Internship Report

DEPARTMENT OF
COMPUTER ENGINEERING

PCET's Pimpri Chinchwad College of Engineering, Pune

Internship report of work in **Department of Computer Engineering, PCET's Pimpri Chinchwad College of Engineering** done by **Kunal Umeshrao Biradar (123B1B098)**

During the period of 02/05/2025 – 01/08/2025 under the guidance of
Dr. Swati V. Shinde

AN INTERNSHIP REPORT ON

Detection of Diabetic Retinopathy using Machine Learning and Deep Learning

SUBMITTED TO THE PIMPRI CHINCHWAD COLLEGE OF ENGINEERING, PUNE
IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE COURSE INTERNSHIP

OF

BACHELOR OF TECHNOLOGY
(COMPUTER ENGINEERING)

SUBMITTED BY

Kunal Umeshrao Biradar (123B1B098)

DEPARTMENT OF COMPUTER ENGINEERING

PCET'S PIMPRI CHINCHWAD COLLEGE OF

ENGINEERING, NIGDI, PUNE 411044

(Academic Year 2025-26)

CERTIFICATE

This is to certify that **Kunal Umeshrao Biradar** has successfully completed his internship work on Research Intern at **Department of Computer Engineering, PCET's Pimpri Chinchwad College of Engineering** during the **02/05/2025 – 01/08//2025** in partial fulfillment for the award of the **Engineering Degree in Computer Engineering.**

Name of Faculty Mentor
Dr. Swati V. Shinde

Head, Department of Computer Engineering
Prof. Dr. Sonali D Patil

Place: Pune

Date:

ABSTRACT

This report details the research work, projects, and learning outcomes accomplished during **Three Month Research Internship** in **Machine Learning and Data Science** at **Department of Computer Engineering, Pimpri Chinchwad College of Engineering** from **May 2, 2025, to August 1, 2025**. The program provided a comprehensive experience by integrating rigorous academic training with the practical application of Deep Learning and Multimodal data analysis principles to solve real-world medical imaging problems.

The research internship was structured around a core research project on Multimodal Diabetic Retinopathy (DR) Classification. This project focused on computer vision and multimodal fusion, utilizing deep learning backbones to classify DR severity levels (NODR, MILD, MODERATE) from RGB fundus images, grayscale images, and clinical metadata (HbA1c, age, glucose levels, comorbidities), and presenting comprehensive performance analysis through interactive evaluation dashboards with confusion matrices, ROC curves and plots, and model comparison visualizations.

This research internship provided invaluable hands-on experience in data preprocessing (image augmentation, metadata engineering), multimodal model building (early-fusion vs late-fusion architectures), and deploying research-grade evaluation pipelines. It was instrumental in bridging the gap between academic machine learning theory and clinical research practice, significantly strengthening my technical skills in deep learning, model interpretability (SHAP), and medical AI evaluation metrics.

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INTRODUCTION

1.1 ORGANIZATION OVERVIEW

Pimpri Chinchwad College of Engineering (PCCOE) is a leading autonomous engineering institution located in Nigdi, Pune, Maharashtra, under the Pimpri Chinchwad Education Trust (PCET). Established in 1999, PCCOE is affiliated with Savitribai Phule Pune University and is recognized for its strong academic culture, industry-oriented training, and focus on research and innovation in engineering and technology. The college offers undergraduate and postgraduate disciplines such as Computer Engineering, Information Technology, Electronics and Telecommunication, Mechanical Engineering, and related fields.

From an institutional standpoint, PCCOE aims to provide quality technical education while simultaneously encouraging applied research and industry collaboration. The institute maintains well-equipped laboratories, modern computing infrastructure, and active industry–academia interfaces through guest lectures, workshops, internships, and sponsored projects

PCCOE also places a strong emphasis on student development beyond the classroom by promoting participation in technical clubs, research groups, hackathons, and professional societies. Students and interns are encouraged to work on live projects in emerging domains such as data science, artificial intelligence, machine learning, and cybersecurity. These initiatives provide a platform to translate theoretical knowledge into practice, build research aptitude, and develop project management and teamwork skills.

As a Research Intern, the work carried out in this project is aligned with PCCOE's broader vision of fostering a research-driven ecosystem. The internship provided an opportunity to contribute to an applied machine learning problem in healthcare (diabetic retinopathy classification), utilizing the college's academic guidance, computational resources, and research-focused environment to design, implement, and evaluate advanced data-driven solutions.

1.2 INTERNSHIP SCOPE

The research internship at **PCCOE** emphasizes a project-driven, academically supervised approach designed to integrate theoretical knowledge with practical research experience. Interns work closely under the guidance of faculty mentors and research supervisors within the college's well-established framework for student internships, which promotes rigorous work ethics and application of domain knowledge.

Internship projects, including the current project on Multimodal Diabetic Retinopathy classification, are expected to promote in-depth learning through hands-on implementation and experimentation. The internship was conducted remotely and onsite within the college's computer engineering department facilities, utilizing PCCOE's computational resources and research support systems.

Key components of the internship structure are:

- **Project-Based Learning:** Interns contribute significantly to theme-specific research projects in my case, designing and evaluating multimodal deep learning models combining retinal images with metadata.
- **Learning and Skill Development:** The internship fosters technical skills in deep learning, medical image analysis, data preprocessing, model fusion, and performance evaluation, alongside soft skills in research communication, time management, and problem solving.
- **Certification:** On successful completion, PCCOE awards an internship certificate endorsed by the department and faculty mentor, valuable for academic credit and professional development.

This structured environment is designed to bridge the gap between classroom learning and real-world research, providing interns with not only technical expertise but also exposure to typical research workflows, critical thinking, and scientific rigor practiced at PCCOE.

1.3 TOOLS AND TECHNOLOGIES USED

1. **TensorFlow/Keras**

   TensorFlow is an end-to-end open-source platform for deep learning, providing GPU acceleration and distributed training capabilities. Keras, a high-level API running atop TensorFlow, facilitates rapid implementation of neural network architectures through its intuitive, object-oriented interface.

2. **Pre-trained CNN Backbones**

   Pre-trained convolutional neural networks leverage transfer learning, where models initially trained on massive datasets like ImageNet capture general visual features (edges, textures, shapes). Fine-tuning these models on domain-specific data significantly reduces training time, computational requirements, and data needs while achieving superior performance compared to training from random initialization.

3. **Scikit-learn**

   Scikit-learn is a comprehensive machine learning library built on NumPy, SciPy, and Matplotlib. It provides consistent interfaces for preprocessing (LabelEncoder, StandardScaler), classical algorithms (DecisionTreeClassifier, RandomForestClassifier), and evaluation metrics, enabling robust train-test splitting and model validation pipelines.

4. **SHAP (SHapley Additive exPlanations)**

   SHAP employs game-theoretic Shapley values to attribute prediction importance to individual features. TreeExplainer provides exact explanations for tree-based models, quantifying clinical metadata contributions (HbA1c, age, comorbidities) in the late-fusion pipeline.

5. **Data Preprocessing and Visualization**

   OpenCV (Open Source Computer Vision Library) handles image preprocessing tasks including resizing, grayscale conversion, and normalization essential for consistent CNN inputs. Pandas provides DataFrame structures for tabular metadata manipulation (missing imputation, feature engineering). NumPy enables efficient multi-dimensional array operations underpinning all numerical computations. Matplotlib generates publication-quality static visualizations. Seaborn builds statistical graphics atop Matplotlib for confusion matrices, ROC/PR curves, and model comparison heatmaps.

1.4 OBJECTIVES OF INTERNSHIP

1. To perform multimodal data preprocessing, including Exploratory Data Analysis (EDA) to understand patterns in fundus images and clinical metadata (HbA1c, age, glucose levels, comorbidities).
2. To engineer clinical features to improve model performance by capturing interactions between image embeddings and metadata variables, such as comorbidity indicators and normalized glucose metrics.
3. To provide side-by-side comparison of CNN backbones using key performance metrics like Accuracy, Macro F1-Score, Quadratic Kappa, MCC, and AUC.
4. To implement early-fusion and late-fusion architectures, combining RGB fundus features, grayscale features, and metadata for comprehensive DR severity classification (NODR, MILD, MODERATE).
5. To develop comprehensive evaluation dashboards to track and visualize key metrics including confusion matrices, ROC/PR curves and plots (ECE), and per-class sensitivity/specificity.
6. To apply model interpretability techniques using SHAP analysis to quantify clinical metadata contributions and validate feature importance in the fusion pipeline.
7. To analyse model robustness across subgroups (age bins, HbA1c levels, test types) and generate publication-ready comparison tables and visualizations for research reporting.

1.5 DURATION AND DATES :

Duration: February 2, 2025 to August 1, 2025 (3 months)

The research internship was a six-month intensive program from May 2, 2025, to August 1, 2025, focused on developing multimodal machine learning models for diabetic retinopathy classification. During this period, I worked under faculty supervision on a research project involving multimodal data preprocessing, deep learning model development, and performance evaluation.

By the end of the program, I had successfully completed the Multimodal Diabetic Retinopathy Classification project, implementing and comparing five CNN with early-fusion and late-fusion architectures. The work produced publication-ready artifacts including confusion matrices, SHAP interpretability plots, and comprehensive model comparison tables, significantly strengthening my research capabilities and readiness for academic publications in medical AI

INTERNSHIP DISCUSSION

Overview of the Internship Experience

Over a three-month period from May 2 to August 1, 2025, I immersed myself in developing a comprehensive Multimodal Diabetic Retinopathy Classification system from the ground up. The goal was to address a critical medical imaging challenge using state-of-the-art deep learning techniques. Moving beyond theoretical coursework, I gained hands-on experience across the complete machine learning pipeline from multimodal data preprocessing to advanced model fusion architectures and rigorous performance evaluation.

Multimodal DR Classification Pipeline Development

The project began with multimodal data preprocessing and EDA, analyzing patterns in RGB fundus images alongside clinical metadata (HbA1c, age, glucose levels, comorbidities). Using TensorFlow/Keras, I implemented and compared five CNN backbones (ResNet50, InceptionV3, VGG16, EfficientNetB0, MobileNetV2) with both early-fusion (CNN embeddings + metadata MLP) and late-fusion (CNN features + DecisionTree probabilities = final classifier) architectures. Performance was rigorously evaluated using metrics like Accuracy, Macro F1-Score visualized through confusion matrices, ROC curves, and plots.

Model Interpretability and Clinical Validation

A key contribution was SHAP-based interpretability analysis using TreeExplainer to quantify clinical metadata importance, validating that HbA1c and comorbidities significantly enhance model predictions beyond image features alone. Risk-coverage analysis demonstrated practical deployment trade-offs, while subgroup robustness testing (age bins, HbA1c levels) ensured clinical relevance across patient demographics.

Summary of Skills and Achievements

This research internship provided comprehensive exposure to the end-to-end medical AI research lifecycle—from data engineering and deep learning implementation to statistical evaluation and interpretability. The project demonstrates proficiency in building publication-ready multimodal models, generating reproducible evaluation pipelines, and producing research artifacts including comparison tables, heatmaps, and calibration curves. This experience transformed complex clinical data challenges into actionable, interpretable AI solutions ready for academic publication and clinical research validation.

LEARNING EXPERIENCE

The research internship at PCCOE provided a practical, hands-on learning experience centered around developing a complete multimodal machine learning system from start to finish. It was a six-month intensive program from May 2 to August 1, 2025, where the focus was on applying deep learning theory to solve a critical medical imaging problem. The experience was structured around a major individual research project under faculty supervision, allowing deep exploration of computer vision, multimodal fusion, and clinical AI evaluation.

3.1 KNOWLEDGE ACQUIRED

During the internship, I acquired comprehensive knowledge across key machine learning and medical AI domains. I gained deep understanding of transfer learning with CNN backbones, learning to fine-tune pre-trained architectures for medical image classification tasks.

In multimodal learning, I mastered techniques for fusing image embeddings with structured clinical data using both early-fusion (concatenation + dense layers) and late-fusion (feature extraction + tree-based classifiers) approaches. The experience provided significant knowledge in model interpretability, applying SHAP analysis to quantify metadata contributions alongside image features.

Finally, I developed strong foundation in clinical AI evaluation, mastering metrics like quadratic kappa, MCC, expected calibration error (ECE), and risk-coverage analysis essential for medical deployment.

3.1.1 SKILLS LEARNED

Technical Skills: Proficiently used Python, TensorFlow/Keras, Scikit-learn; implemented CNN backbones and fusion architectures; applied SHAP TreeExplainer; created OpenCV image pipelines.

Data Science Skills: Mastered multimodal preprocessing, EDA on images+metadata, feature engineering, model evaluation using Accuracy, Macro F1, ROC curves.

Research Skills: Developed publication-ready visualization pipelines, subgroup robustness analysis, and reproducible experiment tracking.

3.1.2 ATTITUDE AND VALUES

The project fostered an attitude of scientific rigor and commitment to clinically interpretable solutions. The focus extended beyond model accuracy to comprehensive evaluation (calibration, subgroup performance) and explainability (SHAP analysis). This reflects values of precision, thorough validation, and understanding end-to-end research workflow required to translate AI models into medical research contributions

3.1.3 MOST CHALLENGING TASK

The multimodal fusion pipeline integration was the most demanding aspect. This required:

- **Architecture Design:** Seamlessly combining RGB CNN, grayscale CNN, and metadata MLP outputs while maintaining gradient flow.
- **Data Alignment:** Synchronizing image-metadata pairs across preprocessing pipelines with varying sample sizes.
- **Evaluation Complexity:** Implementing metrics with plus interpretability (SHAP) and robustness testing (subgroups). Successfully integrating these components into a cohesive, publication-ready system represented higher complexity compared to single-modality baselines.

3.2 SUMMARY OF WORK

The internship was a three-month research program from May 2, 2025, to August 1, 2025, focused on developing a Multimodal Diabetic Retinopathy Classification system. The work centered on completing a comprehensive research project from data preprocessing through model deployment analysis. This involved implementing five CNN backbones with early/late-fusion architectures, generating confusion matrices, ROC/PR curves, calibration plots, SHAP interpretability, and model comparison visualizations.

OUTCOME

The internship provided a practical, hands-on learning experience focused on developing complete, real-world data-driven applications. Conducted over three months from May 2, 2025, to August 1, 2025, the program bridged academic theory with applied research and development in medical AI.

A major outcome was the successful implementation of a Multimodal Diabetic Retinopathy Classification system that uses retinal images and clinical metadata to classify diabetic retinopathy severity levels. The project delivered:

- A comprehensive pipeline for multimodal data preprocessing and feature engineering.
- Implementation and comparison of multiple pretrained CNN backbones combined with clinical metadata through early and late fusion architectures.
- Generation of publication-quality evaluation metrics including accuracy, macro F1-score, quadratic kappa, and expected calibration error.
- Visualization assets such as confusion matrices, ROC/PR curves, calibration plots, and risk-coverage curves.
- Model interpretability analysis using SHAP to explain the impact of clinical features.

Beyond technical deliverables, the internship enhanced skills across the data science lifecycle: experiment design, model training, validation, interpretation, and scientific reporting. Completion earned formal internship certification from PCCOE.

This experience demonstrates the ability to translate complex medical data challenges into functioning AI research prototypes suitable for publication and further development in clinical decision support.

APPENDIX

The following documents and screenshots are attached as part of the appendix to support and validate the internship experience carried out at Department of Computer Engineering. These documents serve as official proof of participation, completion and the work environment experienced during the internship.

A. Internship Offer Letter

The official Mail issued by Dr. Pooja Bidwai Assistant Professor Department of Computer Engineering confirming the internship position of Research Intern from May 02, 2025 to August 01, 2025.

Research Internship Finalization 25 May- 30 June and Action Plan External Inbox ×

POOJA BIDWAI <pooja.bidwai@pccoepune.org>
to sonali.patil, Samarth, SHRAWANI, me

Fri, May 30, 1:07 PM

Dear Ma'am,
Greetings of the day!

As per the directions received during the departmental meeting, I have initiated the Research Internship program scheduled from **25 May to 30 June** for Second Year (SY) and Third Year (TY) students. Various problem statements were shared, and the response was quite encouraging.

After a thorough screening process, including one-on-one interviews conducted via Google Meet, I have finalized the following three students for the internship:

1. **Kunal Biradar** – SY, Division B – CGPA: 8.2
2. **Shrawani Pandey** – TY, Division C – CGPA: 8.16
3. **Samarth Mule** – TY, Division C – CGPA: 7.26

I have collected individual action plans from the selected students, and they have commenced their respective tasks accordingly.

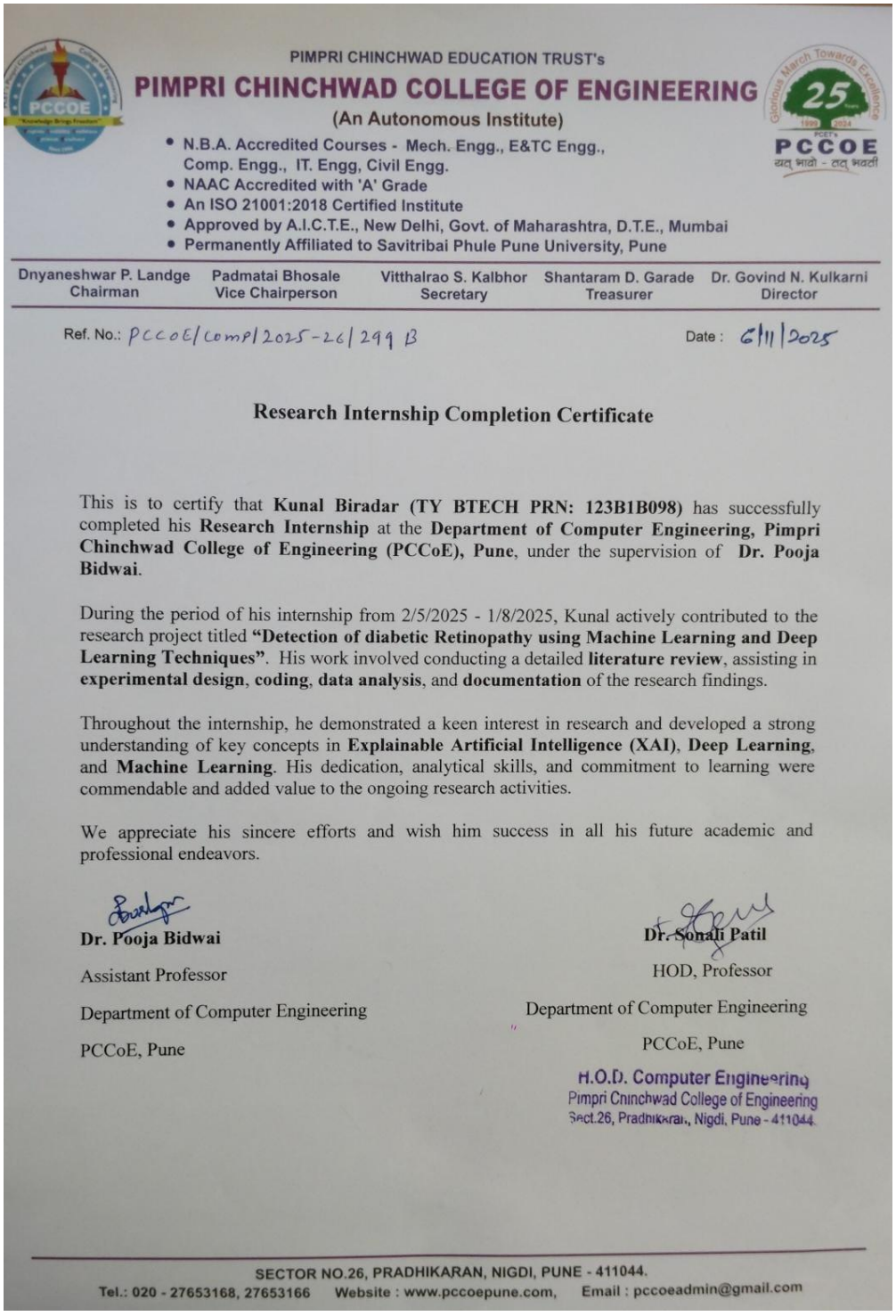
Please find attached the list of problem statements floated and the detailed action plans submitted by each student selected for this internship.

Regards,
Dr. Pooja V Bidwai
Assistant Professor
Department of Computer Engineering
Pimpri Chinchwad College of Engineering
Akurdi Pune 411044

B. Internship Completion Certificate

The completion certificate issued by Department of Computer Engineering on 6th November 2025, certifying the successful completion of the three-month internship program.

Internship Completion Certificate



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Research Internship Completion Certificate

This is to certify that **Kunal Biradar (TY BTECH PRN: 123B1B098)** has successfully completed his **Research Internship** at the **Department of Computer Engineering, Pimpri Chinchwad College of Engineering (PCCoE), Pune**, under the supervision of **Dr. Pooja Bidwai**.

During the period of his internship from 2/5/2025 - 1/8/2025, Kunal actively contributed to the research project titled **"Detection of diabetic Retinopathy using Machine Learning and Deep Learning Techniques"**. His work involved conducting a detailed **literature review**, assisting in **experimental design**, **coding**, **data analysis**, and **documentation** of the research findings.

Throughout the internship, he demonstrated a keen interest in research and developed a strong understanding of key concepts in **Explainable Artificial Intelligence (XAI)**, **Deep Learning**, and **Machine Learning**. His dedication, analytical skills, and commitment to learning were commendable and added value to the ongoing research activities.

We appreciate his sincere efforts and wish him success in all his future academic and professional endeavors.

Dr. Pooja Bidwai
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Dr. Sonali Patil
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LIST OF ABBREVATIONS

ABBREVIATION	ILLUSTRATION
Python	Programming Language used for Data Science and Machine Learning
Pandas	Python library for data manipulation and analysis
NumPy	Python library for numerical computing
Matplotlib	Python library for 2D data visualization
Seaborn	Python library for statistical data visualization
Scikit-learn	Python library for machine learning and predictive modeling
EDA	Exploratory Data Analysis

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