Fall 2023
Pushing Intelligence to the Edge
IAB Meeting

October 25-26
University of Michigan-Flint
Riverfront Conference Center
1 Riverfront Plaza
Flint, MI 48502

https://www.ppicenter.org/
Welcome to University of Michigan-Flint, host of the fall 2023 PPI Center Advisory Board Meeting! The campus is located in the heart of downtown Flint, Michigan. Our community takes great pride in its strong history and reputation for attracting, cultivating, and recognizing “doers” — resilient individuals who aren’t afraid to take initiative and make the world a better place. We welcome the thought leaders in academic and industry research for this exciting Industry/University event.

The Riverfront Conference Center is Genesee County’s largest conference venue, hosting thousands of visitors each year. Parking for Riverfront Conference Center is located in the attached parking structure located on Beach Street. Guests will take the elevator/stairs to level one and cross Union Street to the front entrance of the Riverfront Conference Center. A parking map is available at [https://www.umflint.edu/campus-map/](https://www.umflint.edu/campus-map/)

**Airports**
- Flint Bishop International Airport
  - Flint, MI
  - Daily connecting flights to Chicago
- DTW International
  - Romulus, MI
  - 90 minutes by car to UM-Flint

Car rental is available at both airports.

**Contact**
Any questions regarding the meeting logistics, travel, hotel, and accommodation can be directed to Laurel Ming, laurelmi@umich.edu
Industry and Universities Coming Together for Intelligent IoT

We are an interdisciplinary group of academic researchers and industry thought leaders coming together to work on the common challenges to realize intelligent software systems that we would want and are confident in. At the PPI Center, we believe that an open forum with startups, large corporate partners, and government agencies connecting directly with university researchers is necessary to turn fundamental research into innovative products.

We seek to

- Enable Diverse Thinking
- Collaborate on Industry-wide Challenges
- Leverage Access and Resources

Welcome to this unique opportunity to network with industry leaders, academic scholars, and researchers as we come together to discuss the development of applications and platforms that push personalized intelligence to the edge of the network in the aerospace, automotive, manufacturing, national labs, and high-tech industries.

Internet of Things (IoT) marks the dawn of a technological revolution that rivals the industrial revolution. In this new era, intelligent computing becomes anticipatory, proactive, and adaptive. The next big growth in IoT systems will come from pushing Pervasive Personalized Intelligence (PPI) to the edge of the network, where latency is critical, and mobility, privacy, and context awareness are essential qualities of the application. The PPI Center will support the thrusts that enable an entirely new class of applications with intelligence that is predictive instead of reactive, thus making processes more efficient and saving time, energy, and money.

The PPI Center is a multi-university, industry-focused research center under the supervision of the US National Science Foundation (NSF). We operate under the NSF IUCRC model. The pre-competitive (i.e., of interest to many companies) and industry-applied research projects we work on are funded by industry members, by our universities, and by the NSF.

Our 60+ companies represented at our meetings include many of the global high-tech companies, the leading companies in the IoT domain (smart buildings, smart home, smart city, Industry 4.0, smart health), and many medium-size and startups from Michigan, Colorado, Oregon, Silicon Valley, and Japan. Our mission is to engage our industry members through twice-a-year workshops, progress reports, student internships, etc. We do not simply accept members as Corporate Affiliations; we want to work with engaged industry members. We are project-driven, and we stay accountable to our members for the progress we make. It is this accountability that makes us better and helps us to serve our members.
WHAT WE DO
In discussions with our industrial members and partners, we understand the importance of intelligent transportation, software engineering, edge intelligence and smart energy so that businesses run more smoothly and profitably. It is for this reason that we have brought together leading experts from different sites in Colorado, Michigan, and Oregon.

The University of Michigan-Flint site pursues activities primarily in the following areas:

**Secure and intelligent transportation**
How do we manage the complexity in deploying ML applications on the edge in limited/constrained hardware environments such as embedded devices in cars?

**Software engineering**
How do we ensure isolated failure/impacts of applications? How do we quickly deliver and install software updates in a secure manner on the edge?

**Explainable multimodal distributed intelligence**
How can we design a common data-collection solution for fast-changing data on zonal controllers?

**Artificial intelligence (AI) and digital twins**
Can we develop personalized, context-aware sensing-analysis-actuation solutions in smart vehicles?

**Smart energy**
How can we enable smart electric systems that help customers use the most energy when demands are lower?
The Oregon State site pursues activities primarily under three thrusts:

**Machine Learning and Artificial Intelligence**
How do we increase the trust of developers and end-users in software that learns and detects anomalous behaviors and patterns, and on-board new users?

**Security and Privacy**
Can we help end-users make configuration decisions that do not violate their privacy and compute on users’ private data without revealing private information?

**Visualization and Visual Analytics**
How do we translate data into insight visually? Can we make this process of data-to-insight not only possible but also easy for our users? How can we help users better understand what their AI programs are telling them?

Weng-Keen Wong
Director, OSU Site
Associate Professor, Oregon State University
Expertise: ML (Time Series)

Eugene Zhang
Co-Director, OSU Site
Professor, Oregon State University
Expertise: Visualization

The Colorado site leads activities primarily under three thrusts:

**Edge and Cloud Computing**
Is it possible to identify and develop a small set of fundamental system-level services at the middleware layer to integrate mobile nodes, IoT devices, and edge servers?

**Programming Languages and Verification**
Can new techniques be created that enable software developers to effectively create rich PPI applications that, by construction, are secure, privacy-preserving, and reliable?

Danny Dig
Executive Director, PPI Center
Associate Professor, UC Boulder
Expertise: SE for ML Systems

Bor-Yuh Evan Chang
Co-Director, CU Site
Associate Professor, UC Boulder
Expertise: PL

**Software Engineering and Human-Computer Interaction**
How can we retrofit and evolve PPI programming models into existing software? How do people interpret visualized data and how can we use these models to drive novel visualization systems that support accurate analysis of complex data that better scale to the needs of modern analytics?

Shivakant Mishra
Co-Director, CU Site
Professor, UC Boulder
Expertise: Edge Computing
Industry Keynote

Raj Polanki

Head of Analytics & Data Science
Wacker Chemical Corporation
Ann Arbor, Michigan

Oct 26 @ 8:30am

*Digital Enterprise Intelligence – Accelerating the journey beyond transformation and innovation*

*Raj Polanki* is a CIO and Head of Analytics and Data Science at Wacker Chemical Corporation. He has 25+ years of experience in progressive and influential leadership positions at global companies with a focus on leading Data Science/Analytics and digital transformation initiatives. He is also an author, speaker, and recognized thought leader. Polanki earned an Advanced Executive Certificate from MIT Sloan, and an MBA from Ross Business School at the University of Michigan.
Industry Panel

Enabling Data Analytics on the Edge

Steve Brumer
PPI Center Industry Liaison
BH IoT Group
Panel Moderator

Tim Bates
CTO, Lenovo

Ali Husain
Director, Vehicle Software and AI Research & Advanced Engineering
Ford Motor Company

Ramesh S
Technical Fellow
General Motors

Ghassan Azar
Technical Coach
United Wholesale Mortgage
### Day 1: Wednesday October 25
Riverfront Conference Center

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<th>Time</th>
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| 7:50 - 8:30am | Check-in/registration  
Continental Breakfast                                      |
| 8:30 - 8:40am | Welcome from the PPI Leadership  
Marouane Kessentini                                           |
| 8:40 - 9:00am | Opening Remarks  
UM-Flint Leadership                                           |
| 9:00 - 9:10am | Introductions from Industry Members and Guests                     |
| 9:10 - 9:30am | Vision, Capabilities, and Value of the PPI Center  
Danny Dig, University of Colorado Boulder                      |
| 9:30 - 10:00am | NSF IUCRC Model  
IUCRC Success Stories                                             |
| 10:00 - 10:20am | Networking Break  
Refreshments in the Lobby                                          |
| 10:20 - 11:30am | Project Status Reports from PPI Faculty  
Correlation Changepoint Detection  
Lead PI: Weng-Keen Wong                                           |
|               | Global Explanations for Image Classification  
Lead PI: Prasad Tadepalli                                         |
|               | ML Over Dirty Data Without Manual Cleaning  
Lead PI: Arash Termehchy                                            |
|               | Context-Preserving Spatiotemporal Representation Learning for IoT Data  
Lead PI: Morteza Karimzadeh                                        |
|               | Augmented Reality as an Interface for the Internet of Things and People  
Lead PI: Ellen Do                                                  |
|               | Decision Support through Decentralized, Privacy-Preserving Data Collection and Aggregation at The Edge  
Lead PI: Bradley Hayes                                             |
<p>| 11:30 - 12:30pm | Industry Panel on Enabling Data Analytics on the Edge               |
| 12:30 - 1:30pm | Lunch &amp; Networking Break                                             |</p>
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<th>Time</th>
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<tr>
<td>1:30 - 2:40pm</td>
<td><strong>New Project Proposals from PPI Faculty</strong></td>
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<td>Personalized Explanation of Knowledge</td>
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<td>Generation using Multimodal Edge AI Models</td>
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<td>Lead PI: Khalid Malik</td>
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<td>Generative AI Programming Assistant</td>
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<td>Lead PI: Danny Dig</td>
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<td>My AI: Towards a Platform for Involving</td>
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<td>Customers in Design of Artificially Intelligent Technology</td>
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<td>Lead PI: Douglas Zytko</td>
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<td>System Support to Enable AI on the Edge</td>
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<td>Lead PI: Shiv Mishra</td>
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<td>Intelligent Software Defined Vehicle Management Technology</td>
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<td>Lead PI: Marouane Kessentini</td>
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<td>Natural Language Explanations for Understanding AI System Failure Modes</td>
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<td>Lead PI: Steve Wilson</td>
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<td>2:40 - 3:00pm</td>
<td>Networking Break</td>
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<td>Refreshments in the Lobby</td>
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<tr>
<td>3:00 - 3:30pm</td>
<td>Lightning Talks from Poster Presenters</td>
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<td>5:30 - 8:00pm</td>
<td>Banquet Dinner and Student Poster Awards</td>
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<td>Hilton Garden Inn</td>
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**Day 2: Thursday October 26
Riverfront Conference Center**

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<th>Time</th>
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<tr>
<td>8:00 - 8:30am</td>
<td>Check-in/registration</td>
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<td>Continental Breakfast</td>
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<tr>
<td>8:30 - 9:30am</td>
<td>Industry Keynote</td>
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<td>Raj Polanki, Wacker Chemical Corporation</td>
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<td>9:30 - 10:45am</td>
<td>PPI Faculty Review Project Feedback w/ Industry</td>
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<td>10:45 - 10:55am</td>
<td>NSF Surveys</td>
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<td>Dee Hoffman, NSF IUCRC Evaluator</td>
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<td>10:55 - 11:10am</td>
<td>Networking Break</td>
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<tr>
<td>11:10 - 12:00pm</td>
<td>Industry Meeting for Project Voting</td>
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<td>Beppe Raffa, Intel</td>
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<td>12:00 - 12:30pm</td>
<td>Moving Forward &amp; Closing</td>
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<td>PPI Leadership</td>
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<td>12:30 - 2:00pm</td>
<td>Lunch</td>
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Correlation Changepoint Detection  
**Lead PI: Weng-Keen Wong, Oregon State University**  
The precision matrix (the inverse of the covariance matrix) captures important partial correlation relationships between variables in the data. Precision changepoint detection involves identifying changes to the precision matrix and has many real-world use cases including detecting failures in manufacturing, discovering unusual changes to stock prices, and detecting spatio-temporal events like storms. The goal of this project is to develop computationally efficient precision changepoint detection algorithms for high-dimensional data that can identify which groups of dimensions cause the change. We introduce a changepoint detection algorithm which uses a linear decomposition of the precision matrix to identify a change in the partial correlation structure of a time series. We show that our approach can be computationally efficient in high dimensions. Our approach uses likelihood ratio tests to identify clusters of dimensions that are responsible for the change, thus providing more of an explanation as to why the changepoint occurs.

**Weng-Keen Wong** is a Professor in the School of Electrical Engineering and Computer Science at Oregon State University. He received his Ph.D. (2004) and M.S. (2001) in Computer Science from Carnegie Mellon University, and his B.Sc. (1997) from the University of British Columbia. From 2016-2018, he served as a Program Director at the National Science Foundation under the Robust Intelligence Program in the Division of Information and Intelligent Systems. His research areas are in data mining and machine learning, with specific interests in anomaly detection, probabilistic graphical models, computational sustainability and human-in-the-loop learning.

Global Explanations for Image Classification  
**Lead PI: Prasad Tadepalli, Oregon State University**  
Much of the current research in Explainable AI is aimed at explaining classification decisions of image instances through a variety of activation maps. In this research, we focus on the decisions of a neural network over an image dataset in terms of symbolic part labels. Building on earlier work, we compute the minimal sufficient explanations (MSXs) for image instances by perturbing the inputs of the opaque neural network model and examining its outputs. By finding correspondences between similar parts of different images and mapping them to symbolic part labels, we construct a human-interpretable model that is nearly consistent with the decisions of the network. We propose to extend this work to Visual Question Answering (VQA) in the context of activity recognition by constructing interpretable models of activities from videos and text.

**Prasad Tadepalli** is a Professor in the School of Electrical Engineering and Computer Science of Oregon State University. His main research interest is to understand learning and thinking by simulating them in computers. His work ranges from theoretical analyses of learning problems and algorithms to their implementation, evaluation, and application to real-world problems. He has co-authored over a hundred papers in artificial intelligence and machine learning in various journals, conferences, and workshops. He has organized many workshops and tutorials and co-chaired the international conference on inductive logic programming in 2007.

ML Over Dirty Data Without Manual Cleaning  
**Lead PI: Arash Termehchy, Oregon State University**  
Real-world data is often incomplete, contains missing or inconsistent values. To train accurate models over real-world datasets, users need to spend a substantial amount of time and resources imputing and finding proper values for missing and inconsistent data items. We demonstrate that it is possible to learn accurate models directly from data with missing values for some training data and target models. We propose a unified approach for checking the necessity of data imputation to learn accurate models across various widely-used machine learning paradigms. We build efficient algorithms with theoretical guarantees to check this necessity and return accurate models in cases where imputation is unnecessary. Our extensive experiments indicate that
Context-Preserving Spatiotemporal Representation Learning for IoT Data
Lead PI: Morteza Karimzadeh, University of Colorado Boulder

Mentored by Intel Research, our project is focused on leveraging and improving spatiotemporal graph neural networks for representation learning in multi-modal data environments. Spatiotemporal graph neural networks are emerging as a powerful tool in artificial intelligence that can effectively learn representations of data that vary across space and time, such as data captured by the vast arrays of sensors and IoT devices. Graph neural networks can seamlessly merge diverse inputs from multiple modes, thereby improving predictive tasks like node classification and graph classification, but also, create learned non-linear representations that can be used in various downstream tasks. As a first step, we are working to compare the performance of graph models and ASPNet, a leading non-graph neural network, using the 50 Salads benchmark dataset. The preliminary results, even with the exclusive use of video modality, are not only promising but also comparable. We believe that incorporating additional modalities, such as accelerometer and depth, will improve performance metrics. Beyond mere performance enhancement, the learned representations on graphs can be more versatile compared to those learned on models such as ASPNet. These representations in turn enable a myriad of downstream applications in multi-modal environments, including manufacturing environments, IoT data fusion, and autonomous driving. The findings are applicable in any environment relying on data from multiple sources and modes.

Dr. Morteza Karimzadeh is an Assistant Professor of Geography and affiliate Assistant Professor of Computer Science and Information Science at the University of Colorado (CU) Boulder. He is a geospatial data scientist, with research cutting across machine learning, geovisualization, geographic information retrieval, and visual analytics. His primary research focuses on method development, extended to various domains including environmental monitoring and forecasting, epidemiological modeling, human-mobility analyses, geo-text analytics, situational awareness, precision agriculture, and digital humanities. His research is use-inspired, human-centered, and product-oriented, from visual design to ground truth creation, algorithm integration and evaluation, to domain deployment and field studies. He collaborates with a vast array of practitioners, scientists, and stakeholders in different fields. His currently research is funded by agencies including the National Science Foundation, NASA, Population Council, National Institutes of Health and the Department of Energy.

Augmented Reality as an Interface for the Internet of Things and People
Lead PI: Ellen Do, University of Colorado Boulder

In-person human interaction relies on our spatial perception of each other and our surroundings. Current remote communication tools partially address each of these aspects. Video calls convey real user representations but without spatial interactions. Augmented and Virtual Reality (AR/VR) experiences are immersive and spatial but often use virtual environments and characters instead of real-life representations. Bridging these gaps, we introduce DualStream, a system for synchronous mobile AR remote communication that captures, streams, and displays spatial representations of users and their surroundings. DualStream supports transitions between user and environment representations with different levels of visuospatial fidelity, as well as the creation of persistent shared spaces using environment snapshots. We demonstrate how DualStream can enable spatial communication in real-world contexts, and support the creation of blended spaces for collaboration. A formative evaluation of DualStream revealed that users valued the ability to interact spatially and move between representations, and could see DualStream fitting into their own remote communication practices in the near future. Drawing from these findings, we discuss new opportunities for designing more widely accessible spatial environments.
Decision Support through Decentralized, Privacy-Preserving Data Collection and Aggregation at The Edge

Lead PI: Bradley Hayes, University of Colorado Boulder

The increasing ubiquity and decreasing cost of deploying capable sensors on mobile robots, as wearables on people, or fixed on structures presents opportunities for inexpensive and non-labor-intensive data aggregation and operationalization. Connecting networked “always-on” sensors introduces data privacy and data efficiency concerns, which if left unaddressed limit the ability to aggregate data toward collective situational awareness. This work addressed a technical gap that exists in addressing how these data can be 1) captured at the edge, 2) centrally aggregated and fused to maximize collective utility, and 3) returned to the edge for decision support while mitigating liability issues and inefficiency.

Bradley Hayes is an Assistant Professor of Computer Science at the University of Colorado Boulder, where he directs the Collaborative AI and Robotics (CAIRO) Lab. Brad’s research exists at the intersection of Explainable AI and Human-Robot Interaction, developing techniques to create and validate autonomous systems that learn from, teach, and collaborate with humans to improve efficiency, safety, and capability. His work has been recognized with best paper nominations and awards from the University of Colorado Boulder, the ACM/IEEE International Conference on Human-Robot Interaction, the International Conference on Autonomous Agents and Multi-Agent Systems, and the IEEE International Symposium on Robot and Human Interactive Communication. Prior to joining the faculty at CU Boulder, Brad spent eight years conducting research on the algorithmic foundations of human-robot interaction at the Yale Social Robotics Lab and the Interactive Robotics Group at the Massachusetts Institute of Technology.

Ellen Yi-Luen Do is a professor of ATLAS Institute and Computer Science at University of Colorado, Boulder. She invents at the intersection of people, design, and technology. Ellen works on computational tools for design, especially sketching, creativity, and design cognition, including creativity support tools and design studies, tangible and embedded interaction, and, most recently, computing for health and wellness. She holds a PhD in Design Computing from Georgia Institute of Technology, a Master of Design Studies from the Harvard Graduate School of Design, and a bachelor’s degree from National Cheng Kung University in Taiwan. She has served on the faculties of University of Washington, Carnegie Mellon, and Georgia Tech, and as co-director of the Keio-NUS CUTE Center in Singapore.

https://arxiv.org/abs/2309.00842
Generative AI Programming Assistant
Lead PI: Danny Dig, University of Colorado Boulder
Generative AI and Large Language Models (LLMs) are rapidly transforming the field of software development. Among others, developers use Generative AI to (i) search for code fragments using natural language, (ii) generate code, documentation, comments, commit messages, (iii) explain code, bug fixes, summarize recent changes, etc. A top concern remains the trustworthiness of the solutions provided by Generative AI. While many solutions resemble the ones produced by expert developers, LLMs are known to produce hallucinations, i.e., solutions that seem plausible at first, but are deeply flawed. To help developers trust Generative AI solutions, we discover novel approaches that synergistically combine the creative potential of LLMs with the safety of static and dynamic analysis from program transformation systems. Our current results show that our approach is effective: it safely automates code changes and is up to 39x more effective than previous state of the art tools. Moreover, our approach produces results that expert developers trust: we submitted patches generated by our LLM-powered tools to famous open-source projects whose developers accepted most of our contributions. Our surveys with dozens of professional developers reveal that they agree with the recommendations provided by our tools. This shows the usefulness of our novel approach and ushers us into a new era when LLMs become effective AI assistants for developers. Your organization can also benefit from these big advancements. We invite you to partner with us so that we can turn your software developers into super-human developers. Together we go further.

Danny Dig is an Associate Professor of Computer Science at the University of Colorado. He is the founder and the Executive Director for the Center for Pervasive Personalized Intelligence (https://ppicenter.org), an industry-university consortium under the US National Science Foundation. Together with partners from industry,
System Support to Enable AI on the Edge

Lead PI: Shiv Mishra, University of Colorado Boulder

Edge computing introduces middle-tier compute servers closer to the sensors and end users to build IoT applications. Our research goal is to develop core system-level services to enable a distributed, microservice-based system architecture that facilitates building complex AI applications at the edge. The key features of this system include incorporating humans in the loop, optimized placement of compute and data elements in a dynamically changing environment, and computing over a diverse set of processing elements including CPUs, GPUs and FPGAs. The proposed system aims to integrate and augment elements of current edge solutions such as EdgeX and Azure IoT Edge.

Shivakant Mishra is a professor in the Department of Computer Science at The University of Colorado, Boulder. He enjoys doing research in Distributed Computing & Networking as well as in Social Computing. His current research includes developing system-level support for edge computing, building socio-technical systems, investigating cybersafety issues in social networks, and multi-player online game analytics. He is also involved in a range of outreach activities engaging local K-12 teachers and students as well as members of environmental justice communities. His research has been supported by grants from National Science Foundation, Department of Defense, NASA and Office of Naval Research. He has also collaborated with a number of high-tech industries, including Google, Microsoft, IBM, Intel, Nokia, QualComm, Chatroulette, and Omegle.

My AI: Towards a Platform for Involving Customers in Design of Artificially Intelligent Technology

Lead PI: Douglas Zytko, University of Michigan-Flint

Consumers are rapidly accruing distrust for modern implementations of AI. In many cases consumers exhibit little understanding of an AI’s functionality and in some cases they even express overt disdain. These concerns have made clear that simply having AI integrated into products will not be a sustainable business advantage. Based on patterns with prior technological advances, consumers will migrate to the artificially intelligent products that they consider the most understandable, trustworthy, and most beneficial to their lives. Historically, the way companies have made their emerging technologies the most usable, understandable, and trustworthy is with UX research methods that directly involve customers in the design process. This is a persistent challenge in industry because consumers often have little understanding of AI and are thus stifled in their capacity to contribute to design of artificially intelligent products. We propose a web application called MyAI that enables everyday consumers to understand early-stage AI product concepts from industry and contribute to its design and development. The crux of the application is a series of “brainstorming “widgets” or design patterns that enable AI novices to independently create and revise key elements of artificially intelligent technology, such as: scenarios for new AI use cases, data for model training, and interfaces for explaining the AI’s decision-making.

Douglas Zytko is an Associate Professor in the College of Innovation & Technology at University of Michigan-Flint, and Director of the PhD Program in Computing. His research uses consent as a lens to study and design for human-computer interaction and human-AI interaction. To the latter, Dr. Zytko's lab explores voluntary donation of personal data for AI model training and uses methods such as participatory design to directly involve end-users in creation and improvement of artificially intelligent technologies. His research into computer-mediated consent to interpersonal activity in virtual reality and mobile dating apps has received multiple awards at leading HCI publication venues and has been funded by the National Science Foundation. He has advised over 40 student researchers at the graduate and undergraduate levels, 29 of whom are authors on peer reviewed publications and recipients of multiple research awards including the Thesis Award, Thesis with Distinction, and a Distinguished Achievement Award.
Metrics such as Accuracy, F1-score, and ROC AUC provide useful, high-level scores which summarize the performance of AI and ML models. However, by collapsing all of the information about a model’s performance into a small set of numbers, a great deal of information about the nature of the model’s failure modes is often lost. We aim to develop an improved error analysis interface that allows for the automatic clustering of error slices — groups of incorrectly handled data with similar features — and for the automatic summarization, in natural language, of the unique properties of each error slice that need to be addressed in order to improve the model’s performance. We will also provide an interface for viewing and manually modifying the detected clusters. This work will require exploration of novel multi-modal and multi-document summarization techniques to make the system robust to a variety of input types and AI tasks.

Khalid Malik is currently professor, director of cybersecurity center, and director of Secure Modeling and Intelligent Learning in Engineering Systems (SMILES) lab at College of Innovation and Technology at University of Michigan-Flint. He is also an adjunct professor at the School of Engineering and Computer Science at Oakland University. Before joining the University of Michigan, he was distinguished associate professor in the School of Engineering and Computer Science and the director of the SMILES Lab at Oakland University. His research focuses on the integrated area of AI, healthcare, and information security to design secure, intelligent, and decentralized decision support systems by employing multimodal, federated, trustworthy, and neuro-symbolic AI. In healthcare, he focuses on prediction of neurological disorders using clinical text and multiple medical imaging modalities (e.g. DSA, MRA). In cybersecurity, his research focus is on developing forensic examiners for authenticity, integrity and veracity of audios, videos, images; and multimodal neuro-symbolic AI for web filtering. Limited to Oakland’s Young Investigator Research award (2018), SECS Outstanding Research award (2019), and Distinguished Associate Professor award (2021).

Natural Language Explanations for Understanding AI System Failure Modes
Lead PI: Steve Wilson, Oakland University

Metrics such as Accuracy, F1-score, and ROC AUC provide useful, high-level scores which summarize the performance of AI and ML models. However, by collapsing all of the information about a model’s performance into a small set of numbers, a great deal of information about the nature of the model’s failure modes is often lost. We aim to develop an improved error analysis interface that allows for the automatic clustering of error slices — groups of incorrectly handled data with similar features — and for the automatic summarization, in natural language, of the unique properties of each error slice that need to be addressed in order to improve the model’s performance. We will also provide an interface for viewing and manually modifying the detected clusters. This work will require exploration of novel multi-modal and multi-document summarization techniques to make the system robust to a variety of input types and AI tasks.

Steven R. Wilson is an Assistant Professor in the School of Engineering and Computer Science at Oakland University where he leads the OaklandNLP lab. He received his MS and PhD in Computer Science & Engineering from the University of Michigan and later worked as a Research Associate at the Institute for Language, Cognition, and Computation at University of Edinburgh, Scotland, before joining OU. His current research focuses on studying online human communication using natural language processing, providing scalable solutions to gather insights from large amounts of unstructured data, and promoting AI and internet literacy. His work has been published at top NLP venues such as ACL and EMNLP and received best paper awards at the International Conference on Social Informatics.
**Student Project Posters/Presentations**

**Shivendra Agrawal, University of Colorado Boulder**
**Advisor: Bradley Hayes, University of Colorado Boulder**

**ShelfHelp: Empowering Humans to Perform Vision-Independent Manipulation Tasks with a Socially Assistive Robotic Cane**

The ability to shop independently, especially in grocery stores, is important for maintaining a high quality of life. This can be particularly challenging for people with visual impairments (PVI). Stores carry thousands of products, with approximately 30,000 new products introduced each year in the US market alone, presenting a challenge even for modern computer vision solutions. Through this work, we present a proof-of-concept socially assistive robotic system we call ShelfHelp, and propose novel technical solutions for enhancing instrumented canes traditionally meant for navigation tasks with additional capability within the domain of shopping. ShelfHelp includes a novel visual product locator algorithm designed for use in grocery stores and a novel planner that autonomously issues verbal manipulation guidance commands to guide the user during product retrieval. Through a human subjects study, we show the system’s success in locating and providing effective manipulation guidance to retrieve desired products with novice users. We compare two autonomous verbal guidance modes achieving comparable performance to a human assistance baseline and present encouraging findings that validate our system’s efficiency and effectiveness and through positive subjective metrics including competence, intelligence, and ease of use.

**Shiventra Agrawal** is a 4th year Ph.D. student at CU Boulder. I work in the CAIRO Lab under the supervision of Prof. Bradley Hayes. I am broadly interested in Accessibility, Human Computer interaction (HCI), Human Robotics Interaction (HRI), Computer Vision (CV), and Explainable AI. My research aims to create real-world Assistive Technology (AT) through an amalgamation of the above mentioned sub-fields. I am currently working towards creating a smart cane to assist people with visual impairment (PVI) to perform day-to-day tasks more independently.

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**Wajdi Aljedaani, University of Michigan-Flint**
**Advisor: Marouane Kessentini, University of Michigan-Flint**

**Empirical Investigation of Accessibility Bug Reports in Mobile Platforms: A Chromium Case Study**

Accessibility is an important quality factor of mobile applications. Many studies have shown that, despite the availability of many resources to guide the development of accessible software, most apps and web applications contain many accessibility issues. Some researchers surveyed professionals and organizations to understand the lack of accessibility during software development, but few studies have investigated how developers and organizations respond to accessibility bug reports.

Therefore, this paper analyzes accessibility bug reports posted in the Chromium repository to understand how developers and organizations handle them. More specifically, we want to determine the frequency of accessibility bug reports over time, the time-to-fix compared to traditional bug reports (e.g., functional bugs), and the types of accessibility barriers reported. Results show that the frequency of accessibility reports has increased over the years, and accessibility bugs take longer to be fixed, as they tend to be given low priority.

**Dr. Wajdi Aljedaani** received a bachelor’s degree in software engineering from the Athlone Institute of Technology, Ireland, in 2014 and received his master’s degree in software engineering from Rochester Institute of Technology, New York, in 2016. He received his Ph.D. in computer science and engineering at the University of North Texas in 2023. He worked as a teaching Fellow for two years (2021-2022) at the University of North Texas. Currently, Dr. Aljedaani is postdoctoral researcher at UM-Flint working with Dr. Kessentini. His research interests are accessibility, HCI, software engineering, mining software repository, machine learning, and NLP.
Mohamed Almukhtar, Oakland University/University of Michigan-Flint
Advisor: Marouane Kessentini, University of Michigan-Flint
An Empirical Study on Data Refactoring in Machine Learning Projects
Data plays a crucial role in powering Machine Learning (ML) models and significantly impacts their accuracy. However, in the rapidly evolving landscape of ML, data can quickly become outdated or irrelevant, necessitating data updates. Unfortunately, a knowledge gap exists concerning how data evolves during the development of ML projects, and data refactoring—the process of improving data quality and usefulness during ML model development—has not yet been explored in the literature. In our paper, we address the above gap by analyzing open-source ML projects on GitHub, in order to identify data refactoring operations, patterns, and contexts of data refactoring. Through an evaluation of commit messages and changes made to data files, we have developed a taxonomy comprising 12 distinct data refactoring operations across four categories. Moreover, we have identified three contexts in which data refactoring occurs. The findings presented in this work can serve as a foundational resource for detecting and implementing data refactoring techniques to enhance ML model development process in future endeavors.

Mohamed Almukhtar is currently a PhD student at Oakland University. His PhD research area is concerned with the application of intelligent software engineering and MLOps. His current research spans diverse areas, including AI, DL, Automation, Refactoring, Data Science, Data Analytics, and Software Quality.

Isha Datey, Oakland University/University of Michigan-Flint
Advisor: Doug Zytko, University of Michigan-Flint
Designing Data Donation to Improve AI Model Training
Data donation, a user-driven process, has rapidly become pivotal in shaping AI advancements. This approach involves users voluntarily contributing data, culminating in the creation of ecologically valid datasets essential for training AI models effectively. AI’s relentless growth and impact on society underscore the burgeoning need for data donation to ensure both the quality and diversity of training data. Our work highlights insights from a usability testing study conducted with potential end users of our sexual experience data donation application, known as UBE. Our work bridges expert feedback, particularly from sexual violence experts, with end user feedback garnered through usability testing and provides design guidance on how to design data donation to improve AI model training. This collaborative endeavor not only strengthens AI training but also underscores a user-centered approach to design, especially within the ever-evolving landscape of technology.

Isha Datey is a Masters’ Student in Human-computer interaction at Oakland University. Her research experience spans diverse topics including data donation, online dating, consent, but most notably participatory design of AI models. Her work has been published in and accepted to peer-reviewed conferences including CSCW and IEEE RO-MAN. She holds a Bachelor’s degree in Information Technology and is presently a UX researcher on a collaborative project funded by the National Science Foundation. This project applies a participatory approach to designing data donation journeys with domain experts and end-users in the context of sexual experience data donation. Isha is currently leading a usability study for the project to understand high-risk users’ opinions and feedback on the in-development data donation application.

Muhammad Umar Farooq, Oakland University/University of Michigan-Flint
Advisor: Khalid Malik, University of Michigan-Flint
Novel Behavioral Features for Interpretable Deepfake Detection
The proliferation of deepfake technology presents a grave challenge to the authenticity and integrity of digital content. In response, this research introduces an Interpretable Framework for deepfake detection, grounded in behavioral features. This framework encompasses blendshape characteristics and derived behavioral attributes in spatial and spatio-temporal domains, allowing for a comprehensive assessment of media authenticity. To optimize the efficiency of the framework, a rigorous feature selection process is employed, guided by the significance of each feature in the detection task. This meticulous feature curation ensures the preservation of high detection accuracy while promoting computational efficiency. Through extensive experimentation, the Interpretable Framework demonstrates its effectiveness by achieving an exceptional 99% detection accuracy
and Area Under the Curve (AUC) on widely recognized datasets, including the WLDR dataset, DFD dataset, and all categories within the FaceForensics++ dataset. Furthermore, our model exhibits commendable performance, attaining detection scores ranging from 85% to 95% across various cross-corpora evaluations. This research contributes significantly to the ongoing endeavor to combat the proliferation of deepfake content by providing an interpretable and robust framework for deepfake detection, underpinned by comprehensive empirical validation.

Muhammad Umar Farooq is an ML engineer and Full-stack Web Developer. I have an industry experience of around 4 years. I have bachelors and master’s in software engineering from University of Engineering and Technology, Taxila, Pakistan. Currently enrolled in PhD Computer Science at Oakland, MI, USA.

Anwar Gammam, Oakland University/University of Michigan-Flint
Advisor: Marouane Kessentini, University of Michigan-Flint

An Empirical Study of Refactorings and Technical Debt in Build Systems

Build systems that convert source code into software artifacts play a crucial role in modern software engineering endeavors. Like source code, build systems are prone to classic technical debt issues, and their maintenance can present significant challenges. Hence, it is imperative to refactor the build scripts in order to ensure their long-term maintainability and utility. Recent research has undertaken an examination of the causes of build failures, though at a high-level analysis. However, there is limited knowledge regarding the specific types of refactoring that developers must undertake to improve build configuration and the extent to which these changes address technical debt.

This paper aims to fill the aforementioned gap by examining refactoring types that were applied to build scripts in open-source projects utilizing Maven, Ant, and Gradle as build systems. Additionally, we investigate the extent to which these refactorings mitigate technical debt concerns. The analysis was conducted on 609 projects, along with a total of 725 examined build commits; among these, 248 are for Gradle, 173 for Ant, and 304 for Maven. The findings suggest that in addition to source code refactoring, developers often engage in the process of refactoring build scripts for various reasons, such as organizing dependencies, organizing subroutines, etc. Through our analysis, we identified 26 Build-related refactorings categorized into seven main categories. Out of the total, 11 of the refactoring types are focused on build domain-related, while the remaining 15 refactoring types are analogous to refactoring in other artifacts (e.g., source code). However, none of them have been previously identified in prior research. Additionally, we have introduced 9 technical debts that were addressed by the identified refactorings. Our analysis also identified that several build refactoring types co-occur together, but there is no direct co-evolution relation between build script refactoring and source code refactoring. The findings of this study will provide valuable insights for practitioners, tool developers, and educators, enabling them to enhance the overall quality of build scripts and, consequently, software systems.

Anwar Gammam is currently a PhD student at Oakland University. Her Ph.D. project is concerned with the application of intelligent search and machine learning in different areas such as Software Containers, web services, refactoring, and mobile app reviews. Her current research interests are AI, web services, refactoring, data analytics, and software quality.

Achyutarama Ganti, Oakland University
Advisor: Steven Wilson, Oakland University

Narrative Style and the Spread of Health Misinformation on Twitter

Using a narrative style is an effective way to communicate health information both on and off social media. Given the amount of misinformation being spread online and its potential negative effects, it is crucial to investigate the interplay between narrative communication style and misinformative health content on user engagement on social media platforms. To explore this in the context of Twitter, we start with previously annotated health misinformation tweets ($n≈15,000$) and annotate a subset of the data ($n=3,000$) for the presence of narrative style. We then use these manually assigned labels to train text classifiers, experimenting with supervised fine-tuning and in-context learning for automatic narrative detection. We use our best model to label the remaining portion of the dataset, then statistically analyze the relationship between narrative style, misinformation, and user-level features on
engagement, finding that narrative use is connected to increased tweet engagement and can, in some cases, lead to increased engagement with misinformation. Finally, we analyze the general categories of language used in narratives and health misinformation in our dataset.

Achyutarama Ganti is a second year Ph.D. student in the Department of Computer Science at Oakland University advised by Dr. Steven Wilson and I’m part of the Oakland NLP Lab. Prior to joining OU, I graduated with a masters degree in Computer Science from Grand Valley State University. My research interests broadly include natural language processing, machine learning, computational social sciences and understanding narratives on social media.

Connor Homayouni, Oakland University/University of Michigan-Flint
Advisor: Doug Zytko, University of Michigan-Flint
“How can I protect what’s not even there?”: Understanding Safety Risks and Needs with Cross-Reality Social Technologies in the Context of XR Dating

Social VR has facilitated new social opportunities, but also new forms of harassment and other harms. With the growing popularity of cross-reality (CR) social platforms users will also be at risk of harm across the physical-virtual continuum. This is perhaps most apparent with XR dating applications given extensive evidence of online and physical sexual violence through mobile dating apps. Towards informing design of harm-mitigative social cross-reality experiences we present a focus group study with women and LGBTQIA+ stakeholders (n=16) about safety needs in the context of cross-reality dating. Findings elucidate four overarching safety needs and concerns: 1) ambiguity in consent to interpersonal behavior across realities; 2) uncertain cross-reality audience to identity disclosure; 3) exploiting anonymity in VR for deception; and 4) aggression due to misunderstanding trans status across realities. The findings are used to chart future research and design directions for harm mitigation in social cross-reality technologies.

Connor Douglas Homayouni, an award-winning scholar and published author, is pursuing his Master’s in Computer Science and Artificial Intelligence at Oakland University. A recent graduate with honors in Information Technology, Connor is a dedicated member of the Oakland HCI Lab and a graduate assistant at OU’s Augmented REality Center. His research focuses on VR/AR/XR development, consent, and harm mitigation, emphasizing the inclusion of marginalized groups in XR’s evolving landscape. Under the mentorship of Dr. Douglas Zytko, Connor delves into the complexities of Human-Computer Interaction (HCI) and is actively involved in research aimed at reducing online-to-offline harm. He is currently exploring the development and safety protocols of the VR Metaverse, ensuring a secure and inclusive virtual environment for all users.

David Hunter, University of Colorado Boulder
Advisor: Ellen Do, University of Colorado Boulder
Community-Based Digital Twins

We propose to create a Digital Twin that is distributed, owned, and run by the community. Community members contribute data through personal smart devices like mobile phones and IoT devices, and incorporate external data feeds, providing a real-time glimpse of the world around us created by the nodes in that moment. All inputs are aggregated and visualised in real-time. We will research how to present the Digital Twin information on different devices, considering the spatio-temporal nature of the contributed data. We will research how Machine Learning can play a role in sensing and presenting Digital Twin information. We will research how to offer community members control over what is sensed and what is contributed to the Digital Twin, considering privacy.

David Hunter is a designer, coder, educator and now PhD student at ATLAS, University of Colorado at Boulder. I have 15 years professional experience as a designer and educator. My research interests lie in creating novel tools and interfaces to information and data. I am currently exploring Machine Learning for sensing, community-based Digital Twins, and tangible user interfaces to wildlife data and climate simulation.
Efficient One-Shot Learning Approach for Medical Image Classification in IoMT Environment

The Internet of Things (IoT), such as the Internet of Medical Things (IoMT), has made significant advancements in the field of healthcare and medical devices by providing on-premises model development and privacy-preserving data processing and analysis. However, the lack of computing resources and large annotated medical imaging datasets is a key barrier to developing robust models in the IoMT. This calls for the development of lightweight machine-learning models using minimal available data. Hence, this work proposes a generalized and robust lightweight one-shot learning method for medical image classification for various image modalities including X-Ray, microscopic, and CTS. The proposed method introduces a collaborative one-shot training (COST) approach that incorporates meta- and metric-learning, and uses very few training samples (i.e., one image per class). A gradient generalization at dense and fully connected layers is performed to accelerate the generalization of the model with a smaller number of epochs, ensuring its compatibility with IoT networks. More in detail, a lightweight Siamese network with triplet loss and shared parameters is trained to map features on a target embedding aiming that samples of the same class should have less distance and vice versa. During the training process, reparametrizing the weights vectors is performed by taking zero mean and standard deviation to speed up the process of gradient computation. The evaluation of the proposed method on 12 medical image datasets with various modalities from MedMNIST2D shows its effectiveness in terms of classifying diseases using an edge device. We also conduct various sets of ablation studies and analyze the compatibility of the proposed framework with IoT network.

Muhammad Irfan

Muhammad Irfan is a PhD student in Computer Science & Informatics at Oakland University in Rochester, Michigan. His research interests include medical image analysis, machine learning, deep learning and computer vision.

Rania Khalsi

Rania Khalsi, Tunisian born in Muscat, Oman. She obtained her M.Sc. in Data Science and Ph.D. in Computer Vision from the National School of Computer Science (ENS1), Manouba, Tunisia, in 2020 and 2023, respectively. In 2021, she joined the Higher Institute of Multimedia Arts (ISAMM), Manouba, Tunisia, as a Lecturer. In 2022, she became an associate teacher-trainer at the School of Engineering and Technology (ESPRIT), Ariana, Tunisia. In 2023, she assumed the role of an Artificial Intelligence Research Fellow and LEO Lecturer at the College of Innovation and Technology, University of Michigan - Flint, USA. Her research interests encompass Artificial Intelligence, Machine Learning, and Deep Learning, with current research focus on the certification, robustness, explainability, and interpretability of deep learning architectures.
Awais Khan, Oakland University/University of Michigan-Flint
Advisor: Khalid Malik, University of Michigan-Flint
Securing Voice Biometrics: One-Shot Learning Approach for Audio Deepfake Detection

The Automatic Speaker Verification (ASV) system is vulnerable to fraudulent activities using audio deepfakes, also known as logical-access voice spoofing attacks. These deepfakes pose a concerning threat to voice biometrics due to recent advancements in generative AI and speech synthesis technologies. While several deep learning models for speech synthesis detection have been developed, most of them show poor generalizability, especially when the attacks have different statistical distributions from the ones seen. Therefore, this paper presents Quick-SpoofNet, an approach for detecting both seen and unseen synthetic attacks in the ASV system using one-shot learning and metric learning techniques. By using the effective spectral feature set, the proposed method extracts compact and representative temporal embeddings from the voice samples and utilizes metric learning and triplet loss to assess the similarity index and distinguish different embeddings. The system effectively clusters similar speech embeddings, classifying bona fide speeches as the target class and identifying other clusters as spoofing attacks. The proposed system is evaluated using the ASVspoof 2019 logical access (LA) dataset and tested against unseen deepfake attacks from the ASVspoof 2021 dataset. Additionally, its generalization ability towards unseen bona fide speech is assessed using speech data from the VSDC dataset.

Awais Khan is currently pursuing a Doctor of Philosophy in Computer Science from Oakland University, MI, USA. His research interest revolves around the captivating realm of speech processing, with a particular emphasis on topics such as Voice Deepfake Detection, Automatic Speaker Verification, and Voice Anti-Spoofing.

Emna Ksontini, Oakland University/University of Michigan-Flint
Advisor: Marouane Kessentini, University of Michigan-Flint
Reinforcement Learning in Action: Elevating Code Quality Through Automated Refactoring Strategies

As software systems grow in complexity, the necessity for effective refactoring mechanisms to ensure code maintainability and quality becomes paramount. In this context, our work pioneers an approach that employs reinforcement learning to intuitively automate the detection and recommendation of refactoring opportunities. Diverging from conventional methods, which frequently depend on genetic algorithms or traditional machine learning techniques, our reinforcement learning-driven strategy promises enhanced adaptability, ensuring its relevance across diverse coding environments. Through rigorous evaluations on widely-accepted benchmarks, our approach has demonstrated significant proficiency, highlighting its value in real-world applications.

Emna Ksontini is a Ph.D. candidate in the Intelligent Software Engineering (ISE) lab at the University of Michigan-Flint. Her research focuses on leveraging intelligent search and AI across various domains, including Software Containers, web services, refactoring, and analysis of mobile app reviews. Her primary research interests encompass AI, web services, refactoring, data analytics, and software development.

Malinda Malawa Arachchige and Abrahim Bellur, University of Colorado Boulder
Advisor: Danny Dig, University of Colorado Boulder
Unprecedented Code Change Automation: The Fusion of LLMs and Transformation by Example

Because of the naturalness of software, developers often repeat the same code changes within a project or across different projects. We call these “code change patterns” (CPATs). Automating CPATs is crucial to expedite the software development process. While current Transformation by Example (TBE) techniques can automate CPATs, they are limited by the quality and quantity of the provided input examples. Thus, they miss transforming code variations that do not have the exact syntax, data-, or control-flow of the provided input examples, despite being semantically similar. Large Language Models (LLMs) are pre-trained on extensive datasets of source code. If we can harness LLMs’ creativity to produce semantically equivalent, yet previously unseen variants of the original CPAT, we can significantly increase the effectiveness of TBE systems.
In this poster, we discover best practices for harnessing LLMs to generate code variants that meet three criteria: correctness (semantic equivalence to the original CPAT), usefulness (absence of hallucinations), and applicability (aligning with the primary intent of the original CPAT). We instantiate these practices into our tool PyCraft, which synergistically combines static code analysis, dynamic analysis, and LLM capabilities. By employing chain-of-thought reasoning, PyCraft generates both variations of input examples and comprehensive test cases that can identify correct variations with an F-measure of 96.6%. Our algorithm uses a fixed-point iteration to create relevant variations and expands the original input examples by a factor of 44x. Using these richly generated examples, we inferred transformation rules and then automated these changes, resulting in an increase of up to 39x, with an average increase of 14x in target codes compared to a previous state-of-the-art tool that relies solely on static analysis. We submitted patches generated by PyCraft to a range of projects, notably esteemed ones like microsoft/DeepSpeed and IBM/inFairness. Their developers accepted and merged 83% the 86 CPAT instances submitted through 44 pull requests. This confirms the usefulness of these changes.

Malinda Malawa is a PhD candidate in the department of computer science at University of Colorado-Boulder. Malinda received his B.Sc. from University of Moratuwa, Sri Lanka in 2015. He is a former senior software engineer in London Stock Exchange Technology (2015-2018). Malinda enjoys doing research on software refactoring, static code analysis, and program synthesis. He was awarded the Gold Prize at the ACM Student Research Competition held at the flagship ACM conference in Software Engineering.

Abhiram Bellur is a Masters student at the University of Colorado, in the computer science department. He received his Bachelors degree from PES University, India in 2020. His research interests lie in automating tasks for software developers and developing tools to do so.
Together We Go Further: LLMs and IDE Static Analysis for Extract Method Refactoring

Excessively long methods that encapsulate multiple responsibilities within a single method are challenging to comprehend, debug, reuse, and maintain. In this poster, we show how we advance the science and practice of refactoring by augmenting the refactoring capabilities of IDEs with the power of LLMs to perform Extract Method. Our formative study on 2,849 Extract Method scenarios revealed that LLMs are very effective in giving expert suggestions, yet they are unreliable: up to 62.3% of the suggestions are hallucinations. We propose a novel approach that synergistically combines the creative potential of LLMs with static analysis to enhance the refactoring suggestions generated by LLMs. Additionally, we utilize the safety measures of static analysis within IDEs to execute refactorings safely. Starting from candidates suggested by LLMs, we filter, further enhance, and then rank suggestions based on static analysis techniques from program slicing. We designed, implemented, and evaluated this approach in an IntelliJ IDEA plugin called EM-Assist. We empirically evaluated EM-Assist on a diverse, publicly available corpus that other researchers used in the past. The results show that EM-Assist outperforms previous state-of-the-art tools: at 1% tolerance, EM-Assist suggests the correct refactoring among its top-5 suggestions 60.6% of times, compared to 54.2% reported by existing ML models, and 52.2% reported by existing static analysis tools. When we replicated 2,849 actual Extract Method instances from open-source projects, EM-Assist’s recall rate was 42.1% compared to 6.5% for its peers. Furthermore, we conducted firehouse surveys with 29 industrial developers and suggested refactorings on their recent commits. 81.3% of the respondents agreed with the recommendations provided by EM-Assist. This shows the usefulness of our approach and ushers us into a new era of refactoring when LLMs become effective AI assistants for developers.

My name is **Dorin Pomian**, I’m currently a Research Assistant at the University of Colorado, Boulder. My research focuses on code quality improvements through automatic software refactoring tools. I have a solid background in software engineering, working for a good number of years in C++ and Python at several tech companies in Europe. I love sports and outdoor activities such as cycling, and hiking. Don’t be shy, reach out, let’s discuss potential collaborations. You can reach me at dorin.pomian@gmail.com, or my LinkedIn profile.

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Learning Spatiotemporal Graphs for Detection of Human Activities in Multimodal Data

With the rise of IoT technology there is an increasing number of ubiquitous sensors in industrial domains including smart manufacturing, smart homes, patient monitoring, autonomous and connected vehicles, and virtual education, and workplace safety monitoring, among others. These devices collect continuous streams of data from different positions in space, temporal resolution, and sensor modality, resulting in large, messy data. Current algorithms are lacking in their ability to handle these challenges, with current solutions circumnavigating these problems with “brute force” models requiring large amounts of training data, computational resources, and even ignoring multimodal inputs altogether. This project focuses on the development of techniques which specifically leverage spatiotemporal and multimodal information in order to learn and run on smaller data and less computational resources with faster runtime. This work explores (understudied) graph-based deep learning models to encode spatiotemporal information and novel techniques to leverage cross-modal and within-modal information, leading to higher efficiency. We use a high profile dataset called 50 Salads to evaluate our model on hierarchical action recognition (recognizing multiple levels of actions).

**Julia Romero** is a 4th year PhD student in computer science, co-advised by Morteza Karimzadeh and Christine Lv. She has a B.S. in biomedical engineering from UT-Austin. Her research focuses on data analytics on ubiquitous and wearable sensor data with health applications. She has worked on injury prediction in runners, measuring advanced clinical respiratory parameters with wearable sensors, and human activity recognition algorithms. She has technical expertise in full stack data analytics: data collection, signal processing, data exploration and visualization, machine learning, and deep learning, with special interests in methods for multimodal data fusion and leveraging spatiotemporal information in data. In her free time she runs ultramarathons in the mountains, among many other outdoor activities.
Recent performance studies conducted at Google and Facebook data centers have revealed that the CPU cycles consumed by operations that are not part of the application logic can be as high as 80% of the total compute times and a majority of that overhead comes from a need for moving data between different microservices that are implemented using containers. We propose to address this major performance limitation by designing an abstract data type called Container Data Item (CDI) to simplify data sharing among containers. On one hand, the proposed CDI abstraction would allow different containers, possibly running on different hosts to compute on the same data item (same logical memory) reducing performance overhead significantly, and on the other hand, preserve container semantics, particularly the important isolation guarantees that containers provide. We develop the semantics of CDI along with the set of compute operations on CDI, and its implementation over a variety of popular system infrastructures, including containers running on the same host using System V shared memory, containers running on different hosts connected via a TCP/IP network using RDMA, and containers running on different hosts sharing CXL-enabled memory pool.

Scalable Architecture for Building Digital Twins at the Edge
Digital twin technology is an emerging paradigm that involves the creation of a high-fidelity virtual replica of a physical system or process. This virtual replica is used for simulation, prediction, optimization, and control, among other applications. Digital twins have recently gained significant attention in IoT systems, ranging from smart automotive, industrial IoT (IIoT), transportation, healthcare (Internet of Medical Things), smart agriculture, and smart cities. In the current state-of-the-art, a digital twin is implemented in the cloud and the sensor data from the physical infrastructure is transmitted via a communication layer that involves communication over the Internet. This approach suffers from several critical limitations: (1) Communication between the IoT sensors on the field and the cloud incurs high latency. This is a critical problem particularly for digital twins because low communication latency between physical and digital entities is of paramount importance to ensure a close, near real-time synchronization between the physical infrastructure and its digital twin. (2) Computing on the cloud incurs high bandwidth costs since all the raw sensor data needs to be transmitted over the Internet, and modern IoT systems can comprise thousands and even tens of thousands of sensors transmitting rich IoT environmental data continuously. (3) Several IoT systems such as smart automotive or smart agriculture are often deployed in remote areas where Internet connectivity is at best intermittent. In such scenarios, it is challenging and sometimes even infeasible to maintain a high-fidelity virtual replica of a physical system. (4) Finally, current digital twins are mostly domain-specific and it is difficult to reuse their code or design for building a digital twin for a different domain. This project addresses these limitations by investigating the design and implementation of digital twins at the edge. In particular, we present a system architecture for building digital twins at the edge that is highly scalable and flexible incorporating two novel architectural components: a Context-Aware Communication Component (CACC) that addresses the scalability issue in communication between physical and virtual environments, and a second, an application-agnostic methodology, a service registry component for integrating digital twin with EdgeAI (DT-EdgeAI integration) at the edge.

Md Rezwanur Rahman is a 3rd-year Ph.D. student in Computer Science at the University of Colorado Boulder. He is working as a Teaching and Research assistant at the same university and is supervised by Dr. Shiv Mishra. His area of interest is Software Systems, more specifically Memory Sharing in multi-host environments at the edge. Currently, he is working to develop and implement an abstract data type for container-based communication enforcing isolation and security policy. He holds a bachelor's degree in Computer Science and Engineering from Bangladesh University of Engineering and Technology. Before starting his Ph.D., he worked as a full-stack Software Engineer for 6 years in Bangladesh.

My name is Shubham Sati, and I’m currently in my second year of master’s studies at the University of Colorado,
Boulder. At present, I am researching how to enhance the performance of edge applications by leveraging shared memory communication channels for inter-container communication. Before pursuing my graduate studies, I served as a backend engineer at Amazon, where I contributed to the development of products for their Global Shipping business.

My name is Mohit Snehal, and I am currently pursuing a Master’s degree in Computer Science at the University of Colorado, Boulder. I am working under the guidance of Professor Shivakant Mishra, focusing my research on enhancing IoT systems comprehensively, with a particular emphasis on improving both performance and security aspects with the use of several tools and techniques such as, and not limited to, Machine Learning, CXL, and Digital Twins. Before starting my master’s program, I worked as a backend developer, accumulating three years of experience in developing, maintaining, and enhancing backend systems for prominent Fintech and e-commerce companies in India.

James Ryan and Muhammad Anas Raza, Oakland University/University of Michigan-Flint
Advisor: Khalid Malik
From Virtual Blueprint to Real-World Shield: Safeguarding Connected Autonomous Vehicles with Digital Twins
As the paradigm shifts into the mainstream applications of Industry 4.0 and the world shifts toward autonomous vehicles, care must be taken to ensure that emerging technologies are mature enough to handle the strain. The newest generation of vehicles, essentially on-the-road computers with a sophisticated networking infrastructure but perhaps imperfect security, will become the primary focus of the next generation of hackers. Digital twins, however, are one technology that may be able to help. Using joint representation machine learning techniques on a dataset of multiple forgery types, this paper seeks to develop a new genre of digital twins to validate the integrity of onboard sensor data, the cognitive digital twin for cybersecurity. With their ability to learn and make changes to onboard software in real-time, cognitive digital twins for cybersecurity stand poised to fill gaps in existing cybersecurity strategies.

James Ryan is a Cybersecurity Master's student at Oakland University in Rochester, MI. His research interests include digital twins and their security applications, and cybersecurity curriculum development. After finishing his Master's this coming December he plans to start a PhD in Computer Science at the University of Michigan—Flint.

Muhammad Anas Raza is a PhD student working on developing novel frameworks that use synchronization between audio and visuals for accurately detecting forged multimedia.

Bhavan Vasu, Oregon State University
Advisor: Prasad Tadepalli, Oregon State University
Global Explanations for Complex Multimedia Data
Deep learning networks, particularly those that interpret complex multimedia input, have a fundamental need for interpretability, as evidenced by the rise of GPT models and Deep Learning Networks. Although effective, current research mostly describes decision-making processes on a case-by-case basis and with local explanations. Our method, in contrast, focuses on developing comprehensive explanations that shed light on a variety of choices made in various actions and scenarios with the help of Minimal Sufficient Explanations. This not only clarifies the complex decision-making processes of deep networks but also paves the way for the creation of a “recipe” for an action that can help with other downstream tasks. Our results have significant ramifications for any industries that use vision-based sensors, particularly in manufacturing, activity monitoring, security, and opening up new vistas in knowledge discovery.

Bhavan Vasu is a Ph.D. candidate at Oregon State University working on making machine learning models interpretable. Bhavan has worked on ML interpretability for organizations such as NASA/CalTech Jet Propulsion Laboratory, Kitware, Defense Advanced Research Projects Agency (DARPA), and Air Force Research Laboratory.
(AFRL). He received his B.S. degree in Electronics and Communications Engineering from Visvesvaraya Technological University, India, in 2015, and his M.S. degree in Computer Engineering from the Rochester Institute of Technology, New York, in 2018. In 2019, he joined Kitware Inc’s Computer Vision Team, where he worked as a Research and Development Engineer on topics such as explainable AI, domain adaptation, human-factor analysis, context-based image retrieval, image generation, and remote sensing. He currently serves as the Workflow Chair of the Association for the Advancement of Artificial Intelligence.

Suibi Che-Chuan Weng, University of Colorado Boulder
Advisor: Ellen Yi-Luen Do
Dream Mesh: A Speech-to-3D Model Generative Pipeline in Mixed Reality
Generative Artificial Intelligence (AI) models have risen to prominence due to their unparalleled ability to craft and generate digital assets, encompassing text, images, audio, video, and 3D models. Leveraging the capabilities of diffusion models, such as Stable Diffusion and Instruct pix2pix, users can guide AI with specific prompts, streamlining the creative journey for graphic designers. However, the primary application of these models has been to graphic content within desktop interfaces, prompting professionals in interior and architectural design to seek more tailored solutions for their daily operations. To bridge this gap, Augmented Reality (AR) and Mixed Reality (MR) technologies offer a promising solution, transforming traditional 2D artworks into engaging 3D interactive realms. In this paper, we present "Dream Mesh," a MR application MR tool that combines a Speech-to-3D generative workflow based on Dream-Fusion model without relying on pre-existing 3D content libraries. This innovative system empowers users to express 3D content needs through natural language input, promising transformative potential in real-time 3D content creation and an enhanced MR user experience.

My name is Che Chuan “Suibi” Weng, and I am an accomplished interactive media engineer and digital artist. My primary focus is on developing interactive installations, with a particular specialization in the AR/VR and Arduino components. I have had the privilege of teaching technical courses such as Unity Development and Arduino Basic at three esteemed universities. As a digital artist, my works have been selected for inclusion in several highly regarded festivals, including the Digital Arts Festival in Taipei and the 404 International Festival of Art and Technology in Argentina. Currently, I am enrolled in the Ph.D. program at the ATLAS institute, University of Colorado Boulder, which I commenced in 2021. I am co-advised by Dr. Ellen Yi-Luen Do and Dr. Daniel Leithinger. My research interest is centered on the human perception in Virtual Reality and Augmented Reality, and I am enthusiastic about advancing this area of study.

Emma Walquist and Wenqi Zheng, Oakland University/University of Michigan-Flint
Advisor: Doug Zytko, University of Michigan-Flint
Towards Trauma-Informed Data Donation of Sexual Experience in Online Dating to Improve Sexual Risk Detection AI
Sexual risk detection AI has been touted as a scalable solution for computer-mediated sexual violence. Data donation is a user-centered approach to producing ecologically valid datasets for sexual risk detection AI: voluntarily providing personal data that is representative of risk. However, the act of donating intimate sexual experience data can itself be traumatizing. We propose Ube: a trauma-informed sexual experience data donation app for online daters that is developed in collaboration with sexual violence experts and care practitioners. Cognitive walkthroughs of Ube with sexual violence experts elucidated several design approaches to mitigating retraumatization during data donation, including a conversational agent and mental health checks.

Emma Walquist is a UX researcher working on an interdisciplinary project funded by the National Science Foundation. This project is working to produce and implement a data donation app for sexual experiences utilizing the trauma informed approach to mitigate harm that may accompany data donation of sensitive experiences such as online to offline sexual violence. She is also a Masters’ Student in the Science of Psychology at Oakland University. Her research centers around prevention of sexual assault. Some of her recent projects include examination of the following: women’s fear of rape, sexual assault gossip, victim blame, and technology facilitated sexual violence.
Wenqi Zheng is a PhD student in Psychology at Oakland University. She earned her BA and MS in Psychology from University of Washington, Seattle and University of Texas at San Antonio respectively. Her past research has focused on sexual aggression perpetration, sexual risk behaviors and their risk factors, such as impersonal sex, pornography consumption and alcohol use. Currently, she serves as a UX researcher on a National Science Foundation-funded project dedicated to preventing computer-facilitated sexual violence. Specifically, the project involves collaboration with experts from HCI, Computer Science, Psychology, and Forensic Nursing to design a trauma-informed data donation app aim to collect contextualized online-to-offline sexual violence data to inform sexual-risk detection AI. Moving forward, she will continue to work with the team on longitudinal data collection using the app.

Yi (Ada) Zhao, University of Colorado Boulder
Advisor: Ellen Do, University of Colorado Boulder
AR TimeVault
The AR TimeVault is designed as an indispensable companion for frontline workers in various industries, empowering them to effortlessly recall past events. It not only comprehends the intricacies of your activities but also meticulously captures and archives essential details, turning every moment into a treasure trove of knowledge. Harnessing the power of natural language, users can effortlessly retrieve a wealth of insights and recordings from the past in augmented reality.

Yi Zhao (Ada) is a graduate student at the University of Colorado Boulder with interests in enhancing the sense of presence in AR/VR, spanning across context-aware AR/VR, tangible user interfaces, and novel interactions.

Cheng Zhen, Oregon State University
Advisor: Arash Termehchy, Oregon State University
Certain Statistical Models
Imputing missing data is costly, leading people to avoid it. To tackle this, we propose a method to identify when data cleaning isn’t needed in machine learning. If a model can minimize loss regardless of missing data values, cleaning is unnecessary. Our efficient algorithms confirm this in various ML scenarios, especially when dealing with irrelevant or redundant data. Our experiments prove our algorithms markedly cut cleaning costs compared to a benchmark method on real-world datasets, with minimal computational overhead test.

Cheng Zhen is a Ph.D. student in Computer Science and a Provost's Distinguished Graduate Fellow at Oregon State University. Cheng holds a Master's degree in Electrical and Computer Engineering and a bachelor's degree in Material Science and Engineering. His research interests lie in data systems for machine learning, with a specific focus on efficient and reliable data preparation in machine learning pipeline.