Chayan Banerjee

35 Howard Street, Brisbane City, QLD, Australia
c.banerjee@qut.edu.au chayannet Homepage Google Scholar

Research Interests

Physics-Informed Machine Learning, Reinforcement Learning, Embodied Agentic AI & World Models, LLM Grounding, Neuro-Symbolic AI

Career Summary

I am an Early Career Academic (ECA) with over three years of postdoctoral research experience in **Physics-Informed Machine Learning (PIML)**, **Embodied Agentic AI**, and **Reinforcement Learning (RL)**. My research aims to ground embodied agents in physical and robotic reality, combining physics-informed learning with Vision-Language-Action (VLA) models.

Recent key published works include **Mining-Gym**, a RL benchmarking/simulator framework in **Applied Soft Computing (2026)**, a Physics-Informed Reinforcement Learning survey in **Expert Systems with Applications (2025)**, original RL algorithmic work in **IEEE Transactions on Cybernetics (2025)**, and highly cited reviews in **ACM Computing Surveys** (Physics-Informed Machine Learning for Medical Image Analysis, 2025; Physics-Informed Computer Vision, 2024).

I have developed several agentic AI systems spanning embodied reasoning and multi-agent decision-making, including the Contrastive World Model (**CWM**), an LLM contrastively fine-tuned to score action feasibility and penalize physically implausible actions in embodied agent pipelines, and the **FORGE** environment, a physics-informed multi-agent simulator with a Neural-Linear UCB allocator for task allocation. I have also developed a dual-layer **neuro-symbolic** recommender agent that pairs a physics-informed soft regularizer with an explicit optimizer enforcing physiological hard constraints in nutrition-aware recommendation.

My academic leadership includes **supervising undergraduate and postgraduate students** across Australia and overseas, leading undergraduate **curriculum development** at QUT, and serving as **Executive Guest Editor** for a special issue on PIML (2025–2026) in *Engineering Applications of Artificial Intelligence*(EAAI).

Academic Appointments

Lecturer July 2026 – Current
Queensland University of Technology (QUT), Australia

Postdoctoral Researcher & Academic Dec 2022 – June 2026
Queensland University of Technology (QUT), Australia

Education

Ph.D. in Electrical Engineering 2018 – 2023
University of Newcastle (UON), Callaghan, Australia
Thesis: Improving Sample Efficiency in Reinforcement Learning-Based Control of Dynamic Systems
Supervisors: Prof. Zhiyong Chen, A/Prof. Nasimul Noman

M.Tech in Embedded Systems 2011 – 2013
SRM Institute of Science and Technology, Kattankulathur, India
Thesis: Developing a Re-configurable Swarm Robot Controller
CGPA: 8.82/10

B.Tech in Electronics & Communication Engineering 2006 – 2010
MAKAUT, Kolkata, India
GPA: 7.94/10

Research Experience

Postdoctoral Research Fellow Dec 2022 – Present

Queensland University of Technology (QUT), Australia

- **Contrastive World Models (CWM) for Action Feasibility** (2026): To ensure LLM-driven agents remain grounded in physical reality, I developed Contrastive World Models (CWM) to solve action feasibility bottlenecks. By utilizing a contrastive objective, I trained the system to differentiate between valid maneuvers and "hard negatives" —actions that are semantically plausible but physically impossible. The model outperformed standard fine-tuning by 6.76% on complex benchmarks and significantly improved safety margins during out-of-distribution stress tests.
- **Physics-Informed Neuro-Symbolic Recommender System** (2025–2026): Developed a dual-layer neuro-symbolic architecture addressing the "structural blindness" of e-commerce agents to physiological limits in personalized nutrition. Utilized a Semantic Knowledge Graph , a Thermodynamic Loss Function , and an Explicit Physics Optimizer to generate discrete grocery bundles that strictly satisfy caloric and protein targets.
- **Sustainable Multi-Agent Crowdsourcing via Physics-Informed Bandits** (2025–2026): I addressed workforce burnout and turnover in gig-economy marketplaces by formalizing a coordinated leader-follower based (Stackelberg game) interaction between allocator and rational agents. I introduced FORGE, a simulator where agents declare fatigue-based thresholds, and developed a Neural-Linear UCB allocator with a Physics-Informed Prior. This approach reduced "cold-start" inefficiencies, achieving high rewards and maintaining a sustainable 7.6% utilization rate despite high workforce turnover.
- **Reinforcement Learning for Dynamic Truck Dispatching** (2024–2025): Designed a Reinforcement Learning (RL)-based training and evaluation framework for autonomous haul-truck fleets, using a custom-built discrete-event simulation model – later released as the open-source **Mining-Gym** benchmark – to derive optimal dynamic scheduling policies.
- **Physics-Informed Surrogate Model for Flood Prediction** (2025): Developing surrogate models that integrate limited observational data with governing equations to enhance flood prediction accuracy in data-scarce environments.
- **Automatic Calibration of Landscape Evolution Models** (2023–2024): Developed an automatic calibration algorithm for numerical models, to aid in sparse data scenarios for model training in geomorphological domain.
- **AI-Driven Mine Rehabilitation** (2023): Contributed to data preparation and model development for AI-enabled monitoring and decision-support software for accurate mine site rehabilitation, in collaboration with Verterra Ecological Engineering, Brisbane.

Ph.D. Researcher 2018 – 2022

University of Newcastle (UON), Australia

- **Intrinsic Reward-Based Exploration in RL**: Designed exploration strategy using intrinsic rewards based on plausible state novelty, i.e. combining state novelty with policy optimization utility. Enhanced sample efficiency in off-policy reinforcement learning by addressing traditional exploration limitations.
- **Mixing prioritized off-policy samples with on-policy experiences**: Enhanced Soft Actor-Critic algorithm with a novel prioritization scheme and combining sampled off-policy experiences with latest on-policy data, significantly improving sample efficiency.
- **Hybrid On-Policy and Offline RL**: Developed framework integrating on-policy with offline learning through dataset optimization. Created strategy using best-performing episodes, parameter-fitness modeling, and genetic algorithms to achieve superior performance with fewer samples.

Academic Researcher (A/Professor) 2013 – 2016

Brainware University, Kolkata, India

- **Swarm Intelligence & Multi-Agent Systems:** Consensus algorithms, coalition formation, and pattern-based communication using bio-inspired approaches.

- **Cellular Automata Applications:** Energy conservation, localization, and routing in wireless sensor networks using cellular automata.
- **Chaos Theory Applications:** Random bit generation and patrol robot trajectory planning using chaotic systems.

Research & Project Supervision

Postgraduate Students

- *Enhancing Reinforcement Learning with Large Language Models* — Mohammed Saif Nazir, IIT Patna, India (2024–2025), *Master's Supervision*

Undergraduate Students

- *Reinforcement Learning in Traffic Management* — Anirud N, IIT Madras, India (2024–present)
- *Bus Travel-time Prediction using Physics-Informed Approaches* — Atmadip Goswami, IIT Madras, India (2024–present)
- *Physiological Modelling Using Deep Operator Networks* — Ryan Chappell, QUT Australia (2024–2025)
- *Optimizing Real-World Tennis Players with Reinforcement Learning* — Charlie Turner, QUT Australia (2023–2024)
- *Lane Occlusion Inpainting and Detection for Enhanced Autonomous Driving Systems* (published, *Machine Vision and Applications*, 2025) — Aayush Agrawal, Ashmitha Jaysi Sivakumar, Ibrahim Kaif, IIT Madras, India (2024)
- *Reinforcement Learning Optimization of Traffic Signal Timing: Leveraging Google Data* — Apoorva Prashant, IIT Madras, India (2024)

Teaching and Academic Experience

Lecturer July 2026 – Current

Queensland University of Technology (QUT), Australia

- Led curriculum content design, assignment development, and hands-on laboratory/practical session design across undergraduate units, enhancing student learning outcomes and aligning with engineering accreditation standards.

Sessional Tutor 2024 – Current

Queensland University of Technology (QUT), Australia

- Artificial Intelligence in Real World (QUT001), Artificial Intelligence (CAB320), Machine Learning (CAB420), Data Analytics and Optimization (ENN543), and Reinforcement Learning & Optimal Control (ENN582)

Assistant Professor 2013 – 2016

Brainware Group of Institutions, India

- *Teaching Theory and Lab:* Basic Electronics, Embedded Systems, and Computer Architecture.
- *Curriculum Development:* Developed comprehensive course materials and performance assessment strategies, including exam papers.
- *Project supervision:* Undergraduate projects on Electronics, and Embedded systems.

Research Collaborations

Interdisciplinary Collaborations

- **RL and PIML for traffic engineering** – Indian Institute of Technology, Madras (IITM), India (*Prof. Lelitha Devi Vanajakshi*).
- **PIML in Medical Imaging, Computer Vision and RL** – CSIRO (*Prof. Olivier Salvado*) & Deakin University, Australia (*Prof. T. Tran*) [Medical Imaging]; Brown University, USA (*Prof. George Karniadakis*) [Computer Vision]; University of Colorado Boulder, USA (*Prof. Maziar Raissi*) [Reinforcement Learning].

- **Geomorphological modeling augmentations using AI** – University of Newcastle, Australia (*Prof. Gregory Hancock*) & University of Hull, UK (*Prof. Thomas Coulthard*)
- **Industry Partners** – Verterra Ecological Engineering – *AI solutions for mining.*

Selected Publications

For extended list of publications check on Google Scholar Link.

- Banerjee, C., Kien Nguyen, and Clinton Fookes. **Mining-Gym: A Configurable Mining Process Simulator for Dynamic Dispatch Scheduling using Reinforcement Learning**. Applied Soft Computing (2026). [D1, IF: 6.6] [Paper]
- Goswami, A., **Banerjee, C.**, Bharathi, D., and Vanajakshi, L. **Adaptive Physics-Informed Machine Learning for Bus Travel Time Prediction: Solving the Peak Prediction Problem.** Applied Soft Computing (2026). [D1, IF: 6.6] [Paper]
- Banerjee, C., Kien Nguyen, Olivier Salvado, Truyen Tran, and Clinton Fookes. **Physics-Informed Machine Learning for Medical Image Analysis.** ACM Computing Surveys 58, no. 4 (2026): 1–35. [D1, IF: 23.8][Paper]
- Banerjee, C., Kien Nguyen, Clinton Fookes, George Karniadakis. **Physics-Informed Computer Vision: A Review and Perspectives**. ACM Computing Surveys, 2024. [D1, IF: 23.8] [Paper]
- Banerjee, C., Z. Chen, and N. Noman. **Enhancing Exploration in Actor-Critic Algorithms: An Approach to Incentivize Plausible Novel States.** IEEE Transactions on Cybernetics (2025): doi: 10.1109/TCYB.2025.3637764. [D1, IF: 10.5][Paper]
- Banerjee, C., Kien Nguyen, Clinton Fookes, and Maziar Raissi. **A Survey on Physics-Informed Reinforcement Learning: Review and Open Problems.** Expert Systems with Applications (2025). [D1, IF:7.5] [Paper]
- Agrawal, A., Sivakumar, A. J., Kaif, I., and Banerjee, C. **LOID: Lane Occlusion Inpainting and Detection for Enhanced Autonomous Driving Systems.** Machine Vision and Applications 36 (2025): 120.[Paper]
- Chappell, R., Banerjee, C., Nguyen, K., and Fookes, C. **Physics-Informed Operator Learning for Hemodynamic Modeling**, accepted at DICTA 2025. [Paper]
- Banerjee, C, Kien Nguyen, Clinton Fookes, Gregory Hancock, and Thomas Coulthard. **Introducing Iterative Model Calibration (IMC) v1.0: a generalizable framework for numerical model calibration with a CAESAR-Lisflood case study**. Geoscientific Model Development (2025): 803-818.[D1, IF: 4.0] [Paper]
- Banerjee, C., Zhiyong Chen, Nasimul Noman. **Boosting exploration in actor-critic algorithms by incentivizing plausible novel states.** IEEE CDC, 2023. [Paper]
- Banerjee, C., Zhiyong Chen, Nasimul Noman. **Improved Soft Actor-Critic: Mixing Prioritized Off-Policy Samples With On-Policy Experiences.** IEEE TNNLS, 2022.[D1, IF: 0.2][Paper]
- Banerjee, C., Zhiyong Chen, Nasimul Noman, and Mohsen Zamani. **Optimal actor-critic policy with optimized training datasets.** IEEE Transactions on Emerging Topics in Computational Intelligence 6, no. 6 (2022) [Q1, IF: 5.3][Paper]

Ongoing Works

- Banerjee, C. **CWM: Contrastive World Models for Action Feasibility Learning in Embodied Agent Pipelines**, arXiv preprint arXiv:2602.22452 (2026). [Paper]
- Banerjee, C. **Sustainable Multi-Agent Crowdsourcing via Physics-Informed Bandits**, arXiv preprint arXiv:2602.22365 (2026). [Paper]
- Banerjee, C. **Physics-Informed Neuro-Symbolic Recommender System: A Dual-Physics Approach for Personalized Nutrition**, arXiv preprint arXiv:2601.19244 (2026). [Paper]
- Nandakumar, A., **Banerjee, C.**, and Vanajakshi, L. D., **Reinforcement Learning Based Traffic Signal Design to Minimize Queue Lengths**, submitted to IEEE Transactions on Intelligent Transportation Systems [Paper]
- Nazir, M. S., **Banerjee, C. Zero-Shot LLMs in Human-in-the-Loop RL: Replacing Human**

Feedback for Reward Shaping, submitted to IEEE Transactions on Artificial Intelligence [Q1, IF: 6.4][Paper]

- **Banerjee, C.**, Datta Mitra, D., Noman, N. **Addressing GNN Limitations via Deep Reinforcement Learning: Principles, Patterns, and Design Insights**, TechRxiv preprint (2026), submitted to IEEE TNNLS [D1, IF:8.9]

Academic Service & Editorial Activities

Invited Talk/ Interview:
"Unlocking Reinforcement Learning's Secrets: From Online Exploration to Offline Mastery", at University of Engineering & Management, Kolkata, India – October 2024.
Contributed towards the article *"PINNing hopes on the future"*, Shaastra Magazine IIT Madras, India – April, 2025.

Peer Reviewer: Reviewed manuscripts for journals including *IEEE Transactions on Neural Networks and Learning Systems (TNNLS)*, *IEEE Transactions on Cybernetics*, *Neurocomputing*, *Expert Systems with Applications*, and *Pattern Recognition.*

Executive Guest Editor: Special Issue on *Physics-Informed Machine Learning in Engineering Applications (2025-26)*, in *Engineering Applications of Artificial Intelligence* [Q1, IF: 7.5] [Link]
Defining the scope, setting rigorous quality standards, and managing the peer review process to curate high-quality research at the intersection of PIML and engineering applications.