

Rafal Krzysiak
Merced, CA, 95348
Krzysiakgoral@gmail.com
(630)-842-4220

1. Education

Northern Illinois University, 2017-2019
Bachelor of Science in Mechanical Engineering (B.S.M.E.)
Emphasis in Mechatronics/Robotics
GPA: 3.8

Northern Illinois University, 2019-2021
Master of Science in Mechanical Engineering (M.S.M.E.)
Emphasis in Dynamical Systems and Control
GPA: 4.0

University of California Merced, 2022-2025
Doctor of Philosophy in Mechanical Engineering (PhD)
GPA: 4.0

2. Undergraduate work

2.1 Research and design projects

- i) Object tracking with a robot
 - Using the iRobot creates 2 robotic research platform, Raspberry Pi 3B, and a Logitech web camera with OpenCV, converting color space from RGB to HSV and defining the objects features such as eccentricity, area,
- ii) Human following robot
 - Using the iRobot creates 2 robotic research platform, Raspberry Pi 3B, and a Logitech web camera with OpenCV
- iii) Senior design
 - Autonomous obstacle avoiding robot, using IR and ultrasonic sensors as well as Lidar
 - ROS and OpenCV for object and color tracking/following

2.2 Assistantships

- i) Teaching Assistant (TA), Mechanism Design and Analysis
Dr. Sachit Butail, Northern Illinois University, 2018-2019
 - Graded quizzes, assignments, projects, and exams
 - Laser cut acrylic components for walker project and consulted with student teams on walker designs and analysis

3. Graduate work

3.1 Research

3.1.1 Publications

- i) R. Krzysiak and S. Butail, “Information based control of robots in search and rescue missions with human prior knowledge”, *IEEE Transactions on Human-Machine Systems*, accepted, 2021
- ii) Thesis: Human-aware information-theoretic control of robotic swarms (defending Oct. 18)
- iii) R. Krzysiak et al., “XAI – The future of wearable Internet of Things”, *IEEE/ASME MESA conference*, 2022
- iv) An, Di, et al. "Battery-health-aware UAV mission planning using a cognitive battery management system." 2023 International Conference on Unmanned Aircraft Systems (ICUAS). IEEE, 2023.
- v) An, Di, et al. "Long Endurance Site-Specific Management of Biochar Applications Using Unmanned Aircraft Vehicle and Unmanned Ground Vehicle." IFAC-PapersOnLine 56.2 (2023): 8908-8913.
- vi) R. Krzysiak, et al. “XCardio-Twin: An Explainable Framework to Aid in Monitoring and Analysis of Cardiovascular Status”, DTPI, 2023
- vii) An, Di, R. Krzysiak et al. “A Proximal Point Sensing System for Mapping Soil Moisture Using A Miniaturized Spectrometer”, ICCMA, 2023
- viii) D. Hollenbeck, An, Di, R. Krzysiak et al. “Towards Cognitive Battery Monitoring on Hybrid VTOL Fixed-Wing sUAS with Maximized Safe Endurance”, ICCMA, 2023
- ix) R. Krzysiak et al. “Thermally conductive-radiative driven digital twin of miniature tunable laser spectrometer in micro-gravity”, submitted, *Journal of Applied Thermal Engineering*, 2023
- x) R. Krzysiak et al. “Human prior knowledge estimation from movement cues for information-based control of mobile robots during search”, submitted, *ACM Transactions on Human-Robot Interaction (THRI)*, 2024
- xi) F. Winiberg, M. Fradet, R. Krzysiak et al. “Design and Performance of Indium Seals for Size-Constrained Tunable Laser Spectrometers”, *Review of Scientific Instruments*, 2024
- xii) R. Krzysiak et al., “Explainable Multi-task Learning for Improved Land Use Classification in Planetary Health Monitoring”, DTPI, 2024.
- xiii) R. Krzysiak et al., “Advancing Multi-Task Learning With Fractional Order Sgd and Quantus-Assessed Explainability for Planetary Health Monitoring”, *IDETC2025*
- xiv) S. Giri, R. Krzysiak, et al. “Avis-Ng-Like Smart Virtual Remote Sensing via Spectra-Aware Physics Informed Gans”, *IDETC2025*
- xv) R. Krzysiak, “Modeling and Control of a Prescribed Fire with UAVs as Sensors and Actuators”, *ICCMA 2025 (Accepted)*
- xvi) D. Hollenbeck, R. Krzysiak, et al., “Developing An Optimal Mobile Measurement sUAS using Digital Twins and the Observability Gramian”, *ICCMA 2025 (Accepted)*
- xvii) F. Winiberg, M. Fradet, K. Schwarm, I. Sanders, M. Bryk, V. Cretu, R. Krzysiak, K. Mansour, N. Tallarida, J. Wallace, P. Dodd, A. Noell, L. Christensen, “Tunable Laser Spectrometer for the Miniaturized Total Organic Carbon Analyzer”, *Acta Astronautica (Accepted)*

3.1.2 Projects

- i) Mutual information-based control tested in realistic simulations

- Small swarm of differentially driven robots searching for a missing target in a large obstacle free environment with varying degrees of accuracy of human prior knowledge of target location. Simulated using MATLAB
- Large swarm of UAVs searching for a missing hiker in a large state park with varying degrees of accuracy of human prior knowledge of the hiker's dynamics. Simulated using MATLAB
- ii) Human subject experiment in realistic environment
 - Developed a method of controlling an iRobot creates robotic research platform with a keyboard through Wi-Fi using socketing in python/C++
 - Program a robot to find missing target using mutual information-based control
- iii) Tracking system, teleoperation, and mutual information-based control of iRobot creates 2 platform
 - A single computer with 10 Logitech web cameras mounted to the ceiling of the Omron robotics laboratory at NIU, to have a full 18x9m bird's eye view of the lab using OpenCV and Aruco fiducials
- iv) Autonomous invasive species sampling device
 - Simulations for an autonomous vehicle approaching a point of interest on water
 - Simulations of robot manipulator using inverse kinematics
 - Collaborated with biologists that specialize in sampling the invasive species spiny waterflea
 - Designed the instrument using Solidworks
 - Manufactured the device using Northern Illinois University's machine shop
 - Deformation analysis using Ansys structural
 - Field testing at Lake Shabbona State Recreation Area, Shabbona IL
- v) LEAPFROG endurance flight
 - Developed and demonstrated an autonomous flight of at least 115 miles within a circuit of at least 5 miles in circumference with a small UAV, in full compliance with FAA Part 107 rules
 - Environmental survey mission for residual dry matter quantification using MAPIR camera
- vi) ROS2 agricultural scout
 - Developed unmanned ground vehicle (UGV) equipped with landing pad, millimeter wave radar and spraying device to monitor crops autonomously
 - Developed unmanned aerial vehicle (UAV) equipped with millimeter wave radar to scout locations of interest in more remote locations with coupled communication with UGV
 - Simulations in MATLAB for points of interest localization with coupled UAV and UGV system for fully autonomous remote sensing
- vii) Cognitive stress detection in drone pilots
 - Using research grade medical watch monitoring system equipped with sensors to measure human physiological signals to extract HRV, EDA, skin temperature etc.
 - Performed drone flight experiment in drone cage while extracting physiological indicators of cognitive stress

- Drone pilot was given flight commands and not given flight commands for real world drone flight tests as well as drone simulation software
- viii) Self-aware smart battery management system
 - Using deep learning model trained on battery draining tests
 - Used to help modify mission plan prior to battery being depleted to eliminate possibility of mission failure caused by battery failure
- ix) XAIoT based cardiovascular disease prediction
 - Using research grade medical watch monitoring system equipped with sensors to measure human physiological signals to extract HRV, EDA, skin temperature etc.
 - Developed iOS application to communicate with smart watch using BLE and communicate with server equipped with deep learning XAI model trained on cardiovascular disease data
- x) Miniature tunable laser spectrometer for CO₂ detection on ISS
 - Applied 3D mechanical design/simulation software to improve designs on highly sensitive instruments that will be mounted to drones for planetary science missions
 - Conducted FEA thermal and structural analysis on JPL flight instrument to be used on the International Space Station (ISS). This involved verifying instrument performance and survival under thermal and vibrational launch loads.
 - Constructed a digital-twin (Level-II) of miniature tunable laser spectrometer to measure ISS water quality and verified digital twin via environmental chamber testing.
- xi) Fractional order match filter for improved methane plume detection
 - Using TensorFlow GPU acceleration, implemented integer and fractional order matched filter to extract methane plume information from JPL AVIRIS-NG remote sensing dataset.
- xii) GANs for Physics-Informed Methane Plume Development and Extraction
 - Developed a Generative Adversarial Network (GAN) architecture informed by physical constraints to simulate and detect methane plumes.
 - Trained on satellite and aircraft hyperspectral datasets, improving realism and accuracy of synthetic methane plume generation for data augmentation and plume isolation.
- xiii) XWFDT: Explainable Wildfire Digital Twin
 - Developed a hybrid physics-ML wildfire digital twin integrating 3D wind, fire spread dynamics, and UAV-based multispectral sensing.
 - Integrated explainability methods (GradCAM, LIME, Integrated Gradients) to inform control strategies and model trustworthiness.
 - Designed for real-time UAV-assisted prescribed burn operations and wildfire mitigation.
- xiv) Physics-Informed Neural Networks for Microgravity Instruments
 - Built PINNs for simulating thermal and structural behavior of scientific instruments under microgravity conditions.

- Aimed to enhance performance prediction and real-time validation of onboard sensors for ISS and deep-space missions.

4. Assistantships

- i) Teaching Assistant (TA), Mechanism Design and Analysis
Dr. Sachit Butail, Northern Illinois University, 2018-2019
 - Graded quizzes, assignments, projects, and exams
 - Laser cut acrylic components for walker project and consulted with student teams on walker designs and analysis
- ii) Graduate Assistant (GA), Northern Illinois University 2020-2021
 - National Science Foundation, Great Journeys Assistantship
- iii) Teaching Assistant (TA), Electrical circuits
Dr. Dou, University of California Merced, 2022
 - Graded quizzes, assignments, labs, and exams
 - Taught circuits labs to connect theory with practice
- iv) Teaching Assistant (TA), Statics
Dr. Gutierrez, University of California Merced, 2022
 - Graded quizzes, assignments, and exams
 - Taught discussion course to reinforce concepts from class
- v) Teaching Assistant (TA),
Dr. Brandon Stark, University of California Merced, 2024
 - Graded quizzes, assignments, and exams
 - Taught drone labs to reinforce concepts from class

5. Internships

- i) NASA Jet Propulsion Laboratory, Pasadena CA, 2018, 2019, 2024
 - Applied 3D mechanical designing/simulation software to improve existing designs on highly sensitive instruments that will be mounted to drones for planetary science missions
 - Designed prototype electrical circuits to improve power delivery to various internal components as well as the telemetry system
 - Integrated a methane gas sensor with robotic platforms using ROS
 - Collaborated with industry leaders to review improvements and propose future tests and simulations for the lab and out in the field
 - Developed wireless data collection for instrument monitoring and communication
 - Collaborated with NASA Armstrong Flight Research Center (AFRC) to provide mechanical substantiation for NASA's net generation fire detection instrument
 - Conducted thermal analysis for JPL's airborne program, specifically on radar technology for planetary Earth science missions.

6. Outreach, clubs, and leadership

6.1 Outreach

- i) Northern Illinois University Honors outreach program, 2019

- ii) Northern Illinois University STEMFEST
 - NIU Mars Rover team, 2017-2018
 - NIU Emergent and Autonomous Systems Laboratory (EASeL), 2019, 2021
 - Object tracking, and videos of Aruco based mapping and localization
- iii) University of California Merced MesaLab mentor
 - Teaching underrepresented minorities how to perform research

6.3 Clubs and leadership

- i) Mars Rover team Vice President, 2018-2019
- ii) Mars Rover team Secretary, 2019
- iii) Pi Tau Sigma, 2018-2021
- iv) UCM AIAA graduate mentor, 2022-present