Gandhimathi (Mathi) Padmanaban

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Research Focus

Applied machine learning and geometry-informed computer vision for reliable measurement, perception, and decision support in engineered systems. Recent applications in transportation safety include calibration-free distance estimation, overtaking detection with early warning, and driver behavior modeling.

Research Areas

Methods: geometry-informed computer vision; perception, detection/tracking; uncertainty and evaluation; hybrid data-driven + physics-informed ML; time series and decision analytics.
Applications: transportation safety; human–automation interaction; safe and sustainable intelligent systems engineering; manufacturing systems; energy.

Academic Appointments

2022–Present Graduate Student Research Assistant, University of Michigan–Dearborn, Industrial and Manufacturing Systems Engineering

Education

Apr 2026 **Ph.D., Industrial and Systems Engineering**
University of Michigan–Dearborn
Dissertation: "Enhancing Transportation Safety: Research on Driver Behaviors Using Machine Learning and Data Analytics."
Advisor: Dr. Fred Feng

2021 **M.S., Human Centered Design and Engineering**
University of Michigan–Dearborn
Thesis: "Computational Human Performance Modeling using Queuing Network in an Open-Source Platform."
Advisor: Dr. Fred Feng

2013 **B.E., Computer Science and Engineering**
Anna University, India
Thesis: "Automated Detection of Modifications in Software Requirement Traceability Links."
Advisor: Prof. Ramachandran Alagarsamy

Certifications

Dec 2025 Connected and Automated Transportation Certificate, Center for Connected and Automated Transportation (CCAT–UMTRI)

2025 Rackham Professional Development Diversity, Equity, and Inclusion Certificate, University of Michigan

2011 Post Graduate Diploma in Computer Applications, Computer Software Research Institution, India

Research Statement Snapshot

I develop geometry-informed computer vision and applied ML methods to enable reliable measurement, prediction, and decision support in engineered systems. Current projects:

i) calibration-free 2D distance estimation (perspective-geometry–informed)
ii) overtaking detection with early warning on real-world data
iii) ML for aggressive driving prediction
iv) comparison of fuel-economy cycles for aggressive driving

Planned lab: **Safe AI for Mobility and Society (SAIMS)** — limitation-aware hybrid AI and uncertainty in perception/decision analytics; student training in reproducible, safety-critical ML.

Publications

Peer-Reviewed Conference Papers

1. **Gandhimathi Padmanaban**, Nathaniel P. Jachim, Hala Shandi, Lilit Avetisyan, Garrett Smith, Howrah Hammoud, and Feng Zhou. "An Autonomous Driving System - Dedicated Vehicle for People with ASD and their Caregivers". *AutomotiveUI '21 Adjunct: 13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. Association for Computing Machinery, 2021, pp. 142–147. DOI: https://doi.org/10.1145/3473682.3480282.
2. **Gandhimathi Padmanaban**, Fred Feng, Edward Dai, Ankit Saini, Guopeng Hu, and Yanan Zhao. "A Comparative Analysis of Acceleration and Deceleration Profiles for Aggressive Driving Styles and Fuel Economy Test Cycles". *WCX SAE World Congress Experience*. Aggressive driving profiles, 556 trips. 2025. DOI: http://dx.doi.org/10.4271/2025-01-8605.

Under Review & In Preparation

1. "A Machine Learning Approach to Identify Aggressive Driving Patterns based on Vehicle Longitudinal Jerk". *Under review — 93.8% accuracy (Random Forest), speed-adjusted jerk thresholds.*
2. "A Geometry-Informed Computer Vision Method for Detecting and Examining Overtaking Vehicles From a Bicycle". *Under review — 98.7% precision (YOLOv5+ByteTrack).*
3. "Quantifying Drivers-Overtaking-Bicyclists with Surrogate Safety Measures Derived from High-Resolution Digital Lidar". *Under review.*
4. "Calibration-Free Object Distance Estimation from 2D Images Using Geometry-Informed Computer Vision". *In Preparation.*

Grants and Funding

2024 Upsilon Pi Epsilon (UPE) Scholarship, $1,000. Role: Awardee.

2020–2021 Irma M. Wyman Scholar (CEW+), University of Michigan, $11,500. Role: Awardee.

2020–2021 Non-Resident Graduate Student Scholar, UM–Dearborn, $13,000. Role: Awardee.

Research Software and Data Artifacts

- **GICV Distance Estimation Framework**: geometry-informed CV library for distance estimation (Python/TensorFlow). Used in calibration-free distance and overtaking studies; includes benchmarking/eval harness; enables reproducible pipelines.

- **Vehicle Pass Tracker**: geometry-informed overtaking detection/tracking toolkit; supports cyclist–vehicle safety analyses; used to evaluate 319 events (41.5k frames) and 2.89 s early warnings.
- **DigitwiML**: Digital twin modeling platform for C.,elegans in space (NASA SpaceApps Global Finalist 2023) - GitHub.
- **Human Performance Modeling Tools**: Open-source queuing network simulation platform for computational human performance modeling (Python).

Research Experience

2022–Present **Graduate Student Research Assistant**
University of Michigan–Dearborn, Industrial and Manufacturing Systems Engineering
• geometry-informed overtaking detection (YOLOv5+ByteTrack): 98.7% precision, 98.1% recall; 2.89 s early warning; validated on 319 events (41.5k frames).
• Calibration-free 2D distance estimation: perspective geometry; MAE 12.6 ± 2.9 cm (cross-validation); reproducible pipelines and ablation/error analyses.
• Aggressive driving classification: 93.8% accuracy (Random Forest) across 556 trips; speed-adjusted jerk features; automated preprocessing and CV protocols.

2011–2013 **Research Assistant**
Anna University, India
• Software testing research group; led development of exam cell, attendance, and sports management systems using full-stack methods.

Teaching Experience

2023–Present **Instructor / Certified Instructor**
The Carpentries
Data/Software Carpentry workshops (Python, visualization, Git). Average 25 participants; institutions include UT Knoxville, CZI Foundation, University of Michigan.

2010–2012 **Teaching Assistant / Student Instructor**
Anna University, India
Courses: Artificial Intelligence; Probability and Queuing Theory; Transforms and PDEs; Systems Software Laboratory.

Teaching Interests

Courses I can teach: Industrial and Systems Engineering; Data Science and Analytics; Applied Machine Learning; Computer Vision; Human Factors and Intelligent Systems; Decision Analytics; Physics-informed Machine Learning/Knowledge-guided Machine Learning; Experimental Design.
Training emphasis: responsible AI in safety-critical systems; uncertainty communication; data-centric evaluation; industry-aligned capstones

Advising and Mentoring

- Mentor, [WOC] Code, University of Michigan–Ann Arbor: ML workshop and Summer Boot Camp; open-sourced materials.
- Undergraduate/peer mentoring in research pipelines, benchmarking, and reproducibility.

Professional Experience (Industry)

2017–2018 **Development Lead/Consultant**
Deloitte (Offices of the US), Bangalore, India

2015–2017 **Programmer Analyst**
Cognizant, Chennai, India

2013–2015 **Software Engineer Level-II**
Syncfusion, Chennai, India

Honors and Awards

2025 Willie Hobbs Moore Achievement Award Nominee; Sister Mary Ambrosia Fitzgerald Mentoring Award Nominee, WISE (UM–Ann Arbor)

2023 Global Finalist, NASA Space Apps Challenge

2017 Deloitte Hackathon Special Mention (Opportunity to attend JSFoo by Has Geek, India's premier JS conference)

2015 Syncfusion Hackathon 2nd Place (INR 35,000)

Service and Leadership

Leadership and Memberships

- President, Upsilon Pi Epsilon (Michigan Beta Chapter), 2024–2025.
- Member: Sigma Xi; Upsilon Pi Epsilon;Alpha Pi Mu; ACM; HFES.

Editorial and Reviewing

- Reviewer: ICIS 2025; AutoUI 2024; CHI 2024; AMCIS 2024; CUI 2024; IMX 2024; DIS 2024.

Community and Outreach

- Certified Lesson Maintainer, The Carpentries, May 2025 – Present
- Certified Instructor, The Carpentries, 2023 – Present
- Instructor/Mentor, WocCode – University of Michigan, 2023 – Present
- Organizer, CECS Career Panel, 2024
- Judge, NASA SpaceApps Challenge – Pittsburgh, 2024
- Judge, MHacks, 2024
- Student Volunteer, U-M Annual Data Science & AI Summit, 2023
- Panelist, CECS Open Lab Day, 2023
- Website Designer & Developer, BSE Human-Centered Engineering Design, 2021
- Middle & High School Tutor – Mathematics, physics, chemistry, and computer science, 2010–2013, 2018–2020
- Organizer, 2-Day International Conference for Software Professionals, ASPRO'12

Invited Talks and Presentations

Invited Talks

Feb 2024 **DigitwiML – Open-Source Project to model Digital Twin of C.elegans in Space: NASA SpaceApps 2023 Experience**
[WOC] Code – University of Michigan Ann Arbor. Event page

2021 **Guest Lecture: IMSE 501 Human Factors & Ergonomics**
University of Michigan–Dearborn

Conference Presentations & Demos

Apr 2025 **A Comparative Analysis of Acceleration and Deceleration Profiles for Aggressive Driving Styles and Fuel Economy Test Cycles**
SAE World Congress (WCX) – Detroit. Session details

2021 **An Autonomous Driving System – Dedicated Vehicle for People with ASD and their Caregivers**
Automotive User Interfaces (AutomotiveUI) Conference. DOI: 10.1145/3473682.3480282

Technical Expertise

- Methods: geometry-informed computer vision; deep learning (CNN/RNN/Transformers); supervised learning; ensembles; time series; Bayesian methods; physics-informed ML.
- Tools & Frameworks: PyTorch, TensorFlow, scikit-learn, OpenCV, pandas; object detection & tracking (YOLOv5/Ultralytics, ByteTrack); LiDAR processing; multi-modal data fusion.
- Programming & HPC: Python, MATLAB, R, SQL, Git, LaTeX, Docker; Great Lakes cluster (Slurm).
- Research: experimental design; statistical analysis; scientific writing; peer review; IRB protocols; academic collaboration.
- Evaluation: cross-validation, ablation, uncertainty/error analysis, benchmarking, real-world validation.
- Domains: transportation safety; driver behavior analysis; vehicle–bicycle interactions; aggressive driving detection; human factors engineering; naturalistic driving studies.
- Foundations: optimization; statistical learning; computer vision geometry; transformer architectures and scaling laws; attention; transformers/VLMs (pretraining, alignment, evaluation).

References

Available upon request.