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ICOM'08

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CONTENTS

CHAPTER ONE: Mechatronics System Design and Applications

Title	Conference	Page
Automation of Pump Test Rig System <i>Ahmad Faris Ismail, Iskandar Al Thani Mahmood, and Tasneem Pervez</i>	ICOM'01	3
Auto Cruise System: A System to Assist During Traffic Congestion <i>Taufik Yunahar, Ahmad Imran Ibrahim, Asan Gani</i>	ICOM'05	17
Low Cost SCADA System With Auto Fault Detection Using Micro Controller <i>M. Azman Shah, Khalid A. S. Al-Khateeb, And M. F. Mohammad</i>	ICOM'05	24
Traffic Light Sequencing - An Element Of Adaptability <i>Sheroz Khan, Othman O Khalifa And Azuki Abdul Salam</i>	ICOM'05	32
Thermal Shock in Periodic Edge-Cracked Plate Supported by Elastic Foundation <i>Abd El-Fattah A. Rizk</i>	ICOM'05	38
Design and Development of an Automatic Car Door Opening and Locking System <i>Md. Ataur Rahman, A.K.M Mohiuddin, Irwan, Azoa and Adly</i>	ICOM'08	48
Development Of Unmanned Vehicle Utilizing GPS System <i>M. H. Ali, S.B Abdul Hamid, M. A. Rahman</i>	ICOM'08	53
Design Of An Autopilot For An Autonomous Unmanned Aerial Vehicle <i>M. Idres and R. Kafafy</i>	ICOM'08	59

CHAPTER TWO: Modelling and Simulation

Title	Conference	Page
Finite Element Study of Composite Cones Under Axial Compression Loading <i>Asad A. Khalid, Ahmad F. Ismail and Nurul Amin A. K. M</i>	ICOM'01	69
Design and Analysis of a Solar Still Using Finite Element Method <i>M. I. Ahmed, Y. A. Abakar, T. Pervez and A. F. Ismail</i>	ICOM'01	79
Anisotropic Laminated Composite Theory for Delamination Analysis of Curved Bar <i>T. Pervez and M. I. Ahmad</i>	ICOM'01	90
Free Vibration of Variable Thickness Plates Using Characteristic Orthogonal Polynomial Strip Functions Subjected to Different Combinations of Boundary Conditions <i>Abd El-Fattah A. Rizk, Ahmed S. Ashour</i>	ICOM'01	101
Using Spline Path in Real Time Navigation Simulations Systems, in Continuous Space <i>Ahmed Mustafa, Aisha-Hassan A. Hashim and Othman Khalifa</i>	ICOM'08	112
Semi-Active Suspension System for Off-Road Vehicles <i>Zohir BenLahcene, Waleed F Faris, MD Raisuddin Khan and S.I. Ihsan</i>		119

CHAPTER THREE: Intelligent Systems

Title	Conference	Page
Intelligent Keystroke Pressure-Based Typing Biometrics Authentication System using Multilayer Feed-forward Network <i>A. Sulong, Wahyudi and M.U. Siddiqi</i>	ICOM'08	131

Proposed Intelligent Algorithm for IC Marking Image Inspection <i>Yasser H. and M. J. E. Salami</i>	ICOM'08	138
The Role of Intelligent Systems in Mechatronics Engineering <i>Nahrul Khair Alang Md Rashid</i>	ICOM'08	144

CHAPTER FOUR: Instrumentation, Dynamics and Control

Title	Conference	Page
Hardware Implementation of Intelligent Braking System <i>S. N. Sidek and M. J. E. Salami</i>	ICOM'01	151
Design And Implementation of Dsp-Based Hybrid Controller for Some Motion Applications <i>Yusuf I. Bulale, M.J.E Salami</i>	ICOM'01	156
Fuzzy Logic Based Controller for Maintaining Human Comfort within Intelligent Building System <i>Nasrodin .T. Mustapha, Momoh J. E. Salami, Nazim M. Nasiri</i>	ICOM'05	167
Design and Implementation of Fuzzy Logic Controller for Intelligent Gantry Crane System <i>Wahyudi and J. Jalani</i>	ICOM'05	173
The Use of Scanning Electron Microscope in Evaluating Insulation Property <i>A.G..E. Sutjipto , Afzeri , R. Muhida , I. Sopyan 1 & E. Haruman</i>	ICOM'05	180
A Maximum Power Point Tracking for Photovoltaic System Using Temperature Compensator Method <i>Riza Muhida, Wahyudi Martono, Afzeri, Esa Haruman, Iis Sopyan , Abdul Gani Albagul and Agus Geter Edy Sutjipto</i>	ICOM'05	187
Neural Network Controlled of an Active Engine Mounting System Using a Nonlinear Electromagnetic Actuator <i>Fadly J.D., Wahyudi M. and Waleed F. Faris</i>	ICOM'08	194

A High Linearity CMOS RF Amplifier for Power Control Module in RFID Reader (ICOM 2008)	ICOM'08	203
<i>M. J. Uddin, M.A. Hasan, M. I. Ibrahimy, A. N. Nordin, M. A. M. Ali and M. B. I. Reaz</i>		
Design and Implementation of Fuzzy Control for Two Link Flexible Manipulator	ICOM'08	209
<i>Waleed F. Faris, Wahyudi Martono and Omar H. J. Hajjaj</i>		
State Feedback Control Tuning for Flexible Joint Manipulator Using PSO with Constraint	ICOM'08	215
<i>Mahmud Iwan S., Andika Aji Wijaya, Wahyudi</i>		
Fuzzy-based NCTF Controller for PTP Positioning: Fuzzy Membership and Rule Based Modifications	ICOM'08	223
<i>Purtojo, Rini Akmelawati and Wahyudi</i>		
Analysis of Magnetorheological Brake System with a Fuzzy Logic Controller	ICOM'08	231
<i>M.M.Rashid, Momoh J. E. Salami, M.A.Abd. Rahim and M.A.Hussain</i>		
Neural-tuned PID Control for Point-to-point (PTP) Positioning System	ICOM'08	237
<i>Wali Ahmad @ Myo Min Htut and Wahyudi</i>		

CHAPTER FIVE: Machine Vision

Title	Conference	Page
Review of Image Processing in Industrial Inspection and Quality Control (ICOM 2005)	ICOM'05	245
<i>Othman O. Khalifa and Sheraz Khan</i>		
Recognition of Handwritten Arabic Characters: Challenges and Prospective (ICOM 2005)	ICOM'05	250
<i>Sarra M. Abd Al-Rahim, Othman O Khalifa</i>		

A Review of Path Detection in Intelligent Video Surveillance	ICOM'08	258
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Imran Moez Khan, Yusof Zaw Zaw, Othman O. Khalifa and Lai Weng Kin

CHAPTER SIX: Speech and Image processing

Title	Conference	Page
Reduction of Motion Artifact in Portable Pulse Oximetry (ICOM 2008)	ICOM'08	267
<i>H. Malek, Othman O. Khalifa and I. Muhammad</i>		
Lossless Audio Compression using Psychoacoustic Model and Wavelet Transform (ICOM 2008)	ICOM'08	274
<i>Othman O. Khalifa, Sering Habib Harding and Aisha-Hassun A. Hasim</i>		
An Isolated Character Segmentation Approach (ICOM 2008)	ICOM'08	283
<i>Assma O. H. Ayyad, Othman O. Khalifa and Aisha Hassan</i>		
A study of Independent Component Analysis Applicability to Fetal Heart Rate Detection Using Photolethysmogarph (ICOM 2008)	ICOM'08	288
<i>H. Malek, Othman O. Khalifa and M. A. Mohd Ali</i>		
Educational Project on a Simple Voice Identification Using Frequency Cepstrum Coefficients and Vector Quantization (ICOM 2008)	ICOM'08	294
<i>H. K. Widhiputranto and R. Akmeliawati</i>		

CHAPTER SEVEN: Robotics and Automation

Title	Conference	Page
Movement Analysis for Building Intelligent Reactive Navigation Behaviours for Legged Robot	ICOM'01	303
<i>Adel Ali S. Al-Jumaily</i>		
Conceptual Design and Kinematic Analysis of Robotic Differential Gripper	ICOM'01	317
<i>Sameh Farag M. Ghobashi, Nazim Mir-Nasiri</i>		

Design Of Scara-Type Multi-Loop Robotic Arm <i>Nazim Mir-Nasiri</i>	ICOM'01	324
Humanoid Robot Head <i>A. A. Shafie, M.N. Kasyfi, N. I. Taufik Y.</i>	ICOM'08	331
Development of Mobile Photovoltaic Robot for Exploring Disaster Area <i>Riza Muhida, Suhaimi B Mohd Zaid, Wahyudi, Rifki Muhida, Ari Legowo and Akhmad Unggul</i>	ICOM'08	338
Investigation of a Novel Type of Locomotion for a Snake Robot Suited for Narrow Spaces <i>M. Watanabe, M.R. Khan</i>	ICOM'08	346
Cooperative Robot and User Friendly Robot- New Challenge in Robotics (ICOM 2008) <i>Md. Mozasser Rahman and Md. Raisuddin Khan</i>	ICOM'08	353
Inverse Kinematics of a Hyper-Redundant Robotic Manipulator <i>Syed Musrur Ahamad, Md. Raisuddin Khan, Md. Mozasser Rahman</i>	ICOM'08	358
A Gait Transition Method for Hexapod Robots <i>Md. Masum Billah, Dr. Mohiuddin Ahmed, Soheli Farhana</i>	ICOM'08	364

CHAPTER EIGHT: MEMS and Materials

Title	Conference	Page
Quality of Cu Film Electrodeposited on Silicon Wafer Using Different Current Densities <i>Shahjahan Mridha</i>	ICOM'05	373
Trimming of Atomic Force Microscope Probe Tip by Ion Milling <i>M. Y. Ali and B. H. Lim</i>	ICOM'05	381
Selection of Materials and Design Specification for Hip Joint Prosthesis <i>I. Sopyan, E. Haruman, A.G.E. Sutjipto, and R. Muhida</i>	ICOM'05	386

Generalized One-Dimensional Flow Inside Thermo-Electrically Controlled Micronozzle	ICOM'08	394
<i>Amar Hasan H and Raed Kafafy</i>		

CHAPTER NINE: MEMS and Materials

Title	Conference	Page
Intelligent Generator for Semi-Actual Test Data	ICOM'01	403
<i>Shihab A.Hameed, Abdul Majid A.Al-Abbasi</i>		
Improving Software Testing by Using Statistical Methods to General Multi-Structures Test Data	ICOM'01	414
<i>Shihab A.Hameed</i>		
Cellular Radio Based Vehicular Location Finding	ICOM'01	426
<i>Farhat Anwar</i>		
Controlling Electrical Appliances Using Global Mobile System	ICOM'05	439
<i>Sheroz Khan, Muhammad Fawzi bin Husin, Mohd Halim bin Mohd Noor</i>		
An Autonomous Integrated Architecture for the Next Generation Air Traffic Management and Avionics Systems	ICOM'05	444
<i>I Ahmed, M. J Sadiq</i>		
Overview of Radio Frequency Microelectromechanical Systems Reconfigurable Antennas	ICOM'05	450
<i>A.H.M. Zahirul Alam</i>		
Integrated Emergency and Guidance System Based on WiMAX Wireless Technology (IEGSW)	ICOM'05	458
<i>S. A. Hameed and B. A. Aliyu</i>		
Harmful Data Factors that Affect Internet's Users in Educational Industry	ICOM'05	466
<i>Shihab A. Hameed</i>		
Web based Documentation System for Dynamic Roadmaps	ICOM'05	472
<i>Sajid Hassan, Mohammad Ahsan Chishti, Farhat Anwar, Chandran Elamvazuthi</i>		

The Power of Web Portals as a Gateway to Resources and <i>Shihab A. Hameed, Mohammad Ahsan Chishti</i>	ICOM'05	480
Smart Antenna Design: An Overview <i>Zuhani Ismail Khan and Md Rafiqul Islam</i>	ICOM'05	486
Performance Study of Intra-Domain Mobility Management <i>Nazreen Rusli, Fauzana Ridzuan, Aisha Hassan Abdalla Hashim and Sajid Hassan</i>	ICOM'05	493
Performance Evaluation of Hierarchical Mobile IP <i>Aisha Hassan Abdalla, Farhat Anwar, Shaffiah Mohd, Hatina Banun Liyakthulikhhan, Sajid Hassan</i>	ICOM'05	500

CHAPTER TEN: MEMS and Materials

Title	Conference	Page
Machine Condition Monitoring and Fault Diagnosis Using Spectral Analysis Techniques <i>M.J.E. Salami, Asan Gani and T. Pervez</i>	ICOM'01	509
Development of a New Method of Crack Modeling and Prediction Algorithm <i>A. M. Aibinu, A. A. Shafie, M. J. E. Salami, A.F. Salami, I. A. Bamgbopa and W. A. Lawal</i>	ICOM'08	520
An Overview of Pulse Oximetry System for Noninvasive Monitoring <i>Muslim A. Abu-Umar, Liban A. Kassim and Othman O. Khalifa</i>	ICOM'08	528

CHAPTER ELEVEN: MEMS and Materials

Title	Conference	Page
Effect of Cooling Rate on Properties of Commercially Pure Aluminium <i>Faisal A. Rahim, Nur Izan Syahriah Bt. Hussein and M. M. Haque</i>	ICOM'01	535

Investigation of Chatter Arising during End Milling Operation on VMC and Quality of Machined Surface <i>A.K.M.N. Amin, M.A. Rizal, M. Razman</i>	ICOM'01	542
Surface Roughness of Carbides Produced by Water Abrasive Jet Machining <i>Ahsan Ali Khan, Mohd Efendee Bin Awang, Ahmad Azwari Bin Annuar</i>	ICOM'05	556
An Integrated Approach of Computer Aided Design, Rapid Prototyping and Investment Casting <i>M. M. Haque, Azdy M. Arshad and Irzal K. Helme</i>	ICOM'05	562
Pin Type Reconfigurable Clamping Ability Evaluation for Setup- Free Technology <i>Afzeri, A.G. E Sutjipto, A.K.M Nurul Amin, Riza Muhida</i>	ICOM'05	569
Workpiece Preheating Approach to Reduce Chatter and Improve Machinability of Titanium Alloy - Ti6Al4V <i>A. K. M. Nurul Amin, K. Kamaruddin, M. Abdelgadir</i>	ICOM'05	576
Effect of Processing Force on Architecture And Impact Strength of Glass Fiber Reinforced Epoxy Composites <i>A. Nazrin, S. Mridha and Mohamad A. Rahman</i>	ICOM'05	583
Investigations of the Causes of Chatter in Computer Aided Manufacturing Process during End Milling Operation <i>Md. Anayet U Patwari, A.K.M. Nurul Amin, Waleed Faris, S. Alam</i>	ICOM'08	591

Semi-Active Suspension System for Off-Road Vehicles

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ABSTRACT

Vehicles handling and ride comfort are essential subject because these vehicles operate at different environments. Improving the comfort ability enables the drivers to derive for a long time at critical situations with full activity. This paper deals with dynamics and control policies analysis of semi-active suspension systems for off-road vehicles. Three configurations of these vehicles: 2-axle, 3-axle and 4-axles have been studied and their performances are compared. The application of several control policies of semi-active suspension system, namely skyhook; ground-hook and hybrid controls have been analyzed and compared with passive systems. The results show that the hybrid control policy yields better comfort than a passive suspension, without reducing the road-holding quality or increasing the suspension displacement. The hybrid control policy is also shown to be a better compromise between comfort, road-holding and suspension displacement than the skyhook and ground-hook control policies. Skyhook control generally improves sprung mass responses while at the same time increase unsprung mass responses. On the other hand, ground-hook control generally improves unsprung mass responses at the expense of the sprung mass responses. Ground-hook control also found to take longer time to settle in transient state response. Results show an improvement in ride comfort and vehicle handling using 4-axle over 3-axle and 2-axle when emphasis is placed on the response of the vehicle body acceleration, suspension and tyre deflection.

Keywords: ride comfort; half-vehicle model; semi-active system; ground-hook; skyhook; hybrid; passive suspension system

1. INTRODUCTION

Apparent that comfort level and vehicle handling are two of the most important factors in a vehicle's subjective evaluation. Among the many aspects of a vehicle that influence these two properties, the vehicle suspension often has one of the greatest effects. Conventional suspension systems offer a trade off between ride comfort and vehicle handling, and their performance is often limited by this compromise [1]. Good design of a passive suspension cannot eliminate this trade-off, but can improve ride comfort and handling. Active and semi-active suspension systems can achieve a better compromise, but due to difficulties encountered in using a fully active suspension, it is often more practical to use a semi-active suspension for simplicity. Semi-active solutions are useful trade-off between design constraints and desired performances.

As documented in earlier studies, one of the benefits of semi-active dampers is that they can provide good ride comfort while maintaining good handling, by virtue of their ability to change the damping force. For semi-active damper, the damping force can be changed from relatively low level to much higher levels [2]. Since first introduced by Crosby and Karnopp [3] and Karnopp, Crosby, and Harwood [4], semi-active suspension systems continue to gain considerable attention in vehicle applications. This is due to its advantageous characteristics over passive system in overcoming the traditional conflict between vehicle safety and handling, and ride comfort, as well as its significantly less complexity and power requirement than active suspension system [5][6]. Semi-active dampers draw small amounts of energy to operate a valve to adjust the damping level and thus reduce the amount of energy transmitted from the source to the suspended body.