

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

Editors

Asan G. A. Muthalif
Amir A. Shafie
Momoh J.E. Salami



IIUM Pres

Published by:
IIUM Press
International Islamic University Malaysia

First Edition, 2011
©IIUM Press, IIUM

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without any prior written permission of the publisher.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

ISBN: 978-967-0225-68-5

Member of Majlis Penerbitan Ilmiah Malaysia – MAPIM
(Malaysian Scholarly Publishing Council)

Printed by :
IIUM PRINTING SDN. BHD.
No. 1, Jalan Industri Batu Caves 1/3
Taman Perindustrian Batu Caves
Batu Caves Centre Point
68100 Batu Caves
Selangor Darul Ehsan

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
--	---------	-----

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

Inverse Kinematics of a Hyper-Redundant Robotic Manipulator

Syed Masrur Ahamad, Md. Raisuddin Khan, Md. Mozasser Rahman

Department of Mechatronics Engineering, Faculty of Engineering
International Islamic University Malaysia, Jalan Gombak, 53100 Kuala Lumpur, Malaysia
raisuddin@iiu.edu.my

ABSTRACT

Serial robots, Snake or, Worm robots, Tentacle robots or continuum robots are known as hyper-redundant robots and possess very large degrees of kinematics redundancy. Inverse kinematics of hyper-redundant robots can have infinite number of solutions, which is a great challenge against position control of such robots. Various techniques have so far been proposed for inverse kinematics of hyper-redundant robots that involve wide range of mathematics, which include nonlinear optimization, Artificial Neural Network, Fuzzy System etc. In this paper a new technique has been proposed that assumes a configuration with a virtual layer, where probable singularities are included. In the successive steps the singularities are removed following some geometric propositions to have the final version of the configuration, which ultimately gives the inverse kinematics of the hyper-redundant robot. Mathematics involved in this new technique is the traditional inverse kinematics solution of two link subrobots, which are selected to satisfy the geometric propositions. The proposed technique has been tested on four link and six link robots and some comparison are made with one of the recent techniques known as ANFIS.

1. INTRODUCTION

Hyper-redundant robots have lots of advantages over the nonredundant robots for the flexibility of configurations in achieving the same goal. Due to the flexibility of configurations such robots are able to continue operations successfully even after mechanical failure of few joints. However, it is not an easy task to manage this flexibility due to the involvement of mathematical complexity in determining inverse kinematics (IKS) of these robots, especially, handling of pseudo inverse of non-square matrices. Literature on hyper-redundant robots shows various approaches for their inverse kinematic solutions. Chirikjian and Burdick [1,2] approximated continuous curve through the joints of the robots using Bessel function and then applied differential geometry, which helps avoid calculation of pseudo inverse matrices. This method works well for high level of redundancy that occurs in continuous robots and shows poor performance for reduced level of redundancy in discrete robots. Variable length links and artificial potential functions are used in [3] in reaching desired positions avoiding obstacles. References [4,5] applied optimization techniques in solving IKS of hyper-redundant robots, while [6-8] used ANFIS, Fuzzy logic or ANN. All these methods discussed involve complex mathematics, and some of them take considerable time to come up with useful IKS solution. When a manipulator is made of more than three links, the conventional technique of finding the joint variables is not useful. To come up with inverse kinematic solution the hyper-redundant robots are divided into small sub-robots and the small sub-robots are controlled separately and successively to control the parent robot [7].

Asl et al [9] came up with two IKS techniques of hyper-redundant robots, where one of these techniques known as VLA assumes few virtual layers and the other one known as DDS uses proportional distribution of displacements of the virtual layers. The DDS is used when the VLA gives singular configuration. In the present paper we have proposed a similar method with virtual layers. However, this new method instead of checking singular configuration at every step assumes the first virtual layer in singular configuration and then gradually removes the singularities to arrive at the final configuration that gives a coil shape.