-3 Implementation of a BCF Mode Biomimetic Robotic-Fish Underwater Vehicle based on Lighthill Mathematical Model 437
ABHRA ROY CHOWDHURY

WD07-4 Collision Avoidance of Smart UAV in Multiple Intruders 443
Changsun Yoo, Am Cho, Bumjin Park, Youngshin Kang, Sang-wook Shim and Ilhyung Lee

WD07-5 Integrated Terrain Following Algorithm for UCAV 448
Gyeongtaek Oh, Hyoung-Seok Kim, Joong-Bo Seo and Youdan Kim

WD07-6 Robust Mobile Ground Target Localization Using Ground Image Features with UAV Position Compensation Techniques 454
Hyukseong Kwon, Rajnikant Sharma, Josiah Yoder and Daniel Pack

WD08 : [OS] Machine Vision and Its Application

WD08-1 Localization of Mobile Robot using Laser Range Finder and IR Landmark 459
Jong-Eun Ha, Kangwook Her and Dong-Hwan Kim

WD08-2 Homographic Tracking Algorithm of Moving Objects for Multiple Video Surveillance System 462
Kyung-Taek Hong

WD08-3 Orientation based multi-scale corner detection for mobile robot application 466
Sungho Kim, In So Kweon and Wang-Heon Lee

WD08-4 Development of System for Shortest Path Searching in Urban Transportation Network 469
Wangheon Lee, Byuhng-Munn Suhng, Byoung Kyun Kim and Euichul Lee

WD08-5 Robust Face Region Discrimination and Eye tracking in the Environmental changes 471
Wangheon Lee, byoungkyun Kim, Byuhng-Munn Suhng and Euichul Lee

WD08-6 3D Vision Based Local Obstacle Avoidance Method for Humanoid Robot 473
Myotaeg Lim, Do Young Lee, Yan Feng Lu, Tae-Koo Kang and Inhwan Choi

WD09 : Industrial Applications of Control Ⅱ

WD09-1 Ring based In-vehicle network model with RAPIEnet 476
Joon Seok Oh and Dae Hyun Kwon

WD09-2 Comparative study of approximate, proximate, and fast model predictive control with applications to autonomous vehicles 479
Bo-Ah Kim, Seung-Hi Lee, Young Ok Lee and Chung Choo Chung

WD09-3 Energy management strategy for hybrid fuel cell vehicle 485
Ramon da Fonseca, Eric Bideaux, Bruno Jeanneret, Mathias Gerard, Matthieu Desbois-Renaudin and Ali Sari

WD09-4 Verify the Number of Soda Bottles in the Casket by using Computer Vision 491
Teerapong Orachon and Pattana Intani

WD09-5 Missing Step Detection in a High Speed Micro Stepping Motor Using Current Feedback 494
Dong Hwan Kim, Sung Wook Moon, Young Jin Kim and Yoon Taek Lim

WD09-6 Ultra-Small Electric Vehicle Competition Using Small Rechargeable Batteries - pico-EV Eco Challenge 2012 - 498
Yoshihiko Takahashi and Kazufumi Uda

WD10 : Signal Processing and Sensor Fusion

WD10-1 Collision prediction system using intermittent ultrasonic wave 504
Masafumi Tokiwa and Teruo YAMAGUCHI

WD10-2 Sequential Measurement Processing for Tracking with an FMCW Radar Network 508
Dae-Bong Kim and Sun-Mog Hong

WD10-3 A Camera-computer System to Support Safe Walking of a Blind Person 511
Ai Kanayama and Seiji ishikawa

WD10-4 Applying MSC-HOG Feature to the Detection of a Human on a Bicycle 514
HEEWOOK JUNG

WD10-5 CFAR Detectors Employed by Radar Sensor Systems 518
Modar Shbat, Joon Hyung Yi and Vyacheslav Tuzlukov

WD10-6 Local Stereo Matching Using an Variable Window, Census Transform and an Edge-preserving Filter 523
VINH DINH, Duc Dung Nguyen, Dinh Vinh Nguyen and Jeon Jae Wook

TA01 : [OS] Recent Advances in Process Control and Monitoring I

TA01-1 Batch Process Control, From Traditional Approaches to 2D Control 529
Yi Yang, Shengyong Mo and furong gao

TA01-2 Fast moving horizon estimation for a distributed parameter system 533
Hong Jang, Kwang-Ki K. Kim, Jay H. Lee and Richard D. Braatz

TA01-3 Carbon Dioxide Capture Processes: Simulation, Design and Sensitivity Analysis 539
Muhammad Zaman, Jay Hyung Lee and Rafiqul Gani

TA01-4 Industrial Applications of Locally Weighted PLS to Realize Maintenance-Free High-Performance Virtual Sensing 545
MANABU KANO, Sanghong Kim, Ryota Okajima and Shinji Hasebe

TA01-5 IMC-PID controller tuning from closed-loop setpoint response 549
Mudassir Hasan, Mohammad Shamsuzzoha and Moonyong Lee

TA01-6 Efficient Quadratic Programming Algorithm for Model Predictive Control 553
Junghwan Kim and Kwang Soon Lee

TA02 : Disturbance Observer

TA02-1 Analysis of Discrete-time Disturbance Observer and a New Q-filter Design Using Delay Function 556
Chanhwa Lee, Youngjun Joo and Hyungbo Shim

TA02-2 A Novel Disturbance Observer using Adaptive Observation and Time Delay Estimation in Discrete Time Systems 562
Sung Hwan Kim, Kyung Soo Kim and Soo hyun Kim

TA02-3 Disturbance Observer Design Based on Linearized Vehicle Model for Unequal Tractive/Braking Force Identification 567
Jiwon Oh, Seibum Choi and Daeil Kim

TA02-4 On the Unified Approach to the Disturbance Observer 573
Seul Jung

TA02-5 Experimental Studies of a Disturbance Observer for Attitude Control of a Quad-Rotor System 579
Seung Ho Jeong and Seul Jung

TA03 : Process Systems

TA03-1 Using Matlab for Thermal Processes Modeling and Prediction at Mining Dumps 584
Radovan Hajovsky, Blanka Filipova, Martin Pies and Stepan Ozana

TA03-2 Improving Process Data Reporting System Using IT Process Automation Software in Sulfuric Acid Production 588
Prasit Julsereewong, Sakchai Sookjadit, Teerawat Thepmanee and Amphawan Julsereewong

TA03-3 Dynamic Modeling, Simulation and Control (using MPC) of an Industrial Steam Reformer 594
Sankararao Boddupalli and Jay Hyung Lee

TA03-4 A Study About The Ship Status Verification System Using Data Signal Processing 601
Jihun Yu, Seokmin Jang, Eunyoung Kim, Raesoo Lim, Hokyeong Kim, Yeohwan Yoon and Jooho Heo

TA03-5 Steel-yard Planning Support System : Optimizing the Steel-yard Planning and Performance Evaluation with Simulation 605
SEOKHYUN LEE, JIHUN YU, EUNYOUNG KIM, WOOSUNG CHOI, RAESOO LIM, HOKYEONG KIM and JOOHO HEO

TA03-6 A Design of Fuzzy PID Controller Based on ARM7TDMI for Coupled-Tanks Process 610
Arjin Numsomran

TA04 : [OS] Intelligent Systems Ⅲ

TA04-1 Pedestrian Detection Approach Based on Modified Haar-Like Features and AdaBoost 614
Van-Dung Hoang, Kang- Hyun Jo and Andrey Vavilin

TA04-2 Optical Flow Estimation and Error Analysis in Projective Space 619
Teruo YAMAGUCHI and Hiroyasu SHINBORI

TA04-3 Vision-based Vehicle Detection and Inter-Vehicle Distance Estimation 625
Giseok Kim and Jae-Soo Cho

TA04-4 Autonomous Vehicle Detection System using Visible and Infrared Camera 630
Jisu Kim, Sungjun Hong, Jeonghyun Baek, Euntai Kim and Heejin Lee

TA04-5 Adaptive ROI-based Autonomous Pedestrian Detection System 635
Jeonghyun Baek, Sungjun Hong, Jisu Kim, Euntai Kim and Heejin Lee

TA05 : [OS] Command Generation for Flexible System Control

TA05-1 [Invited Paper] Using Approximate Multi-crane Frequencies for Input Shaper Design 639
Joshua Vaughan, Jieun Yoo and William Singhose

TA05-2 Modeling and Input Shaping Control of a Micro Coaxial Radio-Controlled Helicopter Carrying a Suspended Load 645
Christopher Adams, James Potter and William Singhose

TA05-3 Command Shaping for Vibration Reduction of Container Cranes 651
Quang Hieu Ngo, Keum-Shik Hong and Yanghai Nan

TA05-4 Vibration reduction for positioning-system base subjected to moving stage using command shaping 656
Seong-Wook Hong, Gyu-Hyun Bae and Ah-Young Park

TA05-5 Input Command Generation for Flexible Systems with 2nd-Order Actuators 661
Yoon-Gyung Sung, Yoon-Sang Min and A-Ra Ko

TA05-6 Using Input Shaping to Repress Two-mode Residual Vibration on Aerial Lifts 667
Hongxia Jia, Fumin Zhu and Joshua Vaughan

TA06 : Robot Mechanism and Control Ⅰ

TA06-1 Tool-Point Control of a Planar Hydraulically Actuated Manipulator with Compensation of Non-Actuated Degree of Freedom 672
Magnus Berthelsen Kjelland, Michael R. Hansen, Ilya Tyapin and Geir Hovland

TA06-2 Tracking Control of Snake-like Robot with Rotational Elastic Actuators 678
Syunsuke Nansai and Masami Iwase

TA06-3 Dynamic Modeling of Glass Substrate Transfer Robot Arm System by using 5-Revolute Joints Manipulator Modeling Method 684

Minsu Jegal, Tae-hyun Kim, Seok-hyun Hong and Hyun-seok Yang

TA06-4 Design and Workspace Analysis of a New Endoscopic Parallel Manipulator 688
Khalil Ibrahim, Ahmed Ramadan, Mohamed Fanni, Kobayashi Yo, Ahmed Abo-Ismail and Masakatsu Fujie

TA06-5 Kinematic and Force Analysis of a 6 Degrees of Freedom 3-UPS Mechanism with Triangular Platform for Haptic Applications 694
Mohammad Khodabakhsh, Mehdi Sadeghpour, Soroosh Hassanpour and Gholamreza Vossoughi

TA07 : [OS] Autonomous Vehicle System

TA07-1 Study and Dvelopment of The VDC Algorithm for Independent AWD Autonomous Vehicle 699
Hae-Rim Yang, Chan-Se Jeoung, Ok-Jae Lee and Soon-Yong Yang

TA07-2 Control of Virtual Excavating System Base on Real-time Simulation 703
Quang Hoan Le, Young-man Jeong, Chi Thanh Nguyen and Soon-Yong Yang

TA07-3 A Study on Safety Steering for 3 Wheel Autonomous Vehicle 708
Joo-Hyun Ko, Chan-Se Jeong, Young-Man Jeong and Soon-Yong Yang

TA07-4 Robust Back-Stepping Control of Vehicle Steering System 712
Kyoung Taik Park, YoungJin Lee and Han Me Kim

TA07-5 Position Control of Mobile Two Wheeled Inverted Pendulum Robot by Sliding Mode Control 715
JungSu Ha and JuJang Lee

TA07-6 State Etimation of the Nonlinear Suspension System based on Nonlinear Kalman Filter 720
Sung-Soon Yim, Joon-Hong Seok and Ju-Jang Lee

TA08 : Human-Robot Interaction I

TA08-1 Self-Initiated Imitation Learning. Discovering what to imitate 726
Yasser Mohammad and Toyoaki Nishida

TA08-2 Simulation and Analysis of Dynamics of the Force-free Control for Industrial Robot Arms 733
Achala Pallegedara, Yoshitaka Matsuda, Naruto Egashira, Takenao Sugi and Satoru Goto

TA08-3 Human Anthropomorphic Gripper as an Automation Tool 739
Hernando Leon Rodriguez, alvaro Uribe and Edgar Diaz

TA08-4 Preliminary Drawing Test via Predictive Energy Bounding Algorithm for Time-Delayed Bilateral Teleoperation 745
Riaz Uddin and Jeha Ryu

TA08-5 Modified Bilateral Control by Using Intervention Impedance Based on Passivity of Flexible Master-Slave Manipulators and Its Design Methods 748
Takahiko Mori

TA08-6 Optimal EEG Feature Extraction based on R-square Coefficients for Motor Imagery BCI System 754
Pharino Chum, Seung-Min Park, Kwang-Eun Ko and Kwee-Bo Sim

TA09 : Actuators

TA09-1 A Method for Reliable Motion Control of Pressure Compensated Hydraulic Actuation with Counterbalance Valves 759
Pal Andre Nordhammer, Morten Bak and Michael Hansen

TA09-2 Reducing the Static Friction in Hydraulic Cylinders by Maintaining Relative Velocity Between Piston and Cylinder 764
Morten Ottestad, Nicolai Nilsen and Michael Hansen

TA09-3 Development of High Performance Shoes with Human Compatibility 770
Yasuhiro Hayakawa

TA09-4 Controlling the Slewing Motion of Hydraulically Actuated Cranes Using Sequential Activation of Counterbalance Valves 773
Pal Andre Nordhammer, Morten Bak and Michael Hansen

TA09-5 Improved Speed Control using Anti-Windup PI Controller for Direct Torque Control based on Permanent Magnet Synchronous Motor 779
Kraisorn Klinlaor and Nontawat Chuladaycha

TA09-6 A Recognition of the mode of dynamic motions of a vertical –rotating wind turbine in wind power station for the fault detections by indirectly measuring in bearing 784
rai wung park

TA10 : Fault Diagnosis

TA10-1 A n-dimensional Convex Hull Approach for Fault Detection and Mitigation for High Degree of Freedom Robots Humanoid Robots 790
Daniel Lofaro, Kevin Lynch and Paul Oh

TA10-2 Balance Weight Fault Detection in Compressor Using FFT Algorithm 798
Vittaya Tipsuwanporn, Arjin Numsomran and Mongkol Leawsoong

TA10-3 Development of Corrosion Rates Estimation method for CUI using Information Gain Ratio 803
Shigeyuki Tateno and Motoki Ichiyama

TA10-4 Principal Components Analysis based Fault Detection and Isolation for Electronic Throttle Control System 808
Moussa Hamadache and Dongik Lee

TA10-5 Bearing Fault Effect on Induction Motor Stator Current Modeling based on Torque Variations 814
Jaehoon Kim, Inseok Yang, Donggil Kim, Moussa Hamadache and Dongik Lee

TA10-6 Reliability Improvement of Closed Loop Control Systems Via Observer Based Sensor Compensation 819
ernie che mid

TD01 : [OS] Recent Advances in Process Control and Monitoring Ⅱ

TD01-1 Dynamic Simulation and Model Predictive Control for Gas Antisolvent Recrystallization Process 825
Shin Je Lee, Sungho Kim, Hyoun-Soo Kim, Youn-Woo Lee and Jong Min Lee

TD01-2 Global Approximation of Unsteady-State Diffusion and Reaction in Slab, Cylinder and Sphere Catalysts 830
Jietae Lee

TD01-3 An auto-framing method for stochastic process signals for fault detection by using a hidden Markov model based approach 834
Hana Lee and Jay H. Lee

TD01-4 Frequency Response Model Identification Method for Discrete-time Processes with Final Cyclic-Steady-State 840
Kyung Hwan Ryu, Kyung Su Kim, Ho Suk Kang, Si Nae Lee, Jun Young Cho, Jitae Lee and Su Whan Sung

TD01-5 Raman-based estimation of glucose concentration for on-line monitoring of biological process 845
Jong Min Lee, Se-Kyu Oh, Sung Jin Yoo and Shin Je Lee

TD02 : Estimation

TD02-1 On-line estimation of lactic acid concentration during batch fermentations of Streptococcus thermophilus based on pH measurement 851
Eduard Peter and Helmut Röck

TD02-2 Maximum friction estimation and longitudinal control for a full in-wheel electric motor vehicle 856
Marcel-Stefan Geamanu, Arben Cela, Guenael LeSolliec, Hugues Mounier and Silviu-Iulian

Niculescu

TD02-3 Integrated vehicle mass estimation using longitudinal and roll dynamics 862
Daeil Kim, Seibum B. Choi and Jiwon Oh

TD02-4 Parameters Effect in Sampling Importance Resampling (SIR) Particle Filter Prediction and Tracking of Flood Water Level Performance 868
Fazlina Ahmat Ruslan, Ramli Adnan, Abd Manan Samad and Zainazlan Md Zain

TD02-5 Survey of a controller design method based on experimental data, and a proposal of data conversion method 873
Nobuhiko Koyama, Keisuke Kubota, Ichiro Kitamuki, Masuhiro Nitta and Kiyotaka Kato

TD02-6 Collision Prediction System for External Airbag Using an Integrated Multiple Model Estimation Algorithm with Multirate Kalman Filter 878
Chang Mook Kang, Youngseop Son, Young Ok Lee, Chung Choo Chung and Seung-Hi Lee

TD03 : Optimal Control

TD03-1 Randomly occurring Leader-following Consensus criterion for Multi-agent systems with Communication delay 883
Myeongjin Park, Ohmin Kwon, Juhyun Park, Sangmoon Lee and Kihoon Kim

TD03-2 Dual LMI Approach to Linear Positive System Analysis 887
Yoshio Ebihara

TD03-3 IMC-Based PID Controllers Design for Torsional Vibration System 892
Viriya Kongratana and Aniwat Detchrat

TD03-4 Action-Dependent Updated Terminal Cost Receding Horizon Control for Discrete-Time Linear Systems 896
Mi Youn Moon, Jae Young Lee, Jin Bae Park and Yoon Ho Choi

TD03-5 Design of Deadbeat Controller by Polynomial Approach 902
Stepan Ozana, Martin Pies and Radovan Hajovsky

TD03-6 Dynamic Optimization of Guided Missile Trajectory by Use of Matlab and Dynopt Toolbox 908
Stepan Ozana, Martin Pies and Petr Wagner

TD04 : Recent advances in Intelligent Mechatronics

TD04-1 Optimization of Four-bar Steering Mechanism through Artificial Immune System (AIS) Algorithm 913
Yousof Ebneddin Hamidi, Morteza Saeidi Javash, Mir Mohammad Ettefagh and Farshid Abbasi Doust

TD04-2 Using ILS Mathematical Model and Measurements for Detailed Evaluating Results of Thermal Response Tests 918
Radovan Hajovsky, Petr Vojcinak and Jiri Koziorek

TD04-3 A Control Strategy for Designing an Intelligent Controller for Highly Dynamic/Perturbed Systems 924
Omar Mehrez and Ahmed Ramadan

TD04-4 Stabilization Analysis of Stochastic Hopfield Neural Networks 930
Xuyang Lou, Qian Ye and Baotong Cui

TD04-5 Quantized Feedback Control for Hybrid Impulsive Systems 934
Qian Ye, Baotong Cui and Xuyang Lou

TD05 : [OS] Advanced Mechatronic Systems

TD05-1 Incremental Displacement Estimation (IDE) for Structural Health Monitoring Robot 937
Haemin Jeon, Jae-Uk Shin, Wancheol Myeong and Hyun Myung

TD05-2 Adaptive Resource Allocation in Mobile Ad Hoc Computational Grids 941

Sayed Chhattan Shah and Wan Sik Choi

TD05-3 Cartesian Trajectory Control of Humanoid Robot Arms Based on a Disturbance Observer 947
Yeong-geol Bae and Seul Jung

TD05-4 Synchronization Method for Laser Scanner and Robot 952
Hee Shin Kang, Ji Whan Noh and Sung Jo Kwak

TD05-5 Design and Implementation of Path Generation Algorithm for Controlling Autonomous Driving and Parking 956
Kyoungwook Min, JeongDan Choi, Hangeun Kim and Hyun Myung

TD06 : Robot Mechanism and Control Ⅱ

TD06-1 Visual Odometry for Outdoor Environment using a Downward-Tilting Camera and Self-Shadow Removal Algorithm 960
Sungho Hong, Jae-Bok Song, Joo-Hyun Baek and Jae-Kwan Ryu

TD06-2 TAO – A Software Platform for Autonomous Mobile Robots 964
Silas Alves, João Maurício Rosário, Humberto Ferasoli Filho and Ivan Nunes da Silva

TD06-3 An Efficient Backtracking Strategy for Frontier Method in Sensor-based Random Tree 970
Jinho Kim, Kie Jeong Seong and H. Jin Kim

TD06-4 Departability Motion for Car-like Robot Based on GVG Roadmap 975
QUAN YUAN, Changsoo Han and Ji Yeong Lee

TD06-5 RSSI-Based Control of Mobile Cooperative Robots for Seamless Networking 980
Hyun-Ja Im, Chang-Eun Lee, Young-Jo Cho and Sunghoon Kim

TD06-6 Natural Corners Extraction Algorithm in 2D Unknown Indoor Environment with Laser Sensor 983
Ruijun Yan, Jing Wu, Weijun Wang, Sungjin Lim, Jiyeong Lee and Changsoo Han

TD07 : [OS] UGV(Unmanned Ground Vehicle) System

TD07-1 Design and Development of Magnetic Position Sensor for Magnetic Guidance System of Automated Ground Vehicle 988
Young J. Ryoo

TD07-2 Quadtree based Path Planning for Unmanned Ground Vehicle in Unknown Environments 992
Young-Min Han, jinbeom jeong and Jung-Ha Kim

TD07-3 Research of V2I Situated Cognition System based on LiDAR 998
Jaehwan Kim, Jungha Kim, Je-Uk Lee and Bok-Joong Yoon

TD07-4 Development of a Multi-resolution Parallel Genetic Algorithm for Autonomous Robotic Path Planning 1002
Carl Crane and Drew Lucas

TD07-5 A modified Dynamic Window Approach in crowded indoor environment for intelligent transport robot 1007
Baehoon Choi, Beomseong Kim, Euntai Kim and KwangWoong Yang

TD07-6 Indoor Localization using Laser Scanner and Vision Marker for Intelligent Robot 1010
Beomseong Kim, Baehoon Choi, Euntai Kim and KwangWoong Yang

TD08 : [OS] Human-Robot Interaction Ⅱ

TD08-1 Human Posture Measurement in a Three-Dimensional Space Based on Inertial Sensors 1013
Pyoung-gook Jung, Gukchan Lim and Kyoungchul Kong

TD08-2 TorqueMode Control of a Bowden Cable-Driven Assistive System 1017
Kyoungchul Kong and Joonbum Bae

TD08-3 Gait Phase-Based Control for a Knee Assistive System 1021
Joonbum Bae and Kyoungchul Kong

TD08-4 Gait Analysis based on a Hidden Markov Model 1025
Joonbum Bae

TD08-5 Back-Drivability Recovery of a Full Lower Extremity Assistive Robot 1030
Byeonghun Na, Joonbum Bae and Kyoungchul Kong

TD08-6 Multi-Class Stationary CSP for Optimal Feature Separation of Brain Source in BCI System 1035
Thanh Ha Nguyen , Seung-Min Park, Kwang-Eun Ko and Kwee-Bo Sim

TD09 : Industrial Applications of Control Ⅲ

TD09-1 The Verification Method for Control Logic Diagram of APR 1400 using Logic Translator 1040
Sunmi Choi and Heetaek Lim

TD09-2 Quality Measurement Of Template Models And Automatic Template Model Selection 1044
HYOHOON CHOI, Ram Mohan Gupta and SUNGHO SUH

TD09-3 Decoupling Control of 2-link Manipulator with Model Following Control and Proposed Control Gains Design 1049
linfeng lan

TD09-4 Low-Cost Automatic Screw Machine Using a Commercial Electric Screwdriver 1055
Jooyeon Hwang, Doohee Jung, Youngjun Roh, Keejun Nam and Dalyeon Hwang

TD09-5 Development of 4 Degree-of-Freedom ultra-precision Stage with millimeter motion range 1061
Dahoon Ahn, Youngman Choi, Siwoong Woo and Jaehwa Jeong

TD09-6 How to Diagram a Production Control System 1065
Sabah Al-Fedaghi and Faisal Al-Shahin

TD10 : Sensors and Instrumentation

TD10-1 Simple Resistance-to-Period Converter for Resistive Sensors 1071
Apinai Rerkratn, Jaturon Tongpakpanang, Anucha Kaewpoonsuk, Wandee Petchmaneelumka and Vanchai Riewruja

TD10-2 Simple Interface Circuit with Lead-Wire-Resistance Compensation for Single Resistive Sensors 1076
Wandee Petchmaneelumka, Prasit Julsereewong, Amphawan Julsereewong and Jaturon Tongpakpanang

TD10-3 Auto Gain Tuning Algorithm for Automation of Atomic Force Microscope 1080
Jiseong Jeong, Jisoo Kim, Kyihwan Park and Jong-kyu Jung

TD10-4 Development of a Knee Brace with a Locking Mechanism and its Locking Control to Reduce Applied Load to the Knee 1083
carlos reyes, Soon Geul Lee and Chae hyeuk Lee

TD10-5 On-line Drift Reduction for Portable Electronic Nose Instrument in Monitoring Indoor Formaldehyde 1088
Jingwei Feng, Fengchun Tian, Bo Hu, Qi Ye, Bo Xiao and Jielian Guo

TD10-6 Energy Efficient Distributed Interacting Multiple Model Filter in UWSNs 1093
Changho Yu, JeongCheor Lee, JaeWeon Choi, Myeong-Kwan Park and DongJoong Kang

TCI : Interactive Session Ⅰ

TCI-1 A High Performance CMOS Reference Current Generator with Negative Feedback Loop for Biomedical Neural Stimulator 1099
Ko Hyoungho, Kyomuk Lim and Jindeok Seo

TCI-2 Parallel Compressed Sensing Method to Accelerate MRI 1103
Intaek Kim and Nguyet-Lan Vu

TCI-3 Fast Thresholding Based on Improved Minimum Cross Entropy 1108
Yongliang Zhang, Wen Zhang, Gang Xiao, Jiafa Mao, shanshan huang and Xiaowei Zheng

TCI-4 An Electricity Energy and Water Consumption Model for Korean Style Apartment Buildings 1113
Dongjun Suh, Yoon-Sik Yoo, Il-Woo Lee and Seongju Chang

TCI-5 Robust Urban Road Surface Monitoring System using Bayesian Classification with Outlier Rejection Algorithm 1118
IL YOUNG SONG and VLADIMIR SHIN

TCI-6 Attraction Force Improvement Strategy of a Proportional Solenoid Actuator for Hydraulic Pressure Control Valve 1123
So-Nam Yun, Young-Bog Ham and Jung-Ho Park

TCI-7 MEMS vibratory gyroscope with highly programmable capacitive interface circuit 1128
Ko Hyoungho, Kyomuk Lim and Jindeok Seo

TCI-8 A Study on Energy Saving by Application of Energy Storage Device 1132
Hanmin Lee

TCI-9 MPPT Control of Photovoltaic System using the Two-Mode IC Method 1135
Dong-Hwa Chung, Jin-Kook Lee, Jae-Sub Ko and Da-Eun Jeong

TCI-10 MPPT Control of Photovoltaic System using Optimization Voltage with Temperature 1139
Dong-Hwa Chung, Da-Eun Jeong, Jae-Sub Ko and Jin-Kook Lee

TCI-11 System Modeling and Controller Design Using Time Series Data 1144
Hyun Jin Ahn, Kwan Shik SHIM, youngcheol lim, Euisun Kim, Young Jin Ko, Kyung-Min Park, Il-Hyun Baek and Yun Sik Ro

TCI-12 Reliability Management of Advanced Electrical Multiple Unit 1148
Euijin JOUNG and Gildong KIM

TCI-13 Commercialization and Popularization of Robotic Intelligent Components 1152
Young-Ho Choi, Jung-Woo Lee, Sung-Jo Yun, Sung-Ho Hong, Jin-Ho Suh, Suk-Joong Kim and Jin-Ho Park

TCI-14 ATP Functional Allocation for Korean Radio based Train Control System 1157
Sehchan Oh, Yongki Yoon, Minsoo Kim and Yongkyu Kim

TCI-15 Analysis on the Wireless Coverage to Operate Korea Radio based Train Control Systems 1161
Kangmi Lee, Eun-Gyeong Chae, Gonyop Kim Kim, Yong-Su Song and Jae-ho Lee

TCI-16 DC Motor Control using CDM based Two-Degree-of-Freedom Controller for Desired Tracking and Disturbance Rejection Characteristics 1167
Don Isarakorn

TCI-17 A Real-time Equipment Interface for Controlling Production Equipment 1173
Seung Woo Lee, So Jeong Nam and Jei Kyung Lee

TCI-18 Precise Welding Line Detection of a Hexahedron based on Twisted Motion of a Scanning LRF 1178
Sungmin Lee and Jaebyung Park

TCI-19 Identification of Flexible Mode and Motion Simulation for Beam Type Solar Cell Substrate Transport Robot 1181
CheolHoon Park, Dong Il Park and TaeKwang Yoon

TCI-20 Development of Ultra Lightweight Static Inverter for Electrical Multiple Unit 1185
Jeong-Min Jo, Yong-Jae Han, Chang-Young Lee, Jin-Ho Lee and Hyun-Seung Jeong

TCI-21 The Study of Train Power Energy Saver Control System on High Speed Tilting Train 1188
Su-Gil Lee and Seong-Ho Han

TCI-22 A Study of Propulsion System Operating Characteristics of Tilting Train 1194
Su-Gil Lee

TCI-23 Consensus Problem of Second-order Multi-agent Systems with Communication Channel Constraint on Signal Amplitude 1198
MingHui Wang and Kenko Uchida

TCI-24 Location Recognition for Elderly-Care Robot Services Using Received Signal Strength Indicator and Light Sensors 1203
Sangseung Kang

TCI-25 A study on the on-board centered train control system through ICT convergence 1206
Hyunjeong Jo, Gonyop Kim, Jonghyen Baek, Kangmi Lee, Ducko Shin, Kyungho Shin and Jaeho Lee

TCI-26 Analysis of Return Current for Rolling Stock Operation on Electrical Railroads 1211
Jonghyen Baek, Yongkyu Kim, Sehchan Oh, Hyunjeong Jo and Kangmi Lee

TCI-27 Modeling and real-time control of permanent magnet synchronous motor on cRIO 1217
Libor Vesely and Lukas Pohl

TCI-28 VCD: A Network Visualization Tool Based on Community Detection 1221
Runpeng Liang, Jun Hua and Xiaofan Wang

TCI-29 An Analytical Fault Detection Algorithm Using Euler Angles-Numerical and Practical Results 1227
seiied saeed nasrolahi, Hossein Bolandi and Mostafa Abedi

TCI-30 The Study of the transient radiation effects on electronic devices caused by pulsed high energy gamma-ray 1233
Oh Seungchan, Lee Namho and Heungho Lee

TCI-31 Design of Train Integrity Monitoring System for Radio based Train Control System 1237
Sehchan Oh, Yongki Yoon, Kyunghee Kim and Yongkyu Kim

TCI-32 Analysis on the Effect of Beam Overlap of a Low Directivity Ultrasonic Sensor Ring 1241
Hyunbin Kim and Sungbok Kim

TCI-33 Implementation of Sensor-embedded Main Wing Model of Ultra Light Airplane for Health and Usage Monitoring System (HUMS) Test-bed 1247
Jae-Hoon Song, Jae-Won Yang, Mi-Sun Rim and Ji-Hwan Kim

TCI-34 Solving 2pi ambiguity problem of a laser scanner based on phase-shift measurement method for long distances measurement 1250
Sungui Hwang, Junhwan Jang and Kyihwan Park

TCI-35 A Method of Zero self-modification and Temperature Compensation for Indoor Air Quality Detection Based on a software Model 1253
Cuiping Li, Jiuqiang Han, Qibin Huang, Xiaoqiang Dong, Xuequan Ding, yaming Ding, dianguo ZHANG and Ning Mu

TCI-36 Detection of Bruise Damage of Pear Using Hyperspectral Imagery 1258
Hong Quan Dang, Intaek Kim, Byoung-Kwan Cho and Moon S. Kim

TCI-37 Design of Automatic Tension Control Device for a Vibrating Wire Sensor 1261
Seok Jo Go, Keun Ho Rew, Jang Sik Park, Ki Ho Yu and Seung Hoon Lee

TCI-38 KTX's Interior Noise Reduction Performance Comparison for Each Section using Multichannel Active Noise Control 1265
HyeonSeok Jang, Young Min Kim, Jin-Do Chung and Kwon Soon Lee

TCI-39 Person location estimation using an inertial sensor unit and wireless modules 1271
Tran Duy Long and Young Soo Suh

TCI-40 Defect detection of Aerial images without reference image 1275
Sun Insun and Hong Jeong

FA01 : Artificial Intelligence

FA01-1 Statistical Performance of Conjugate Gradient Method for Wave-front Reconstruction in Adaptive Optics 1279
Hiroki Sakaematsu and Yohei Saika

FA01-2 Generalized MAP Estimation Via Parameter Scheduling and Maximizer of the Posterior Marginal Estimate For Image Reconstruction Using Multiple Halftone Images 1285
Yohei Saika and Kenta Morimoto

FA01-3 Reduction of ANFIS-Rules Based System through K-Map Minimization for Traffic Signal Controller 1290
azura che soh and Yee Kean Koay

FA01-4 Evaluation of Multimedia Distribution Systems in the Field of Foreign Language Acquisition 1296
Yuichi Ono, Manabu Ishihara and Mitsuo Yamashiro

FA02 : Robust Control

FA02-1 Further Improvement of Delay-Dependent Stability Criteria for Linear Systems with Time-Varying Delays 1300
Won Il Lee, Changki Jeong and PooGyeon Park

FA02-2 Set Invariance Approach to H∞ Control for Input-Saturated Systems with Disturbances 1305
Bum Yong Park, Sung Wook Yun and PooGyeon Park

FA02-3 Robust and adaptive control of Euler-Lagrange systems with an attractor independent of uncertainties. 1309
Nguyen Trung Quan

FA02-4 Quantitative Measures of Output Noise Sensitivities of Linear Systems in Modal Domain 1313
Haemin Lee and Youngjin Park

FA02-5 Robust Control of Permanent Magnet Synchronous Motor 1317
Petr Blaha and Pavel Vaclavek

FA02-6 Gain Scheduling GMV using Gaussian Function for nonlinear hystretic structural systems 1323
Lakhdar GUENFAF

FA03 : Linear/Nonlinear Control Ⅰ

FA03-1 On the adaptation of the air-conditioner to the indoor environment using the Constant-Trace Algorithm 1328
Ryo Yanagawa, Kenji Sawada and Seiichi Shin

FA03-2 Observer Based Nonlinear Tension Control for Multi Motor Wire Winding System 1333
Donghoon Shin, Wonhee Kim, Youngwoo Lee, Daehee Won and Chung Choo Chung

FA03-3 An Unmanned Bicycle versus Linear Quadratic Optimal Controls 1337
Krit Smerpitak, Prapart Ukakimaparn, Thanit Trisuwannawat and Sitthikorn Trakoonkootaworn

FA03-4 Three-Axis Magnetic Attitude Control Algorithms for Small Satellites in the Presence of Noise 1342
Jaime Rubio Hervas, Mahmut Reyhanoglu and Sergey Drakunov

FA03-5 An Output Feedback Controller for Practical Distributed Coordinated Tracking of Double Integrators 1348
Juhoon Back, Kun-hee Ryu and Seoung-wook Kim

FA03-6 General Subtask Controller for Redundant Robot Manipulators 1352
Omar Maaroof, Erkin Gezgin and Mehmet İsmet Can Dede

FA04 : [OS] Navigation Technology

FA04-1 Simultaneous State and Disturbance Estimation for Seeker System using Sliding Modes 1358
Bhagyashri Tamhane, Shailaja Kurode, Prasad Parkhi and Dharmveer Singh

FA04-2 Integration of Limited GNSS Signals with Monocular Vision based Navigation 1364
sangkyung sung, Dae Hee Won, Sukchang Yun and Young Jae Lee

FA04-3 An Indoor Positioning System for a First Responder in an Emergency Environment 1368
Gong Bo Moon, Moon Beom Heo and Gyu-In Jee

FA04-4 A design of synchronization method for TDOA-based positioning system 1373
Seong Han Cho, Sang Rae Yeo, Heon Ho Choi, Chansik Park and Sang Jeong Lee

FA04-5 Online Adaptive Optimal Tracking Control of Nonholonomic Mobile Robot 1376
kai wang

FA04-6 Fully Characterization of Strictly Positive Real Transfer Function Matrices 1381

Mojtaba Hakimi Moghaddam and hamid khaloozadeh

FA05 : [OS] Control and Optimization of Energy Systems

FA05-1 Optimal input design for sensitivity analysis of microalgal bioreactor systems 1386
Sung Jin Yoo, Se-kyu Oh, Jong Min Lee and Shin Je Lee
FA05-2 Iterative Learning Control of a Reactive Batch Distillation Process 1390
Hyunsoo Ahn, Kwangsoon Lee, Mansuk Kim and Juhyun Lee
FA05-3 Exergetic Analysis of Power and Freshwater Cogeneration systems 1396
Iman Janghorban Esfahani and ChangKyoo Yoo
FA05-4 Energy Planning for a Residential Network of micro Combined Heat and Power Generators 1402
Georgios Kopanos, Michael Georgiadis and Efstratios Pistikopoulos
FA05-5 Dynamic Modeling and Control Studies for the Elevated Pressure Air Separation Unit in an IGCC Power Plant 1407
Kosan Roh, Hyojin Lee and Jay. H Lee
FA05-6 Active Disturbance Rejection Control For Circulating Fluidized Bed Boiler 1413
Yuqiong Zhang, Donghai Li and Yali Xue

FA06 : Robot Mechanism and Control Ⅲ

FA06-1 A Method to Detect Object Grasping without Tactile Sensing on a Humanoid Robot 1419
Junwon Jang, Kyungrock Kim, Kicheol Park, Hoseong Kwak and Kyungsik Roh
FA06-2 Development of Electromagnet Brake Robot Finger for Highly Dexterous Motion through a Single Motor 1423
Young June Shin, Ho Ju Lee, Keun-Ho Rew, Kyung-Soo Kim and Soohyun Kim
FA06-3 Racket Control for Robot Playing Table Tennis Ball 1427
Chunfang Liu, Yoshikazu Hayakawa and Akira Nakashima
FA06-4 A Strategy for Connector Assembly using Impedance Control for Industrial Robots 1433
HyunCheol Cho, Young-Loul Kim, Byeong-Sang Kim and Jae-Bok Song
FA06-5 Discussion of Alternating Muscular Activity for the Design of an Automatic Saddle Positioning System 1436
Tatsushi Tokuyasu and Shimpei Matsumoto

FA07 : [OS] Navigation, Guidance, and Control Ⅰ

FA07-1 Indoor 3D pedestrian tracking algorithm based on PDR using smartphone 1442
Beomju Shin
FA07-2 Omni-directional Image Matching for Homing Navigation Based on Optical Flow Algorithm 1446
Youngseo Cha and DaeEun Kim
FA07-3 An Efficient Localization Method using RFID Tag Floor Localization and Dead Reckoning 1452
Jewon Lee, Youngsu Park, Daehyun Kim, Minho Choi, Taedong Goh and Sang woo Kim
FA07-4 Visual Navigation using Pixel Intensity Information 1457
Changmin Lee and DaeEun Kim
FA07-5 Ceiling vision based SLAM approach using sensor fusion of sonar sensor and monocular camera 1461
Sungjin Jo, Hyukdoo Choi and Euntai Kim
FA07-6 CV-SLAM using Line and Point Features 1465
Hyukdoo Choi, Sungjin Jo and Euntai Kim

FA08 : [OS] New Approaches and Methods for Human-Robot Interaction Design

FA08-1 Assistive Control of a Surgical Robot Based on Bilateral Interacted Force Analysis 1469
Ping-Lang Yen

FA08-2 Receding Horizon Passive Control for a Walk-Assist Robot 1474
Chun-Hsu Ko, Kuu-young Young and Sunil K. Agrawal

FA08-3 [Invited Paper] User Identification Design by Fusion of Face Recognition and Speaker Recognition 1480
Kai-Tai Song, Chao-Yu Lin, Yi-Wen Chen, Shuo-Cheng Chien, Sin-Horng Chen, Chen-Yu Chiang, Jyh-Her Yang, Yi-Chiao Wu and Tzu-Jui Liu

FA08-4 Development of Direct Operation System for Mobile Robot by Using 3D CG Diorama 1486
Kenta Kato, Noritaka Sato and Yoshifumi Morita

FA08-5 Mechatronics Design of Multi-Finger Robot Hand 1491
Chwan Hsen Chen

FA09 : Power Electronics

FA09-1 A Single Phase 9-Level Inverter Controlling Based On Phase Lock Loop Technique 1497
Vittaya Tipsuwanporn, Arjin Numsomran and Kowit Phipek

FA09-2 Improving the protective performance of the Gas turbine and HRSG Trip from Hydraulic Damper Closing in Power Plant 1503
Prasit Phoosomma

FA09-3 A Generalized Optimization in Cascade and Modular Multi-level Inverters by Harmony Search Method 1506
Seyed Hossein Hosseini

FA09-4 Multilevel Z-Source Inverter Based SVC Algorithm 1512
Seyed Hossein Hosseini

FA09-5 Robust Digital Control of a Broadband PWM Power Amplifer 1518
Nobutaka Suzuki, Kohji Higuchi and Tatsuyoshi Kajikawa

FA09-6 A New Switching charger for Photovoltaic Power System By Soft-Switching 1522
Chamnan Ratsame

FA10 : Biomedical Signal Processing

FA10-1 Analysis of Gene Network in MCF-7 Human Breast Cancer Cells 1527
Ryohei Shiraishi and Takashi Nakakuki

FA10-2 Development of NIRS-BCI system Using Perceptron 1531
Kazuki Yanagisawa, Hideyuki Sawai and Hitoshi Tsunashima

FA10-3 A Neural Analysis on Motor Imagery and Passive Movement Using a Haptic Device 1536
Hagil Kang, Laehyun Kim, Wanjoo Park, Jae-Hwan Kang, Gyu-Hyun Kwon and Sung-Phil Kim

FA10-4 Frequency Response Analysis of Large-Scale Biological Systems 1542
Takaaki Moriyama and Takashi Nakakuki

FA10-5 Detection of Dermis and Fascia on Skin Layers for Liposuction Surgery Robot using Texture and Geometric Information 1546
Sangha Song, Yo Kobayashi and Masakatsu G. Fujie

FA10-6 A Novel, Robust Method of Measuring IMT(intima-media thickness) Using Graph Cut and Snake Model in Ultrasound Imaging 1552
Jaeeun Seo and DeukHee Lee

FB01 : [OS] Rehabilitation Mechatronics

FB01-1 Effect on Exercise Instrument of Horseback Riding indoor for Basic Fitness Evaluation 1558 seung rok kang and Tae Kyu Kwon

FB01-2 Effect on Improvement of Muscle Strength Unbalance according to Load Deviation Pattern in Upper Limbs 1562
seung rok kang and Tae Kyu Kwon

FB01-3 Evaluation of Simplified Repeated Resistance Training System for Severe Hemiplegic Stroke Patient 1566
Michito Yasukita, Yuki Iida, Kazunori Yamazaki, Noritaka Sato, Yoshifumi Morita, Hiroyuki Ukai, Yoshiaki Takagi, Yoshitaka Aoki, Hirofumi Tanabe and Rumi Tanemura

FB01-4 Development of Anti-Gravity Control Model for Robot Gait Traing System 1570
SungJae Kang, Hyunseok Cho, Seongyun Jung, GyoSeok Kim, JeiCheong Ryu and MunSeong Mun

FB01-5 Development of Knee Joint Robot for Students Becoming Therapists 1573
Yoshie Maeda, Tatsuya Hirano, Noritaka Sato, Yoshifumi Morita, Hiroyuki Ukai, Kouji Sanaka, Keiko Takao and Ayako Satonaka

FB01-6 Design and Control of an Exoskeleton Device for Active Wrist Rehabilitation 1577
Inhyuk Moon and Ju-hwan Bae

FB02 : PID Control

FB02-1 Synthesis of PD-type Anti-windup Compensators for LTI Systems with Asymmetric Input Saturation 1581
Yoshitaka Matsuda, Toshiki Haraguchi, Satoru Goto and Takenao Sugi

FB02-2 Discrete-Time PIDA Controller Designed by Kitti's Method with Bilinear Transform 1585
Prapaisri La-orsri, Krit Smerpitak, Prapart Ukakimaparn and Thanit Trisuwannawat

FB02-3 Bilinear Discrete PID×(n-2) stage PD Cascade Controller for SISO Systems 1591
Krit Smerpitak, Prapart Ukakimaparn, Thanit Trisuwannawat and Prera Lavanprakai

FB02-4 PID controller with feedforward low pass filters for permanent magnet stepper motors 1597
Youngwoo Lee, Donghoon Shin, Wonhee Kim and Chungchoo Chung

FB02-5 DISCRETE TIME ROBUST INTEGRAL SERVO WITH PID × (n-2)/2 STAGE PDA CONTROLLERS FOR UNSTABLE SYSTEMS 1601
Prachaya Achariyapagon, Pittaya Pannil and Thanit Trisuwannawat

FB02-6 Proportional-Derivative (PD) controllers for Haptics subject to Distributed Time-Delays: A Geometrical Approach 1605
Bogdan Liacu, Irinel-Constantin Morarescu, Silviu-Iulian Niculescu, Claude Andriot, Didier Dumur, Patrick Boucher and Frederic Colledani

FB03 : Linear/Nonlinear Control Ⅱ

FB03-1 A Design of H∞ Model-matching Multivariable Controller by Spectral Analysis using Model-free Controller Tuning 1611
Masataka Ishizaki, Kazuhiro Yubai and Junji Hirai

FB03-2 Boundary control of marine risers with bending couplings 1615
Tung Lam Nguyen, Khac Duc Do and Jie Pan

FB03-3 Control of a Spacecraft with Time-Varying Propellant Slosh Parameters 1621
Jaime Rubio Hervas and Mahmut Reyhanoglu

FB03-4 Orbital and Attitude Control of a Spacecraft Around an Asteroid 1627
Mahmut Reyhanoglu, Niloofar Kamran and Takahiro Kuhara

FB03-5 A Method of the Diagnosis through Descriptor Model of a Constrained Dynamic Motion of a Robot Gripper by the Indirect Measurement 1633
rai wung park and rai wung park

FB03-6 Silk dryer oven for a comunity with close-loop contol 1639
nitipong somchaiwong and Wirot Ponglangka

FB04 : [OS] Special Environmnet Localization and Navigation

FB04-1 Development of Autonomous Vehicle Control Algorithm Based on DGPS(RTK) and Test Vehicle Performance Verification 1644
Young-Geun Moon, Moon-sik Kim and Min-cheol Lee

FB04-2 Accurate Velocity Control based on the distance of a Mobile Robot and Obstacle using a Haptic Joystick 1649
Dong Hyuk Lee, Kyung Wook Noh, Sook Hee Park and JangMyung Lee

FB04-3 Performance Improvement and Height Estimation of Pedestrian Dead-Reckoning System using a Low Cost MEMS Sensor 1655
Yun-Ki Kim, Seung-hwan Choi, Hyun-Woo Kim and Jang-Myung Lee

FB04-4 Abrasion Diagnosis and Assessment of Marine engine Using the Wavelet Transform 1661
Hyunseop Lim, Jia-Jun Liu, Jong-ho Han and Jangmyung Lee

FB04-5 Path-Tracking Control of a Laser Guided Vehicle using Fuzzy Inference System 1666
Hajun Song, Jungmin Kim, EunKook Jung, Junha Lee and Sungsin Kim

FB04-6 Improvement of Travel Distance at the Outdoor Environment by using IMU and Encoder 1669
Kyoung-hwan Kim, Beom-seok Seo, Gun-woo Jeong and Jang-myung Lee

FB05 : [OS] Measurement, Control and Systems in the Steel Industry

FB05-1 Modeling of DC Electric Arc Furnace Using Chaos Theory and Neural Network 1675
Kyu-hwan Kim, Jae Jin Jung, Sang Jun Lee, Seokbae Moon and Sang Woo Kim

FB05-2 Development of The Real Time Hardware-in-the-Loop Simulator for 5 Stand Cold Rolling Mill 1679
Young-il Kang, Sung-Hoon Choi, Gyoo-taek Lee and Sang-Chul Won

FB05-3 Automated Surface Inspection System for Black Resin Coated Steel 1683
ChangHyun Park, HoMoon Bae, JongPil Yun and SungWook Yun

FB05-4 Application S/W re-engineering approach in the steel plant to improve productivity efficiently 1686
Youngbok Park, Jinseok Yang, Jinhee Lee and Kyyoung Shin

FB05-5 Measurement of Mechanical Properties of High Strength Steel Sheets using Laser-Based ultrasonics 1691
Choongsoo Lim and Hyeongjun Huh

FB06 : Bio-Systems and Control Ⅰ

FB06-1 A Synthesis Method of Gene Regulatory Networks Having Cyclic Expression Pattern Sequences and Its Evaluation 1694
Yoshihiro Mori and Yasuaki Kuroe

FB06-2 Nano carriers based targeted drug delivery path planning using hybrid particle swarm optimizer and artificial magnetic fields 1700
Syed Hassan and Jungwon Yoon

FB06-3 Hemodynamic Study for New Stent Design with Mesh-Typed Stents in a Cerebral Aneurysm Model using PIV 1706
CHANG-HO YU, MAKOTO OHTA and TAE-KYU KWON

FB06-4 Biologically Inspired Grasp Primitives for a Dexterous Robotic Hand to Catch and Lift a Sphere 1710
John Lavery, Ben Kent and Erik Engeberg

FB06-5 Image-based Force Estimation of Deformable Tissue using Depth Map for Single-Port Surgical Robot 1716
Seong Young Ko, Wooyoung Kim, Sungmin Seung, Hongseok Choi, Sukho Park and Jong-Oh Park

FB06-6 Design of Robotic Surgical Instrument for Minimally Invasive Surgical Robot System 1720

Chul Sung Kim, Chang-Woo Park, Bong-Seok Kim, Jae-Bok Song and Jung-Hoon Hwang

FB07 : [OS] Navigation, Guidance, and Control Ⅱ

FB07-1 A Terrain Referenced Precision Approach based on LiDAR for Lunar Landing 1724
Wonhee Lee, Young Min Yoo, Sun Min Lee and Chan Gook Park
FB07-2 Vision-only UAV Navigation Aided by Terrain Elevation Map 1729
Yeongju Kim, Dongjin Lee and Hyochoong Bang
FB07-3 Integration of Terrain Rerenced Navigation System with INS using Kalman Filter 1734
Dongjin Lee, Hyochoong Bang and Cheonjoong Kim
FB07-4 Flight Test of Flight Control Performance for Airplane Mode of Smart UAV 1738
Youngshin Kang, Bumjin Park, Am Cho, Changsun Yoo and Samok Koo
FB07-5 Design of Self-Tuning Gain Depth Controller for an Autonomous Underwater Vehicle with Mass Shifter Mechanism 1742
Hyeungsik Choi
FB07-6 Design of Hovering Underwater Robotic Platform to Capture Harmful Marine Organisms 1747
TaeWon Seo, Jin Sangrok, Seokwoo Lee, Jihoon Kim and Jongwon Kim

FB08 : [OS] Medical Robotics and Simulation

FB08-1 Combined Kinematic Analysis of a Hybrid 7-DOF Rehabilitation Robot 1752
Hyun Soo Woo and Ohwon Kwon
FB08-2 Multi-criteria Optimization of the 4 Links of an 8 DOF Haptic Master Device for a Surgical Robot 1756
Seung Gyu Kang, Hashim Iqbal and Doo Yong Lee
FB08-3 H_∞ Control of Bilateral Telesurgical Systems with Communication Constraints 1762
Ayoung Hong, Jang Ho Cho and Doo Yong Lee
FB08-4 Affective Classification Using Bayesian Classifier and Supervised Learning 1768
Seong Youb Chung and Hyun Joong Yoon
FB08-5 Effects of Imperfect Communication Network on Haptic Teleoperator's Performance 1772
Hyoung Il Son, Ayoung Hong, Heinrich H. Buelthoff and Dongjun Lee

FB09 : Power Systems

FB09-1 Building Power Management for Energy Saving: A Case Study of University Building 1778
Amphawan Julsereewong, Prasit Julsereewong and Satit Mangkalajan
FB09-2 Model Predictive Control in Dynamic Economic Dispatch for Improving Grid Reliability 1783
Chung Hun Kim, Yonghao Gui, Young Ok Lee and Chung Choo Chung
FB09-3 Torque Control Methods for Wind Turbines and Their Responses 1788
Chae Wook Lim
FB09-4 Novel Unit Commitment Approach for Wind Farm 1791
Yonghao Gui, Chung Hun Kim, Young Ok Lee and Chung Choo Chung
FB09-5 Model Based PID Control Design for Bus Voltage Regulation in Multi-Machine Power Systems 1796
Seok-Kyoon Kim, Young Il Lee, Hwachang Song and Jung-Su Kim
FB09-6 Comparison of Power Quality and Luminous Efficacy of Commercial Energy Saving Lamps in Thailand 1800
nitipong somchaiwong, Ekkachai Chaidee and Prasan Ruchirasak

FB10 : [OS] Medical Imaging

FB10-1 Temporal Subtraction Method for Abdominal Contrast and Non-contrast Image Based on Image Matching Techniques 1805
Masashi Minashima, Syouhei Ogihara, Hyoungseop KIM, Joo Kooi TAN, Seiji ISHIKAWA, Seiichi MURAKAMI and Takatoshi AOKI

FB10-2 A Temporal Subtraction Method for Thoracic CT Images Using Non Rigid Warping Technique 1809
Takumi Tokisa, Hyoungseop Kim, Joo Kooi Tan, Seiji Ishikawa, Young Lae Moon, Sung Ho Yoon and Wontae Kim

FB10-3 Classification of Lung Nodules on Temporal Subtraction Image Based on Statistical Features and Improvement of Segmentation Accuracy 1814
Takahiro Miyajima, Takumi Tokisa, Shinya MAEDA, Hyoungseop Kim, Joo Kooi TAN, Seiji ISHIKAWA, Seiichi MURAKAMI and Takatoshi AOKI

FB10-4 Detection of Bone Regions on Legs from CTA Image Using Concentration Gradients 1818
Kodai Wada, Akiyoshi Yamamoto, Hyoungseop Kim, Joo Kooi TAN and Seiji ISHIKAWA

FC02 : Control Theory

FC02-1 A Continuous Canonical Form for Static Output Feedback in Linear System 1822
Ho-Chan Kim and Sin Kim

FC02-2 Robust Stabilization of Approximately Feedback Linearizable Time-varying Systems with Uncertainties Using Singular Perturbation 1828
Young-Jun Cho, Kyungin Kang, Min-Sung Koo and Jong-Tae Lim

FC02-3 Stability analysis of standard and non-standard nonlinear singularly perturbed system with uncertainty 1833
Kyun-Sang Park, Hyun-Wook Jo and Jong-Tae Lim

FC02-4 Analysis of input-output characteristics of boundary value linear systems 1838
Yoshiki Kagitani, Naoyuki Hara and Keiji Konishi

FC02-5 Damping Characteristics of the K-Polynomial 1842
Young Chol Kim and Jinghua Wu

FC02-6 Observer Design for a Class of Nonlinear Delayed Systems with Unknown Inputs and Markovian Jump Parameters 1848
Amir H. Abolmasoumi and Saleh S. Delshad

FC03 : [OS] Assistive, Rehabilitative and Medical System

FC03-1 Force Transmission in Joint-less Tendon Driven Wearable Robotic Hand 1853
Brian Byunghyun Kang, HyunKi In and Kyujin Cho

FC03-2 A Novel Registration Method for Total Knee Arthroplasty Using a Patient-Specific Registration Guide 1859
Taeho Jang and Kunwoo Lee

FC03-3 Development of Actuation System for Wearable Robots using Spiral Spring 1863
Yongtae Kim, Changyong Song and Jaeheung Park

FC03-4 Application of EEG for Multimodal Human-Machine Interface 1869
Jangwoo Park, Il Woo and Shinsuk Park

FC03-5 Power-Assisted Wheelchair with Gravity Compensation 1874
Soon-Wook Hwang, Chang-Hyuk Lee and Young-bong Bang

FC04 : [OS] ROBOTICS

FC04-1 An Intelligent Control of Mobile Robot Based on Voice Command 1878
Sung Hyun Han, Sung-Won Jung, Jong-Baem Won, Won-Jong Hwang and Chang-Jae Cho

FC04-2 A Real-Time Implementation of Walking Control for Humanoid Robot 1882
Sung Hyun Han, Ki-Won Sung, In-Man Park, Min-Sung Kim and Le Xuan Thu

FC04-3 A Study on Visual Servoing Control of Industrial Robot 1886
Sung Hyun Han, Woo-Song Lee, Jae-Hong Eom, Jong-Dae Won and Nguyen Huu Cong

FC04-4 A Robust Grasping Control of Robot Hand with Four Fingers 1891
Sung Hyun Han, Yoo Ki Cho, Eok-Gon Kim, Young-Ho Ha and Nguyen Huu Cong

FC04-5 A Study on Real-Time Implementation of Obstacle Avoidance for Autonomous Travelling Robot 1896
Sung Hyun Han, Byoung Kyun Shim, Won-Jun Hwang, Kyung-Sun Choi and Le Xuan Thu

FC05 : [OS] Control and Sensing System Application to Ocean Vehicle

FC05-1 Nonlinear Observer and Sliding Mode Control Design for Dynamic Positioning of a Surface Vessel 1900
Bui Van Phuoc, Sang Won Ji, Kwang Hwan Choi and Young Bok KIM

FC05-2 The H∞ Controller Design Including Control Allocation for Marine Vessel 1905
Sangwon JI, YoungBok KIM, JiHyun Jeong and JiSeong JANG

FC05-3 Improvement of Template Matching for Distance Measurement System Based on Image Sensors 1908
akio kita, yoshinobu hagiwara, yongwoon choi and Kazuhiro Watanabe

FC05-4 Development of a learning support system with PaPeRo 1912
Nozomi Fujiwara, Yoshinobu Hagiwara and Yongwoon Choi

FC05-5 Indoor Human Navigation System on Smartphones using View-Based Navigation 1916
Mitsuaki Nozawa, Yoshinobu Hagiwara and Yongwoon Choi

FC05-6 Analysis of Motion Response of Barge Ships in Regular Waves 1920
Lee Seung Chul, Kim Young Bok and Goo Ja Sam

FC06 : Bio-Systems and Control Ⅱ

FC06-1 Biomimetic Swimming Mini-Robots Using Electro-Magnetic Actuation (EMA) System 1923
Sukho Park, Hyunchul Choi, Semi Jeong, Cheong Lee, Youngho Ko, Seong Young Ko and Jong-Oh Park

FC06-2 Adaptive Synergy Control for a Dexterous Artificial Hand Based on Grasped Object Orientation 1927
Nareen Karnati, Benjamin A. Kent and Erik Engeberg

FC06-3 Direction of Slip Detection For A Biomimetic Tactile Sensor 1933
Erik Engeberg, Morteza Vatani and Jae-Won Choi

FC06-4 Simple Structured Tactile Sensor for Tissue Recognition in Minimal Invasion Surgery 1938
Joon Ho Kwon, Daehie Hong and Jung-Hoon Hwang

FC06-5 Arm exoskeleton rehabilitation robot with assistive system for patient after stroke 1943
Guan-De Lee, Wei-Wen Wang, Kai-Wen Lee, Sheng-Yen Lin, Li-Chen Fu, Jin-Shin Lai, Wen-Shiang Chen and Jer-Junn Luh

FC06-6 Distributed Series Elastic Actuator: analysis and simulations 1949
Hamed Ali Yaghini Bonabi, Majid Nili Ahmadabadi and Fariba Bahrami

FC07 : Navigation, Guidance, and Control Ⅲ

FC07-1 Optimal Geometric Allocation of Ground Stations for Navigation Satellites 1955
Young Hoon Kim, Jin Young Suk, Young-Rock Kim, Sang-Young Park, Myeong-Jong Yu and Young-Bum Park

FC07-2 A Hybrid Differentiator for Strapdown Guidance System 1960
Jun-fang Fan, Zhong SU, Qing LI and Jiang WANG

FC07-3 Development of driving support system for electric vehicle by using image processing technology 1965

YUXIANG SUN, NAN WU, Shigeyuki TATENO and Harutoshi OGAI

FC07-4 Low-Thrust Guidance Scheme for the Spacecraft using B-plane Targeting and Lyapunov Feedback control 1969
Dong-Hyun Cho and Hyochoong Bang

FC07-5 Model Predictive Planning and Control of Rotary-wing Unmanned Aerial Vehicle 1974
Kwangjin Yang and Salah Sukkarieh

FC07-6 An Improved Method to Integrate Low-Cost Sensors for the Navigation of Small UAVs 1980
fei liu

FC08 : [OS] Tele-Robot System

FC08-1 Remote Variable Access Protocol for Data-Centric TeleRobotics 1985
Jeong Seok Kang, Jong Whan Kim and Hong Seong Park

FC08-2 Field of View Deficiency-based Dominance Distribution for Collaborative Teleoperation 1990
Boris Gromov, Galina Ivanova and Jee-Hwan Ryu

FC08-3 Development of a Master Station for Remote Control of Rescue Robots 1994
Jae-Hee Kim, Jae-Cheol Lee and You-Rack Choi

FC08-4 3D-based Visual Assistance System for Tele-operation 1998
Ga-Ram Jang, Moon-Hong Baeg, Yong-Deuk Shin, Jae-Shik Yoon, Ji-Hun Bae and Jae-Han Park

FC08-5 An improved speed ratio control 2001
Soohee Han, Kwangsik Woo, Dooam Lee, Donguen Jung and Sanghun Oh

FC08-6 Implementation of a Work Distribution Function for Tele-operation under Multi-User and Multi-Robot Environments 2004
Joomin Kim, Sekwon Oh and Daewon Kim

FC09 : Robotic Applications

FC09-1 Slope Driving Experiment of Front Drive Type Electric Wheelchair with Casters using Yaw-rate Compensation 2008
Aydin Tarik Zengin, Yutaro Maruno, Hiroshi Okajima and Nobutomo Matsunaga

FC09-2 Development of Lane Estimator using the Vehicle’s Kinematic Motion 2014
Youngseop Son, Young Ok Lee, Chung Choo Chung and Seung-Hi Lee

FC09-3 Master-slave mapping and slave base placement optimization for intuitive and kinematically robust direct teleoperation 2017
Joao Rebelo and Andre Schiele

FC09-4 Sensorless Torque Control of Humanoid Arm having Highly Back-drivable Joints 2023
KyungWon Moon, Youngbo Shim, Yong-Jae Kim, Dong-Hun Lee, JongDo Choi, YoonSoo Kim and Kyungsik Roh

FC09-5 A Three Degree of Freedom Force/Torque Sensor to Measure Foot Forces 2028
CHAO YUAN and Changsoo Han

FC09-6 Design of an Intelligent Duct Cleaning Robot with Force Compliant Brush 2033
Seung Woo Jeon, Wootae Jeong, Duckshin Park and Soon-Bark Kwon

FC10 : [OS] Recent Advances in Brain Engineering

FC10-1 Investigation of cortical activation patterns in response to the inter-digit vibrotactile stimulation 2038
Sung-Phil Kim, Yoon Gi Chung, Junsuk Kim, Hyung-Sik Kim, Soon-Cheol Chung and Jang-Yeon Park

FC10-2 Imaging of Functional Network Properties in Intractable Epilepsy Based on Neural Signal Analysis 2042
Chang-Hwan Im

FC10-3 Analysis of fNIRS Data in the Prefrontal Cortex by Blind Separation into Independent Components 2046
Keum-Shik Hong, Hendrik Santosa and Xiaosu Hu

FC10-4 FNIRS based functional connectivity during task state and resting state 2049
Keum-Shik Hong, Xiaosu Hu and Shuzhi Ge

FC10-5 Feasibility of hybrid BCI using ERD- and SSSEP- BCI 2053
Sung-Chan Jun and Sangtae Ahn

FDI : Interactive Session Ⅱ

FDI-1 Global Set Point Robust Regulation for a PVTOL Vehicle With Bounded Inputs 2057
Obregón-Pulido Guillermo, Meda-Campaña J. A, Solis-Perales Gualberto and Castillo-Toledo B.

FDI-2 Semi-autonomous Navigation of an Unmanned Ground Vehicle for Bird Expellant in an Airport 2063
Chang-hoi Kim, Tae-won Jeong and Kyung-Min Jeong

FDI-3 Object and ground classification for a mobile robot in urban environment 2068
Jeong Hyo Ha, Sijong Kim and Myung Jin Chung

FDI-4 Design of T-S Fuzzy-Model-Based Diving Control of Autonomous Underwater Vehicles : Line of Sight Guidance Approach 2071
Sung Woo Jun, Do Wan Kim and Ho Jae Lee

FDI-5 Combinatorial Optimization Using FOA and GA in Futures Market Technical Analysis 2074
yuwen zhang and Chen Fang

FDI-6 Design Analysis of Precision Navigation System 2079
Seongkyun Jeong, Taehee Kim, Jae-Eun Lee, Sanguk Lee and Jiyun Lee

FDI-7 Analysis of Effect of Spoofing Signal in GPS Receiver 2083
Tae-Hee Kim, Cheon Sig Sin and Sanguk Lee

FDI-8 Modeling and Simulation of a Launch Vehicle Thrust Vector Control System 2088
Choong-Seok Oh

FDI-9 Improved Accelerometer and Magnetometer-Based Solution to Solve Quaternion 2093
Feng Zhou and Yanxuan Wu

FDI-10 E1 Signal Processing of Galileo IOV-1 PFM Satellite 2097
Inone Joo and Sanguk Lee

FDI-11 Accurate Calibration Method for SDINS Incorporating Earth-Rate Injection Technique 2100
Kyung-Jun Han, Byung-Su Park, Sang-Woo Lee and Myeong-Jong Yu

FDI-12 Real Time Inspection Method for Laser Welding Process 2106
Hee Shin Kang, Ji Whan Noh and Kyung Han Kim

FDI-13 The Assessment of Remote Accessibility for Processing Equipment Using the Graphic Simulator 2110
Sung-Hyun Kim

FDI-14 Study on the Requirements of Joint Torque Sensors considering Mechanical Condition of the Joint Mechanism of a manipulator 2114
Chanhun Park

FDI-15 Analysis of large range rotational flexure in precision 6-DOF tripod robot 2117
Dongwoo Kang and Daegab Gweon

FDI-16 Handling Gripper Using Multi Links Mechanism 2121
Kyoung Taik Park, Doo Hyung Kim and Hanme Kim

FDI-17 Design and Modeling of an Image Stabilizing Device for Small Unmanned Ground Vehicle 2125
Dooyeol Koh, Soohyun Kim and Kyungsoo Kim

FDI-18 Vibration simulation of hybrid type substrate handling robot in the vacuum environment 2131
DONG IL PARK, Cheolhoon Park and Yijun Yoo

FDI-19 Assembly phase estimation in the square peg assembly process 2135

DONG IL PARK, Chanhun Park, Hyunmin Do, Taeyong Choi and Jin-Ho Kyung

FDI-20 Design and Control of High-Speed Parallel Robot 2139
Hyun Min Do, Chan Hun Park, Byung In Kim, Gwang Jo Chung and Jin Ho Kyung

FDI-21 Motion Analysis of Lizard Locomotion Using Motion Capture 2143
Chang-hoi Kim, Ho-Cheol Shin and Tae-won Jeong

FDI-22 Simple and Complex Obstacle Detection Using an Overlapped Ultrasonic Sensor Ring 2148
Hyunbin Kim and Sungbok Kim

FDI-23 Adaptive Sliding Window for Hierarchical Pose-Graph-Based SLAM 2153
Seungwook Lim, Tae-kyeong Lee, Seongsoo Lee, Shounan An and Se-young Oh

FDI-24 Sliding Mode Control for a Two-Wheeled Inverted Pendulum Mobile Robot Driving on Uniform Slopes 2159
Dong Sang Yoo, Min-Sun Key and Chang-Gook Jeon

FDI-25 Occlusion Filling in Dynamic Programming with Simple Index Treatment 2163
JeongMok HA and Hong JEONG

FDI-26 Face Recognition by Weighted Multi-resolution Uniform Local Gabor Binary Patterns 2167
Kyung Joong Jeong and Dai Jin Kim

FDI-27 Vision-based metric topological SLAM 2171
Jihong Min, Jungho Kim, In So Kweon and Yong Woon Park

FDI-28 Online 3D World Reconstruction with Independently Moving Point Detection Using Stereo Vision 2177
Jungwon Kang, Bo Gil Seo and Myung Jin Chung

FDI-29 Monocular Vision based Independently Moving Feature Detection using Image Correspondences 2181
Sijong Kim, Jungwon Kang and Myung Jin Chung

FDI-30 A Night Firing System by One Camera Equipped Convex Mirror for Monitoring Tracer Bullet to Teach Exercises 2185
In Jeong Lee

FDI-31 Design of a Joint Actuation Module for External Force Detection 2189
Chanhun Park

FDI-32 Study on the User Interface for a Dual Arm Robot Manipulator 2192
Chanhun Park

FDI-33 Endoscopic Vision Based Tracking of Multiple Surgical Instruments in Robot-assisted Surgery 2195
Jaesoon Choi

FDI-34 DSP-based motion control of master-slave manipulator system developed for use in pyroprocess research facility 2199
Jong Kwang Lee, Byung Suk Park, Kiho Kim and Il-Je Cho

FDI-35 PRIDE remote handling systems 2203
KIHO KIM, Jongkwang Lee, Byungsuk Park and Ilje Cho

FDI-36 Advanced Manufacturing with Robot 2207
Taeyong Choi, Hyunmin Do, Chanhun Park, Kwangcho Chung, Dongil Park and Jinho Kyung

FDI-37 Augmented Reality Based Teaching Pendant for Industrial Robots 2210
syed mohsin abbas, syed hassan and Jungwon Yoon

FDI-38 A Predictive Collision-Free Fuzzy Algorithm for Mobile Robots to Avoid Obstacles Moving at Variable Speeds 2214
Jin-Woo Jung and Hoang Minh Do

FDI-39 A Proposal of User Friendly Alive Human Detection Robot to Tackle Crisis Situation 2218
shuddha Chowdhury and Mahmud Rafiq

FDI-40 Optimization of Driver Selection for Minimizing Cost on LNG Plant Considering Risk Factor 2222
Inkyu Lee, Kyungjae Tak, Wonsub Lim, Kwang-ho Choi and Moon Il

2012 12th International Conference on Control, Automation and Systems
Oct. 17-21, 2012 in ICC, Jeju Island, Korea

CFAR Detectors Employed by Radar Sensor Systems

Modar Safir Shbat[1*] , Joon Hyung Yi[2], and Vyacheslav Tuzlukov[3]

[1] College of IT Engineering, Kyungpook National University, Daegu, 702-701, Korea
(Tel : +82-10-9010-1319; E-mail: modboss80@gmail.com)* Corresponding author
[2] Hyundai Mobis, R&D Division, Seoul, 135-977, Korea
(Tel : +82-10-9234-9128; E-mail: 1620841@mobis.co.kr)
[3] College of IT Engineering, Kyungpook National University, Daegu, 702-701, Korea
(Tel : +82-10-4460-3517; E-mail: tuzlukov@ee.knu.ac.kr)

Abstract: This paper is devoted to detection performance evaluation of the constant false alarm rate (CFAR) detectors employed by radar sensor systems used to construct the middle range radar (MRR) and short range radar (SRR) based on linear frequency modulation continuous wave (LFMCW) radar sensor system. Several CFAR detectors are compared under the same initial conditions and the evaluation criterion is an ability to detect the target return signals at different signal-to-noise ratio (SNR) with and without interfering targets. Simulation results are presented.

Keywords: Signal detection, Radar sensor, Constant false alarm rate (CFAR), Frequency modulation continuous wave (FMCW) radar sensor.

1. INTRODUCTION

Radar sensor system offers high information content and provide very good ranging ability and relative velocity measurement at the same time in addition to other advantages, namely, functioning under any weather conditions and harsh environments (dust, dirt, light, snow) [1]. The linear frequency modulation continuous wave (LFMCW) radar sensor system with 24 GHz operation frequency is a trend technology recommended for middle range radar (MRR) and short range radar (SRR) applications [2], for example, intelligent transportation and safety driving systems like blind spot detection (BSD) [3], and closing vehicle detection (CVD) [4].

In this paper, several constant false alarm rate (CFAR) detectors are discussed, namely, the cell averaging CFAR (CA-CFAR) detector, the ordered statistic CFAR (OS-CFAR) detector, the generalized censored mean level (GCML) detector, and the adaptive censored greatest-of CFAR (ACGO-CFAR) detector. All these detectors can be employed by LFMCW radar sensor system and are compared by target return signal detection performance under the same initial conditions. We consider two main cases. The first case if there are no any interfering targets. The second case when there are one or more interfering targets. The performance analysis for the proposed detectors is made based on simulation.

The paper remainder is arranged as following: the LFMCW radar sensor waveforms and relation between the beat frequencies, the target range and relative velocity are presented in section 2. The CFAR detectors are analyzed in section 3. In section 4, the performance comparison and the simulation results are introduced. Finally, the conclusions are discussed in section 5.

2. LFMCW RADAR SENSOR WAVEFORMS

The LFMCW radar sensor system changes the transmitted waveform frequency linearly as a function of time. The modulating waveform consists of two sweeps: the up-sweep and down-sweep (triangle waveform). This shape helps us to define the target range and relative velocity between the radar sensor and target [5]. The instantaneous transmitted frequency $f_T(t)$ can be presented in the following form:

$$f_T(t)=\begin{cases} f_c+\dfrac{B}{0.5T_m}t, & 0<t<0.5T_m \\ f_c-\dfrac{B}{0.5T_m}t, & 0.5T_m<t<T_m, \end{cases} \tag{1}$$

where f_c is the radar sensor operation frequency, B is the transmitted waveform bandwidth (sweep bandwidth), and T_m is the sweep time. The sinusoidal LFMCW transmitted signal $S_T(t)$ is defined as:

$$S_T(t)=\sin\left[2\pi\left(f_c t+\frac{B}{T_m}t^2\right)\right]. \tag{2}$$

The target return signal delay in the case of moving target (with Doppler shift) takes one of the following forms:

$$\tau=\begin{cases} \dfrac{2(R-V_r t)}{c} \textit{ for approaching target;} \\ \dfrac{2(R+V_r t)}{c} \textit{ for receding target,} \end{cases} \tag{3}$$

where R is the target range, V_r is the relative velocity between the radar sensor system and the target, and c is the speed of light. The target return signal coming in at the input of the detector is defined in the following from:

$$S_R(t)=\sin\left\{2\pi\left[f_c(t-\tau)+\frac{B}{T_m}(t-\tau)^2\right]\right\}. \tag{4}$$

The difference in frequency between the transmitted and target return signals is called the beat frequency that is very important to define the target parameters. The frequency difference during the up-sweep part of the modulating waveform is the up-beat frequency f_{bu} , and the frequency difference during the down-sweep part of the modulating waveform is the down-beat frequency f_{bd} . The relation between these beat frequencies and the target parameters R and V_r is illustrated by the following equations:

$$f_{bu} = \frac{4BR}{T_m c} - \frac{2V_r}{c} f_c \,, \qquad f_{bd} = \frac{4BR}{T_m c} + \frac{2V_r}{c} f_c \,. \tag{5}$$

In practice, the target return signal is corrupted by noise and interference. Thus, the signal detection is a complicated problem and detection performance is an important factor for evaluation of any radar sensor system. By these reasons, the CFAR detector is an attractive solution for signal detection in radar sensor system.

3. CFAR Detectors

For any radar sensor system with high duty cycle, for example, FMCW radar sensor, the noise sensitivity seems to be very serious and important problem. Constant probability of false alarm P_{FA} is a desirable requirement for most radar sensors applications. Thus, there is a need to define the target return signal detection threshold based on the noise power (or noise variance) estimation that is varied as a function of time. The CFAR technique is based on implementation of the Neyman-Pearson criterion that can be expressed more formally for signal detection terminology as follows: there is a need to fix the probability of false alarm P_{FA} and maximize the probability of detection P_D . In any CFAR detector, the noise power is estimated after processing the number of reference cells using the sliding window technique. The required threshold is defined by multiplying the estimated noise power with scaling factor. This threshold is compared with signal power in the test cell or cells (the cell that is under investigation). The CFAR detectors are differed based on reference cells processing method and scaling factor. The threshold of any CFAR detector can be presented in the following form [6]:

$$V_T = TZ \,, \tag{6}$$

where T is the scaling factor, and Z is the estimated noise power. The relation between the P_{FA}, threshold, and the noise variance can be defined as:

$$P_{FA} = \exp\left(-\frac{V_T^2}{2\sigma_n^2} \right) , \tag{7}$$

where σ_n^2 is the noise variance. We consider four types of CFAR detectors.

3.1 CA-CFAR detector

The CA-CFAR detector [6] has an optimum performance under homogeneous noise conditions when the neighboring reference cells contain the noise samples with the same statistics as the test cell. This detector is relatively simple. It estimates the noise power by averaging the power values of the data samples in the reference cells of the sliding window and then defines the threshold. A basic CA-CFAR detector structure is shown in Fig. 2.

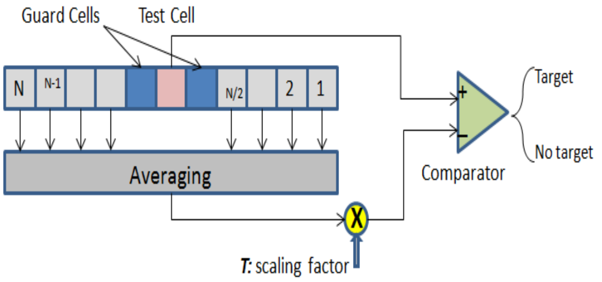

Fig. 1 CA-CFAR detector main structure.

The estimated noise power is given in the following from:

$$Z_{CA} = \frac{1}{N} \sum_{i=1}^{N} X_i \,, \tag{8}$$

where X_i , $i = 1,\dots,N$, are the square law detector output samples (that are stored by the reference cells) where the output signal amplitude is proportional to the square of the input signal amplitude. The probability of detection P_D can be presented in the following form:

$$P_D = \left[1 + T(1 + \overline{SNR}) \right]^{-N} , \tag{9}$$

where $\overline{SNR}$ is the average signal-to-noise ratio. The scaling factor for CA-CFAR detector is a function of the number of cells N and the P_{FA} :

$$T = (P_{FA})^{-1/N} - 1 \,. \tag{10}$$

3.2 Ordered statistic OS-CFAR detector

In many practical cases, the non-homogeneous noise conditions can be happened according to spatial and temporal variations in the noise power or closely spaced target return signals that may cause a bias in the estimated noise power and, consequently, the threshold. The OS-CFAR detector is designed to work under non-homogeneous conditions [7]. In the multi-target case, the performance of OS-CFAR detector is much better than mean level CFAR detectors family that includes the CA-CFAR, greatest of CFAR (GO-CFAR), and smallest of CFAR (SO-CFAR). This detector rearranges the reference cells data samples $\{X_1,\dots,X_N\}$ to form a new sequence according to the increasing power $\{X_{(1)} \le X_{(2)} \le \dots \le X_{(k)} \le \dots \le X_{(N)}\}$, where the $X_{(k)}$ element of the ordered samples is called the kth order statistic which is selected as a representative of the noise power (Fig. 3). This approach is based on the fact that the interfering target signal power is usually higher than the noise power. Thus, the OS-CFAR is able to reject the number of interfering targets equal to $N-k$ located in the reference window. The minimal loss for this detector is achieved when the k has a reasonable value given by

$$k = \frac{3}{4} N \,. \tag{11}$$

The probability of detection P_D for OS-CFAR is

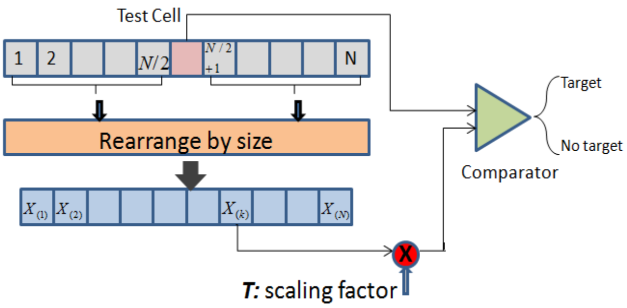

Fig. 2 OS-CFAR detector main structure.

determined by the following from:

$$P_D = \prod_{i=0}^{k-1} \frac{N-i}{N-i+\frac{T}{1+SNR}} \ . \qquad (12)$$

The scaling factor in this case is given by

$$T = (P_{FA})^{-1/k} - 1 \ .$$

Finally, the threshold is determined as:

$$V_T = TZ = TX_{(k)} \ . \qquad (13)$$

3.3 GCML detector

This detector operates under the non-homogeneous noise conditions [8]. The GCML detector defines the number and location of interfering targets in the reference window and discards them prior to define the noise power and the threshold, so there is no need to know the number of interfering targets (Fig. 4).

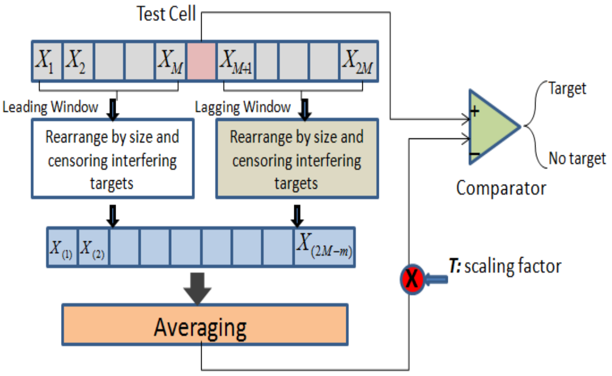

Fig. 3 GCMLD main structure.

The reference window is divided into two windows equal by length, the leading window $\{X_1, X_2, ..., X_M\}$ when $M = N/2$, and the lagging window $\{X_{M+1}, X_{M+2}, ..., X_{2M}\}$. These two windows are processed independently and in parallel way by the censoring processors. The censoring algorithm ranks the outputs of these two windows in ascending order of the amplitude like $\{X_{(1)} \le X_{(2)} \le ... \le X_{(M)}\}$ and $\{X_{(M+1)} \le X_{(M+2)} \le ... \le X_{(2M)}\}$ respectively. The algorithm considers the lowest order $X_{(1)}$ as the noise power representative and defines the threshold $V_{X(1)} = T_1 X_{(1)}$. This threshold is compared with $X_{(2)}$ and if $X_{(2)}$ is greater than $V_{X(1)}$ the censoring processor decides that the data samples corresponding to $\{X_2, X_3, ..., X_M\}$ are signals from interfering targets, and if $X_{(2)} < V_{X(1)}$ the algorithm decides that $X_{(2)}$ is a noise sample without interference. After that the censoring algorithm forms the sum of two lower ordered samples $X_{(1,2)} = X_{(1)} + X_{(2)}$ and defines the threshold $V_{X(1,2)}$ and compares this threshold with $X_{(3)}$. The censoring process is stopped when the hypothesis H_1 is decided to be true. More details about this detector can be found in [8].

3.4 ACGO-CFAR detector

This detector can be considered as a modified version of the GCML detector in order to reduce the clutter edge false alarm, when the test cell is at or near the boundary between two interference regions. Thus, the statistics in the leading and lagging windows will not be the same [9]. The detector suppresses the clutter edge false alarm by calculating the average noise power in the leading and lagging windows separately after applying the censoring process, and then selects the highest averaged value to consider it as the required estimated noise power. The structure of this detector is shown in Fig. 5.

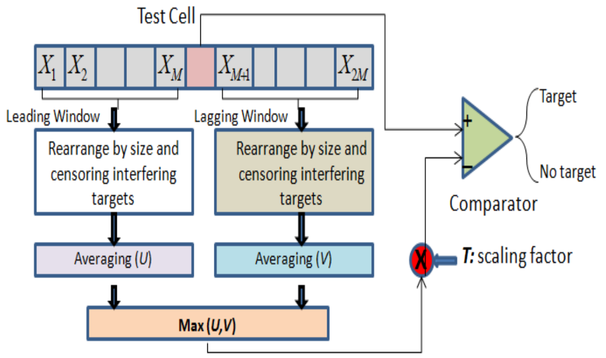

Fig. 4 ACGO-CFAR detector main structure.

Assuming that after applying the censoring process to the leading and lagging windows, n_1 samples are censored from the leading window cells and are censored from the lagging window cells, the remaining samples from the leading window $m_1 = M - n_1$ and from the lagging window $m_2 = M - n_2$ are used to estimate the noise power as follows:

$$U = \frac{1}{m_1} \sum_{i=1}^{m1} X_{(i)} \ , \qquad V = \frac{1}{m_2} \sum_{i=1}^{m2} X_{(i)} \ . \qquad (14)$$

The estimated noise power is set to be the maximum of U and V :

$$\hat{\sigma}_n^2 = \max(U, V) \ . \qquad (15)$$

4. SIMULATION RESULTS

The detection performances of all the discussed detectors are compared in terms of the probability of detection P_D for a specific range of SNR. The P_D is defined as the ratio between the number of observed components that exceed the threshold K and the total number of observations M :

$$P_D = \frac{K}{M}. \tag{16}$$

The performance evaluation is made in two cases. The first case- there are no interfering targets, and the second case- an existence of interfering targets is taken into account. All detectors are evaluated under the same initial conditions. Table. 1 shows the main simulation parameters.

Table. 1 Main simulation parameters.

Simulation Conditions	
Carrier frequency	24 GHz
Bandwidth (B)	600 MHz
Modulation time (T_m)	0.0625 s
First target range (R_1)	60 m
First target relative velocity (V_{r1})	10 m/s
Second target range (R_2)	63 m
Second target relative velocity (V_{r2})	10 m/s
P_{FA}	10^{-4}
Reference cell (N)	20
Selected cell (Kth)	15th (for OS)
Signal power	100 mW
Number of observations (M)	1000
R_3 = 66 m, R_4 = 70 m, R_5 = 73 m, R_6 = 76 m	
V_{r3} = V_{r4} = V_{r5} = V_{r6} = 10 m/s	
Subject target is modeled as Swerling 2	
Interfering targets are modeled as Swerling 2	

Figure 5 shows a comparison between CA and OS-CFAR detection performance when there are no interfering targets, and when there are one and two interfering targets. If there are no interfering targets, the CA-CFAR detector performance is better, but if one or two interfering targets are presented, the OS-CFAR performance is much better and the CA-CFAR performance is very low.

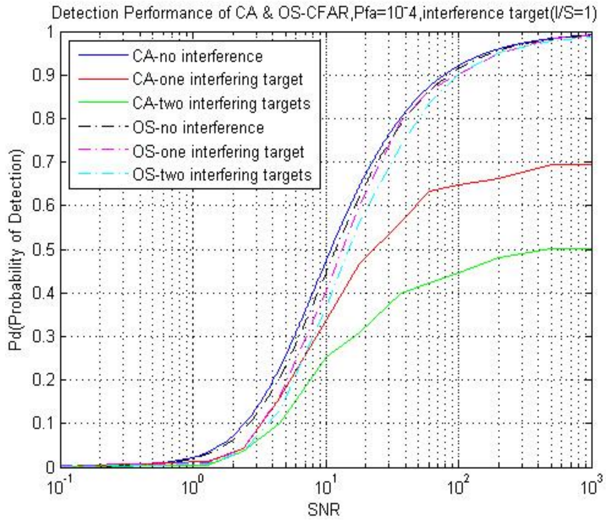

Fig. 5 CA & OS-CFAR performances comparison.

Figure 6 demonstrates a comparison between three detectors, namely, OS-CFAR, GCML, and ACGO-CFAR when there is no interference. The curves are very close with slightly vantage to GCMLD.

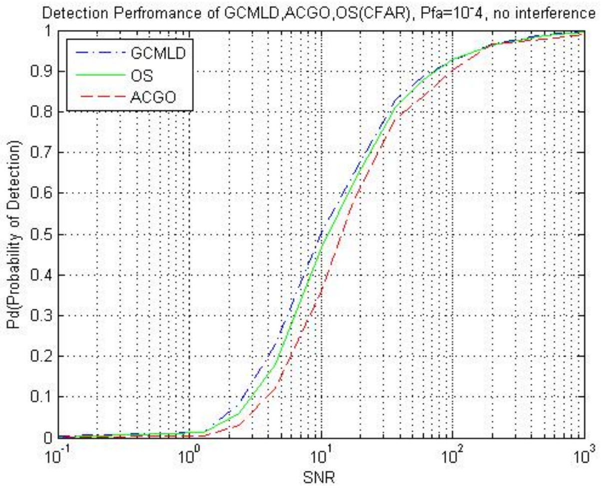

Fig. 6 Performance comparison (no interference).

Figures 7 (one interfering target) and 8 (two interfering targets) present robustness and the same performance ranking of OS-CFAR, GCML, and ACGO-CFAR detectors as in Fig. 6.

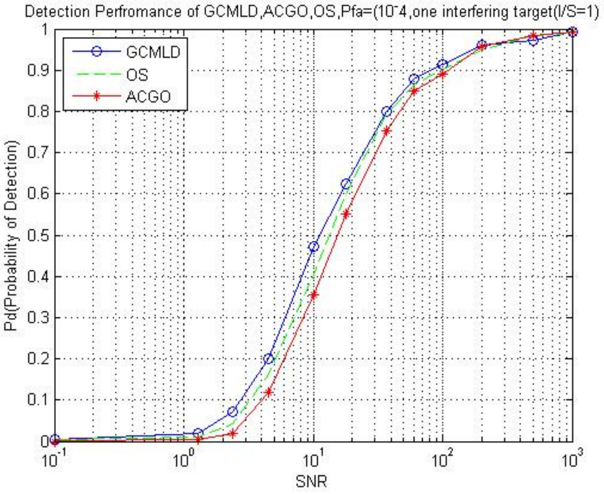

Fig. 7 One interfering target case.

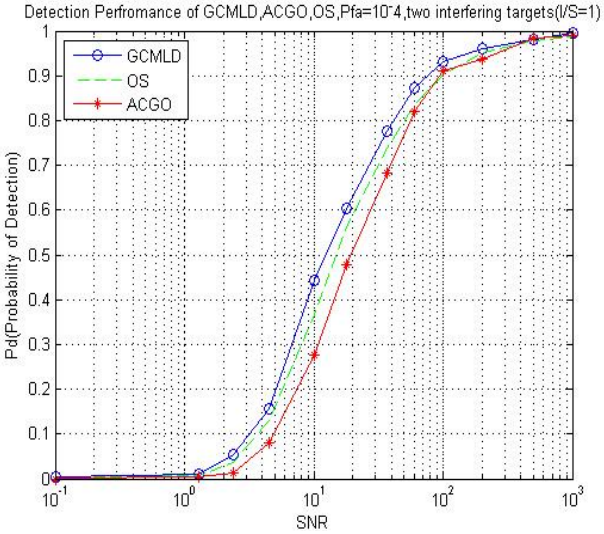

Fig.8 Two interfering targets case.

Figure 9 presents the performance of OS-CFAR, GCML, and ACGO-CFAR detectors when there are five interfering targets. In this case, all detectors show considerable degradation in the performance and also keep similar ranking as before except that the CA-CFAR detector for high SNR values (more the 20 dB) has the lowest performance.

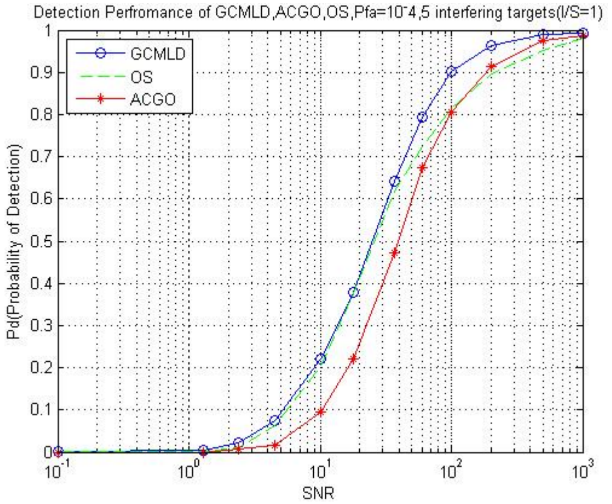

Fig.9 Comparison with 5 interfering targets.

Figure 10 demonstrates that the OS-CFAR performance is the worst. The reason is that there are six interfering targets, and the designed OS-CFAR can deal with no more than five interfering targets since $N = 20$ and the $k_{th} = 15$ ($N - k = 5$). Thus, to have five interfering targets is a critical case and one more interfering target causes big performance degradation.

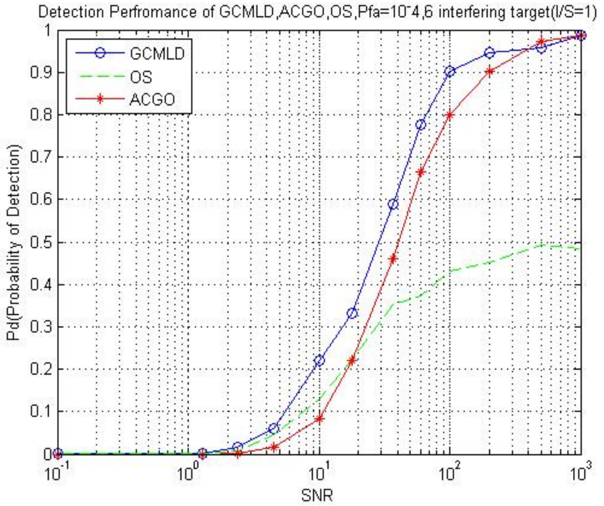

Fig. 10 Comparison with 6 interfering targets.

5. CONCLUSIONS

Based on the theoretical analysis, the simulation is carried out under conditions closed to practice to evaluate the presented CFAR detectors employed by FMCW radar sensor in the case when the interfering targets are absent and present. The CA-CFAR is the optimal detector among all other detectors under homogeneous noise conditions and when there are no interfering targets (target masking). The OS-CFAR detector suffers from minor degradation in the detection performance in comparison with CA-CFAR detector, but its performance in multi-target situation is clearly superior to CA-CFAR for a specific number of interfering targets that is known priori. The GCMLD and ACGO-CFAR detectors maintain a strong robustness against the interfering targets regardless of the number of the interference signals in addition to that the ACGO-CFAR detector is capable to suppress the clutter edge false alarm. The GCMLD has the best overall detection performance in homogeneous and non-homogenous noise conditions, but the main disadvantage of this detector is a very high computation cost as in the case of ACGO-CFAR detector. Thus, the OS-CFAR detector can be considered as the best trade-off between the detection performance and complexity.

REFERENCES

[1] M. S. Shbat, M. R.R. Khan, J. H. Yi, I. B. Lee and V. Tuzlukov, "Modern radar systems and signal detection algorithms for car applications", *Fizika*, Vol. XVII , No.1 e-n, pp.29-60, 2011.

[2] J. H. Yi, I. B. Lee, M. S. Shbat and V. Tuzlukov, "24 GHz FMCW radar sensor algorithms for car applications," *International Radar Symposium* (*IRS*) 2011, Germany, pp. 465-470, 2011.

[3] I. B. Lee, M. S. Shbat, M. R.R. Khan, J. H. Yi and V. Tuzlukov, "Signal processing algorithm for blind spot detection using 24 GHz FMCW radar sensor system," *Proceedings of The 11th Asia-Pacific ITS Forum & Exhibition*, Taiwan, June, 2011

[4] M. S. Shbat, J. H. Yi, and V. Tuzlukov," Signal processing for closing vehicle detection", *Proceedings of 2011 IEEE International Symposium on Antennas and Propagation (ISAP 2011)*, Korea, October 25-28, 2011.

[5] I. B. Lee, J. H. Yi and V. Tuzlukov, "24 GHz FMCW radar systems for blind spot detection system," *Proceedings of The Korean Society of Automotive Engineers (KSAE) 2011*, Korea, pp.1337-1342, May, 2011.

[6] H. Finn and R. Johnson, "Adaptive detection mode with threshold control as a function of spatially sampled clutter-level estimates," *RCA Review*, pp. 414-464, September 1968.

[7] H. Rohling, "Radar CFAR thresholding in clutter and multiple target situations," *IEEE Transactions on Aerospace and Electronic Systems*, Vol. AES-19, No. 4, pp. 608-621, July 1983.

[8] S. D. Himonas and M Barkat, "A robust radar CFAR detector for multiple target situations," *the IEEE National Radar Conference*, pp. 85-90, 1989.

[9] S. D. Himonas, "Adaptive censor greatest-of CFAR detection," *IEE Proceedings-f*, *Radar and Signal processing*, Vol. 139, No. 3, pp. 247-255, June 1992.