A PROJECT REPORT

on

"FACE RECOGNITION"

Submitted to

KIIT Deemed to be University

In Partial Fulfillment of the Requirement for the Award of

BACHELOR'S DEGREE
COMPUTER SCIENCE & ENGINEERING

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UNDER THE GUIDANCE OF
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CERTIFICATE

This is certify that the project entitled

'FACE RECOGNITION'

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Serves as documentation of their legitimate work completed in order to partially fulfill the requirements for the award of a Bachelor of Engineering degree (Computer Science & Engineering) at KIIT Deemed to be University, Bhubaneswar. This work is completed is 2024-25 under our supervision.

Date:07/04/2025

(**DR. SUCHISMITA DAS**)
Project Guide

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We appreciate the hard effort and dedication of our group members, which allowed us to successfully complete this project. Individual participants' combined efforts and spirit of cooperation made this endeavor fruitful and satisfying.

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ABSTRACT

Automated identification and verification are made possible by facial recognition technology, which has become a fundamental component of many fields, including healthcare, security, and human-computer interface. This study thoroughly assesses feature extraction methods and machine learning models to improve the precision and effectiveness of facial recognition systems.We investigate deep learning-based feature representations using VGG19, a convolutional neural network (CNN) architecture renowned for its strong feature extraction capabilities, as well as more conventional handcrafted feature extraction techniques like Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG). We examine the effectiveness of many machine learning models, such as Support Vector Machines (SVM), Random Forest, XGBoost, and Naïve Bayes, in order to categorize facial traits.

With the greatest classification accuracy of 87%, our experimental results show that ensemble-based machine learning techniques—in particular, XGBoost and Random Forest—perform better than traditional models. Even while deep learning techniques like VGG19 helped to improve feature representations, issues including computational cost, dataset bias, and differences in data variety are still major worries. These difficulties show that more sophisticated methods are required to solve problems with efficiency, generality, and fairness across various facial datasets.The significance of striking a balance between model accuracy, computational viability, and ethical considerations in facial recognition is highlighted by this work. Even while ensemble learning techniques work well, in order to guarantee fair, dependable, and scalable facial classification systems, future research must concentrate on reducing biases, maximizing computational resources, and improving dataset diversity.

Keywords:

1. Neural Networks
2. Real-time Processing
3. Feature Extraction
4. Object Detection
5. Deep Learning
6. Computer Vision
7. Machine Learning
8. Image Processing

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Introduction

Facial recognition technology are now widely used in many industries, such as security, healthcare, and social media user experience. Its capacity to swiftly and precisely identify people has improved user interactions, expedited access management, and increased public safety. Even with these improvements, there are still a lot of issues with the facial recognition systems in use today.Among the difficulties raised are possible prejudices, privacy concerns, and the need for more robust legal systems. By assessing machine learning models including Support Vector Machines (SVM), Random Forest, XGBoost, and Naïve Bayes, as well as deep learning-based approaches like VGG19 and feature extraction strategies like Local Binary Patterns (LBP) and Histogram of Oriented Gradients (HOG), this research seeks to close these gaps. The research aims to improve the accuracy and equity of facial recognition systems by methodically assessing different models and approaches.

Figure 1.1: Face Recognition

This research helps create more accurate, equitable, and morally sound systems by methodically tackling the present issues in facial recognition technology, increasing their usefulness in a variety of fields.

Essential Ideas/Review of the Literature

This literature review synthesises methodologies pertinent to developing a robust face classification system using facial images, with emphasis on deep and handcrafted features.

The system utilizes a twofold feature extraction approach combining deep (VGG19's block5 conv4 layer) and handcrafted approaches. Deep features (4,096 dimensions) encode high-level facial semantics, and handcrafted descriptors such as RGB histograms (color patterns), GLCM (texture), LBP (local textures), and Hu Moments (shape invariance) introduce understandable, low-level cues (789 dimensions). This hybrid feature representation provides an optimal balance between automatic deep feature abstraction and hand-crafted domain expertise, making it well-suited for diverse facial datasets.

It is in keeping with our project's aim of establishing a generalizable system that is compatible with varied facial datasets. Five-classifier experiments highlight ensemble approaches (Random Forest, XGBoost) as better performers, harnessing sequential error correction (boosting) or decorrelated trees (bagging) for precision. Linear SVM's max-margin learning and Naive Bayes' accuracy-vs-speed tradeoff serve as comparative baselines. The standard preprocessing workflow—label encoding, stratified splits, and metric-driven evaluation (accuracy, F1-score, specificity, ROC Curve)—guarantees uniformity. Tree-based models are ideal for deployment on account of computational efficiency with high-dimensional data.

Our face classification system's fundamental needs are addressed directly by this framework:

- Accuracy: The hybrid capabilities add discriminative signals by merging different facial traits.
- Scalability: Tree-based models handle feature-rich inputs effectively, making the system suitable for large-scale datasets.
- Interpretability: Handcrafted features provide a level of interpretability on top, filling the gap between human-interpretable visual cues and deep learning black-box nature.

Future research should focus on hyperparameter optimization and bias reduction to achieve optimal real-world performance.

Problem Statement / Requirement Specifications

Facial recognition plays a significant role in security, healthcare, and human-computer interaction. But attaining high accuracy in facial classification, and performing it in a fair manner, poses further challenges due to dataset diversity, bias, and computational costs. This project we are trying to make a powerful facial recognition system using a combination of handcrafted features (LBP, HOG, GLCM, Hu Moments) along with deep learning based feature extraction (VGG19) features. The goal is to test and compare different machine learning algorithms: SVM, Random Forest, XGboost and Naïve bayes to find the best facial classification algorithm.

3.1 Planning a Project

The project development is sequential:

1. **Requirement Analysis:** Determine user requirements, data sources, and significant features for classification.
2. **Data Collection:** Use the VGG19 dataset to extract features.
3. **Feature Extraction:** Apply handcrafted methods (LBP, HOG, GLCM, Hu Moments) and deep learning-based features.
4. **Model Training and Evaluation:** Train models such as XGBoost, SVM, Random Forest, and Naïve Bayes and evaluate their performance based on accuracy, specificity, and F1-score.
5. **System Implementation:** Develop the system using Python, TensorFlow, and Google Colab.
6. **Testing and Validation:** Compare results with current methods.
7. **Final Deployment and Documentation:** Present findings and suggest future enhancements.

3.2 Analysis of the Project

The gathered requirements and problem statement were examined to determine possible ambiguities, inconsistencies, and difficulties. Some of the main areas of concern are:

- **Data Diversity**: To guarantee a diverse dataset to reduce bias.
- **Computational Efficiency:** Balancing performance with hardware limitations.
- **Model Selection:** Choosing the best algorithm based on evaluation metrics.
- **Security Concerns**: Addressing ethical considerations and potential misuse of biometric data.

3.3 System Design

3.3.1 Design Restrictions

The project operates with the following constraints:

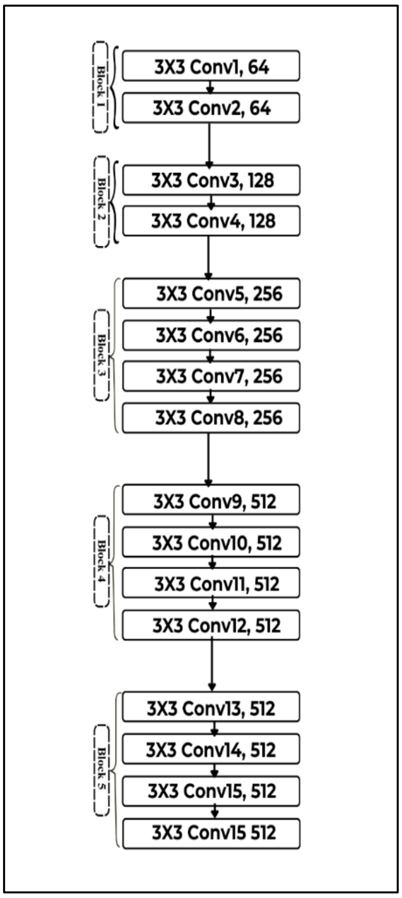
- **Software Requirements:**
  - Programming Languages: Python
  - Development Tools: Jupyter Notebook, VS Code
  - Libraries: TensorFlow, Scikit-learn, OpenCV, Matplotlib

- **Hardware Requirements:**
  - Processor: Intel Core i7
  - RAM: 8GB
  - GPU: Nvidia GeForce GTX 1650
  - Storage: 512GB SSD

- **Experimental Setup:**
  - The system is coded and tested on Google Colab for cloud-based execution.
  - Feature extraction and model training are executed using Python-based machine learning libraries.

3.3.2 System Architecture

- **Block 1(Conv1_64 & Conv2_64):** Two convolution layers with 3×3 filters and 64 channels. Purpose: To learn some of the more basic low level features such as edges, corners and texture patterns from face images.



- **Block 2(Conv3_128 & Conv4_128):** Two convolution layers with 128 filters. Learns slightly more complex features such as contours of eyes, lips etc.

- **Block 3(Conv5–Conv8, 256 filters):** Four convolution layers with 256 filters. Captures mid-level facial structures such as face shape, eye separation etc.

- **Block 4(Conv9–Conv12, 512 filters):** Four convolution layers with 512 filters. Learns high level abstract features which are useful for face differentiation (e.g. identity specific features).

- **Block 5(Conv13-Conv16, 512 filters):** One more set of 512 filter layers to learn more refined discriminative identity features. These features are invariant to pose, lighting and expressions, important for face recognition tasks.

Implementation

4.1 Approach OR Suggestion

To implement the facial recognition system, the following methodology was adopted:

1. **Data Preprocessing:**
   - Collected facial image datasets and applied preprocessing steps such as image resizing, normalization, and augmentation.
   - Implemented OpenCV and PIL for image processing tasks.
2. **Feature Extraction:**
   - Handcrafted Features:
     - LBP: Local Binary Patterns for texture analysis.
     - HOG (Histogram of Oriented Gradients) for edges detection.
     - Gray Level Co-occurrence Matrix (GLCM) for texture classification.
     - Hu Moments for shape based feature representation.
   - Feature Extraction Based on Deep Learning:
     - High-level facial features extracted from the VGG19 pre-trained convolutional neural network (CNN)
3. **Model Training:**
   - Trained various classifiers using the extracted features, including:
     - Support Vector Machine (SVM)
     - Random Forest
     - XGBoost
     -
     - Naïve Bayes
   - Used cross-validation to optimize hyperparameters and improve generalization.
4. **Evaluation Metrics:**
   - Analyzed model performance based on:
     - Accuracy
     - Precision
     - Recall
     - F1-score
     - Specificity
   - Compared results from different classifiers to select the best-performing model.
5. **System Deployment:**
   - Implemented the model using Python and integrated it into a user-friendly application.
   - Utilized Flask/Django for developing a web-based interface.
   - Tested the final system using real-world facial datasets to validate its robustness.

4.2 Plan for Testing or Verification

The system was tested using multiple test cases to verify its correctness and performance. The table below outlines key test cases:

Test ID	Test Case Title	Test Condition	System Behaviour	Expected Result
T01	Model Accuracy Validation	Dataset Input	Model classifies images	Accuracy above 85%
T02	Feature Extraction Check	Input images	Extracted features using LBP, HOG, etc.	Features correctly extracted
T03	Performance Evaluation	Run trained model	Classifier executes in reasonable time	Low latency and high efficiency
T04	GUI functionality	User uploads an image	System processes and classifies	Correct classification displayed
T05	Security Test	Unauthorized access attempt	System denies access	Secure authentication enforced

4.3 Result Analysis

Comparison Table of all classification models:

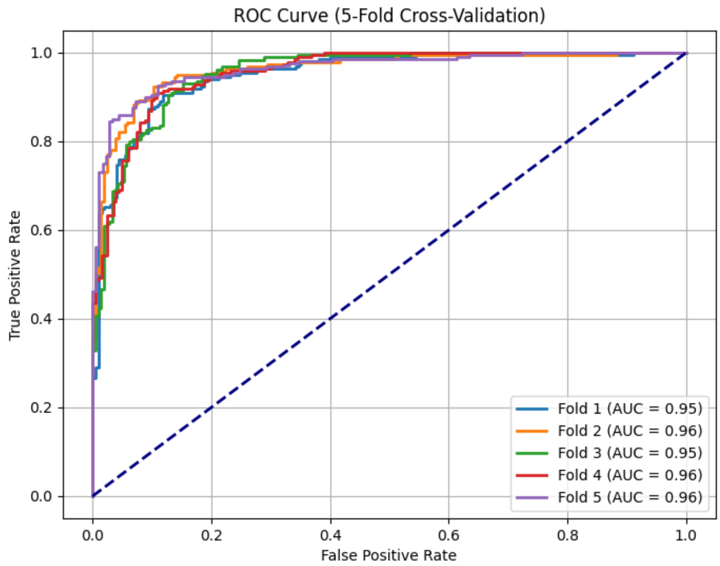
Models	Accuracy	Specificity	F1 Score
SVM	0.85	0.8441	0.85
Random Forest	0.87	0.8707	0.87
Naive Bayes	0.67	0.6046	0.67
XGBoost	0.87	0.8441	0.87
Decision Tree	0.79		

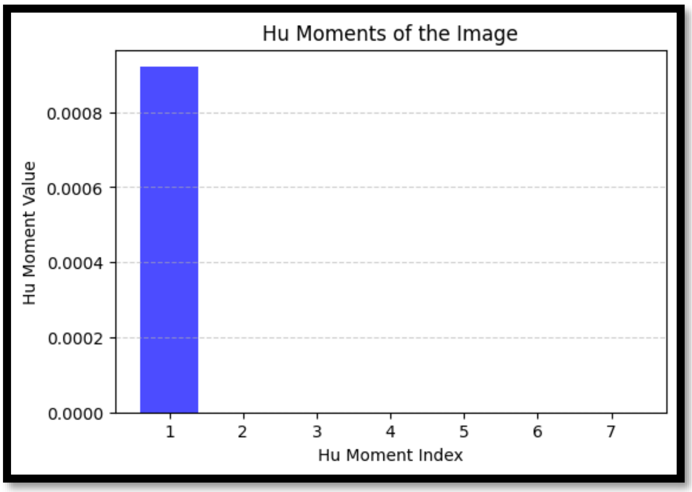
In this project, the XGBoost model showed good performance across several evaluation measures with an *accuracy* of 87%. The *specificity* of *0.8441* also reflects well on the model in classifying true negative cases accurately, and the model's *mean squared error (MSE)* of *0.1277* indicates a relatively low difference between the predicted and true values, highlighting its strength in regression operations.

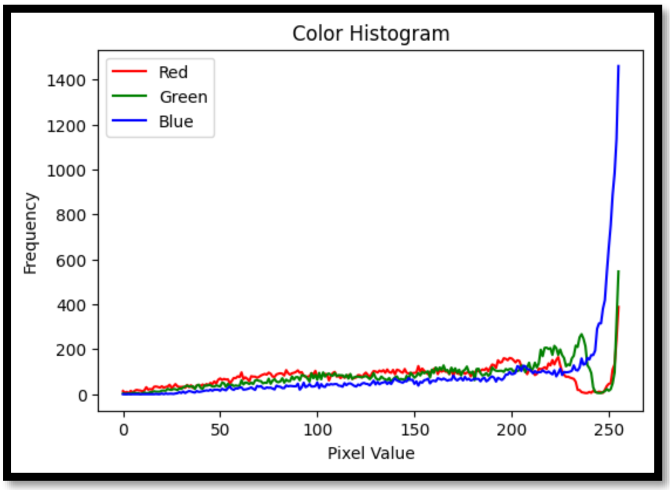
According to the Classification report,

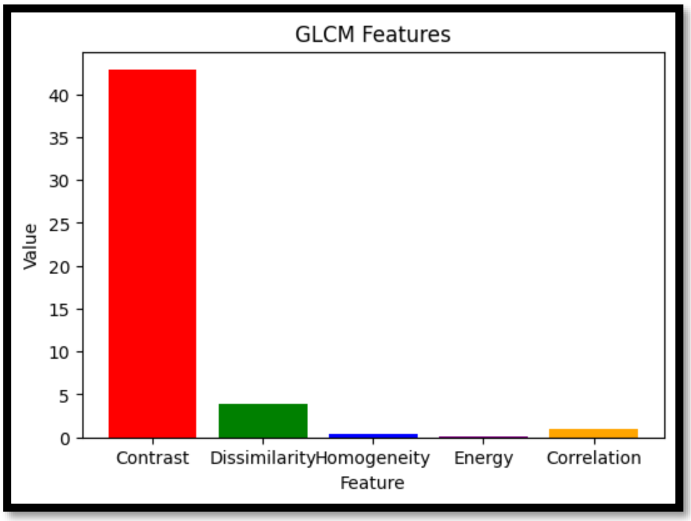
	Precision	Recall	F1-score	Support
Men	**0.91**	**0.84**	**0.87**	**263**
Women	**0.84**	**0.90**	**0.87**	**238**
Accuracy			**0.87**	**501**
Macro Avg	**0.87**	**0.87**	**0.87**	**501**
Weighted Avg	**0.87**	**0.87**	**0.87**	**501**

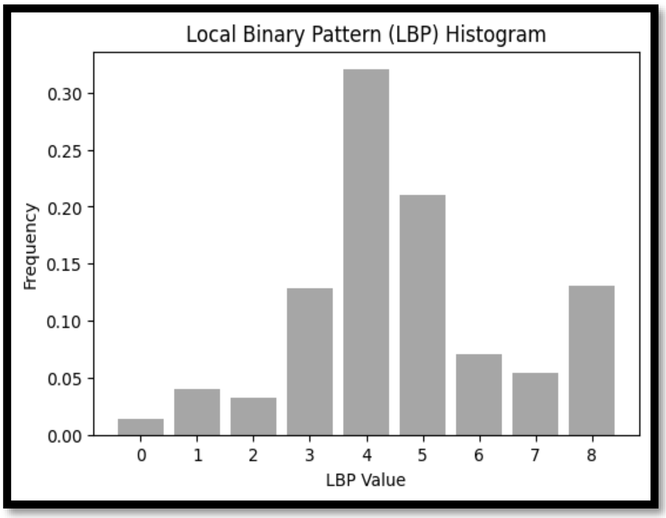
The ROC curve shows that the model has excellent performance, with AUC values between 0.95 and 0.96 across all five folds. The model achieves a high true positive rate with a low false positive rate, reflecting strong sensitivity and specificity.











4.4 Quality Assurance

To ensure the quality of the project, we followed standard machine learning and software development best practices, such as:

- **Dataset Validation:** Validating that there is sufficient quality, diversity in the training data to avoid bias.
- **Model Evaluation:** Comparing multiple models with multiple performance metrics.
- **Code Review:** To maintain clean and efficient code regular reviews.
- **Testing procedures:** Testing every part, including edge cases.
- **Documentation:** Full documentation of processes, results, and improvements.

Adopted Standards

5.1 Design Standards

The project follows internationally recognized design standards such as:

- **IEEE Standards:** IEEE 830-1998 for software requirements specifications.
- **ISO Standards:** ISO/IEC 9126 for software quality attributes.
- **UML Diagrams:** Standardized UML diagrams for system design representation.
- **Database Design:** Normalization techniques to ensure data integrity.

5.2 Coding Standards

To maintain high-quality code, the following coding standards were adopted:

1. Write efficient and concise code.
2. Follow appropriate naming conventions.
3. Maintain modular code structures with well-defined functions.
4. Use consistent indentation and formatting.
5. Apply error handling and exception management.

5.3 Testing Standards

The project adheres to standard testing methodologies, including:

- **IEEE 829:** Software test documentation standard.
- **ISO/IEC 25010:** Software product quality model.
- **Automated Testing:** Unit and integration tests to validate system performance.

Conclusion and Future Scope

This study demonstrates the effective combination of deep learning-based and handcrafted features for facial classification.Ensemble-based techniques like Random Forest and XGBoost demonstrated resilience in managing facial recognition tasks by surpassing the other models examined in terms of accuracy. The findings also demonstrate the shortcomings of probabilistic techniques, such as Naïve Bayes, which have trouble recognizing intricate facial traits.Despite significant advancements, real-world applications still encounter challenges like diverse datasets, high processing costs, and potential biases in recognition.

Significant progress is expected in facial recognition technology, with expected increases in speed and accuracy expanding its uses in security, healthcare, and customized user experiences. Innovative solutions like seamless access management and customized services are anticipated when artificial intelligence and the Internet of Things are integrated. Addressing privacy and ethical issues is still essential as adoption increases, though, in order to guarantee responsible and fair deployment.

The technology in facial recognition is advancing rapidly, and future breakthroughs should increase speed and accuracy to enable real-time identification in diverse environments. There are expected to be sweeping changes in sectors such as security, healthcare, and personalized user interfaces as artificial intelligence converges with the Internet of Things.AI-powered facial recognition, for example, may promote customer experience in retail and home automation use cases, with IoT integration enhancing access control solutions to be more secure and efficient. While the growth in adoption continues, privacy and ethical concerns need to be addressed to ensure responsible deployment and continue to enjoy public trust.

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SAMPLE INDIVIDUAL CONTRIBUTION REPORT:

1. **Deep Saha (2205029)**
   My role was focused on writing the Modeling and Classification and Evaluation Metrics sections of the research paper, as well as designing all graphical images and preparing the PPT. In the Modeling and Classification section, I described the model architecture, feature selection, and classification techniques used. In Evaluation Metrics, I examined the output of each model and have provided accuracy, precision, recall, and F1-score of the best performed model for classification. Additionally, I created all graphical images, ensuring clear visual representation of data, entire classification sequence, and comparative analysis. Lastly, I developed a PPT, structuring the presentation to present our research findings effectively. It also My contributions played a crucial role in enhancing the paper's technical clarity, visual appeal, and overall comprehensibility.

   Full signature of the student

2. **Kaustabh Shit (2205131)**
   I have completed all the code for face recognition using a Kaggle dataset. Initially, I used VGG19 to extract features and then integrated them into deep features to form the main feature vector. After that, I applied various deep learning models, including SVM, Naïve Bayes, Decision Tree, and Random Forest, to evaluate accuracy, specificity, and other performance metrics. Additionally, I implemented ROC curves, loss vs. epoch curves, and accuracy vs. epoch curves. I also applied K-fold cross-validation to one of the classifiers and analyzed the results using the aforementioned curves.

   My major contributions included writing a significant part of the code, guiding my teammates throughout the project, merging individual report sections into a single cohesive document, and editing it for conciseness and proper sequencing.

   Full signature of the student

3. **Piyush Anand (2205143)**
   I contributed to the research project in many ways. I helped code the facial recognition system, fixed bugs, and ensured that everything ran smoothly. I also assisted in compiling our findings, simplifying the data, and played a pivotal role in delivering the presentation for the mini project. Apart from that, I contributed to writing the research paper by creating charts and tables to finalize our results, organizing references and endnotes, and drawing conclusions by comparing our model with other standard models.

   Full signature of the student

4. **Ranita Tripathy (2205150)**
My major contribution to this project was writing the introduction and literature review, covering various aspects and research components. I contributed to both the report and the conference paper, including compiling all reference links to ensure consistency in our documentation.I reviewed 7 to 8 research papers, extracting key features such as accuracy, K-fold values, and other performance metrics. I then created a results table by comparing our project outcomes with the findings from these research papers, analyzing the differences between our model's performance and the expected results.Additionally, I worked with extracted features from the code, various curves, and diagrams, and contributed to creating a few slides for the team's PowerPoint presentation. I will also be presenting some parts of the project on behalf of my team.

Full signature of the student

5. **Tannistha Misra (2205168)**
I made significant contributions to the research project in various ways.
I have written abstract of the research paper, which details about the whole research paper and also came up with keywords that describe the paper best and help other people find the research paper. After thoroughly understanding the topic and its details, I have also concluded the research paper. Additionally, I have helped in making presentation and delivering it , ensuring that all the key points are well explained.

Full signature of the student

6. **Pratyush Singh (22051961)**
My role was focused on writing the methodology of the face recognition paper, as well as Problem Statement, Implementation and Standards Adopted in the mini project report. In the face recognition paper I wrote about dataset selection, preprocessing steps sand implementation of the VGG19 model. In Problem Statement, I elaborated on workflow complexity and preprocessing steps for training models while in Implementation, I described the coding, tools, and execution steps, and finally analyzed the performance and results of the model in Standards Adopted. My contributions helped in achieving operational success by ensuring clarity in methodology, technical execution, and result interpretation.

Full signature of the student