ECE MDE Expo Spring 2024

Wednesday, 17 April 2024 - Wednesday, 17 April 2024

The Inn at Virginia Tech

Expo Program

Expo Brochure

Track 1 - Drillfield

Image Recognition AUTOmation

Create an offline Artificial Intelligence tool that uses image recognition to identify a cars make, model, and year which then displays the top 3 predictions onto a Graphical User Interface.

AR Headset Object Identification

Our challenge was to develop an Augmented Reality (AR) system using the Magic Leap 2 headset to guide a worker through the process of performing maintanence on a plumbing system. Our system will provide instruction by clearly highlighting components in the real world that require user interaction in the correct order. This project aims to minimize human error in maintenance through an intuitive, user-friendly interface, enhancing efficiency and safety.

Natural Language Interpreter

Design and develop a standalone, natural language processing tool similar to ChatGPT, which leverages a pre-downloaded library of PDF's created by the user for any specific use case. This system must interpret human input, efficiently retrieve relevant information from the documentation, and display the findings in a readable format using a generative model, all while operating independently of an internet connection.

Car Engine Audio Classifier

For our project, we developed an offline engine detection program that is triggered by engine idling. Using machine learning techniques, the program identifies the engine, it's brand within a 5-minute timeframe, and displays the three closest matches.

Field Guide Vision App: Arabic to English Road Sign Translation for US Soldiers

Our objective is to develop an iOS and Android application for US Army soldiers overseas that translates text extracted from images of Arabic road signs to English. Modern translation solutions commonly cannot detect discrepancies between literal translations and native pronunciation. The goal of our app is to limit the need for human translators and provide higher accurate translations considering these discrepancies.

FPGA Implementation of a Radar System

The goal of this project is to use a software-defined radio (SDR) to implement a real-time radar system. By using an SDR, radio components that are conventionally implemented using analog hardware can instead be implemented in the digital domain with software. This enables the creation of systems that have higher portability, lower cost, and greater reconfigurability. With these benefits in mind, our challenge is to use an SDR to bring these improvements to the radar world.

Track 2 - Duckpond

Decision Tree Graphical Editor and Execution for Cybersecurity Vulnerabilities

Design a graphical editor for generating new decision trees or modifying existing ones. These decision trees, which include inputs, decision points, and potential outcomes, are structured and stored in a database. The main focus for the decision tree is to serve as a cybersecurity tool, detailing how to prioritize patching vulnerabilities for each asset defined by the user.

Digital Inventory as a Software Bill of Materials

Keeping track of software installed on all machines in an organization can be time-consuming for even the best System Administrators. Keeping a history of these software lists and tracking changes can be even more difficult and impossible without automation. The goal of this project is to design and implement software that acts as a comprehensive toolset for identifying applications from Windows and Linux operating system back-up files. Additionally, this tool must be able to extract identified application files directly from those back-up files for further analysis. This software allows for easy viewing of change reports and extraction of all programs in a back-up file from any point in time, enabling for security-focused analysis of back-up files.

Automated Coin Detection

To design and build a coin detection application. Using computer vision and machine learning techniques, images of groups of wheat cents can be identified simultaneously by date and mint mark. The output will be provided to the user through the application and allow the coins of interest to be extracted. The value of this project is to increase the throughput and accuracy of checking for significant coin dates and mint marks.

Lester Labs Automated Grading Service: Saint-Gaudens Double Eagle

Develop a machine learning algorithm capable of accurately grading Saint-Gaudens Double Eagle coins using image processing techniques, with the goal of challenging human-level accuracy on the Sheldon Scale. The machine learning algorithm will be trained using a curated database of coins that can be uploaded on a web page to receive immediate, detailed grading feedback.

Bamboo Canes: Omnidirectional Imaging and 3D Reconstruction

Design a lightweight software system that can interface with an existing bamboo scanning apparatus while being extensible to future hardware, in order to produce a 3D model of a bamboo cane.
The scanning rig consists of a servo motor controlled by a CNC controller, and an array of 4 cameras.
Photographs of the bamboo are taken at 15-degree intervals around its perimeter and then transformed into a detailed 3D model. This model accurately reveals the bamboo's structure, especially the geometry of its nodes (significant deviations along the cane's length).
The system is tasked with identifying the existence and location of these nodes.
This system offers an alternative to the current method of scanning that utilizes a CNC machine, which typically incurs costs in the range of several thousand dollars, while the photographic scanner comes at a price of under \$500.

Dual Input 3D Scanner for Nearly Linear Natural Objects

The objective of this project is to develop and refine a low-cost electrical control and image capture system to rotate a bamboo cane and capture data from it in several different modalities: imagery

and mechanical probe. The canes are up to 10 feet long. Motion of the cane and sensors are controlled by stepper motors. The canes are to be used in countries with greater access to bamboo than lumber as a structural application. The data will be sent to a software system designed to generate a 3D model from these scans.

Track 3 - Smithfield

BURS: Balloon Ultraviolet Radiation Sensor

The team has been tasked with the goal of designing a low-cost, rugged, and reusable instrument for measuring UV radiation from a high-altitude balloon. The device must be able to reliably measure Type A, B, and C ultraviolet radiation at different heights of the atmosphere to create vertical profiles from the stratosphere to the Earth's surface. This project will be used to educate pre-college STEM programs on the topic of atmospheric composition, variation of UV radiation throughout the atmosphere, and how instruments are designed to meet scientific requirements.

Astrochemical Sensor Integration

The project's goal is to miniaturize and complement the instrument electronics to operate a multifunctional sensor platform that was developed by researchers at the NASA Goddard Space Flight Center. The sensor platform should be able to provide autonomous detection of methane and other trace gases that are important to the search of life throughout the solar system. The goal was to make the instrument electronics more compact and suitable for deployment as a drone payload.

Campus-Wide Deployment of Solar Lighting

To design a solar-powered lighting system master plan that would provide green energy to VT, helping to meet current Climate Action Commitment goals while providing improved lighting to campus.

X-band Hybrid Beamforming to Minimize Phased Array Grating Lobes

Develop a hybrid beamforming method to minimize phased array grating lobes using the Analog Devices X-Band Phased Array Development Platform. Grating lobes are unwanted artifacts in the radiation patterns of phased arrays, occurring when the spacing between elements is more than half a wavelength.

Parallelized Photonic Compute Techniques

To analyze the performance of Silicon Nitride, one of the new developements in photonic computing. Additionally we researched network designs, peripheral components, and photonic computings performance compared to traditional computing methods.

Smart Cooling Loop for a Data Rack of the Future

To develop a solution to expand the cooling capacity of a data rack. This is in preparation of increasing heat demand due to the rise of advanced research, artificial intelligence, and cloud computing.

Track 4 - Solitude

Account Interaction System

Design, build, and test a system that extends the work of the VT National Security Institute's ongoing project, which involves analyzing messages (emails, sms, and voicemails) exchanged between dummy users (fake identities) and second-party organizations to investigate the propagation of personal information through the internet.

Counteracting Doppler Using OTFS Zak Transform

Our team was tasked with proving if Orthogonal Time Frequency Space (OTFS) modulation could successfully transmit signals counteracting any doppler and delay that might be present. To do this we use a simplified OTFS model the Zak transform. This is an industry leading project with 6G applications, as it allows the transmission of signals without calculating delay and doppler of the transmission channel and adjusting the signal accordingly. This is a university challenge sponsored by the Air Force Research Lab (AFRL) who provided us 2 USRP-2901 software defined radios (SDR) to use with our project. AFRL has outlied the objectives as The Air Force Research Laboratory (AFRL) in partnership with the Wright Brothers Institute (WBI) is sponsoring the sixth year of a student challenge focused on Software Defined Radio (SDR) and Software Defined Networking (SDN) technology. Students will utilize SDR hardware and development tools to encourage hands-on skill building and experiential student learning, while developing novel solutions to sensing and networking challenges using SDRs concepts.

SCADA System Development for Oversight of all Mars Facilities

Design and implement a SCADA system to integrate all MARS launch pad facilities, providing a unified, secured, reliable, redundant and scalable interface that efficiently collects sensor and relay device data to the central server,Äôs database and GUI.

LLM Powered Room Perception From Autonomous Aircraft

Design an autonomous system that can navigate a room, gather room dimensions and images, and return that data textually with the help of an LLM

Aircraft Data Acquisition Device

To design and construct a data acquisition device that can measure temperature, humidity, vibration, and sound from multiple locations in an aircraft, wirelessly transmit the measurement data to a handheld device, and display the data in real time. This device will allow aircraft technicians and mechanics to remotely inspect conditions in hard-to-reach locations on an aircraft.

Equine Vital Tracking: Real-Time Automated Health Monitoring

The Marion duPont Scott Equine Medical Center receives roughly 100 foals during the January to June season,Äã. Their veterinarians do manual vital checks on foals consistently while they are in intensive care,Äã. Our goal is to help the veterinarians save time, effort, and immediately alert them to abnormal vital readings,Äã. Our device monitors heart rate and respiratory rate, which are vitals that need to be checked often. It also monitors activity level.

Track 5 - Cascade A

Personal Locator Beacon Range Extender and Transceiver Network

This project aims to build upon personal locator beacons (PLB) built previously by another MDE Team. The PLB uses a protocol called LoRa, which is a low-power method of wireless communication. The locator beacons achieve around a mile of range for connecting with the base station, and send only GPS coordinates and a distress signal. This is a problem because most locator beacons are used in rural and spread-out areas, which a device with such limited range does not support, and limited information could make it difficult to locate somebody in an enclosed space. The customer has asked us to work on these issues and improve the system to increase its practicality.

Far-Field Antenna Pattern Reconstruction From Probe Data in the Planar Near-Field of an Antenna

To implement an algorithm to collect antenna near-field data and transform it into its far-field. This allows for the collection of highly useful data without having to set up a complex and expensive far-field measurement range.

Instrument and Control for a Near Field Planar Scanner

To design and build the motor control system for a near field planar scanner to measure antennas operating in the X-band. To ensure positional accuracy, a 60GHz radar system was used.

Signals of Distress: Detecting UAS Damage in High-Powered Microwave Environments

The Naval Surface Warfare Center Dahlgren Division (NSWCDD) utilizes High Powered Microwaves to test their UAS devices to ensure they are battle ready. Utilizing parabolic microphones and signal processing software, the NSWCDD tasked us with determining any differences within a UAS hit by HPMs.

Verification of Microelectronics Protection Technology

The client has developed a protection technology for microelectronics. This project aims to design and implement a test to determine whether modifications made to a microelectronic device can be detected, based on its performance before and after alteration.

Mobile Digital High Frequency Ionosonde

Develop a small form factor ionosonde transmitter that can refract high frequency radio waves off of the ionosphere to gather information on current ionospheric conditions. These conditions are affected by weather changes, time of day, sunspot position, etc. This was achieved using commercial-off-the-shelf components and the utilization of an open source software repository to process and create visualizations of the data.

Track 6 - Cascade B

Manual Control Brushless DC Motor Two-Axis Control Box

When performing NDE (Non-Destructive Evaluation) inspections at nuclear power plants our customer typically has a NDE tool with 2 BLDC (brushless DC motors with hall sensors) connected

by cables to a control box that is then connected to a remote computer.
During the equipment set up phase of an outage it is typical for a tooling technician to have the NDE tool set up, ready to be function checked, prior to having LAN communication established to the remote computer, and prior to having a computer operator available to help with the tool functional checks.
Our manual control box will be used to test the NDE device's motors before a remote computer is set up.

Cyberchase Tabletop Board Game

Our team was tasked with creating a tabletop board game that simulated a cybersecurity exercise. The initial stages of game creation included; gaining experience with cyber terminology, procedures, and success probabilities from three phases: Network Analysis, Host Configuration, and Exploit Testing. The final phase included game design and gameplay. The game was designed for users of different skill levels. The game needed to be educational and entertaining for novice users, while competitive and accurate to real-world cyber exercises for professionals in the field. The overall goal of this project was to increase cybersecurity awareness through an engaging and entertaining method.

Cimel Data Relay and Storage Unit

To design and build a low-power device to collect data from photometers in remote locations around the world and upload data to a server hosted by NASA using WiFi or cellular reliably. The data collected creates a public domain database for aerosol research and characterization, validation of satellite retrievals, and synergism with other databases.

Low-Cost Portable Antenna Range

To enhance a low-cost portable antenna range based on a design developed by VT ECE graduate Christian Hearn and his fellow faculty at Weber State University by investigating signal processing to remove reflected signals and multipath that distort antenna pattern measurements through FPGA time-gating approach.

Optimization of Embedded Systems Chatbot

The customer desires to create a platform in which her students can access the chatbot and receive timely responses to their inquiries. Our team is tasked with deploying the chatbot application on a stable and reliable hosting (web) server.

Open ERCOT: Open Source Grid Modeling

To design an open-source model for the Texas grid that is capable of simulating a variety of conditions and use it to analyze various configurations and scenarios. This model can be used to view the impact of renewable energy sources on the grid and give concrete answers on where we should begin adding batteries.

Track 7 - Alumni Assembly Hall

ECE Robotics Competition Team 1 (Hardware)

To design and build a robot to compete in the IEEE SoutheastCon 2024 Hardware Competition to be held in Atlanta, Georgia.

ECE Robotics Competition Software Team

Our challenge entailed the conception and realization of a fully autonomous robot primed for participation in the IEEE SoutheastCon 2024 Student Hardware Competition. The competition scenario mirrors a real-world crisis, tasking robots with the crucial mission of thwarting potential asteroid collisions with Earth by deploying cargo containers and rocket thruster fuel tanks. The contest unfolds through a demanding obstacle course, where robots must navigate within a stipulated timeframe while delivering essential components. Initial objectives include retrieving and transporting varied-sized cargo containers to designated zones. Subsequently, robots face the daunting task of ferrying rocket fuel tanks across a chasm, employing either direct traversal or utilizing an overhead zipline. Upon crossing the chasm, the robot must precisely position the fuel tanks into their assigned slots. Culminating the challenge, the robot must reach the course's end and activate a button to conclude its run. Achieving completion of the course constitutes half of the total 120 points that can be earned, while additional points can be earned by the successful delivery of both cargo containers and fuel thrusters.

Early Failure Detection of Lithium-Ion Batteries Using Gas Sensing

Lithium-Ion Batteries pose a risk of failure and combustion during transportation and intensive use applications. We have developed an early failure detection system using a BME688 gas and environment sensor and a bluetooth capable microcontroller. Using a trained ai model the system is able to detect the unique gas composition released by a failing lithium ion battery in its early stages of failure and issue a warning to a connected parent system. The developed system is small and portable for multiple applications.

A Germanium Laser for Future Quantum Technologies: Design and Implementation

Over the past 60 years, using scaled Silicon transistors the semiconductor industry has made technological leaps unlike any other. Beyond classical computing, quantum computers can achieve quantum supremacy provided their building blocks can be scaled and manufactured on-chip leveraging the existing semiconductor fabrication infrastructure. Students will design a Germanium quantum well laser and optimize the various physical parameters to make the laser suitable for applications in quantum technologies, while understanding the various design intricacies, metrics, and trade-offs. Materials which are naturally suitable for light emission are called direct band gap materials, but Germanium is pseudo-direct which poses interesting challenges for tenting light emission. Using tensile strain applied through small atomic lattice differences between Ge and InGaAs, light emission using Ge is made possible. Utilizing their design knowledge and a developed photolithography mask, the students will also prototype laser devices to provide analytical retrospect on their functionality, merits, improvements, and applications. The societal impact of Ge QW Lasers specifically can be attributed to their wavelength tunability through tensile strain which allows for reaching impact in applications including fiber communication, quantum metrology, integrated Si optics, medical imaging, and gas spectroscopy.

Germanium Based Multi-Gate FETs for Ultra-Fast, Low-Power CMOS Computing

Over the past 60 years, using scaled Silicon transistors, the semiconductor industry has made technological leaps unlike any other. These innovations have been possible through research and development in the physics of operation, transistor design, material optimizations, advanced characterization, advanced fabrication, and efficient design. Ultra-fast, low-power transistors have societal benefits in areas such as AI, personal computing, and defense. Unfortunately, the benefits of scaling Silicon transistors have been diminishing for the past decade and further scaling will soon reach a dead-end. This project aims to design a germanium-based, multi-gate CMOS transistor and

optimize the various physical parameters to boost its performance beyond its Si-counterparts, while understanding the various design intricacies, metrics, and trade-offs.

Simulation of Thermal Transport in Resistive Memory Arrays

To accurately model, simulate, and calculate the thermal characteristics of an experimental form of random-access memory based on memresistors, called Resistive Random-Access Memory Arrays, or ReRAM.