UTRGV

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

NSF CREST MECIS – Fall 2025 Webinar Series – 11/25/2025

Presentation 1: **Kenneth Duran (Master's Student), Dr. James Li, University of Texas Rio Grande Valley (UTRGV)**

Title: Robotic Forming and Bending of Aluminum Sheets for Fixed-Wing Drone Manufacturing

Abstract:

This study highlights the integration of robotic manufacturing with advanced simulation technologies to accomplish Robotic Forming/Bending (RFB) incorporating a pre-stress method, a process well-suited for agile, on-demand fabrication. RFB offers significant potential to manufacture lightweight, structurally efficient components, such as airfoils for fixed-wing drones. These components often require customized profiles and rapid iteration cycles, which traditional manufacturing processes struggle to support cost-effectively. Our research explores how simulation tools and robotic path planning can be leveraged to model and control the RFB process with high accuracy. By coupling industrial robots with real-time simulations, we aim to reduce lead time, improve repeatability, and enhance process monitoring. This framework aligns closely with the Army's interests in deployable, digitally driven manufacturing systems that can deliver mission-critical hardware with speed and precision.

Presentation 2: **Gabby Gutierrez (Doctoral Student), Dr. Gasser Ali, University of Texas Rio Grande Valley (UTRGV)**

Title: Modeling the Impact of Extreme Weather Events on the US Rail Network

Abstract:

The US rail network is a large and crucial element of its infrastructure and economy, with approximately 140,000 miles of track. Rail failures can result in large accidents, putting lives at risk and causing huge economic damage. Extreme temperature events, such as heatwaves, are increasingly frequent and intense and can trigger rail damage causing train derailments. High rail temperatures can lead to heat-induced buckling, while freezing temperatures can create cracking. Research has investigated the effects of temperature on rail failure and the probability of their failure using various approaches such as finite element analysis, lab experiments, machine learning, and others. However, most research is focused on the failure on the rail element level. There is a need for research that investigates the impact of extreme weather events on the rail network and its operations. Accordingly, this paper investigates the vulnerability of the network using a probabilistic modeling and graph theory approach. A graph of the US rail network is created and embedded with weather data simulating historic extreme weather events; and a probabilistic risk assessment is conducted based on the probability, impact, and severity of temperature related risks. The outcomes of the model can indicate the risk severity on all railroads connecting any two nodes, such as any two major cities, on the US rail network. The model can identify critical railroads as to support decision making as related to improving the resilience of existing roads and planning new alternative routes to minimize the impact of extreme weather events and improve rail safety.

Presentation 3: **Chenwei Huang (Doctoral Student), Dr. Alireza Talebpour, University of Illinois at Urbana-Champaign (UIUC)**

Title: Multi-Depot Capacitated K-Chinese Postman Problem for UAV Patrolling

Abstract:

The introduction of Unmanned Aerial Vehicles (UAVs) has allowed UAV-based patrolling to emerge as a promising alternative for surveilling roadway networks, offering improved responsiveness to persistent traffic issues (e.g., safety). This patrolling problem is a network coverage problem and can be modeled as an Arc Routing Problem (ARP), specifically as a K-Chinese Postman Problem (K-CPP), where K UAVs are assigned to generate K walks such that all edges in the network are covered at least once while minimizing total cost. Most existing heuristics for solving the K-CPP do not account for multi-depot operations or capacity constraints (e.g., energy limitations), which are critical in large-scale UAV patrolling networks. To address these limitations, this paper models the UAV patrolling problem as a Multi-Depot Capacitated K-Chinese Postman Problem (MDC-K-CPP), formulated as an Integer Linear Program (ILP). Since this problem is NP-hard by nature, we propose a novel heuristic framework composed of three algorithms: Walk Generation under Constraints Algorithm, Depot Node Setting Optimizer Algorithm, and Post-Processing K-Reduction Merge Algorithm. These algorithms work to generate K UAV patrol walks under energy capacity constraint, insert and optimize the placement of depots, balance and optimize energy consumption across walks, and ensure full edge coverage. Experimental studies are conducted on both small- and large-scale patrolling grid instances, with performance compared against two baselines: an ILP solution implemented in Gurobi and the Augment-Merge Algorithm. Results show the proposed heuristic framework outperforms both baselines, particularly in large-scale instances, highlighting its scalability and computational efficiency.

Presentation 4: **Mario Camarena (Master's Student), Dr. Fatemeh Nazari, University of Texas Rio Grande Valley (UTRGV)**

Title: AD-SAM: Fine-Tuning the Segment Anything Vision Foundation Model for Autonomous Driving Perception

Abstract:

This work presents the Autonomous Driving Segment Anything Model (AD-SAM), a fine-tuned vision foundation model for semantic segmentation in autonomous driving (AD). AD-SAM extends the Segment Anything Model (SAM) with a dual-encoder and deformable decoder tailored to spatial and geometric complexity of road scenes. The dual-encoder produces multi-scale fused representations by combining global semantic context from SAM's pretrained Vision Transformer (ViT-H) with local spatial detail from a trainable convolutional deep learning backbone (i.e., ResNet-50). A deformable fusion module aligns heterogeneous features across scales and object geometries. The decoder performs progressive multi-stage refinement using deformable attention. Training is guided by a hybrid loss that integrates Focal, Dice, Lovász-Softmax, and Surface losses, improving semantic class balance, boundary precision, and optimization stability. Experiments on the Cityscapes and Berkeley DeepDrive 100K (BDD100K) benchmarks show that AD-SAM surpasses SAM, Generalized SAM (G-SAM), and a deep learning baseline (DeepLabV3) in segmentation accuracy. It achieves 68.1 mean Intersection over Union (mIoU) on Cityscapes and

59.5 mIoU on BDD100K, outperforming SAM, G-SAM, and DeepLabV3 by margins of up to +22.9 and +19.2 mIoU in structured and diverse road scenes, respectively. AD-SAM demonstrates strong cross-domain generalization with a 0.87 retention score (vs. 0.76 for SAM), and faster, more stable learning dynamics, converging within 30-40 epochs, enjoying double the learning speed of benchmark models. It maintains 0.607 mIoU with only 1000 samples, suggesting data efficiency critical for reducing annotation costs. These results confirm that targeted architectural and optimization enhancements to foundation models enable reliable and scalable AD perception.

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The University of Texas Rio Grande Valley / 1201 West University Drive / Engineering Portable EPOB13 1.100 / Edinburg, Texas 78539-2999
Phone: +1 (956) 665-3070 / mecis@utrgv.edu / http://utrgv.edu/mecis