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Contact Details

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Research Interests

- LLMs (Generation and Evaluation)
- VLMs (Multimodal Learning)
- Large-scale Image Analytics
- Image Classification & Segmentation
- Detection and Gesture Recognition
- Time-series Forecasting
- Deep Learning Optimization

Research Domain

- Computer Vision
- Biomedical AI and Medical Imaging
- Multimodal and Generative AI
- Cloud and Distributed Computing

Selected Research Publications

- MICCAI 2026
- CVPR 2026
- NeurIPS 2025
- Expert Systems with Apps. 2024
- ACM Computing Surveys 2023

Professional Memberships

- IEEE – Senior Member
- ACM

Technical Skills

Generative AI

◇ Architectures: Transformers, LLMs, Attention Mechanisms, Multimodal Learning
◇ LLM Systems: RAG, LangChain, Vector Databases (ChromaDB)
◇ Model Optimization: LoRA Fine-tuning, Knowledge Distillation, Quantization
◇ Training Paradigms: Self-supervised Learning, Pretraining, Fine-tuning

Computer Vision

◇ Image Classification: Vision Transformers (ViT) and Multiple Instance Learning
◇ Object Detection: YOLO, DETR (Detection Transformer)
◇ Image Segmentation: U-Net, nnU-Net, SegFormer, Segment Anything Model
◇ Gesture Recognition: MediaPipe, Gesture-to-Audio Mapping
◇ Annotation Tools: QuPath, Roboflow, LabelMG

MLOps & Data Engineering

◇ Lifecycle: MLflow, Experiment Tracking, Model Versioning
◇ Inference & Deployment: vLLM, Streamlit Prototyping, Docker Containerization
◇ Infrastructure: GPU Cluster Management with Slurm, Linux Administration (Ubuntu)
◇ Distributed Systems: Hadoop, Apache Spark, Apache Kafka
◇ Databases: NoSQL Databases (MongoDB, Cassandra), Vector Stores (ChromaDB)

Cloud & DevOps

◇ Platforms: AWS, Google Cloud Platform (GCP), OpenStack
◇ Virtualization: KVM, VirtualBox, Docker
◇ CI/CD: GitHub Actions, Git Version Control

Programming: Python, Groovy Script; working knowledge of C and Java
Frameworks: PyTorch, PyTorch Lightning, TensorFlow

Hands-on Experience

- Designed end-to-end digital pathology pipelines for artifact filtering, tissue mask generation, classification, survival prognostication, and tissue segmentation.
- Developed visualization frameworks for WSI-level predictions, tile-level attention maps, and interpretability in attention-based MIL models.
- Fine-tuned medical multimodal models, including CLIP, Qwen, and Meditron, for medical image analysis, clinical feature extraction, and report generation.
- Fine-tuned pathology foundation models, including UNI, CONCH, Virchow, Prov-GigaPath, PLIP, and CTransPath, for tile-level and WSI-level pathology tasks.
- Applied segmentation models, including nnU-Net and SegFormer, for tissue segmentation and augmentation under limited-data settings.
- Developed a semi-automated framework (DeepCluster++) to generate large-scale tile-level dataset (STARC-9) to support benchmarking and reproducibility.
- Designed optimization and activation-function enhancements to improve deep learning convergence and prediction under data-constrained settings.
- Built applied computer vision systems for manufacturing defect detection and face anti-spoofing using YOLO and FFT-based feature analysis.
- Developed a real-time gesture-driven music generation system using MediaPipe and causal convolution for gesture-to-audio mapping.
- Orchestrated GPU workloads using Slurm and managed multi-user GPU servers and NAS systems for large-scale medical image analysis.
- Deployed OpenStack-based virtual clusters and Hadoop/Spark environments for large-scale data processing.
- Applied meta-heuristic optimization methods, including ACO, GA, and PSO, to solve discrete and continuous optimization problems.

Employment History

Post-Doctoral Scholar **10/2024 – Present**
◇ Stanford University, California, USA.

Post-Doctoral Fellow **08/2023 – 10/2024**
◇ University of Houston-Victoria, Texas, USA.

Post-Doctoral Associate **03/2021 – 08/2023**
◇ Kyungpook National University, Daegu, South Korea.

Research Scientist and Corporate Trainer **09/2019 – 08/2020**
◇ Duratech Solutions, Coimbatore, India.

Education

Overseas Visiting Research Scholar **2018 – 2019**
◇ Kyungpook National University, Daegu, South Korea.

Ph.D. in Information Technology **2015 – 2020**
◇ National Institute of Technology Karnataka, India.

Research Proposals

Contributed to the development of the following research proposals:

1. Unsupervised learning-based WSI classification and clinical text generation using multimodality (2024)
2. Smart prostheses: real-time knowledge augmentation and direct neural sensory feedback (2023)
3. Multimodal biometric authentication: integrating voice, vision, and motion for enhanced security (2023)
4. Transparent artificial intelligence for healthcare technologies (2023)

Research Projects Involved

AI-based Histopathology **10/2024 – Present**

Funder: National Institutes of Health (NIH), USA.
Objective(s): Develop end-to-end WSI and multimodal analysis workflows for histopathology.
Role: Post-doctoral Scholar
Responsibilities:

- Building end-to-end pipelines for whole-slide image (WSI) and tile-level tissue classification and segmentation.
- Implementing autoencoder-based, multi-task preprocessing for pathology images covering artifact filtering, tile extraction, and quality control, to deliver clean, consistent inputs at scale.
- Managing multiple GPU resources to run large-scale image analytics.
- Training and deploying multimodal pathology foundation models (image+text) for analysis and report generation.
- Annotating tumor regions in WSIs with QuPath to produce high-quality ground truth for model development.
- Curating a large tile-level tissue dataset to support benchmarking and reproducible research.
- Developing a patch- and cell-level segmentation model to detect signet cell ring.

AI-Driven Climate Risk Assessment at the Hanford Site **08/2023 – 09/2024**

Funder: U.S. Department of Energy (DOE) Office of Environmental Management, Minority Serving Institution Partnership Program (MSIPP) in collaboration with University of Houston-Victoria.
Objective(s): Apply AI-based climate forecasting to assess environmental risk factors at the Hanford Site.
Role: Project Associate
Responsibilities:

- Developing multivariate sequence models (LSTM, GRU, attention) to forecast groundwater contamination.
- Generating realistic sequential synthetic data using GANs and diffusion models to augment limited observations.
- Imputing missing values and subsequences in time-series data to improve model fidelity.
- Implementing Transformer architectures for long-horizon forecasting of environmental timeseries dataset.

Optimizer Enhancements for Deep Neural Networks **05/2022 – 05/2023**

Funder: School of Computer Science and Engineering, Kyungpook National University, South Korea.
Objective(s):

- Improving model reliability by accelerating convergence of gradient-based optimizers (e.g., SGD, Adam).
- Enhancing nonlinear representational capacity using modified activation functions to capture complex relationships.

Role: Project Lead
Responsibilities:

- Designing and implementing deep learning models to evaluate the proposed methods.
- Integrating the proposed methods into TensorFlow by overriding core modules.
- Developing mathematical proofs and theoretical analyses of the proposed methods.
- Provisioning a distributed compute cluster and a shareable GPU server to support experiments.
- Running experiments and conducting empirical analyses and ablation studies.

Automated Fabric Defect Detection and Visualization **09/2022 – 05/2023**

Funder: National Research Foundation (NRF), South Korea.
Objective(s): Abnormal image detection and Localization of fabric products.
Role: Project Associate
Responsibilities:

- Applied targeted data augmentation to expand the training set and improve model generalization.
- Built a preprocessing pipeline (denoising, contrast enhancement) to improve image quality.
- Developed and evaluated autoencoder-based methods for anomaly localization.
- Benchmarked models on anomaly-detection datasets and performed error analysis and ablations.
- Documented experiments, configurations, and results to ensure reproducibility.

Real-time fault detection in fused deposition modelling **07/2022 – 10/2022**

Funder: Department of Mechanical Engineering, National Institute of Technology Calicut, India in collaboration with the School of Computer Science and Engineering, Kyungpook National University, South Korea.
Objective(s): Real-time error detection in fused deposition modelling using CNN.
Role: Project Associate
Responsibilities:

- Collecting sample images across defect categories—staircase, overfill, and void—during fused deposition modelling (FDM).
- Generating additional images via targeted data augmentation to mitigate overfitting.
- Designing a convolutional neural network (CNN) to train and classify defect types.
- Benchmarking the proposed approach against standardized classification algorithms.

Gesture recognition system for sign language and music generation **02/2022 – 05/2023**

Funder: School of Computer Science and Engineering, Kyungpook National University, South Korea.
Objective(s):

- Real-time music generation driven by hand-gesture recognition.
- Sign-language recognition from hand gestures.

Role: Project Coordinator
Responsibilities:

- Modified GRU model to enhance gesture recognition accuracy and performance.
- Developed a validation framework to ensure model effectiveness across various gesture types for maintaining project quality standards.
- Coordinated the technical integration of deep learning models with application interfaces, streamlining the real-time translation of recognized gestures into output.
- Managed technical documentation and project guidelines, supporting project scalability, and ensuring knowledge transfer for future development.
- Facilitated collaboration between technical and user experience teams, bridging the gap to optimize user interface design for gesture-based applications.

Korean handwritten text recognition **12/2021 – 02/2022**

Funder: Medium business technology information promotion agency, South Korea.
Objective(s): Generating Korean text from old-fashioned Korean handwriting.
Role: Project Technical Support Specialist
Responsibilities:

- Annotated bounding boxes for handwritten text datasets.
- Engineered a preprocessing pipeline using histogram of oriented gradients (HOG) and contrast normalization to extract robust stroke features.
- Contributed to a Bi-LSTM-based OCR model for handwriting transcription.
- Evaluated performance with character error rate (CER) and conducted error analyses to guide model improvements.

Object detection in manufacturing and smart city **03/2021 – 02/2022**

Funder: Medium business technology information promotion agency, South Korea.
Objective(s):

- Automated detection of illegal parking in accessible (disabled) spaces.
- Automated detection of improperly placed objects (e.g., stickers, badges).

Role: Project Associate
Responsibilities:

- Collected on-site imagery of accessible (disabled) parking spaces to build a diverse training set.
- Preprocessed and annotated images to label illegal-parking cases and object placement issues (e.g., stickers, badges).
- Identified and benchmarked suitable deep learning architectures for automated detection, selecting the best-performing model.
- Conducted iterative testing, error analysis, and model tuning to improve detection accuracy.

Research Publications

Current Submissions (3)

1. Rathinaraja Jeyaraj, Barathi Subramanian, Jeanne Shen, et al., "MUFASA: An Information Utility-Aware Preprocessing Framework for Reliable Model Reasoning in Computational Pathology," in preparation for submission to Nature Biomedical Engineering.
2. Rathinaraja Jeyaraj, Barathi Subramanian, Anand Paul, et al., "HMS: Bounded Harmonic Mean Perturbations for Stabilizing SGD-Based Regression Optimization," in preparation for submission to AAAI 2027.
3. Barathi Subramanian, Rathinaraja Jeyaraj, Anand Paul, et al., "APALU: A Trainable, Adaptive Activation Function for Deep Learning Networks," in preparation for submission to Neurocomputing.

Journal Articles (12)

1. Basil Kuriachen*, Rathinaraja Jeyaraj*, Deepak Raphael, P. Ashok, P. Shanmuga Sundari, and Anand Paul, "Defect Detection in Fused Deposition Modelling using Lightweight Convolutional Neural Networks," Engineering Applications of Artificial Intelligence (ScienceDirect), Volume 141, **2025**. *Equally contributed.
2. K. Gangadharan, A. Purandaran, K. Malathi, B. Subramanian, Rathinaraja Jeyaraj, S. K. Jung, "From Data to Decisions: The Power of Machine Learning in Business Recommendations," IEEE Access, vol. 13, 17354-17397, **2025**.
3. Rathinaraja Jeyaraj, Thirunavukarasu Balasubramaniam, Anandkumar Balasubramaniam, and Anand Paul, "DeepWalk with Reinforcement Learning (DWRL) for Node Embedding," Expert Systems with Applications (ScienceDirect), Volume 243, 122819, **2024**.
4. Gurwinder Singh, Rathinaraja Jeyaraj, Anil Sharma, and Anand Paul, "A Novel Data Management Scheme in Cloud for Micromachines," Electronics (MDPI), Volume 12, Issue 18, pp. 1-20, **2023**.
5. Rathinaraja Jeyaraj, Anandkumar Balasubramaniam, Ajay Kumara M.A, Nadra Guizani, and Anand Paul, "Resource Management in Cloud and Cloud-Influenced Technologies for IoT Applications," ACM Computing Surveys, Volume 55, Issue 12, pp. 1-37, **2023**.
6. S. Divya, Swati Panda, Sugato Hajra, Rathinaraja Jeyaraj, Anand Paul, Sang Hyun Park, Hoe Joon Kim, Tae Hwan Oh, "Smart Data Processing for Energy Harvesting Systems using Artificial Intelligence," Nano Energy (ScienceDirect), Volume 106, **2022**.
7. Rathinaraja Jeyaraj and Anand Paul, "Optimizing MapReduce Task Scheduling on Virtualized Heterogeneous Environments using Ant Colony Optimization," IEEE Access, 10, pp. 55842-55855, **2022**.

5. Gurwinder Singh, Anil Sharma, Rathinaraja Jeyaraj, Anand Paul, “Handling Non-Local Executions to Improve MapReduce Performance using Ant Colony Optimization,” IEEE Access, Vol. 9, pp. 96176-96188, **2021**.
6. Rathinaraja Jeyaraj, Ananthanarayana V S, Anand Paul, “Fine-grained data-locality aware MapReduce job scheduler in a virtualized environment,” Journal of Ambient Intelligence and Humanized Computing (Springer), Volume 32, Issue 7, pp. 4261–4272, **2020**.
7. Rathinaraja Jeyaraj, Ananthanarayana V S, Anand Paul, “Improving performance of MapReduce Scheduler for Heterogeneous Workloads in a Heterogeneous Environment,” Concurrency and Computation: Practice and Experience (Wiley), Volume 11, Issue 10, **2019**.
8. Rathinaraja Jeyaraj, Ananthanarayana V S, Anand Paul, “Dynamic Ranking based MapReduce Job Scheduler to Exploit Heterogeneous Performance on Virtualized Environment,” Journal of Supercomputing (Springer), Volume 75, Issue 11, pp. 7520-7549, **2019**.
9. Anand Paul, Rathinaraja Jeyaraj, “Internet of Things: A Primer,” Human Behavior and Emerging Technologies (Wiley), Volume 1, Issue 1, pp. 37-47, **2019**.

Conference Proceedings (20)

1. Barathi Subramanian, Rathinaraja Jeyaraj, Songmi Noh, George Fisher, Jeanne Shen, “TRIAGE-MIL: Tumor-anchored Risk-aligned Instance Selection with Attentive Graph Embedding for Survival Prediction,” accepted as a top 9% paper at Medical Image Computing and Computer Assisted Intervention (MICCAI) **2026**.
2. Rathinaraja Jeyaraj, Barathi Subramanian, Kapilya Gangadharan, Anand Paul, “Gesture2Music: A Low-Latency Real-Time Framework for Continuous Gesture-Driven Music Generation,” First International Workshop on Interactive Physical AI (IPA), The IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) **2026**.
3. Barathi Subramanian, Rathinaraja Jeyaraj, Anand Paul, “Contrast-Enhanced Gating in GRUs for Robust Low-Data Sequence Learning,” Workshop on Women in Computer Vision Proceedings Track, The IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) **2026**.
4. Barathi Subramanian*, Rathinaraja Jeyaraj*, Mitchell Nevin Peterson, Terry Guo, Nigam Shah, Curtis Langlotz, Andrew Y. Ng, Jeanne Shen, “STARC-9: A Large-scale Dataset for Multi-Class Tissue Classification for CRC Histopathology,” The Thirty-ninth Annual Conference on Neural Information Processing Systems Datasets and Benchmarks Track (NeurIPS) **2025**. *Equally contributed
5. Rathinaraja Jeyaraj, Barathi Subramanian, Songmi Noh, Mitch Peterson, Terry Guo, George Fisher, Jeanne Shen, "A Novel AI-Powered Preprocessing Framework for Maximizing Whole-Slide Image Dataset Quality for Machine Learning Applications," Pathology Research Retreat, Stanford University, California, USA, **2025**.
6. Barathi Subramanian, Rathinaraja Jeyaraj, Songmi Noh, Mitch Peterson, Terry Guo, George Fisher, Jeanne Shen, "Generating Morphologically Diverse, Class-Balanced Training Datasets for Enhanced Histopathologic Tissue-Type Classification," Pathology Research Retreat, Stanford University, California, USA, **2025**.
7. Rathinaraja Jeyaraj, Barathi Subramanian, Songmi Noh, Mitch Peterson, Terry Guo, George Fisher, Thomas Montine, Jeanne Shen, "Artificial intelligence-based tile preprocessing for more effective whole-slide image tissue segmentation," 2nd Annual Congress of the Asian Society of Digital Pathology (ASDP), India, **2025**.
8. Barathi Subramanian, Rathinaraja Jeyaraj, Songmi Noh, Mitch Peterson, Terry Guo, George Fisher, Thomas Montine, Jeanne Shen, "A novel training sample collection framework for improving the performance of multi-tissue type classification in histopathology," 2nd Annual Congress of the Asian Society of Digital Pathology (ASDP), Mumbai, **2025**.
9. Rathinaraja Jeyaraj, Barathi Subramaniam, Karnam Yogesh, Aobo Jin, and Hardik A Gohel, “YSAF: Yolo with Spatial Attention and FFT to Detect Face Spoofing Attacks,” IEEE 3rd International Conference on AI in Cybersecurity (ICAIC), Houston, Texas, USA, pp. 1-6, February **2024**.
10. Rathinaraja Jeyaraj, Aobo Jin, Hilary Emerson, Daniel I. Kaplan, and Hardik A. Gohel, “Application of a GRU-Based Deep Learning Model to Environmental Monitoring at Complex Sites,” 50th WM Symposia, Phoenix, USA, March **2024**.
11. Rathinaraja Jeyaraj, Aobo Jin, Hilary Emerson, and Hardik A Gohel, “BTS-GANs: Impute Missing Values to Improve Predictive Modelling Power in Climate Change,” 50th WM Symposia, Phoenix, Arizona, March **2024**.
12. Karnam Yogesh, Aobo Jin, Rathinaraja Jeyaraj, Hilary Emerson, and Hardik A Gohel, “Analyzing Seq2Seq and Transformer Models for Time Series Forecasting in Climate Change Modeling at Hanford Site,” 50th WM Symposia, Phoenix, **2024**.
13. Aobo Zhou, Michael Stassi, Maulin Raval, Rathinaraja Jeyaraj, Aobo Jin, Hilary Emerson, and Hardik A. Gohel, “Utilizing U-Net Architecture for Advanced Climate Modelling at Hanford Site,” 50th WM Symposia, Phoenix, Arizona, **2024**.
14. M.Shyamala Devi, J.Arun Pandian, D.Umanandhini, Aayush Kumar Sakineti, and Rathinaraja Jeyaraj, “Meat Freshness State Prediction Using a Novel Fifteen Layered Deep Convolutional Neural Network,” 1st International Conference on Data Science and Network Engineering (ICDSNE), India, pp 111-123, July **2023**.

15. Anandkumar Balasubramaniam, Thirunavukarasu Balasubramaniam, Rathinaraja Jeyaraj, Anand Paul and Richi Nayak, “Nonnegative Matrix Factorization to understand Spatio-Temporal Traffic Pattern Variations during COVID-19: A Case Study,” 19th The Australasian Data Science and Machine Learning Conference (AusDM), Melbourne, Australia, **2021**.
16. Rathinaraja Jeyaraj, Ananthanarayana V S, Anand Paul, “MapReduce Scheduler to Minimize the Size of Intermediate Data in Shuffle Phase,” 18th IEEE/ACIS International Conference on Computer and Information Science (ICIS), Beijing, China, June **2019**.
17. Rathinaraja Jeyaraj, Ananthanarayana V S, “Dynamic Performance Aware Reduce Task Scheduling in MapReduce on Virtualized Environment,” 16th IEEE/ACIS International Conference on Software Engineering Research, Management and Applications (SERA), Kunming, China, pp. 211-218, **2018**.
18. Rathinaraja Jeyaraj, Ananthanarayana V S, “Multi-Level Per Node Combiner (MLPNC) to Minimize MapReduce Job Latency on Virtualized Environment,” 33rd ACM Symposium on Applied Computing (SAC), Pau, pp. 167-174, **2018**.
19. Ganeshkumar Pugalendhi, Rathinaraja Jeyaraj, T.Aruldoss Albert Victoire, “A Combined MI-AVR Approach for Informative Gene Selection,” IEEE International Conference on Sustainable Energy and Intelligent Systems (SEISCON), Tamil Nadu, India, pp. 870-875, **2011**.
20. Rathinaraja Jeyaraj, Ganeshkumar Pugalendhi, “Workflow Scheduling using Heuristics-based Ant Colony Optimization,” SUNIIST, Tamil Nadu, India, pp. cse106, **2011**.

Books (4)

1. Pethuru Raj Chelliah, Ramamurthy Venkatesh, N.A. Natraj, and Rathinaraja Jeyaraj, "Artificial Intelligence for Cloud-Native Software Engineering", IGI Global Scientific Publishing, **2025**.
2. Rathinaraja Jeyaraj, Ganesh Kumar Pugalendhi, Suresh Arumugam, Sujiya Sreedharan, and Rani Chellasamy, “Cloud Computing,” Global Aasan Research, **2024**.
3. Chandra Eswaran, Rathinaraja Jeyaraj, “Big Data Infrastructure and Analytics for Education 4.0,” Big Data Applications in Industry 4.0, CRC Press/Taylor & Francis, **2022**.
4. Rathinaraja Jeyaraj, Ganeshkumar Pugalendhi, Anand Paul, “Big Data with Hadoop MapReduce – A Classroom Approach,” Apple Academic Press, CRC Press/Taylor & Francis, **2020**.

Professional Services

Associate Editor

- Journal of Biomedical and Health Informatics (JBHI) (2026 – Present)
- IEEE Systems, Man, and Cybernetics (SMC) (2023 – Present)

Co-organizer and Track Chair

- The International Conference on Recent Advances in Electronics, Communication, Computing, Automation, and Power (RECCAP 2026), IIT Palakad, India.
- North American Young Investigators Symposium on Mathematical Oncology 2026, Stanford University, California, USA.

Program Committee Member

- International Conference on Soft Computing and its Engineering Applications (2021 — 2023)
- International Conference on Innovative Computing and Communications (2021)

Reviewer

- CVPR (2026), MICCAI (2026)
- Journal of Biomedical and Health Informatics (JBHI) (2025 – Present)
- Neural Networks (ScienceDirect) (2024 – Present)
- Journal of Supercomputing (ScienceDirect) (2023 – Present)
- IEEE Transactions in Artificial Intelligence (2023 – Present)
- Engineering Applications of Artificial Intelligence (2023 – Present)
- ECML-PKDD (2022)
- IEEE Access (2021 — Present)