

CSE 4392: Research Experiences for Undergraduates in “Information Processing and Decision Making for Intelligent and Secure Environments”

Summer 2008

REU Project Descriptions

A1: Scheduling parallel jobs on multicore processors

Supervisor(s): Dr. Ishfaq Ahmad (100%)

Size: 1 student

Skills: processor scheduling, simulations, high performance computing

More recently, industry and researchers are eyeing multi-core processors, which can attain higher performance by running multiple threads in parallel. By integrating multiple cores on a chip, designers hope to sustain performance growth while depending less on raw circuit speed and decreasing the power requirements per unit of performance. These workhorses of the next generation of supercomputers and wireless devices are poised to alter the horizon of high-performance computing. However, proper scheduling and allocation of applications on these architectures unfolds several new research challenges. We aim to develop novel scheduling algorithms for applications with and without precedence constraints that incorporate these essential issues. Using a simulation strategy, students will be given a code and simulator to develop new algorithms or improve existing ones.

A2: Emerging technologies in multimedia

Supervisor(s): Dr. Ishfaq Ahmad (100%)

Size: 1 student

Skills: multimedia computing, computer vision, artificial intelligence

IRIS (Institute for Research in Security) is engaged in full-scale research on designing algorithms and systems for the next generation of video technologies that will have 3D or multi-view video. In addition, we are focusing on the detection, analysis and interpretation of human behavior, for example, surveillance and intrusion detection, movies, automatic analysis of sports videos, broadcasts, video conferencing applications, etc. This is a new area of computing in multimedia that requires the integration of various data modalities including video, audio, sensors, and a myriad methods from the area of machine learning and artificial intelligence. This project requires a survey of various surveillance techniques currently reported in the literature.

A3: Video Stitching

Supervisor(s): Dr. Ishfaq Ahmad (100%)

Size: 1 student

Skills: video surveillance, advanced sensor networks, computer vision

We are interested in mimicking a grid of airborne sensors delivering live videos. The sensors essentially would form a huge net over a large area. The video streams from these sensors are sent to a station at the ground where server integrates them to gather what I call video stitching. The view from each sensor provides a small rectangle of video, and when multiple such streams are stitched together (we assume the system will be completely scalable and include 100s or even 1000s of such sensors), they provide an extremely large view virtually providing an "eye in the sky" to see everything, everywhere and anytime. In this projects, students will build only the stitching modules of this systems. Basically, you will take multiple live video streams each covering a rectangular area and you will build a stitching tool to assemble these smaller views to construct a large view. The stitched video could be played back on a normal screen with an interactive control to see a smaller are or total area, with zooming capability, something similar to Google Earth (but with live video instead of static pre-computed images).

A4: COPSE

Supervisor(s): Dr. Ishfaq Ahmad (100%)

Size: 1 student

Skills: video communication, multimedia computing, computer vision, surveillance

COPSE (Collaboration for Public Safety Enhancement) in an integrated platform of a set of software tools, such as mobile audio-visual communication, concealed weapon detection (CWD), surveillance, and video retrieval and mining, installed in police cars or attached to officers' uniforms. It provides police officers with powerful technological means to fight crime and to ensure their own safety as well as that of the environment and citizens. COPSE is also a distributed and networked system for providing and disseminating accurate, timely, and reliable information, in pervasive fashion, anywhere and anytime. One of its major components is ubiquitous and mobile audio-visual communication system tailored to police need using wearable devices attached to officers' uniform. The multi-party video communication is a result of our on-going research in video compression, wireless communication, and video streaming. COPSE ensures inter-operability of widely dispersed heterogeneous data streams, and uses an evolutionary approach, in which additional technologies, such as biometric solutions, can be included. Students are require to take our existing prototype and make it in a form that can be demonstrated.

G1: Real-Time Stereo Correspondence

Supervisor(s): Dr. Gutemberg Guerra-Filho (70%)
Dr. Gergely Záruba (30%)

Size: 1 student

Skills: computer vision, stereo correspondence

In computer vision, the stereo correspondence problem consists in finding corresponding points in different stereo images of the same scene. Stereo images are obtained by cameras with a known geometry. In the case of a stereo configuration, each horizontal line in one image corresponds to the horizontal line at the same height y in the other image. Each pixel $p(x, y)$ in one image corresponds to a pixel $p'(x', y)$ in the other stereo image. This way, the correspondence problem becomes linear. For each pixel p , we seek the disparity value $(x' - x)$ that represents the correspondence between pixel p in one image and pixel p' in the other image.

In this project, we will consider real-time approaches for the stereo correspondence problem. We will test an $O(n)$ optimal algorithm that solves the stereo correspondence problem and compare to other approaches. We will use synthetic data produced with a ray tracer and real data obtained with video cameras and infra-red cameras. We may possibly use structured lighting to project texture on the scene.

Project G2: Human Motion Retargeting

Supervisor(s): Dr. Gutemberg Guerra-Filho (90%)
Dr. Gergely Záruba (10%)

Size: 1 student

Skills: motion capture, motion retargeting, animation

Automatic animation consists in generating motion data to a virtual character in order to produce a video animation without manual intervention. Recently, motion-based approaches have been proposed to synthesize animation automatically. A motion-based approach is designed to reuse a human motion database to generate novel sequences of motion.

In this project, we will study the retargeting of human motion from one source skeleton to a target skeleton. Basically, the human motion retargeting problem consists in converting the motion of one subject (e.g., a tall person) into the motion of another subject (e.g., a short person) satisfying a set of constraints that keep the motion realism intact. Our goal is to survey the state-of-the-art related to motion retargeting, to implement a few techniques, and compare their performances using real motion capture data. We may investigate the retargeting between skeletons with different topologies and may consider non-rigid motion retargeting as well. Another task in this project is the implementation of a converter between standard motion capture files, including bvh, asf/amc, and c3d. This project may include capture real human motion with a Vicon motion capture system, a Moven motion capture suit, data gloves, and eye trackers.

Project G3: Human Motion Splicing

Supervisor(s): Dr. Gutemberg Guerra-Filho (90%)
Dr. Gergely Záruba (10%)

Size: 1 student

Skills: motion capture, motion splicing, animation

Automatic animation consists in generating motion data to a virtual character in order to produce a video animation without manual intervention. Recently, motion-based approaches have been proposed to synthesize animation automatically. A motion-based approach is designed to reuse a human motion database to generate novel sequences of motion.

In this project, we will study the splicing of two different human actions into a single motion. Basically, the human motion splicing problem consists in merging two motions performed by different body parts into a single whole body motion such that the motion realism is intact. Our goal is to survey the state-of-the-art related to motion splicing, to implement a few techniques, and compare their performances using real motion capture data. This project may include capture real human motion with a Vicon motion capture system, a Moven motion capture suit, data gloves, and eye trackers.

T1: Intelligent User Interface for Children with Disabilities

Supervisor(s): Dr. J. Carter Tiernan (90%)
Dr. Gergely Záruba (10%)

Size: 2 students

Skills: intelligent environments, assistive technologies, entertainment for people with disabilities

The organization "A Wish with Wings" grants wishes to seriously ill or handicapped children mainly focusing on bringing more joy to these children (as opposed to things like paying for medical care, etc.). The child we are working for is a 10-year-old living in Arlington who was born with hydrocephalus. He cannot walk or talk, and is legally blind. He has limited physical mobility and motor skills. He lives with his mother who has a back disability and he has a caregiver who is a UTA undergraduate nursing student. The Wish is to provide him with an area in his home that he can interact with and be entertained by on his own. The area to be designed is a wall structure that he could interact with and possibly have a floor area as well. The final decision of the type of structure will depend on if he can maneuver himself in a wheelchair well enough to enjoy the wall versus being on the floor. We tentatively settled on a wall that would be made up of modular panels where each panel could be either the part he manipulates (buttons or handles or ...) or a panel could have the response results (a set of flashing lights, buzzers, music playing, tones, colored lights, vibrations or movement, etc.). The manipulation panels would be at wheelchair height and the response panels either above, below or even outside the main panel. A floor level area with panels could also be created.

Some of the interaction ideas tossed around were: i) Push a button to start a light or sequence of lights, ii) Touch a particular surface (or object) to receive a kinesthetic response (vibration or other), iii) Grab or clutch a handle to play a sound, move the handle to change the sound iv) Manipulate a steering wheel (or other handle) to cause patterns of lights - more turn, longer pattern, v) A remote control on the child's wheelchair that could control some part of the wall from a distance, vi) Start and stop a CD playing (Mom must be able to easily change the CD), vii) Play individual musical notes. The overall system should be designed so that it is modular, maintainable and modifiable in a variety of ways. First, the wall system panels must be able to monitor themselves and deliver this information to a central control system for Mom or the caregiver to use (change the volume on a panel, change the light intensity of a panel, get a message that a light is burned out or an input sensors having problems,...). Second, the panels in the system should be able to be moved around and/or replaced as desired without affecting the other system components. Third, the manipulation and response patterns of a pair of panels should be programmable so that they can be changed over time to allow more complex interactions and resulting behavior to encourage the child's learning.

The project entails helping design software and hardware components for the above described entertainment smart environment and implementation of the hardware and software components, closely working with Dr. Tiernan, the Wish organization, and the interior designer who is developing the overall theme of the wall. This project may involve interaction with the child (if desired by you the student), the child's mother, caregiver, and teacher, and will involve some research into learning and stimulation of severely handicapped children. Through the Wish organization, this project is expected to receive media attention with possible print and television coverage.

H1: Wheelchair Control

Supervisor(s): Dr. Gergely Záruba (70%)
Dr. Manfred Huber (30%)

Size: 1 or 2 students

Devices in assistive environments provide inhabitants with services that improve the quality of life. One of the most apparent of these capabilities are provided through assistive devices such as computer assisted wheelchairs. This project is aimed at establishing a basic computer control and interaction

interface for an assistive wheelchair. The goal here is to design and build basic sensor and control capabilities to enable odometry (the ability of the wheelchair to keep track of its position).

- Student 1: Equip a wheelchair with internal odometric sensors (optical encoders) and interface them with the basic control electronics. Develop and implement basic odometry and PID control capabilities on the wheelchair that integrates the encoder readings to update the position and to control the motors to drive the wheelchair according to given commands

Skills: hardware integration, low-level embedded coding, control

- Student 2: Establish a higher level interface that provides visual information to a computer and integrates the wheelchair to a path planner and a force feedback joystick interface (path planner code already exists).

Skills: path planning, user interfacing

H2: Interactive Service Robot Control

Supervisor(s): Dr. Manfred Huber (50%)
Dr. Gergely Záruba (50%)

Size: 1 or 2 students

Using Pioneer or PeopleBot (Based on some of John's work, a Ph.D. student in RoboSty). Service robots are robots intended to assist users in everyday activities. For many tasks (such as security robots, wheelchairs, etc.) an efficient way to provide services is to allow the robot to be guided by the user with sufficient autonomous control that only the most important commands have to be provided and that no explicit knowledge of the robot is necessary to utilize its capabilities. This project investigates ways to integrate navigation and user input in a semi-autonomous robot for surveillance and investigative tasks. The example task here would be, for example, a robot that provides a live camera and audio stream to a remote physician or health provider and that is indirectly operated by this person to move between rooms in the environment and to locations useful for the physician to examine.

- Based on Active Media's localization and navigation libraries, integrate a system that streams images, sound, and robot data to a desktop that is equipped with a display and a force feedback joystick. Design and implement a force feedback interface that helps the doctor to navigate the robot in narrow places and that avoids collisions with objects in the environment based on a given map of the environment.

Skills: Force feedback control, socket programming, GUI programming

- Use the robot sensors to augment the map to include moving obstacles such as people and static ones that were not originally in the map (chairs, etc).

Skills: Probabilistic sensor modeling

H3: Environment mapping and touch-based localization for cleaning

Supervisor(s): Dr. Manfred Huber (50%)
Dr. Gergely Záruba (50%)

Size: 1 student

Skills: uncertainty reasoning, odometry, Bluetooth interfacing

Using the Roomba robot with the Bluetooth interface. A number of robot tasks in the home are becoming available for robot assistants. Among them, cleaning has received significant attention. The Roomba is an example for this that uses a very primitive approach to navigate the robot. To achieve better results and to enable other capabilities (e.g. avoiding certain parts of the environment, etc), it would be preferable if the robot could use strategies that keep track of the location of the robot in the environment.

This project is aimed at providing the Roomba robot with the capability to keep track of its location in a known environment by using landmarks that it encounters with its bump and infrared proximity sensor to correct errors in its odometric location estimate over time. Research, design, and develop an approach that allows the robot to clean the environment without losing track of its location. The goal is to build a navigation scheme that minimizes the loss of precision in the robot's location estimate and that maximizes its ability to reacquire its location estimate based on known landmarks that it can acquire with its sensors.

H4: Learning Docking Control

Supervisor(s): Dr. Manfred Huber (50%)
Dr. Gergely Záruba (50%)

Size: 1 student

Skills: machine learning, control

Using the Roomba robot. Practical Service robots should be self contained and require minimal intervention by a user. AS part of this, they should have the capability to adjust to their environment and to automatically obtain important information and capabilities.

The goal of this project is to provide the Roomba cleaning robot with the ability to learn to robustly perform a docking procedure to recharge itself. While it currently has such a function, it only works within a very limited range, is not overly robust, and relies on a particular local geometry in the environment. This project aims at giving the robot the functionality to learn to adjust its recharging capabilities to the environment and to make them more robust.

Research and develop learning capabilities for the Roomba robot that use its sensing capabilities to learn to reliably find and connect to the robot's docking station to recharge. The robot should be able to learn to interpret the IR, bump, and guide beam information.

H5: Intuitive User Interfaces: Gesture and/or Voice Control

Supervisor(s): Dr. Manfred Huber (50%)
Dr. Gergely Záruba (50%)

Size: 1 to 3 students

Using Wii remote or cyberglove and voice command package. In intelligent environments interaction with the computer should be noninvasive and intuitive. As a result other ways (besides keyboard and standard mouse entry) are needed to send commands to a computer interface and to manipulate objects. The goal of this project is to establish gesture and/or voice interface capabilities for either a computer desktop system where objects are to be manipulated on the desktop or to a robot system to indicate commands that should be performed. Gestures are intended here to be movements and configurations of fingers and hands that translate into commands (for example object magnification, movement, rotation, etc. for the computer desktop application, or directions and destinations for robot commands.

- Student 1: Design and develop a system that uses the infrared camera in the Wii remote to detect gestures off a glove equipped with a number of infrared LEDs (the Wii remote contains a medium resolution (~800,000 pixels) IR camera that can track up to 4 infrared blobs at 100Hz and transfer the information over Bluetooth to a computer). This part involves design of an appropriate prototype glove, a gesture set that can be used to control a user interface for an intelligent environment. The gesture set should be robust in terms of limiting the number of incorrect detections.

Skills: Bluetooth interface, gesture and interface design.

- Student 2: Add voice command capabilities (using a voice command package) that allow an extension of the interface capabilities. Again, robustness with respect to background noise and

unintended speech have to be addressed to get a robust system for either home interfaces or use with robots.

Skills: Voice processing, silence detection

- Student 3: Design gesture user interface using a cyberglove and evaluate its use compared to the initial camera-based interface.

Skills: Interface programming

H6: 3D Haptic interfaces for learning and disability

Supervisor(s): Dr. Manfred Huber (50%)
Dr. Gergely Záruba (50%)

Size: 1 student

Skills: haptic feedback, performance evaluation

Using Novint Falcon 3D force-feedback joystick. Haptics is an important sense in everyday life, conveying information about surface characteristics, weight, etc. For blind people it provides even more important information about their environment. When interacting with the computer this sense has so far largely been ignored and its benefit has been evaluated only in limited applications. Recently, however, low cost devices have become available which can provide force feedback in multiple dimensions. This project is aimed at designing and evaluating the benefits of 3D force feedback on the interface for different applications. The application domain for the evaluation and design could here be either a simple learning and manipulation environment (either the infant game in which a torus has to be moved along a set of wires. Another application would be for a service robot in a security sensitive application - bomb disposal, nuclear facility, etc.- to use 3D feedback to assist in a manipulation task where objects have to be assembled - a simulation similar to a block stacking task - to assist in the correct assembly by producing forces paralleling the interaction forces encountered.

Design and develop a simulation environment where haptic feedback is used to simulate physical interactions with objects in the simulation. Develop force feedback in the environment and evaluate the effect of the force feedback in task performance and subjective feel of the interface/environment.

H7: Learning Heating and Air-conditioning Control

Supervisor(s): Dr. Manfred Huber (60%)
Dr. Gergely Záruba (40%)

Size: 1 student

Skills: machine learning, thermal modeling

Technology in intelligent environments is aimed at improving the comfort of the inhabitant and as such should adjust to the inhabitants' needs and preferences while optimizing the efficiency. One of the areas this is apparent is in climate control where the comfort of the inhabitant and energy and resource consumption are two important objectives that have to be addressed (and that are usually contradictory). This project is aimed at researching and developing technologies that can learn temperature preferences of inhabitants and control strategies for heating and AC systems in order to regulate the indoor temperature in an intelligent environment to be within the comfort zone of the persons in the environment while minimizing the energy consumption.

Design a system that models and learns inhabitant preferences in terms of environmental temperatures and a system that learns to control the environment to stay within the preference range.

H8: Learning and extracting behavior patterns

Supervisor(s): Dr. Manfred Huber (80%)
Dr. Gergely Záruba (20%)

Size: 1 student

Skills: Machine learning, data mining

Using a person tracking system. Detecting unusual and unexpected occurrences of behaviors is an important capability in security sensitive environments. This applies to unusual behavior of devices (in order to detect or predict system failures) as well as of persons (to indicate security threats or to be able to predict the future behavior of the person - e.g. indicating disorientation in the case of elderly persons - , allowing to improve control. This project is aimed at investigating technologies to detect anomalies in inhabitant behavior and to classify the observed behavior. The goal is to develop a system that uses person tracking information to automatically form a model of the behavior of a person and subsequently utilizes this model to indicate significant changes in behavior of the person.

Research and develop an algorithm that learns a model of the behavior of behavior data gathered by a tracking system and subsequently employ this model to detect if a sequence of observed behavior conforms with the model or represents an anomaly.

H9: Vein pattern recognition for authentication and home entry

Supervisor(s): Dr. Manfred Huber (70%)
Dr. Gergely Záruba (30%)

Size: 1 student

Skills: Biometrics, visual pattern extraction, IR processing

Using IR camera and LEDs. Biometric authentication is an important capability for intelligent environments to regulate access to information, entry to the environment, and access to sensitive control functions. Vein patterns are one means of authentication. This project is aimed at developing a low cost system for vein pattern recognition for authentication and entry detection.

Design and implement a system that can extract and identify vein patterns in controlled environments using near-infrared lighting and camera. Build a setup that provides illumination to detect veins and investigate processing algorithms to extract vein features to identify a person.

Z1: GPS based runway incursion detection

Supervisor(s): Prof. David Levine (50%)
Dr. Gergely Záruba (50%)

Size: 1 (maybe 2) student(s)

Skills: Windows Mobile/Symbian/IPhone, GPS programming, maps

At airports it is becoming an increasing problem to keep service vehicles from accidentally wandering onto the runways. Runway incursions are a major problem for airports that is receiving national and world attention. Developing or identifying a low cost, effective system will enhance DFW Airport's reputation as a leader in airport technology for logistics and hopefully provide job opportunities. Prices are dropping rapidly for many of these technologies so innovative solutions are possible in the short term.

In this project the student will use a programmable GPS device (either a stand alone GPS with an attached phone or a GPS enabled smart phone) and research/design a service that provides visual and audible alerts when a vehicle enters a forbidden region. In addition to the alert, a wireless data packet (in the form of GPRS data or SMS message) will be delivered to a server where it is displayed and logged. Data rates permitting, location of the device will also be transmitted periodically to the server and displayed, e.g., using Google Earth.

Z2: Bioloid control over a wireless interface

Supervisor(s): Dr. Gergely Záruba (70%)
Dr. Manfred Huber (30%)

Size: 1 student

Skills: Zigbee interface, humanoid robotics, robot control

The Bioloid (you can google or youtube this fantasy name) is a small humanoid robot that come in a ready to assemble kit. It has on-board processing, sensors, and 18 actuators once it is assembled. Motion codes can be written in a user interface provided, which are compiled and uploaded on the local processing board of the robot. Alternatively the robot can use a wireless interface to communicate with a powerful host (e.g., a PC) and transmit/receive sensory data and instructions. The same wireless interface can also be used to establish a “swarm” of communicating Bioloids.

The project itself involves setting up the Bioloid to communicate over its Zigbee (like) interface. After setting this up, odometry, kinematics, (maybe vision), and intuitive user interfaces (e.g., the Wii controller, or cyberglove) can be used to control one or a swarm (depending on availability of other kits) of Bioloids.

Z3: Multitouch interface design and interfacing

Supervisor(s): Dr. Gergely Záruba (80%)
Dr. Manfred Huber (20%)

Size: 1 student

Skills: multitouch interfaces, computer vision, user interfaces

“Multi-touch is a human-computer interaction technique and the hardware devices that implement it, which allow users to compute without conventional input devices (e.g., mouse, keyboard). Multi-touch consists of a touch screen (screen, table, wall, etc.) or touchpad, as well as software that recognizes multiple simultaneous touch points, as opposed to the standard touch screen (i.e. computer touchpad, ATM), which recognizes only one touch point. This effect is achieved through a variety of means, including but not limited to: heat, finger pressure, high capture rate cameras, infrared light, optic capture, and shadow capture.” [from Wikipedia].

There are a myriad of techniques out there to create inexpensive multi-finger tracking interfaces. In this project, a multi-touch table (or board) will be built by the student using camera(s) and interfaced to the computer. A video projector is also going to be used to project the screen of a computer to the interface. Once the interface is functional, we will devise a way to control one of the robot arms on robots in the robotic research lab.