SmartBridge – Real-time Bone Fracture Detection with YOLO-V8 Using X-ray Images

Milestone 1: Project Initialization and Planning Phase

The project initialization and planning phase focused on defining objectives, outlining scope, and establishing milestones for real-time bone fracture detection using YOLO-V8. Key activities included identifying high-quality X-ray datasets, selecting YOLO-V8 for its accuracy and speed, and planning data preprocessing, model training, and evaluation steps. The team structured tasks into agile sprints, ensuring efficient resource allocation and timeline management. Critical success criteria, such as achieving high precision and recall, were set, alongside plans for model deployment and integration into real-time diagnostic systems.

Activity 1: Define Problem Statement

Problem Statement: Detecting bone fractures in X-ray images is often slow and prone to errors due to manual analysis, high workloads, and human fatigue. These delays can lead to misdiagnoses and improper treatment, worsening patient outcomes. Radiologists and doctors need a reliable, real-time AI-powered system to assist with accurate and faster fracture detection, reducing errors and enhancing patient care efficiency**.** Bone fractures are a common and potentially debilitating injury. Timely and accurate diagnosis is crucial for effective treatment and prevention of long-term complications. However, interpreting X-ray images to detect fractures can be challenging, even for experienced radiologists.

Problem Statement Report: Click Here

Activity 2: Initial Project Planning

The initial project planning for real-time bone fracture detection involves defining objectives, collecting annotated X-ray datasets, and selecting YOLO-V8 for its speed and accuracy in detecting fractures. The plan includes preprocessing data through normalization, augmentation, and formatting for YOLO compatibility. Tasks are organized into sprints, covering data preparation, model training, validation, and deployment. Key milestones include achieving high precision and recall during validation and integrating the model into a user-friendly interface for real-time diagnostics. Resources, such as GPUs and medical datasets, are allocated to ensure efficient execution**.**

Project Planning Report: Click Here

Activity 3: Project Proposal (Proposed Solution)

The proposed solution utilizes YOLO-V8 to enable real-time and accurate bone fracture detection from X-ray images. It involves preprocessing data, annotating fractures, and training the model to handle variations in image quality and fracture types. The system is optimized for speed and accuracy through hyperparameter tuning. Integrated into a web application, it provides instant diagnostic results, reducing human error and expediting medical decision-making. This approach enhances efficiency in clinical workflows, especially in time-critical scenarios.

Project Proposal Report : Click Here

Milestone 2: Data Collection and Preprocessing Phase

The data collection and preprocessing phase involved sourcing X-ray images from public medical databases and hospital archives, ensuring diverse coverage of fracture types and patient demographics. Images were annotated with bounding boxes in YOLO format to facilitate training. Preprocessing steps included resizing images for consistent input dimensions, normalizing pixel values, and applying noise reduction techniques to enhance clarity. Data augmentation, such as rotations, flips, and brightness adjustments, was employed to improve model robustness. This phase ensured a high-quality dataset ready for effective YOLO-V8 training.

Activity 1: Data Preprocessing

Preprocessing involves resizing X-ray images to a consistent input size, normalizing pixel values for uniformity, and applying noise reduction techniques to enhance image clarity. Data augmentation, including rotations, flips, and brightness adjustments, is used to improve model robustness. Labels are converted into YOLO-compatible formats for efficient training.

Data Collection Report : Click Here

Activity 2: Data Quality Report

The data quality report for the real-time bone fracture detection project highlights key attributes of the X-ray dataset. The dataset consists of images, training and validation, covering diverse fracture types and locations. Images are annotated in YOLO format with bounding boxes to ensure precise labeling. Preprocessing steps, including noise reduction and normalization, were applied to enhance clarity and consistency. Initial analysis revealed

some imbalances in fracture types, which were addressed using augmentation techniques. Overall, the dataset is robust, well-prepared, and suitable for training the YOLO-V8 model.

Data Quality Report : Click Here

Activity 3: Raw Data Sources And Data Quality Report

The data collection plan sources annotated X-ray images from platforms like Kaggle and Roboflow, focusing on diverse fracture types. Raw data will be preprocessed with resizing and noise reduction to ensure quality for YOLO-V8 training.

Raw Data Sources And Data Quality Report: Click Here

Milestone 3: Model Development Phase

The model development phase focused on training the YOLO-V8 model using the preprocessed X-ray dataset. Key tasks included configuring the model architecture, optimizing hyperparameters like learning rate and batch size, and leveraging GPU acceleration for efficient training. The model was evaluated iteratively, achieving an mAP@50 of 95.2%, with high precision and recall. Performance improvements were made through fine-tuning and additional data augmentation. The phase concluded with saving the best-performing model for integration into real-time diagnostic systems.

Activity 1: Initial Model Training Code, Model Validation and Evaluation

The initial model training for real-time bone fracture detection using YOLO-V8 achieved promising results. With training images and validation images, the model reached 95% and a precision of 98.5%. The training process, completed in 2 hours on an NVIDIA V100 GPU, demonstrated efficient convergence with low classification and localization losses. Validation confirmed consistent performance with 94.7%. Although the model performed well in detecting fractures, improvements in recall and handling complex cases are possible with further dataset augmentation and hyperparameter tuning.

Initial Model Training Code, Model Validation and Evaluation: Click Here

Activity 2: Model Selection Report

In the model selection report for future deep learning and computer vision projects, various architectures, such as CNNs or RNNs, will be evaluated. Factors such as performance, complexity, and computational requirements will be considered to determine the most suitable model for the task at hand.

Model Selection Report: Click Here

Milestone 4: Model Optimization and Tuning Phase

The model optimization and tuning phase aimed to enhance the YOLO-V8 model's performance for accurate fracture detection. Key activities included hyperparameter tuning, such as adjusting learning rates, batch sizes, and confidence thresholds, to maximize mAP@50 and recall. Techniques like regularization and early stopping were used to prevent overfitting, while additional augmentation improved generalization. Performance was monitored through iterative validation, achieving an optimized balance between precision (98.5%) and recall (93.6%). This phase ensured the model's robustness and readiness for real-time deployment.

Activity 1: Hyperparameter Tuning Documentation

The hyperparameter tuning process for real-time bone fracture detection involved optimizing key parameters such as learning rate, batch size, and image resolution to enhance model performance. A grid search and iterative testing approach were employed to identify configurations that maximize precision, recall, and mAP@50. Regularization techniques and early stopping were incorporated to prevent overfitting and ensure robust generalization.

Activity 2: Performance Metrics Comparison Report

The performance metrics comparison report evaluates YOLO-V8 across precision, recall, and mAP@50. The model achieved an mAP@50 of 95.2%, precision of 98.5%, and recall of 93.6% on validation data. These metrics highlight the model's strong accuracy in detecting fractures, with minor areas for improvement in recall for better detection of subtle cases.

Activity 3: Final Model Selection Justification

The YOLO-V8 model was selected for its high accuracy, real-time detection capabilities, and robust performance on medical imaging tasks. It achieved an mAP@50 of 95.2%, demonstrating strong fracture detection precision and recall. Its lightweight architecture and adaptability make it ideal for deployment in clinical settings.

Model Optimization and Tuning Phase Report : Click Here

Milestone 5: Project Files Submission and Documentation

For project file submission in GitHub, Kindly click the link and refer to the flow. **Click Here**

Milestone 6: Project Demonstration

In the upcoming module called Project Demonstration, individuals will be required to record a video by sharing their screens. They will need to explain their project and demonstrate its execution during the presentation. **Click Here**