Enhancing wrist fracture detection in wrist x-ray images using deep learning models

Using Feature Concatenation to Enhance Deep Learning for Wrist Fracture Detection

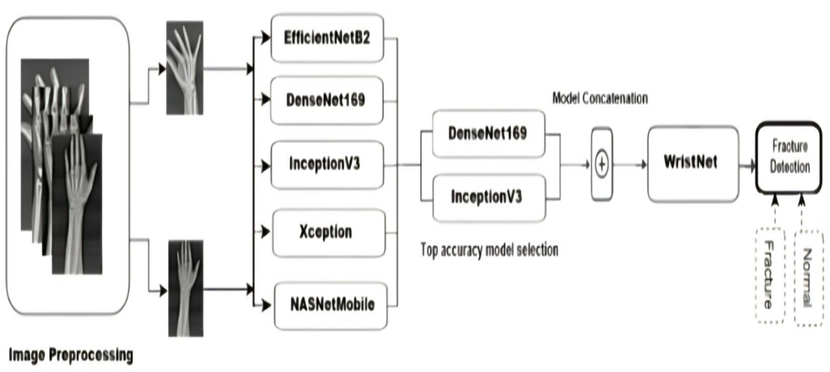
MD. MOSTOFA HASIB (21-44938-2), AHMED FARHAN AMIN (21-44804-1), ALIF HOSSAIN TALHA (21-44923-2), NOKIBUL ARFIN SIAM (21-44793-1)

Introduction

Wrist fractures are very common injuries, often caused by falling on an outstretched hand, and usually involve broken bones in the wrist. It's important to detect them early to avoid long-term problems, but reading X-rays can be difficult and depends a lot on the doctor's experience. To help with this, we created **WristNet**, a deep learning model that combines features from several powerful image recognition models (InceptionV3 and DenseNet169) to better detect wrist fractures. Our aim is to make **WristNet** a helpful tool for doctors to spot fractures more quickly and accurately.

Methods

- **Data:** Used small-scale labeled wrist X-ray dataset with preprocessing and augmentation.
- **Models:** Trained five CNN models – EfficientNetB2, DenseNet169, InceptionV3, Xception, and NASNetMobile.
- **Concatenation :** Combined high-performing models using feature concatenation to enhance learning.
- **WristNet:** Built a fused deep-learning model by integrating selected models into a single architecture.
- **Training:** The final model to optimize wrist fracture detection performance.



Research Methodology Overview

Data Analysis

Used a balanced wrist X-ray dataset (Normal vs. Fracture) with an 80/20 train/validation split. Applied data augmentation (rotation, shifts, shear, zoom, brightness, flipping) to enhance robustness. Trained models with hyperparameter optimization and validated with cross-validation, achieving strong performance in fracture detection across all metrics.

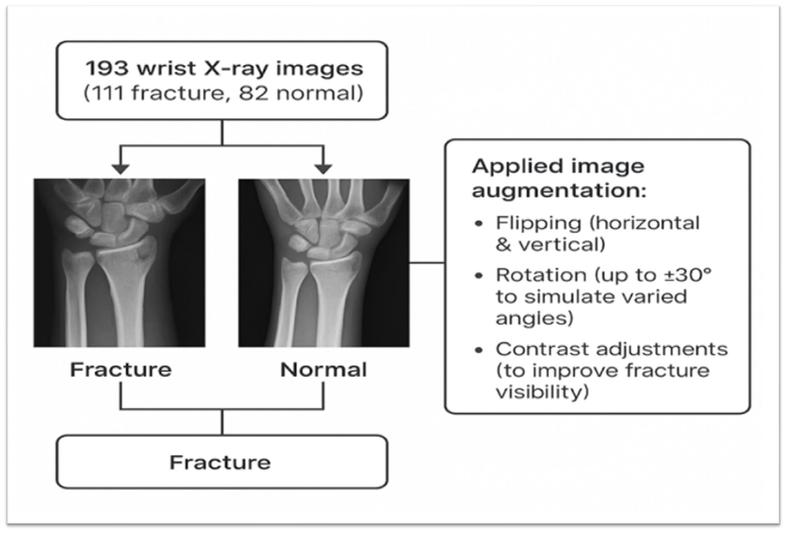


Figure: Dataset and Preprocessing

All Model Accuracy chart	
WristNet	**97.50%**
Densenet169	95.00%
InceptionV3	90.00%
Xception	85.00%
NASNetMobile	85.00%
EfficientNetB2	70.00%

All Model Accuracy Chart

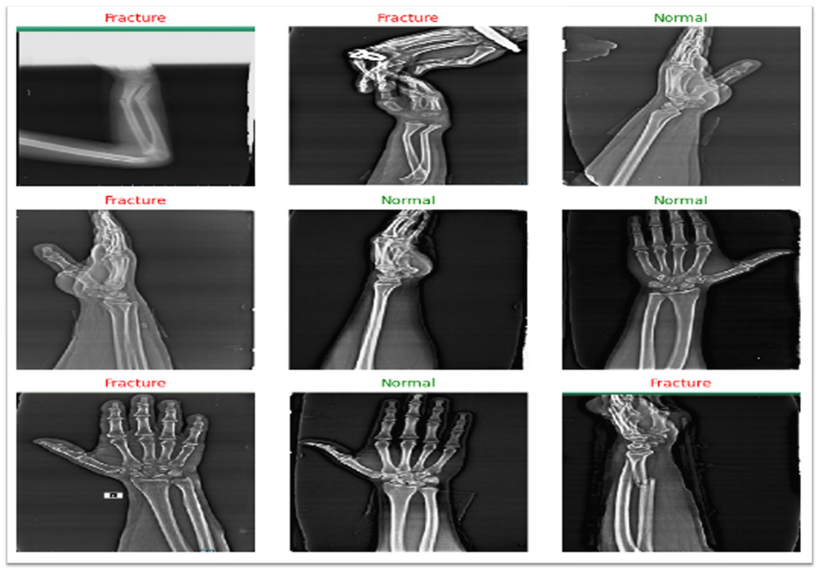


Figure: Prediction Samples

Results

- WristNet demonstrated the highest true positive rate.
- EfficientNetB2 showed the highest false negative rate
- InceptionV3 and DenseNet169 provided balanced performance.

Model	Accuracy	Precision	Recall	F1-Score
WristNet	97.50%	94.44%	99.00%	99.62%
DenseNet169	95.00%	96.8%	98.1%	97.4%
InceptionV3	90.00%	91.7%	93.2%	92.4%
Xception	85.00%	84.3%	85.6%	84.9%
NASNetMobile	85.00%	83.9%	86.2%	85.0%
EfficientNetB2	70.00%	68.5%	71.2%	69.8%

Table : Performance of Individual Deep Learning Models

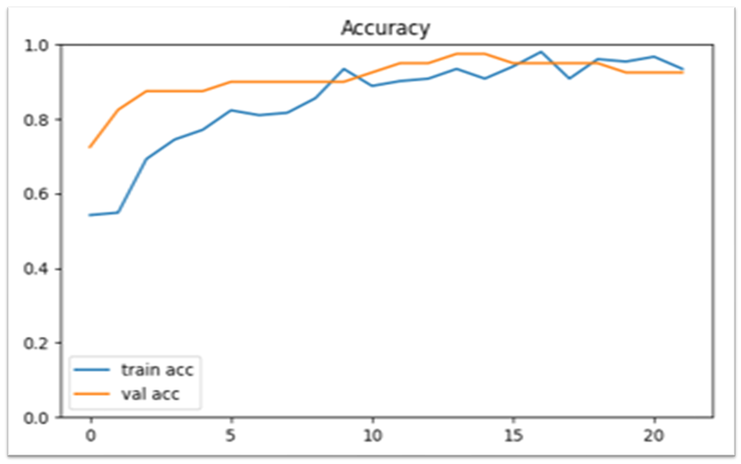


Figure: Validation & Training Accuracy

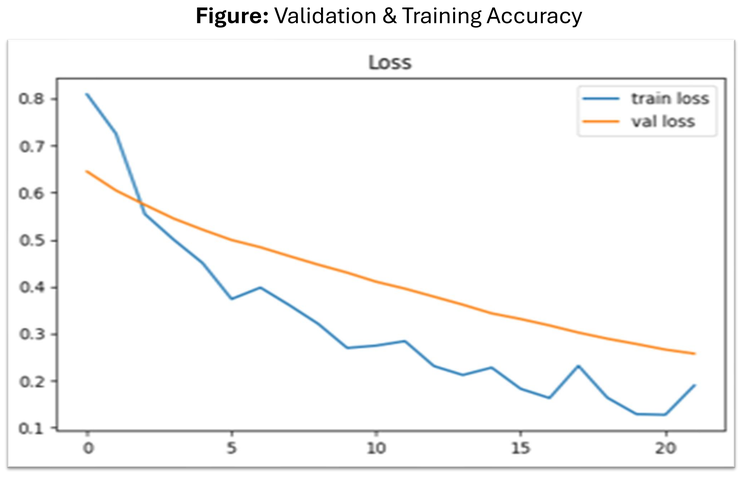


Figure: Validation & Training Loss

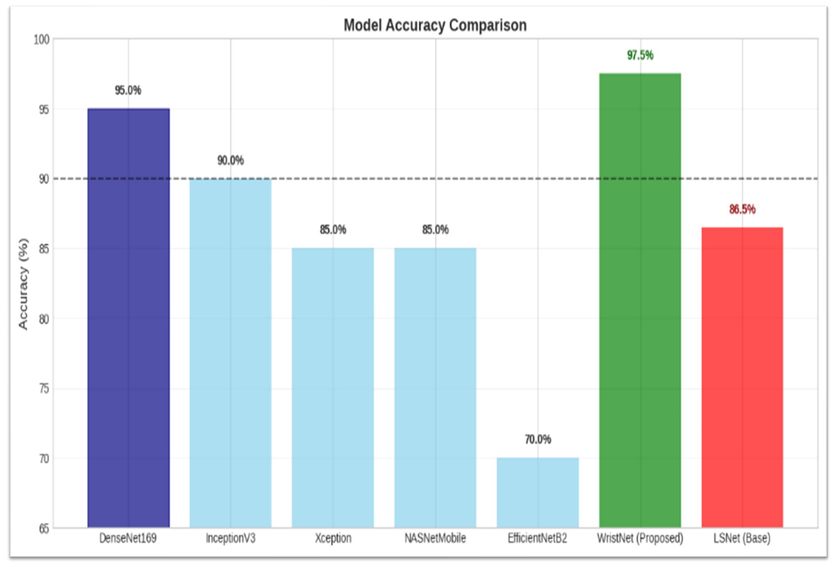


Figure: Dataset and Preprocessing

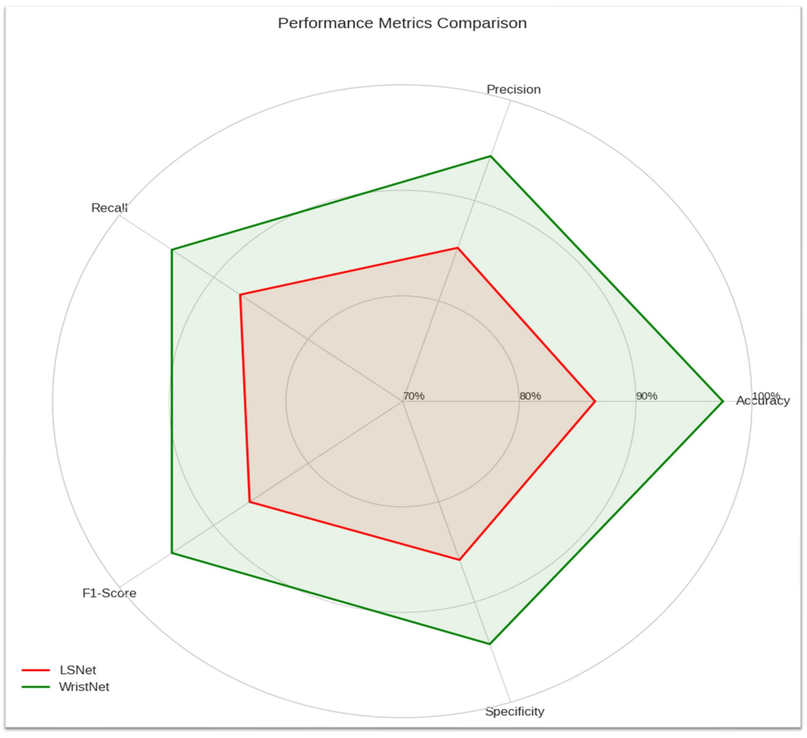


Figure: Performance Metric Comparison

Conclusion

WristNet, an ensemble of DenseNet169 and InceptionV3, achieved 97.50% accuracy, surpassing LSNet by 11%. Using attention-based feature fusion and weighted concatenation, it improves fracture detection and clinical efficiency.

This work reflects my contribution to advancing deep learning in medical imaging, with the goal of improving diagnostic accuracy and efficiency in clinical practice.

References

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Department of Computer Science, Faculty of Science and Technology.
American International University-Bangladesh (AIUB)