# MECHATRONICS BOOK SERIES
# SELECTED PAPERS FROM ICOM'01, ICOM'05 AND ICOM'08


**Editors**

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# CONTENTS

CHAPTER ONE: Mechatronics System Design and Applications


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

## CHAPTER TWO: Modelling and Simulation


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


## CHAPTER THREE: Intelligent Systems


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

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


## CHAPTER FOUR: Instrumentation, Dynamics and Control


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

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

## CHAPTER FIVE: Machine Vision

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

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


## CHAPTER SIX: Speech and Image processing


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


## CHAPTER SEVEN: Robotics and Automation


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

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


## CHAPTER EIGHT: MEMS and Materials


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

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

CHAPTER NINE: MEMS and Materials

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

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


## CHAPTER TEN: MEMS and Materials


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


## CHAPTER ELEVEN: MEMS and Materials


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

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

# Neural Network Controlled of an Active Engine Mounting System using a Nonlinear Electromagnetic Actuator

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## ABSTRACT

In this paper a two degree of freedom active engine mounting system controlled using an extended minimal resource allocation network (EMRAN) was considered where the dynamics of the nonlinear electromagnetic actuator was included in the system. The electromagnetic actuator was placed in parallel with the passive isolators to reduce the vibration induced by the engine to the chassis. Since the electromagnetic actuator had a nonlinear dynamics thus neural network would be one the best candidate to control the system. By training the neural network controller online EMRAN had the ability to grow, prune the number of hidden neurons. In this research the EMRAN neural controller not only showed the ability to control the nonlinear electromagnetic actuator but also able to reduce the vibration attenuated by the engine to the chassis.

## 1. INTRODUCTION

In this paper the dynamics of the nonlinear electromagnetic force actuator was considered as part of the system. The actuator was placed in parallel with the other passive actuators. By placing the actuator in parallel with the rubber mounts the system will have a fail safe mechanism if suddenly the force actuator does not function. A lot have been reported on active engine mounting system but only a few have actually included the dynamics of the force actuator into the system. This was because most force actuators are nonlinear in nature and the classical control theory only work efficiently for linear systems. Therefore, a neural network controller is considered as the nonlinear controller for the system to reduce the vibration induced by the engine.

During travel, vehicles are subjected to road irregularities that can represent the disturbance coming from the foundation which has a frequency range of less than 20 Hz. At the same time vibration induced by the engine caused by the motion of the pistons and connecting rods can caused disturbance which are sinusoidal in nature that ranges between 20 Hz to 50 Hz. To prevent the engine from bouncing off the chassis at lower frequency (below 20 Hz) and isolating the vibration induced to the chassis at higher frequency (above 20 Hz) passive rubber mounts have to inherit two contradicting characteristics i.e. to have a high stiffness at lower frequency range and low stiffness at higher frequency range [1-8]

This contradicting characteristic has led manufacturers to design a trade off between vibration isolation and transient engine response. In addition passive mount is only effective in vibration isolation at frequency level above its natural frequency which therefore shows the inability for the mount to isolate engine disturbance at the lower frequency region such as during idling or when the air conditioner is switched on. Since also the demand for lighter vehicle and powerful engine has resulted in the adverse effect to the comfort of the passenger therefore, the evolution of an active engine mounting is necessary to overcome the limitations of the passive system [2, 8-11].

In this paper the application of neural network in direct inverse control architecture for attenuating the engine vibration to the chassis is proposed. It was reported in [12-15] that neural networks such as the nonlinear autoregressive moving average (NARMA) has the ability to be trained and be used as a controller of a dynamic system and disturbance rejection. Based on the radial basis function architecture the extended minimal resource allocation network (EMRAN) has the ability to be trained online. The most distinct characteristic of EMRAN is the growing and pruning of its hidden layer