Pneumonia Severity Detection from X-ray Images with Captioning

Final Project Proposal Report – Milestone 1

Digital Egypt Pioneers Initiative (DEPI)

Team Members:

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- Omar El Banna
- Ali Mohamed
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Project Description

This project, conducted under the **Digital Egypt Pioneers Initiative (DEPI)**, focuses on developing an intelligent and explainable system to detect pneumonia severity from chest X-ray images. The pipeline integrates **deep learning and image captioning** to enhance diagnostic transparency.

A **Convolutional Neural Network (CNN)** will serve as the base model, while several pretrained architectures such as **DenseNet121**, **ResNet50**, and **VGG16** will be evaluated through transfer learning and fine-tuning. The objective is to determine the most effective architecture for accurate and interpretable pneumonia detection by leveraging **deep learning techniques**, we aim to build an automated system that can accurately classify X-ray images as either pneumonia-positive or normal with the inclusion of captioning provides contextual insights into the model's predictions, improving trust and usability in medical environments.

Group Members & Roles

The project responsibilities are distributed among the team members to ensure efficient progress and collective contribution. The most challenging tasks—such as **model fine-tuning, captioning module integration, and performance evaluation**—are shared among all members to leverage combined expertise.

- **Abdellatif El Batrawy (Team Leader)** – Coordination, Project Integration, and Shared Model Evaluation
- **Ibrahim Hanafy** – Data Preprocessing, Model Training, and Shared Fine-Tuning
- **Ramez Farouk** – Image Annotation, Captioning Pipeline, and Shared Evaluation
- **Omar El Banna** – Model Optimization, Shared Fine-Tuning, and Performance Assessment
- **Ali Mohamed** – Visualization, Reporting, and Shared Captioning Integration
- **Amr Ghoniem** – Dataset Management, Testing, and Shared Fine-Tuning Tasks

Objectives

The objective of this project is to develop an **AI-powered computer vision model** capable of automatically detecting pneumonia from chest X-ray images and accurately scoring disease severity, thereby supporting clinicians in making faster, more reliable, and resource-efficient diagnostic and treatment decisions.

- Develop an AI-powered computer vision model to detect pneumonia and assess severity from chest X-rays.
- Design a deep learning pipeline that integrates multiple pretrained architectures (DenseNet, ResNet50, VGG16) and select the best-performing model. Combine the vision and language components to produce explainable outputs that improve model interpretability and clinician trust.
- Implement an NLP-based captioning module to generate descriptive medical insights from detected features.
- Combine vision and language outputs to improve interpretability and clinician trust. Optimize model efficiency for real-time inference in clinical and research settings.
- Ensure robustness through augmentation, cross-validation, and multi-dataset training.
- Optimize efficiency for real-time inference in clinical settings.
- Prepare the system for deployment as a scalable, web-accessible diagnostic assistant.

Tools & Technology

- **Programming Language:** Python
- **Frameworks & Libraries:** TensorFlow, Keras, PyTorch, Scikit-learn, OpenCV
- **Data Handling:** Pandas, NumPy
- **Deployment:** Flask/FastAPI, Django
- **Collaboration & Version Control:** GitHub**,** Google Collab, Kaggle
- **Visualization:** Matplotlib, Seaborn

Milestones & Deadlines (Milestone 1 Focus)

Milestone 1: Data Collection & Cleaning (14/9/2025)

Objectives:

- Collect and organize chest X-ray datasets suitable for pneumonia detection.
- Preprocess and clean the data to ensure quality and consistency.

Tasks:

1. Data Collection:

- Gather datasets from RSNA Pneumonia Challenge and complementary PNG/X-ray repositories.
- Extract metadata from DICOM files (patient info, image dimensions, imaging parameters).

2. Data Preprocessing:

- Normalize, resize, and enhance image contrast.
- Remove duplicates, corrupted samples, and irrelevant metadata.
- Split data into training, validation, and test sets.

3. Exploratory Data Analysis (EDA):

- Visualize sample images and class distributions.
- Identify imbalances or biases in the dataset.

4. Deliverables:

- Cleaned and preprocessed dataset ready for model development.
- Preprocessing pipeline documentation.
- EDA report with visualizations and identified challenges

Milestone 2: Model Architecture Design (14/9/2025)

Objectives:

- Design baseline and advanced deep learning architectures for pneumonia detection.
- Ensure computational efficiency for real-world deployment.

Tasks:

1. Baseline Model:

- Implement CNN to establish initial benchmarks.

2. Advanced Architectures:

- Explore pretrained models (ResNet, DenseNet, EfficientNet, VGG16).
- Compare architectures for accuracy, speed, and scalability.

3. Design Blueprint:

- Finalize architecture design balancing performance and efficiency.

4. Deliverables:

- Baseline CNN model design.
- Architecture comparison report.
- Finalized architecture blueprint.

Milestone 3: Training & Optimization (5/10/2025)

Objectives:

- Train and optimize selected models for pneumonia detection.
- Improve generalization and reduce overfitting.

Tasks:

1. Model Training:

- Train baseline and pretrained models on the cleaned dataset.

2. Optimization:

- Apply hyperparameter tuning, dropout, and regularization.
- Use transfer learning for improved performance.
- Split data into training, validation, and test sets.

3. Evaluation:

- Compare models using accuracy, F1-score, and error rates.
- Select best-performing model for deployment.

4. Deliverables:

- Trained pneumonia detection models.
- Optimization logs and results.
- Model evaluation report.

Milestone 4: Captioning Module Integration (19/10/2025)

Objectives:

- Integrate an NLP-based captioning module for explainable predictions
- Provide descriptive insights alongside classification results

Tasks:

1. Captioning Pipeline:

- Implement rule-based or lightweight NLP model for captions.
- Link image features to descriptive medical text.

2. Integration:

- Combine vision and language outputs into a unified system.
- Validate captions with sample predictions.

4. Deliverables:

- Captioning module integrated with pneumonia detection model.
- Sample outputs with explanatory captions.

Milestone 5: Deployment & Testing (10/11/2025)

Objectives:

- Deploy the trained model and captioning system as a web-accessible application.
- Test performance, scalability, and usability

Tasks:

1. Deployment Setup:

- Build it using Flask, Fast API, and Django.
- Containerize application for portability.

2. Testing:

- Conduct functional and stress testing.
- Measure response time, uptime, and scalability.

3. User Validation:

- Collect feedback on usability and interpretability.

4. Deliverables:

- Deployed pneumonia detection system with captioning.
- API endpoints for real-time predictions.

Milestone 6: Final Report & Presentation (25/11/2025)

Objectives:

- Summarize the entire project in a final report and presentation.
- Highlight technical achievements, results, and business impact.

Tasks:

1. Final Report:

- Document methodology, results, and challenges.
- Include visualizations, evaluation metrics, and deployment details.

2. Testing:

- Conduct functional and stress testing.
- Measure response time, uptime, and scalability.

3. Presentation:

- Prepare slides and video demo.
- Showcase explainable predictions and system usability.

4. Deliverables:

- Final project report
- Presentation slides and demonstration.

Key Performance Indicators (KPIs)

- 1. Data Quality
    - Missing values handled: 100%
    - Data accuracy after preprocessing: ≥ 95%
    - Dataset diversity (balanced classes): ≥ 90% representation
- 2. Model Performance
    - Accuracy/F1-Score: ≥ 90%
    - Prediction latency: ≤ 200 MS per image
    - Error rate (False Positives/Negatives): ≤ 10%
- 3. Deployment & Scalability
    - API uptime: ≥ 99%
    - Response time per request: ≤ 250ms
- 4. Business Impact & Practical Use
    - Reduction in manual effort: ≥ 65%
    - Expected cost savings: ≥ 45%
    - User satisfaction (via surveys): ≥ 90% positive feedback