UTRGV
Center for Multidisciplinary Research Excellence in Cyber-Physical Infrastructure Systems (MECIS)

NSF CREST MECIS – Spring 2025 Webinar Series – 4/25/2025

Presentation 1: **Het Patel (Doctoral Student) and Dr. Jia Chen, University of California-Riverside (UCR)**

Title: TRAWL: Tensor Reduced and Approximated Weights for Large Language Models

Abstract:

TRAWL (Tensor Reduced and Approximated Weights for Large Language Models) introduces a novel approach for denoising and improving Transformer-based models without requiring additional training or fine-tuning. Unlike existing methods that factorize individual weight matrices or depend on lower-precision formats, TRAWL utilizes tensor decompositions across multiple weight matrices while capturing both local and global structures. This process can eliminate accumulated training noise, often enhancing performance beyond the baseline. In extensive evaluations on RoBERTa and GPT-J with benchmark tasks (BigBench WikiQA, BiosProfession, HotpotQA), TRAWL surpasses single-matrix decomposition methods by up to 16% in accuracy. A key finding is that the most significant improvements occur when focusing on the final fully connected layers rather than the earlier attention components. While CP and Tucker decompositions are examined here, TRAWL's formulation is flexible enough to integrate other tensor approaches, broadening its applicability for large-scale NLP models. These results highlight the potential for more comprehensive post-training denoising strategies to improve efficiency and performance in LLMs, setting the stage for future innovations in rank-adaptive methods and robust inference techniques.

Presentation 2: **Javier Becerril (Master's Student) and Dr. Qi Lu, MARS Lab@ Computer Science, University of Texas Rio Grande Valley (UTCRS)**

Title: A Cost-Efficient Quadcopter UAV with Visual and Laser Sensors for Autonomous Pavement Crack Detection

Abstract:

In this work, we present the development of a cost-efficient quadcopter UAV with visual and laser sensors for pavement crack detection. The drone has been simulated in the Gazebo robotics environment to evaluate its flight dynamics, sensor positioning, and system behavior in various virtual scenarios. The architecture was iteratively refined based on performance in both laboratory and outdoor flight tests, leading to fine-tuning of the flight controller for enhanced stability and control. Currently, our focus lies in processing visual data onboard the drone to detect pavement cracks using deep learning-based object detection methods. While multiple sensor data fusion with a camera and custom-designed laser module is part of our future work. Our ongoing efforts include integrating object recognition capabilities and evaluating their performance in realistic simulation conditions. The ultimate objective is to extend this single-drone system into an autonomous heterogeneous UAV swarm capable of real-time, cooperative infrastructure inspection. By distributing sensing and decision-making, such a system could significantly improve the efficiency and accuracy of pavement health monitoring.

<u>Presentation 3:</u> Jose Rodriguez (Master's Students) and Dr. Wenjie Dong, University of Texas Rio Grande Valley (UTRGV)

Title: Neural Network Aided Drone Estimation in GPS-Denied Environments

Abstract:

Drones typically navigate using GPS, but there are circumstances which cause GPS signals to be interrupted. Data from inertial measurement units (IMU) can be used to estimate position, but the noise and bias present in these measurements typically lead to estimations that suffer from drift. Neural networks have shown the ability to learn and recognize many complex patterns in a variety of applications. The goal is to use the capabilities of neural networks to develop an estimation method which gives better position predictions than traditional mathematical models when only IMU measurements are available. This project covers the development, testing, and results of various neural network-based estimation architectures. Architectures attempted range from pure neural network models with Long Short-Term Memory (LSTM) recurrent neural networks as the basis to architectures that attempt to fuse the benefits of neural networks and physics based mathematical models. The varying results of the architectures attempted shed light on the potential applications of neural networks for guidance, navigation, and control.

<u>Presentation 4:</u> Diego Cantu (Master's Student), Dr. Constantine Tarawneh and Dr. Ping Xu, University of Texas Rio Grande Valley (UTRGV)

Title: Feature Extraction from Railroad Bearing Onboard Vibration Sensors Using Machine Learning Models

Abstract:

The railway industry experiences over 1,000 train derailments annually, highlighting the insufficiency of traditional monitoring and maintenance methods being utilized. This project strives to extract train speed from the vibration signatures collected by the University Transportation Center for Railway Safety (UTCRS) wireless onboard sensors. Train speed is a required input for the developed algorithm that will assess bearing health through three-levels of analysis. Specifically, we developed a hybrid framework that integrates traditional signal processing techniques such as Hilbert and Teager Energy Operator (TEO) as well as Fast Fourier Transform with machine learning techniques to extract train speed. This framework will allow for real-time, accurate monitoring of bearing condition, ensuring more timely interventions and improved railway safety and efficiency.