College of Engineering and Technology

Project Work – Student Hand Book

Name of student	Register Number	Department	Mobile Number	Email ID
Abhay Shaji Valiyaparambil	RA2112704010006	DSBS	9104909364	As3725@srmist.edu.in
Ponnuri Aniruddha	RA2112704010015	DSBS	9205481551	Pp0783@srmist.edu.in

Working Title of the Project:	**Evaluating Multimodal Fusion Strategies for Resilient Agricultural Sensing Systems**
Project Site / Location	
Name and address of the company / organisation (Applicable for projects with industry or industry support)	SRM IST, Kattankulathur, Chengalpattu District-603203

Supervision Team

	Supervisor	Co-Supervisor	External Supervisor (If applicable)
Name	Dr. Sornalakshmi K		
Designation	Associate Professor		
Department	DSBS		
Campus	Kattankulathur		
Telephone	9894290762		**Project Batch ID**
E-mail	sornalak@srmist.edu.in		

Degree/ program	M.Tech	**Specialisation**	Computer Science & Engineering

College of Engineering and Technology

Project Work – Student Hand Book

Academic Year	2024-2025 (Even)	**Semester**	8
Course Code	21CSP401L	**Course Title**	Major Project

Mission Statement

Problem (or) Product Description:

Modern precision agriculture relies on the integration of heterogeneous time series data streams-such as soil moisture, pH, temperature, NPK nutrient levels, and periodic crop imagery-to optimize crop yield, resource use, and sustainability. However, traditional data analysis methods struggle to extract actionable insights from these complex, multimodal datasets due to differences in scale, sampling frequency, and data formats. This project aims to develop and benchmark advanced multimodal data fusion techniques (MDFCL, GSIFN, Perceiver IO) for robust, scalable integration of agro-sensor and image data. The goal is to enable more accurate and timely agricultural decision-making, such as irrigation scheduling, fertilization, and disease detection, by leveraging the complementary strengths of each data modality

Assumptions

- Sensor data (moisture, pH, NPK, temperature, light) and crop images are available at regular intervals and are time-synchronized or can be aligned.
- Data quality is sufficient for model training after standard cleaning and preprocessing.
- Sufficient computational resources are available for training and evaluating deep learning models.
- Stakeholders are open to adopting AI-based tools for agricultural management.

Constraints

- Missing, noisy, or inconsistent sensor readings may affect model accuracy.
- Variability in image quality due to weather, lighting, or sensor faults.
- Limited labeled data for supervised learning; reliance on self-supervised or weakly supervised approaches.
- Real-time deployment may be limited by hardware constraints in field environments.
- Data privacy and security must be ensured for sensitive agricultural information.

Stakeholders

- Farmers and Growers: End-users who benefit from improved crop monitoring and recommendations.
- Agricultural Researchers: Use the platform for experimental validation and agronomic studies.
- AgriTech Companies: Integrate fusion models into commercial precision agriculture solutions.
- Policy Makers and Extension Officers: Leverage insights for regional planning and resource allocation.
- Academic Institutions: Advance research in AI-driven agriculture and provide training.

Division of work and contributors of SPRINT 1 [Include Daily Scrum of Sprint 1]

Division of Work and Contributors – SPRINT 1
Sprint Duration: January – February

Abhay Shaji Valiyaparambil:

- Led the integration of all environmental sensors (NPK, pH, moisture, temperature, light) with the Raspberry Pi 4, ensuring stable data capture and calibration routines for each probe.
- Configured the EZVIZ Security Camera for high-resolution image acquisition, implementing a unified timestamping protocol to synchronize sensor readings and images.
- Developed Python scripts for real-time data logging, creating structured CSV files that link each sensor measurement with its corresponding image, and validated the end-to-end data flow.
- Documented the system architecture, detailing the hardware-software interface and outlining contingency measures for sensor or camera faults.

Ponnuri Aniruddha:

- Designed the dataset schema and organized the storage hierarchy, ensuring each entry paired sensor data with the correct image file for seamless multimodal analysis.
- Conducted initial preprocessing of both sensor and image data, including normalization, outlier removal, and image resizing, to prepare the dataset for downstream model ingestion.
- Performed end-to-end validation of the data acquisition pipeline, verifying the integrity and alignment of multimodal data streams.
- Drafted the functional specifications for the acquisition system, covering sampling intervals, metadata tagging, and health-check routines.

Daily Scrum Activities – Sprint 1:

- Reviewed hardware integration progress and resolved issues related to GPIO conflicts and sensor calibration.
- Synced on the alignment of sensor readings with EZVIZ camera images, ensuring sub-minute synchronization across modalities.
- Debugged and addressed data logging errors, confirming that no data was lost during acquisition.
- Shared updates and blockers in daily stand-ups (~15 minutes), adjusting task priorities as needed.
- Updated the project tracker after each completed milestone, maintaining clear visibility on deliverables and next steps.

Signature of the Supervisor

Division of work and contributors of SPRINT 2 [Include Daily Scrum of SPRINT 2]

Sprint Duration: February – March

Abhay Shaji Valiyaparambil:

- Led the implementation and training of the three fusion models (MDFCL, GSIFN, Perceiver IO) using the curated, synchronized sensor and image dataset.
- Developed the training pipelines in PyTorch, including configuration of cross-validation, hyperparameter tuning, and model checkpointing.
- Engineered and executed robustness testing by simulating sensor dropout and image degradation, systematically evaluating model resilience under real-world data imperfections.
- Benchmarked resource usage and inference latency for each model on Raspberry Pi 4, optimizing deployment scripts for edge efficiency.

Ponnuri Aniruddha:

- Managed dataset preprocessing for model ingestion, including normalization, augmentation, and alignment of sensor and image data.
- Designed and executed the evaluation protocol, calculating accuracy, precision, recall, and F_1-score for each model under both clean and corrupted input scenarios.
- Compiled and visualized comparative performance reports, including confusion matrices and resource efficiency charts.
- Authored the robustness analysis and synthesized findings to inform model selection for deployment.

Daily Scrum Activities – Sprint II:

- Reviewed progress on model training and validation, addressing any runtime or convergence issues encountered.
- Coordinated the robustness testing framework, ensuring consistent simulation of noise and missing data across all models.
- Monitored resource profiling and edge deployment benchmarks, troubleshooting latency and memory constraints on the Raspberry Pi.
- Shared updates and blockers during daily stand-ups (~15 minutes), adjusting priorities to keep training and evaluation on schedule.
- Updated the project management board after each major milestone, maintaining transparency and alignment on deliverables.

Signature of the Supervisor

Division of work and contributors of SPRINT 3 [Include Daily Scrum of SPRINT 3]

Sprint Duration: March – April

Abhay Shaji Valiyaparambil:

- Led the comprehensive documentation of the multimodal data fusion pipeline, including step-by-step guides for data acquisition, preprocessing, model training, and deployment.
- Compiled detailed user and developer manuals, covering sensor calibration, EZVIZ camera integration, and troubleshooting procedures for field deployment.
- Curated and annotated all experimental logs, code snippets, and configuration files to ensure reproducibility and ease of knowledge transfer for future users and collaborators.
- Coordinated the implementation of advanced accuracy improvement strategies, such as hyperparameter tuning (optimizer selection, learning rate scheduling), and ensemble validation across the three fusion models (MDFCL, GSIFN, Perceiver IO).
- Integrated additional data augmentation techniques (random masking, synthetic noise injection) to enhance model generalization and robustness on unseen field data.

Ponnuri Aniruddha:

- Organized and formatted all project deliverables, including the final project report, appendices (source code, conference submission, plagiarism report), and supplementary materials (dataset schemas, architecture diagrams).
- Developed comprehensive result visualizations-accuracy/loss curves, confusion matrices, and robustness comparison charts-to clearly communicate model findings and improvements.
- Led the synthesis of key findings into the final discussion and conclusion sections, highlighting the impact of documentation and iterative accuracy improvements on model reliability and deployment readiness.
- Conducted in-depth error analysis on misclassified samples, identifying root causes and iteratively refining preprocessing and model input pipelines to reduce systematic errors.
- Benchmarked and documented the effects of each accuracy improvement step, ensuring that changes were reflected in both the technical documentation and the user-facing materials.

Daily Scrum Activities – Sprint III:

- Synced daily on documentation progress, clarifying technical details and ensuring consistency across all written materials.
- Reviewed and validated each accuracy enhancement step, sharing interim results and discussing further optimization opportunities.
- Debugged and resolved any discrepancies between experimental logs and reported results, maintaining data integrity throughout the documentation process.
- Finalized the assembly of the project book, user manuals, and supplementary appendices, ensuring all deliverables were complete and ready for submission.
- Updated the project management tracker after each documentation and accuracy improvement milestone, maintaining clear visibility on progress and outstanding tasks.

Signature of the Supervisor

Research Article with Journal Publication Details / Patent disclosure form with patent status

Hello,

The following submission has been created.

Track Name: ICDSA2025

Paper ID: 1166

Paper Title: Evaluating Multimodal Fusion Strategies for Resilient Agricultural Sensing Systems

Abstract:
This paper examines three multimodal data fusion techniques Multimodal Data Fusion-based Graph Contrastive Learning (MDFCL), Graph-Structured & Interlaced-Masked Fusion Network (GSIFN), and Perceiver IO—on agricultural time-series data. MDFCL builds individual graphs for each modality and applies unsupervised contrastive losses to align the embeddings of nodes, inducing cross-modal robustness. GSIFN develops an interlaced masking joint Transformer, capturing higher-order interactions with efficiency, along with self-supervised LSTM-based side tasks to counter redundancy. Perceiver IO adopts an implicit-latent bottleneck Transformer, providing heterogeneous streams of agricultural data flexibly with near-linear complexity without individual encoders per modality. Although these models have been found to be successful with generic multimodal tasks, their applicability to fusion of agro-sensor and growth-image data has thus far remained relatively less explored. We evaluate their adaptation versatility, advantages, and limitations in this study, providing actionable recommendations on fusion of agricultural image and time-series data to support precision agriculture with robustness, scalability, and efficiency.

Created on: Fri, 02 May 2025 11:25:03 GMT

Last Modified: Fri, 02 May 2025 11:25:03 GMT

Authors:
- Pp0783@srmist.edu.in (Primary)
- as3735@srmist.edu.in

Primary Subject Area: Data Science Applications

Secondary Subject Areas:
Data Science

Submission Files:
MajorProjectDatFusion.pdf (472 Kb, Fri, 02 May 2025 11:20:04 GMT)

Submission Questions Response:
1. Conflict of interest
Agreement accepted

This project has been submitted to 6th International Conference on Data Science and Applications.

Track Name: ICDSA2025

Paper ID: 1166

Paper Title: Evaluating Multimodal Fusion Strategies for Resilient Agricultural Sensing Systems