



FCRAR 2007

The Florida Conference on Recent Advances in Robotics
& Robot Showcase

<http://fcrar2007.eng.usf.edu>

Conference Program & Abstracts



Center for
Rehabilitation
Engineering and
Technology

Program Overview

Thursday, 31 May

TECO room

- 08:00 – 09:00 Registration
- 09:00 – 09:15 Welcoming Remarks
- 09:15 – 10:15 Session 1A: Robot Kinematics
- 10:15 – 10:30 Break
- 10:30 – 11:30 Session 1B: Robot Kinematics
- 11:30 – 12:00 Robot Show Presentations (Dancing With Technology)
- 12:00 – 01:00 Lunch Break
- 01:00 – 02:00 Plenary Session 1: Autonomous Vehicle System
- 02:00 – 03:00 Session 2A: Robot Design
- 03:00 – 03:15 Break
- 03:15 – 04:15 Session 2B: Robot Design
- 04:15 – 04:30 Break
- 04:30 – 06:30 Laboratory Tours (Sign up at front desk)
- 07:00 Conference Dinner

Friday, 1 June

TECO room

- 08:00 – 08:30 Registration
- 08:30 – 09:30 Session 3A: Robot Control / Sensors
- 09:30 – 09:45 Break
- 09:45 – 10:45 Session 3B: Robot Control / Sensors
- 10:45 – 11:15 Robot Show Presentations
- 11:15 – 12:15 Plenary Session 2: Biologically-Inspired Robotics
- 12:15 – 12:30 Awards and Closing
- 12:30 Boxed Lunch

Detailed Program

Thursday, 31 May:

Welcoming Remarks

09:00AM – 09:15AM

Session 1A: Robot Kinematics I

Session Chair – Sabri Tosunoglu, FIU

09:15AM – 10:15AM

- Robot Arm Manipulator Control for SG5-UT, Hussain Sultan, Eric Schwartz, UF
- A Metric for Planar Displacements, Venkatesh Venkataramanujam, Pierre Laroche, FIT
- Linkage-Based Prosthetic Fingertips: Stability Analysis, Issa A. Ramirez, Craig P. Lusk, USF, Murray E. Maitland, UW

Session 1B: Robot Kinematics II

Session Chair – Alexander Leonessa, UCF

10:30 AM – 11:30 AM

- Kinematic Analysis of a Planar Tensegrity Mechanism, Jahan Bayat, Carl D. Crane III, UF
- Evaluating the Fault Tolerance of a Parallel Manipulator Based on Relative Manipulability Indices, Hyun Geun Yu and Rodney G. Roberts, FSU-FAMU
- Control of a 9-DoF Wheelchair-Mounted Robotic Arm System, Redwan Alqasemi, Rajiv Dubey, USF

Robot Show Presentations

11:30 AM – 12:00 PM

- Dancing with Technology: The Interplay of Form and Motion (A performance by a group of dancers using robotic devices, including people with disabilities)
- Short 3-minute presentations and demonstrations of various projects in the showcase

Lunch

12:00 PM – 01:00 PM

Plenary Session 1

01:00 PM – 02:00 PM

- Development of an Autonomous Vehicle System for the 2005 DARPA Grand Challenge Event, Carl Crane, UF

Session 2A: Robot Design I

Session Chair – Pierre Larochelle, FIT

02:00 PM – 03:00 PM

- Design, Fabrication, and Characterization of a Microgripper Device, Jose A. Martinez, Roberto R. Panepucci, FIU
- Proposed Design of a Triped Robot, Daniel Kamerling, Pierre Larochelle, FIT
- A Double Claw Robotic End-Effector Design, Redwan Alqasemi, Sebastian Mahler, Rajiv Dubey, USF

Session 2B: Robot Design II

Session Chair – Redwan Alqasemi, USF

03:15 PM – 04:15 PM

- TYROL: Evolution of a 10-Axis Biped Robot, Vishnu Madadi, Sabri Tosunoglu, FIU
- Xanthus: Self-Reconfigurable Modular Robot, Adrian Arbide, Vishnu Madadi, Sabri Tosunoglu, FIU
- Implementation of a Prototype Hybrid Golf Cart, Max Saelzer, Roger Messenger, Ali Zilouchian and Amir Abtahi, FAU

Lab Tours*

04:30 PM – 06:30 PM

- Rehabilitation Robotics Lab
- NNRC lab
- Center for Robot Assisted Search and Rescue Lab

Conference Dinner

07:00 PM – 09:00 PM

* Lab tours are available for a limited number of attendees, please sign up at the registration desk when you arrive at the conference.

Friday, 1 June:

Session 3A: Robot Control/Sensors I

Session Chair – Carl Crane, UF

08:30 AM – 09:30 AM

- Using the Wave Variable Method for a Human-Machine Haptic Interface in the Presence of Time Delay, Marc Alise, Rodney G. Roberts, Daniel W. Repperger, FSU-FAMU
- Adaptive Control for Nonlinear Uncertain Systems with Actuator Amplitude and Rate Saturation Constraints, Alexander Leonessa, Yannick Morel, UCF
- A Multithreaded Implementation of Assist Functions to Control a Virtual Reality Model of a 6-DoF Robot Arm for Rehabilitation Applications, Eduardo J. Veras, Ramya Swaminathan, Rajiv Dubey, USF

Session 3B: Robot Control/Sensors II

Session Chair – Alfredo Weitzenfeld, USF

09:45 AM – 10:45 AM

- Position Tracking Performance of a Redundant Teleoperation System, Mehmet Ismet Can Dede, Sabri Tosunoglu, FIU
- Multi Robot Systems: The EagleKnights/RoboBulls Small-Size League RoboCup Architecture, Alfredo Weitzenfeld, USF
- Determination of Impact Force and Crush Energy Using Abductive Networks, Oren Masory, FAU, Nicolas Putod, IFMA

Robot Show Presentations

10:45 AM – 11:15 AM

- Dancing with Technology: The Interplay of Form and Motion
- Short 3-minute presentations and demonstrations of various projects in the showcase

Plenary Session 2

11:15 AM – 12:15 PM

Biologically-Inspired Robotics: Learning from Nature, Alfredo Weitzenfeld, USF

Awards and Closing

12:15 PM – 12:30 PM

Boxed Lunch

12:30 PM

Abstracts

Session 1A: Robot Kinematics

09:15am

Robotic Arm Manipulator Control for SG5-UT

Hussain Sultan, Eric M. Schwartz

Machine Intelligence Laboratory

University of Florida

ABSTRACT

This paper presents a complete forward and inverse kinematics solution for SG5-UT, 5 DOF robotic arm. The solution is intended to be implemented on a microprocessor to control the arm in any environment. The control presented in the paper makes it possible to manipulate the arm to any reachable position. The algorithm derived in this paper has been successfully tested on the arm. This arm is analyzed for the purposes of being mounted on a humanoid robot, called Gnuman.

09:35am

A Metric for Planar Displacements

Venkatesh Venkataramanujam, Pierre Larochelle

Robotics and Spatial Systems Laboratory

Florida Institute of Technology

ABSTRACT

Metrics, which facilitate the measurement of parameters such as “distance” and “length” are used frequently in rigid body guidance problems. Commonly used metrics have a characteristic of being dependent on the choice of fixed or moving reference frame and the units used. Most motion synthesis algorithms require some notion of the “distance” between two desired locations¹. The metrics in Euclidean space depend on the coordinate frame and units used. A metric independent of these choices is desirable. In this paper we present a metric which is independent of the choice of fixed coordinate frame.

09:55am

Linkage-Based Prosthetic Fingertips: Stability Analysis

Issa A. Ramirez, Craig P. Lusk

Department of Mechanical
Engineering

University of South Florida

Murray E. Maitland

Department of Rehabilitation
Medicine

University of Washington

ABSTRACT:

The purpose of this study is to analyze linkage based prosthetic fingertips. The novel design consists of small four-bar mechanisms attached to each section of the opposing fingers replacing what would be the pulp of normal anatomical fingers. The four-bar mechanisms allow the prosthetic hand to conform to the shape of objects during grasp. The goal of these prosthetic fingertips is to maximize the functionality of the hand while minimizing the number of inputs that the user has to control. This is crucial in prosthetics where the user may have limited input options, but it may also be useful in robotics.

A prosthetic hand has two functions: controlling the orientation of the artificial finger pulps and controlling their position relative to the object. We consider these two functions independently. First, we describe the small fourbar mechanisms which control the orientation of simulated pulps. The stability of the four-bar mechanisms is described as well as their advantages in contrast to a stiffhinged single link. We then propose concepts for positioning the fingertips in two- and three-finger configurations. The focus of this paper is in the function of the four-bar fingertip mechanism; future research will address the optimal configuration of the fingertips on the hand.

The principle method used in this paper is a stability analysis via the principle of virtual work for a crossed four-bar mechanism, and, for comparison purposes, a stiff-hinged dyad. From this analysis we are able to show that four-bar fingertip mechanisms are self-stabilizing for a large range of rotation of the link on which the force is applied and a large range of directions that the force is applied. Stability is indifferent to the magnitude of the force applied to it (assuming that the force does not damage/deform the mechanism).

Session 1B: Robot Kinematics

10:30am

Kinematic Analysis of a Planar Tensegrity Mechanism

Jahan Bayat, Carl D. Crane III

Center for Intelligent Machines and Robotics

University of Florida

ABSTRACT

This paper presents the equilibrium analysis of a planar tensegrity mechanism. The device consists of a base and top platform that are connected by one connector leg (whose length can be controlled via a prismatic joint) and two spring elements whose linear spring constants and free lengths are known. The paper presents two cases, one where the spring free lengths are both zero, and the other where the spring free lengths are nonzero. The purpose of the paper is to show the enormous increase in complexity that results from nonzero free lengths.

10:50am

Evaluating the Fault Tolerance of a Parallel Manipulator Based on Relative Manipulability Indices

Hyun Geun Yu, Rodney G. Roberts
Department of Electrical and Computer Engineering
Florida State University

ABSTRACT

In this article, the authors investigate the fault tolerance of manipulators in their nominal configuration. In this work, fault tolerance is measured in terms of the worst case relative manipulability index. While this approach is applicable to both serial and parallel mechanisms, it is especially applicable to parallel mechanisms with a limited workspace. It is first shown that the relative manipulability indices are characterized by the null space of the manipulator Jacobian. This motivates the problem of determining the class of manipulator Jacobians with a prescribed null space. This approach can be used to find optimally fault-tolerant manipulators. It is then shown through dimensional arguments that there are limits to the amount of redundancy for this problem to be solvable. The authors use these limits to prove that a previously derived inequality for the worst case relative manipulability index is generally not achieved for fully spatial manipulators and that the concept of optimal fault tolerance to multiple failures is more subtle than previously indicated. After presenting an example of a seven degree-of-freedom mechanism that is optimally fault-tolerant to single failure, the authors consider the problem of finding a manipulator Jacobian that is optimally fault tolerant to multiple failures. It is shown that optimal solutions cannot be equally fault tolerant.

11:10am

Control of a 9-DoF Wheelchair-Mounted Robotic Arm System

Redwan Alqasemi, Rajiv Dubey
University of South Florida

ABSTRACT

A wheelchair-mounted robotic arm (WMRA) system was designed and built to meet the needs of mobility-impaired persons with limitations of upper extremities, and to exceed the capabilities of current devices of this type. The control of this 9-DoF system expands on the conventional control methods and combines the 7-DoF robotic arm control with the 2-DoF power wheelchair control. The 3-degrees of redundancy are optimized to effectively perform activities of daily living (ADLs) and overcome singularities, joint limits and some workspace limitations. The control system is designed for teleoperated or autonomous coordinated Cartesian control, and it offers expandability for future research, such as voice or sip and puff control operations and sensor assist functions.

Plenary Session 1: Autonomous Vehicle System

01:00pm

Development of an Autonomous Vehicle System for the 2005 DARPA Grand Challenge Event

Carl Crane
University of Florida

ABSTRACT

The presentation describes the development of an autonomous vehicle system that participated in the 2005 DARPA Grand Challenge event. After a brief description of the event, the architecture, based on version 3.0 of the DoD Joint Architecture for Unmanned Systems (JAUS), and design of the system are presented in detail. In particular, the "smart sensor" concept is introduced which provided a standardized means for each sensor to present data for rapid integration and arbitration. Information about the vehicle design, system localization, perception sensors, and the dynamic planning algorithms that were used is then presented in detail. Subsequently, testing results and performance results are presented. Lastly, current activities related to the 2007 DARPA Urban Challenge are presented.

Session 2A: Robot Design

02:00pm

Design, Fabrication, and Characterization of a Microgripper Device

Jose A. Martinez, Roberto R. Panepucci
Department of Electrical and Computer Engineering
Florida International University

ABSTRACT

In this work, we present the development process of SU-8 polymer based microgrippers applied to novel parallel displacement geometry and assembly techniques. Finite element based simulations were utilized to determine the geometry dimensions, and to verify its operation. Two actuation techniques, mechanical, and piezoelectric are implemented, and characterized. The fabrication process requires a single mask, and it is described along with the assembly process required to implement the actuator-microgripper system. Experimental results are presented for both actuation techniques, along with failure analysis. The microgrippers are designed to manipulate microstructures in the range of 5 to 50 μ m.

2:20pm

Proposed Design of a Triped Robot

Daniel Kamerling, Pierre Larochelle
Florida Institute of Technology

ABSTRACT

Nature may be drawn upon as inspirations for robotic de-sign. Biomimetics is the term used when the goal becomes replicating biological mechanisms. This method leverages the evolution of a life form over the course of many iterations. The concept of "better than bio" has emerged in order to combat functional redundancy that can occur from biomimetics. The goal of design being to take a biologically inspired base and then improve upon it with classical engineering methods.

This paper presents an analysis of the locomotion, energy consumption, and control of a tripedal robot. The aim is to gain insight into a perceived gap in evolution and apply results to robotics design. This is achieved through the construction of a SimMechanics model of an 11 degree of freedom 2S4P triped robot, the characteristics of which are similar to the biped developed by Raibert et. Al [18].

2:40pm

A Double Claw Robotic End-Effector Design

Redwan Alqasemi, Sebastian Mahler, Rajiv Dubey

University of South Florida

ABSTRACT

A new robotic gripper was designed and constructed for Activities of Daily Living (ADL) to be used with the new Wheelchair-Mounted Robotic Arm developed at USF. Two aspects of the new gripper made it unique; one is the design of the paddles, and the other is the design of the actuation mechanism that produces parallel motion for effective gripping. The paddles of the gripper were designed to grasp a wide variety of objects with different shapes and sizes that are used in every day life. The driving mechanism was designed to be simple, light, effective, safe, self content, and independent of the robotic arm attached to it.

Session 2B: Robot Design

03:15pm

TYROL: EVOLUTION OF A 10-AXIS BIPED ROBOT

Vishnu Madadi, Sabri Tosunoglu

Department of Mechanical Engineering

Florida International University

ABSTRACT

This paper presents work demonstrating the evolution of a biped robot named Tyrol from a simulation environment to physical realization. For the past few years, humanoid robot development has been receiving increasing interest by several research groups. The design of this class of robots is quite challenging because of a variety of reasons such as the high number of degrees of freedom involved, balancing issues, power to weight ratio, and complexity of their control. By studying the development of a biped robot, this work addresses humanoid robot design and control in a bottom-up approach. For this purpose, a ten-degree-of-freedom biped robot concept was developed, modeled and constructed. Different gait algorithms have been developed for the biped robot to navigate on flat and inclined surfaces.

03:35pm

Xanthus: Self-Reconfigurable Modular Robot

Adrian Arbide, Vishnu Madadi, Sabri Tosunoglu

Florida International University

Department of Mechanical Engineering

ABSTRACT

Second generation self-reconfigurable modular robotic system Xanthus developed at FIU is presented in this paper. The robot is capable of self-reconfiguring its mechanical structure for efficient walking and crawling as the previous version. In addition, the current version is able to reconfigure and roll conforming to the terrain. In both versions, changing modes is accomplished without human intervention. This work addresses mechanical design, hardware, control and software development for allterrain navigation. Algorithms for quadruped walking, crawling and rolling are generated and tested on the prototype.

Session 3A: Robot Control / Sensors

08:30am

Using the Wave Variable Method for a Human-Machine Haptic Interface in the Presence of Time Delay

Marc Alise, Rodney G. Roberts
Department of Electrical and
Computer Engineering
Florida State University

Daniel W. Repperger
Air Force Research Lab.
Wright-Patterson Air Force Base

ABSTRACT

Even a small amount of time delay in a bilateral teleoperation system will generally degrade the system's performance and cause instability. Consequently, without some form of compensation for time delay, latencies in a teleoperation system would preclude the use of force feedback. Fortunately, there are approaches based on scattering theory and passivity that can compensate for time delay and allow the use of force feedback in teleoperation systems with latencies. In particular, the wave variable method is a passivitybased approach that guarantees stability for any fixed time delay. In this work, the authors take a generalized approach which includes the complete family of scaling matrices. This extended family of scaling matrices is used in an experiment with human subjects and a PHANToM Omni haptic teleoperation system. The experiment will compare the raw data with the users' opinions in order to determine the best set of scaling matrices for the given task.

08:50am

Adaptive Control for Nonlinear Uncertain Systems with Actuator Amplitude and Rate Saturation Constraints

Alexander Leonessa, Yannick Morel
Dep. of Mechanical, Materials and Aerospace Engineering
University of Central Florida

ABSTRACT

A direct adaptive nonlinear tracking control framework for multivariable nonlinear uncertain systems with actuator amplitude and rate saturation constraints is developed. To guarantee asymptotic stability of the closed-loop tracking error dynamics in the face of amplitude and rate saturation constraints, the adaptive control signal to a given reference (governor or supervisor) system is modified to effectively robustify the error dynamics to the saturation constraints. An illustrative numerical example is provided to demonstrate the efficacy of the proposed approach.

09:10am

A Multithreaded Implementation of Assist Functions to Control a Virtual Reality Model of a 6-DoF Robot Arm for Rehabilitation Applications

Eduardo J. Veras, Ramya Swaminathan, Rajiv Dubey
University of South Florida

ABSTRACT

This paper describes a multithreaded platform to implement a haptic interface to control a Virtual Reality (VR) model of a 6-DoF arm with applications towards rehabilitation robotics. The approach allows the defined threads to execute concurrently, resulting in increased utilization of the processor resources and higher instruction execution rates consistent with a realistic rendering of the touch sensation and smooth graphics transitions for the VR simulation. The haptic interface allows for physical rendering of the human-machine interactions through force feedback and velocity scaling enhancing the manipulation capabilities of persons with disabilities. Assist functions are modeled through the use of physical simulation of springs, spring with damping, and velocity scaling. The level of assistance is calculated by concurrent threads running the virtual model of the arm and the haptic loop at two different update rates.

Session 3B: Robot Control / Sensors

09:45am

Position Tracking Performance of a Redundant Teleoperation System

Mehmet Ismet Can Dede, and Sabri Tosunoglu
Florida International University
Department of Mechanical and Materials Engineering

ABSTRACT

Teleoperation has captured the interest of robotics researchers for more than two decades. Many focused on the stability problem when the system experiences time delays. Most of the time, guaranteeing stability has overshadowed the tracking performance. This work differentiates teleoperation systems into two groups as limited and unlimited-workspace teleoperation depending on their position tracking priorities. Specifically, this paper examines limited-workspace teleoperation on a redundant system. The slave is modeled to be the virtual representation of a Fanuc LR Mate 100iB, a five degree-of-freedom (DOF) serial industrial manipulator. The master is selected as a two-DOF force-reflecting joystick. Hence, the teleoperation system is redundant since the degree-of-freedom of the slave is greater than the master. Teleoperation experiments have been conducted for this system under constant time delays and communication losses. The results are presented when the customary and modified wave variable techniques are utilized.

10:05am

Multi Robot Systems: The EagleKnights/RoboBulls Small-Size League RoboCup Architecture

Alfredo Weitzenfeld

University of South Florida

Computer Science and Engineering Department

ABSTRACT

In this paper we present the system architecture of the Eagle Knights/RoboBulls Small Size League RoboCup Team. In this league two teams composed of five autonomous robots each compete against each other in a medium size field. This league is one of the fastest and most thrilling in RoboCup permitting teams to develop complex coordination strategies. We explain the three main components of the architecture: Vision System, AI System and Robots.

10:25am

Determination of Impact Force and Crush Energy Using Abductive Networks

Oren Masory

Department of Mechanical Engineering
Florida Atlantic University

Nicolas Putod

IFMA – Institut Francais
DeMechanique Advancee

ABSTRACT

Sensory based methods as well as approximation methods are currently being used to determine the impact force and the crush energy pertained to vehicles' collision. This paper describes a method, based on Abductive Networks that can be used to develop explicit models by which the above quantities can be estimated. Similar to Neural Networks Abductive Networks are "trained", using experimental data and upon convergence, a model is established. Comparisons between the results, obtained by the different methods, indicate that the models obtained with this method provide more accurate results.

Plenary Session 2: Biologically-Inspired Robotics

11:15am

Biologically-Inspired Robotics: Learning from Nature

Alfredo Weitzenfeld
University of South Florida

ABSTRACT

Biology has been an important source of inspiration in creating new technology. In the robotics realm, an extensive number of architectures have taken inspiration from animal behavior. These biorobotic architectures have sought to mimic animal ethology, i.e. Behavior described by higher-level brain processes, and to a lesser extent animal neuroethology, i.e. behavior mapped to underlying neural structures. From a neuroscientific perspective, advances in brain theory have provided an ever increasing understanding of the underlying mechanisms involved in aspects such as memory, adaptation and learning. To model such systems we have developed a multi-level schema and neural networks approach that we now apply to the development of biologically inspired robotic architectures. We expect these advances to help develop new generations of adaptive robotics systems having an increasing impact on real world applications.

The work to be presented in this talk overviews a number of biologically-inspired robotic architectures developed by our group. A number of models and corresponding biorobotic architectures are presented describing animal behaviors such as prey acquisition, predator avoidance and exploration, based on studies from praying mantis, frogs and toads, rats and monkeys. This work has been funded by a number of national and international research collaborations.

Please send your comments or concerns to:

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