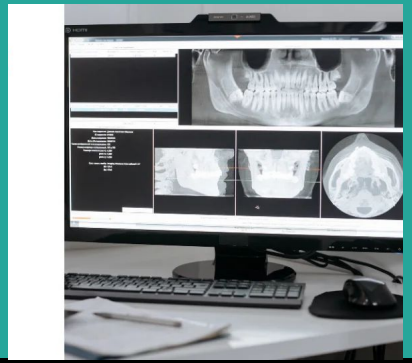
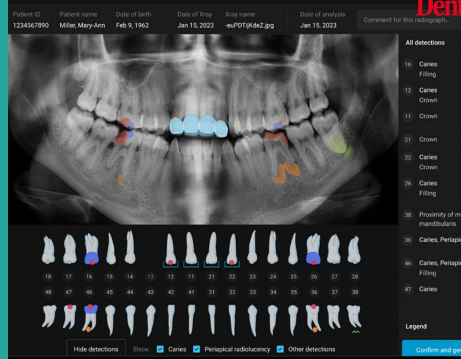




Deep Learning-Based Automatic Diagnosis of Periodontal Diseases from X-rays

By Shamiso Mubatsa and Bindu Mamillapalli

https://youtu.be/109-I9Ij9Jg

Introduction

- Periodontal diseases, such as dental caries, gingivitis and periodontitis affect millions globally.(Cantu et al., 2020).
- They can lead to tooth loss and have been linked to systemic conditions like cardiovascular diseases and diabetes.
- Early diagnosis is critical but often missed in multiple cases.
- This project uses AI to automate cavity detection from dental X-rays.

PROBLEM STATEMENT

- Diagnosing periodontal diseases relies heavily on human expertise through visual inspection of dental X-rays.
- Subject to human error, inconsistency, and time constraints.
- Shortage of dental professionals in rural or underserved regions.

OBJECTIVES

Build an AI-based system to detect periodontal diseases from X-ray images.

Train and fine-tune a deep learning model on a small, publicly available dataset.

Evaluate model performance using accuracy, confusion matrix, and visual explanations

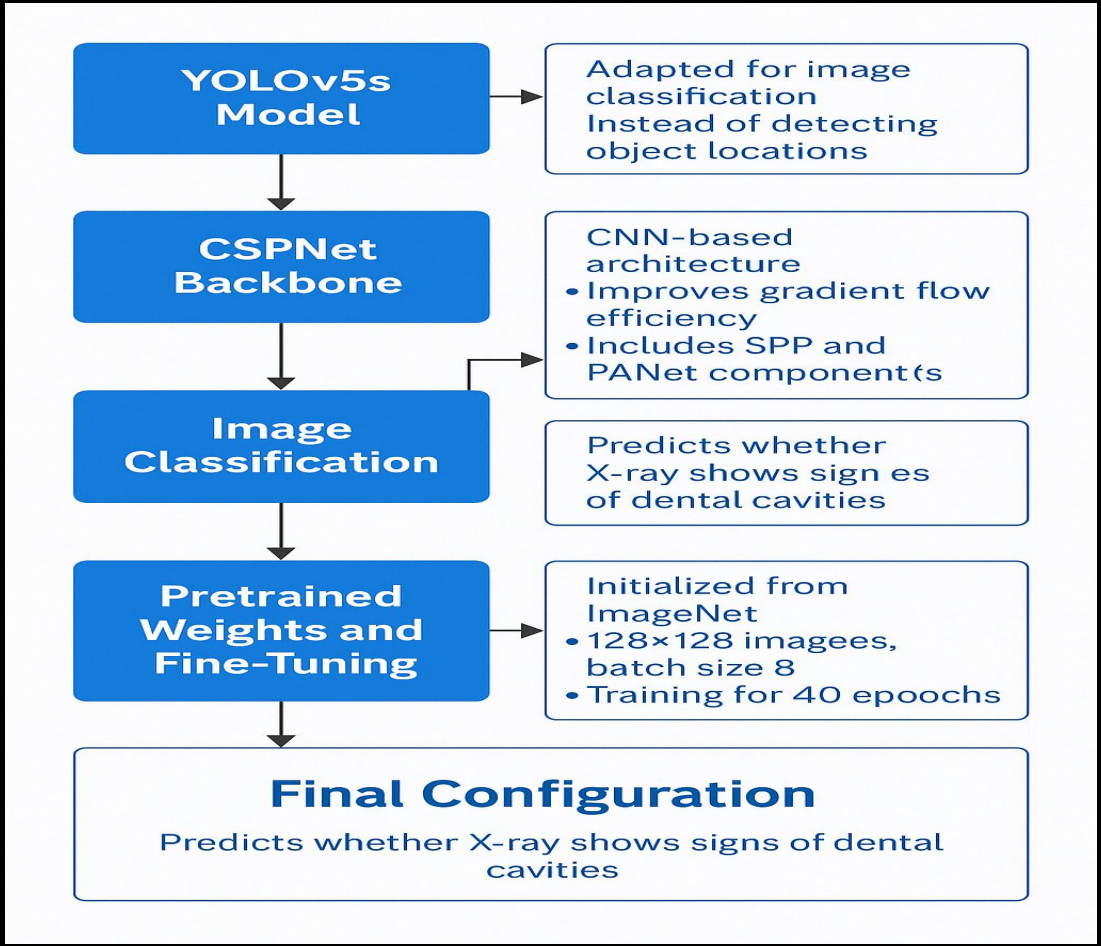
Literature Review

- Previous studies have shown success using CNNs for dental caries detection (e.g., Cantu et al., 2020).
- Grad-CAM has been widely adopted for visual interpretability in medical imaging. (Selvaraju et al., 2017).
- Roboflow and Kaggle datasets have enabled democratized access to annotated dental images.
- Few real-world studies have explored YOLOv5 for X-ray classification, presenting a unique research gap this project addresses.

DATA SET OVERVIEW

- Source: Roboflow Universe (public dataset repository)
- 2,000 labeled images: with_cavity and without_cavity
- Split into training, validation, and test sets
- Preprocessing: resizing, normalization, augmentation

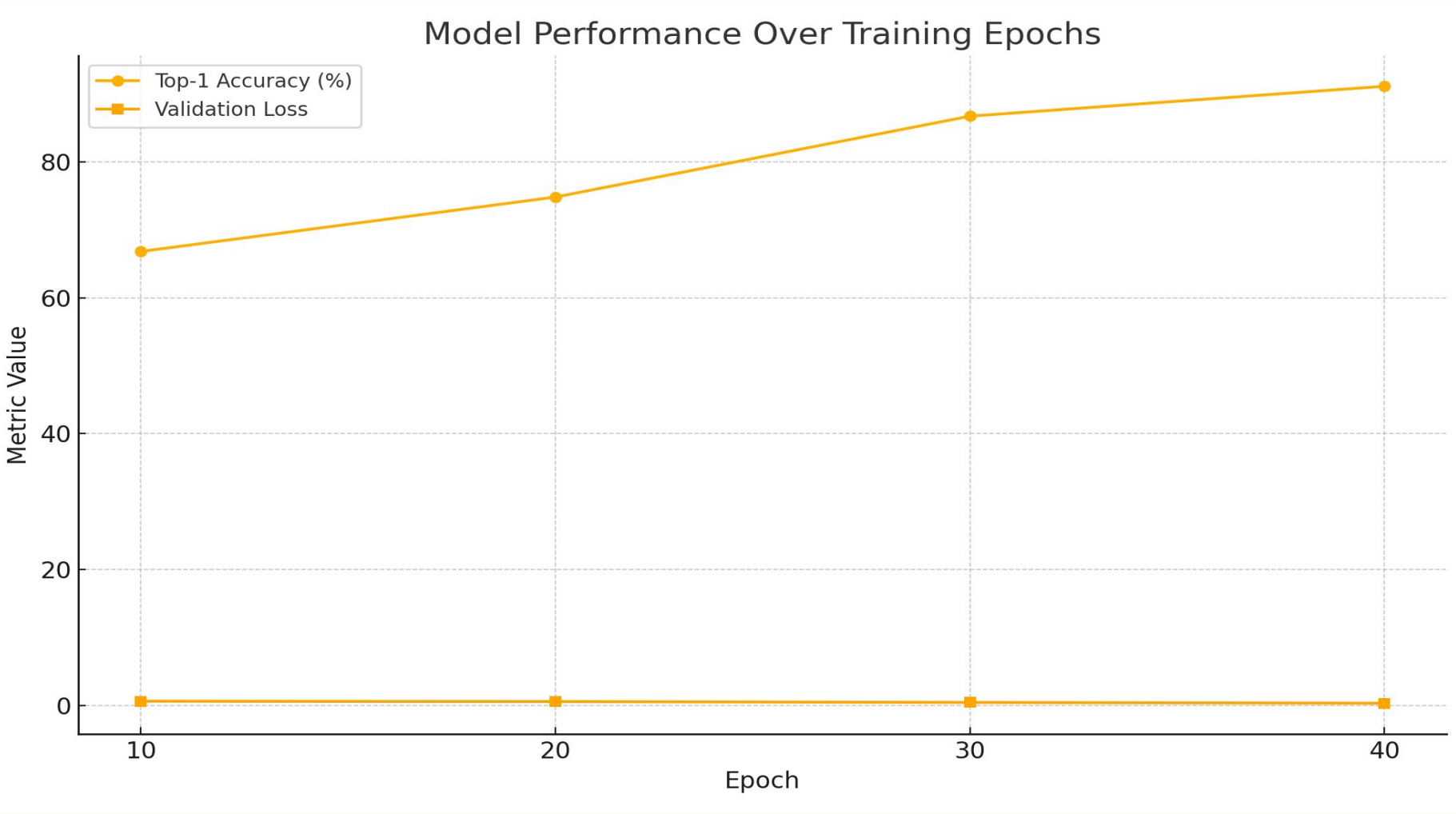
Model Architecture



- The entire project was developed in **Google Colab**.
- Key libraries used include Ultralytics for YOLOv5, PyTorch for deep learning, and OpenCV/Matplotlib for visualization.
- Model training, evaluation, and Grad-CAM generation were done in Colab with GPU acceleration.

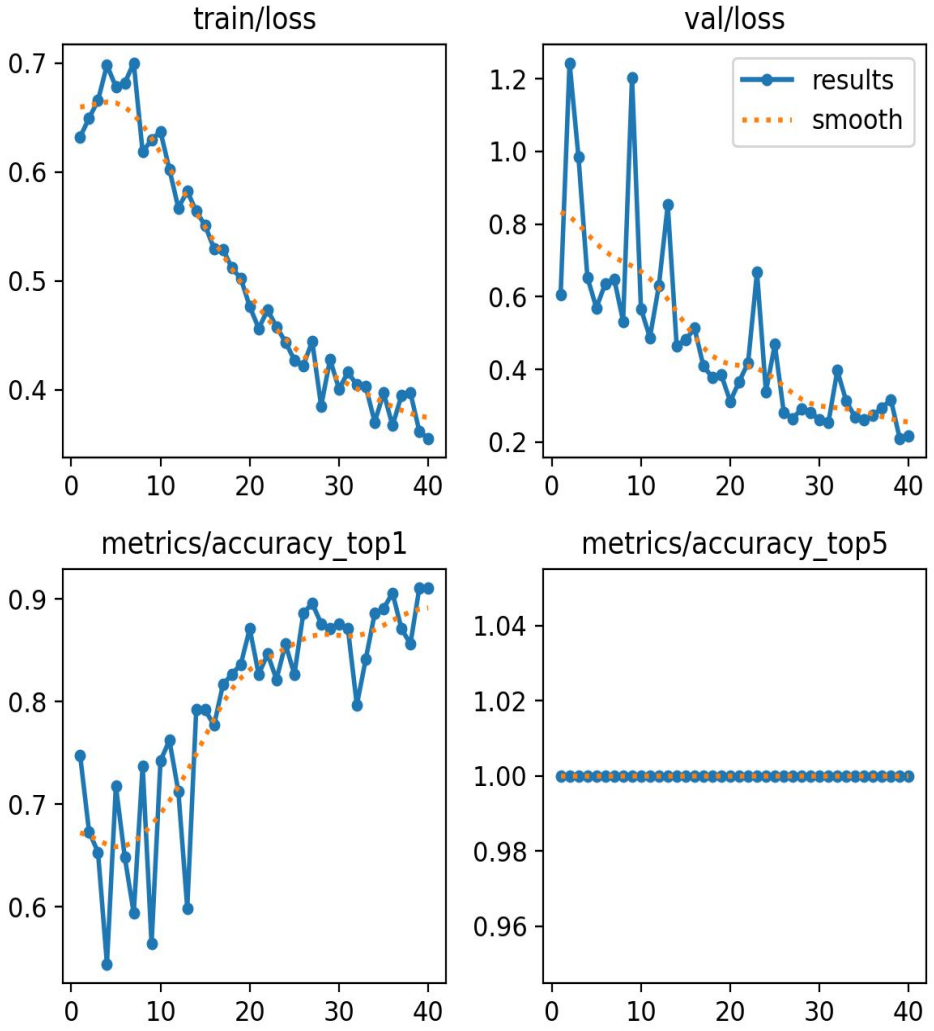
Training progress summary

- Epoch 10: Accuracy = 66.8%, val loss = 0.65
- Epoch 20: Accuracy = 74.8%, val loss = 0.60
- Epoch 30: Accuracy = 86.7%, val loss = 0.47
- Epoch 40: Accuracy = 91.1%, val loss = 0.35
- Confusion matrix improved with each tuning cycle, indicating better class separation and reduced misclassification.


Model Performance Over Training Epochs
Top-1 Accuracy (%)
Validation Loss
Metric Value
0
20
40
60
80
10
20
30
40
Epoch

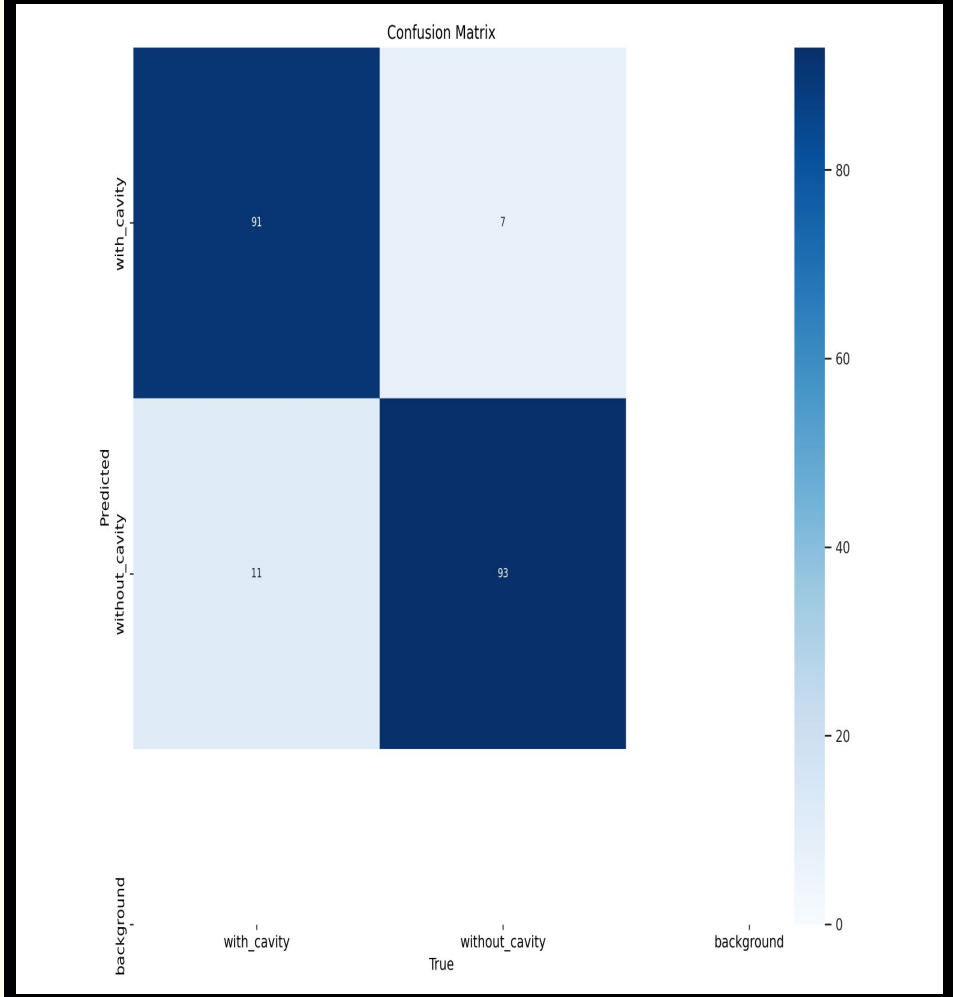
Model Training results

- Final Accuracy: 91.1%
- Validation loss reduced steadily
- Best performance at epoch 40
- No overfitting observed



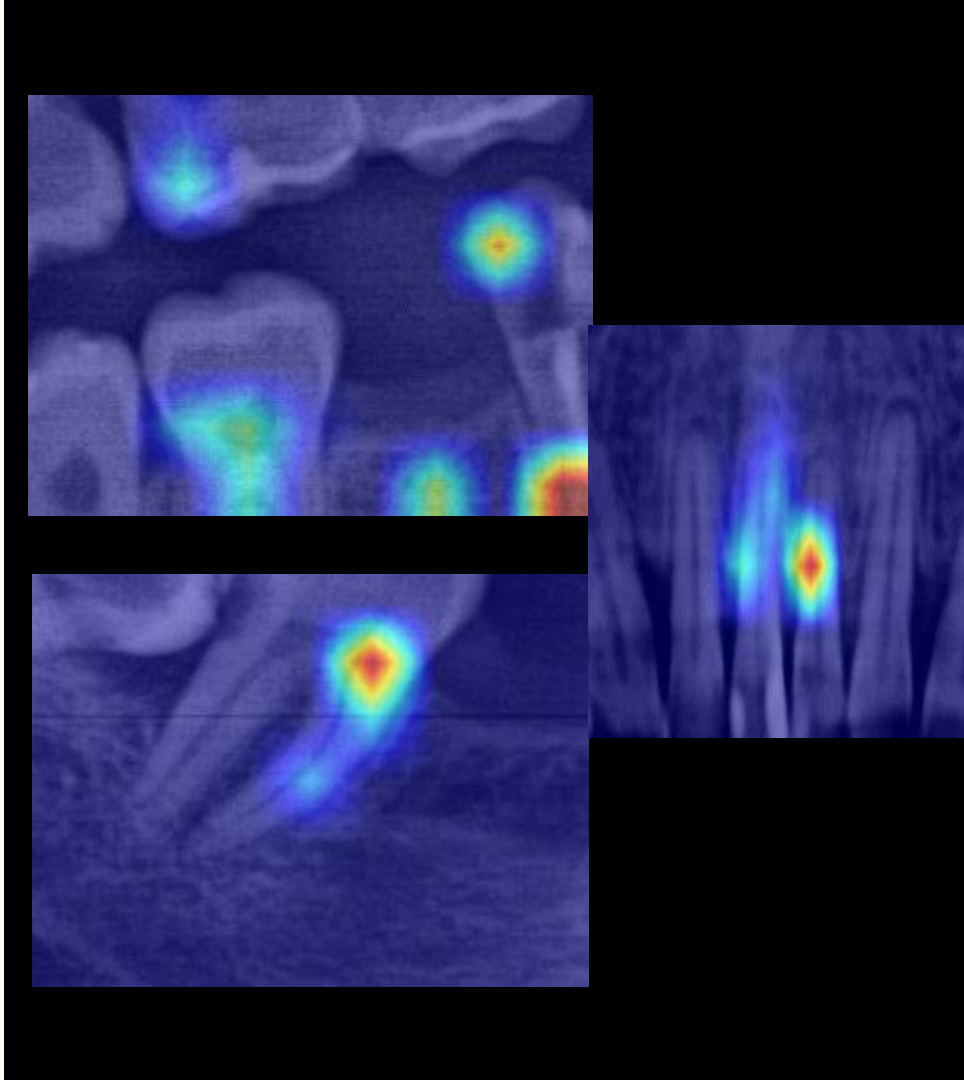
Confusion Matrix

- High true positive and true negative rates.
- Low false positives and false negatives.
- Significant improvement after tuning.



Grad-CAM results

- Heatmaps clearly highlight cavity regions
- Validates model's attention in meaningful areas.
- Enhances confidence in predictions.



Challenges Encountered

- Limited dataset size
- Class imbalance between healthy and diseased images
- Need for hyperparameter tuning
- Understanding internal layers for Grad-CAM targeting

Solutions Applied

- Data augmentation to expand dataset
- Custom learning rate and increased epochs
- Grad-CAM integration for explainability
- Multiple test cycles for consistent results

CONCLUSIONS

- Developed a deep learning-based diagnostic tool with over 91% classification accuracy.
- Successfully integrated Grad-CAM to make AI predictions interpretable and trustworthy for medical use.
- Demonstrated effectiveness even with a limited dataset through careful tuning and transfer learning.
- Paved the way for future enhancements such as cloud deployment, real-time inference, and extension to other dental pathologies.Future work: Web app, multi-condition classification

References

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THANK YOU