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Improving Rib Fracture Detection in CT: Overcoming the Challenge of Non-Displaced and Buckle Fractures

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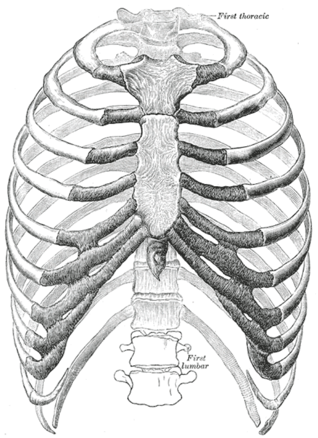
Background

1. Challenges in Rib Fracture Diagnosis

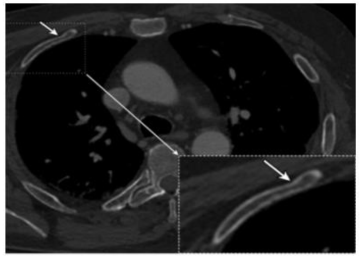
- Identifying 12 pairs of ribs in CT data is a labor-intensive task.
- Buckle fractures are the most frequently missed type of fracture.

[Ref]:] Dankerl P, Seuss H, Ellmann S, Cavallaro A, Uder M, Hammon M. Evaluation of Rib fractures on a single-in-plane image reformation of the rib cage in CT examinations. Acad Radiol 2017;24(2):153–9.

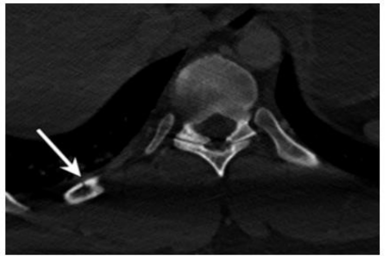
- Non-Displaced fractures are also among the hard-to-detect rib fractures.



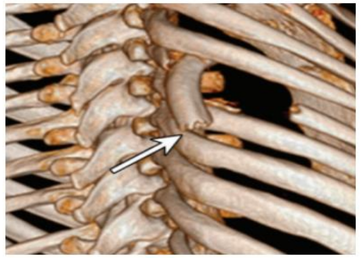
Buckle Rib Fracture



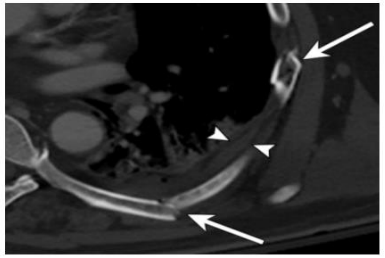
Non-displaced Rib Fracture



Displaced Rib Fracture



Segmental Rib Fracture



[Ref]: Henry Gray's Anatomy of the Human Body

[Ref]: MICCAI 2020 Rib Frac Challenge

Background

2. Limitations of Current Diagnostic Methods

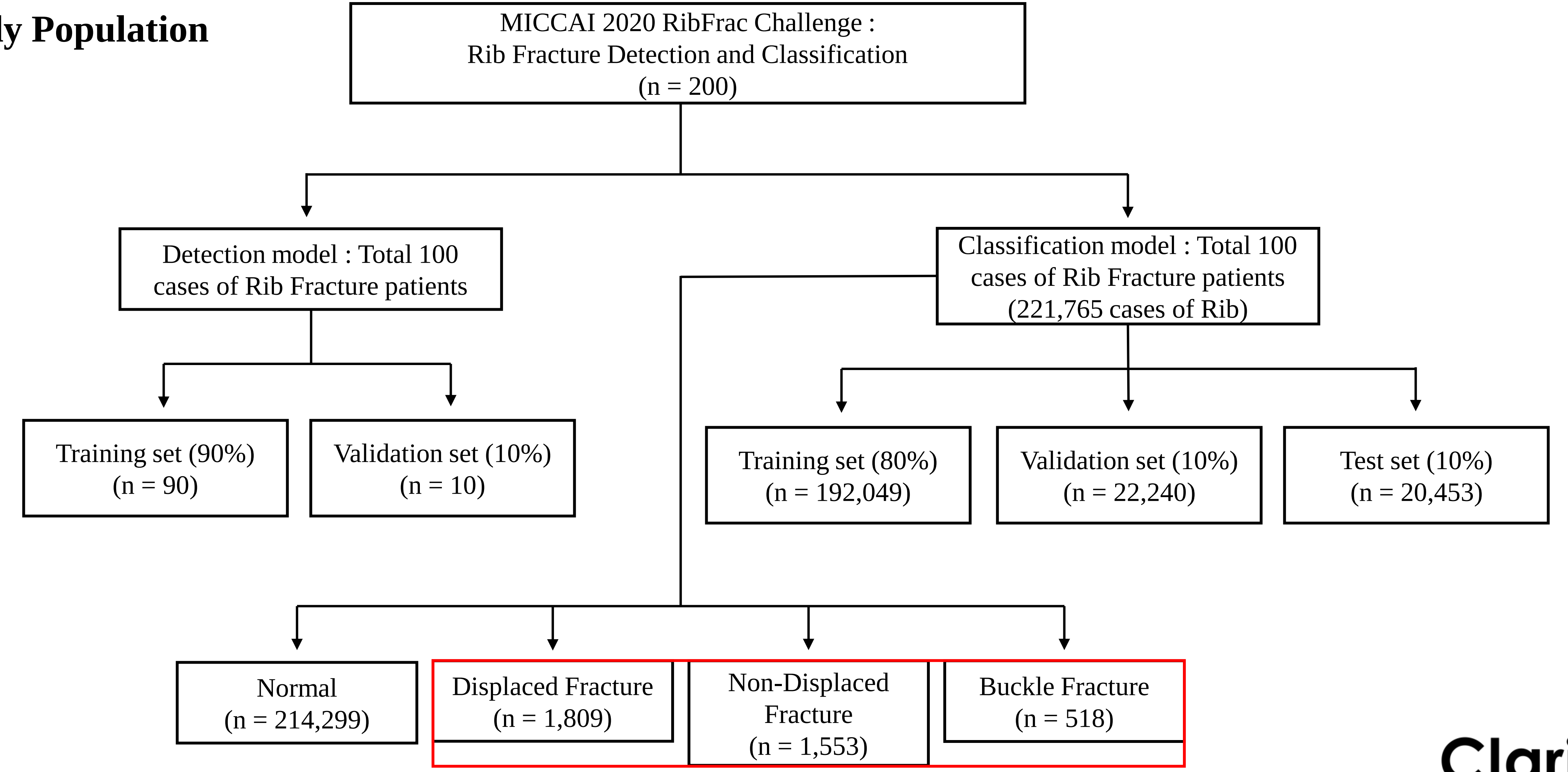
- Diagnosis using CT data involves reviewing numerous images, which is time-consuming.
- The extensive analysis of vast amounts of imaging data leads to increased fatigue among radiologists.
- Analyzing this much data can lead to fatigue accumulates, making it easy to overlook subtle findings such as buckle fractures and non-displaced fractures.

Purpose

- To develop a deep learning model to automatically detect rib fractures from CT data.
- To enhance the ability to identify subtle fractures such as buckle and non-displaced fractures, which are often challenging to detect.

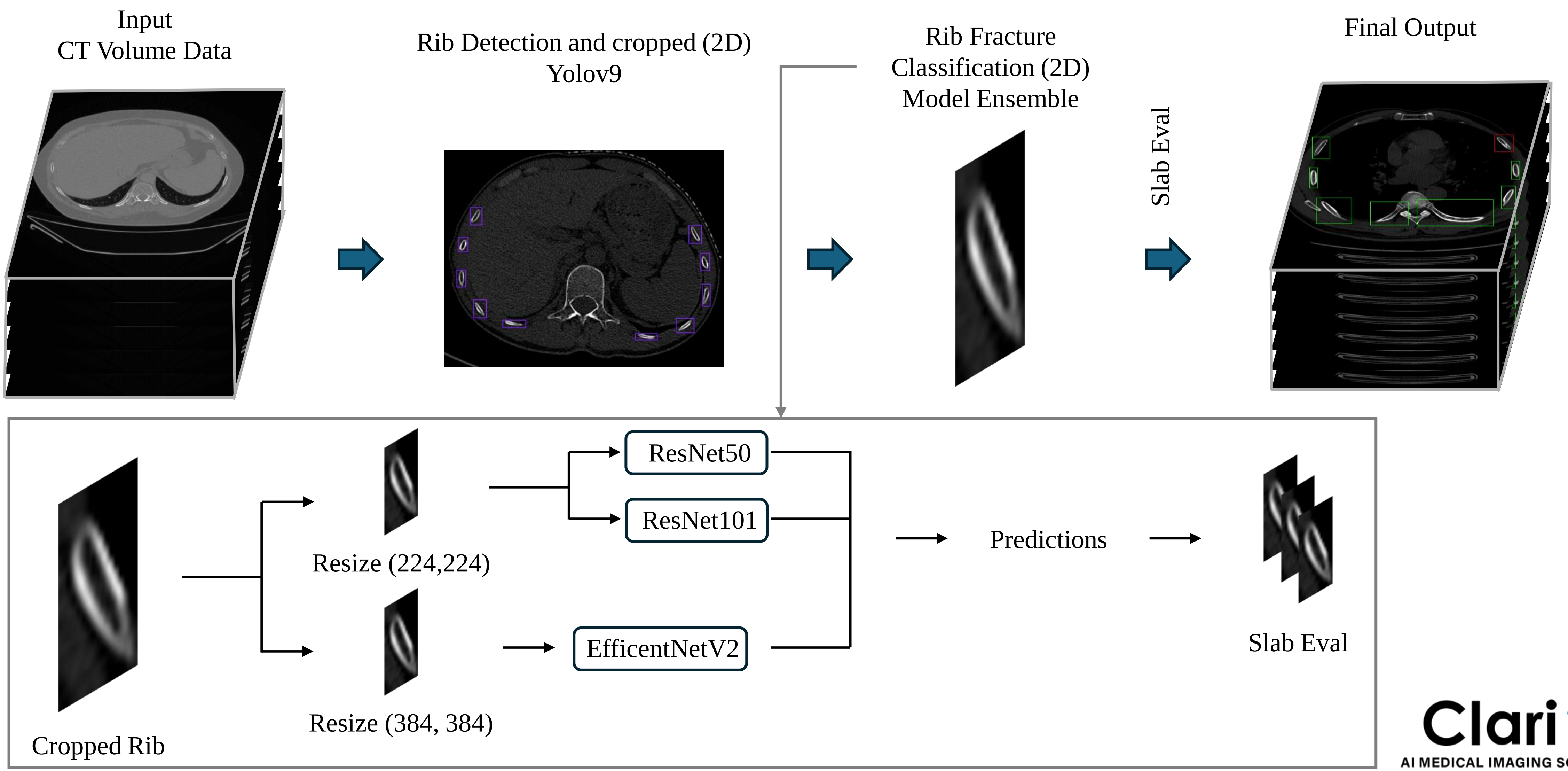
Materials and Methods

Study Population



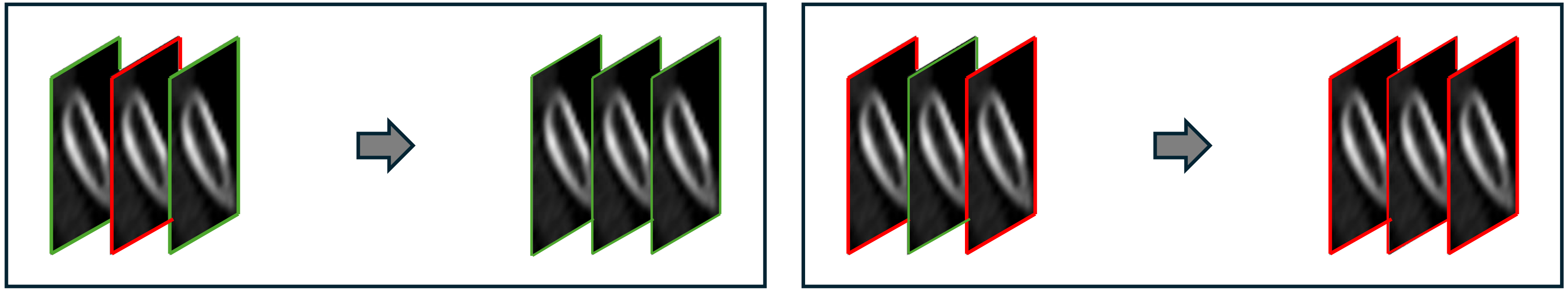
Materials and Methods

Overview of our Rib Fracture detection framework



Materials and Methods

Overview of our Slab Evaluation framework



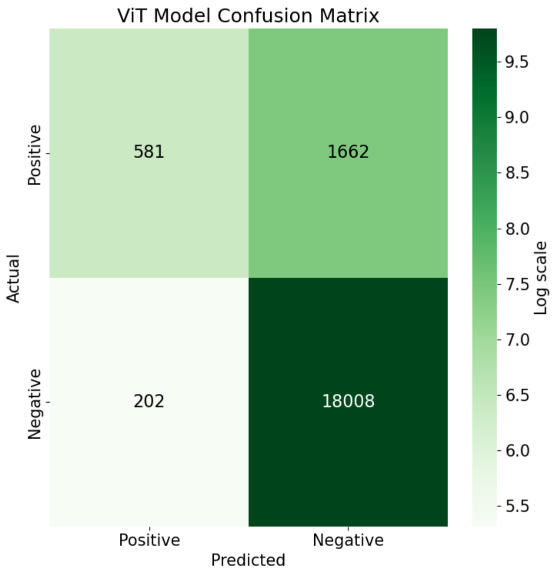
- Rib fractures typically appear continuously across multiple slices. It's uncommon for a single image to show a positive result while the adjacent slices (before and after) show negative results.
- Moreover, if both the preceding and following slices show positive results, there's a very high probability that the rib in the middle slice is also positive.

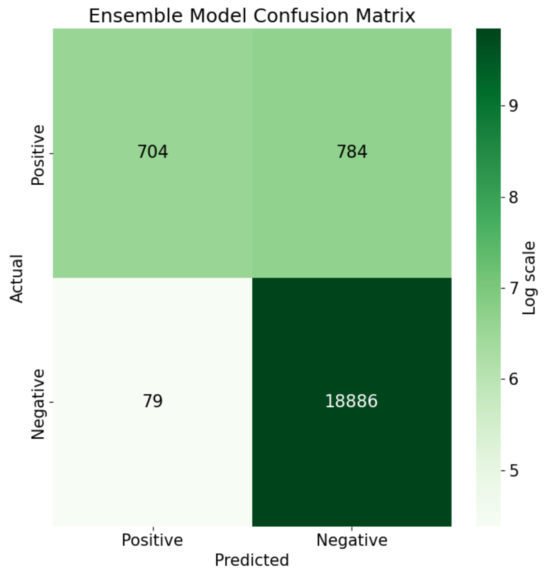
Materials and Methods

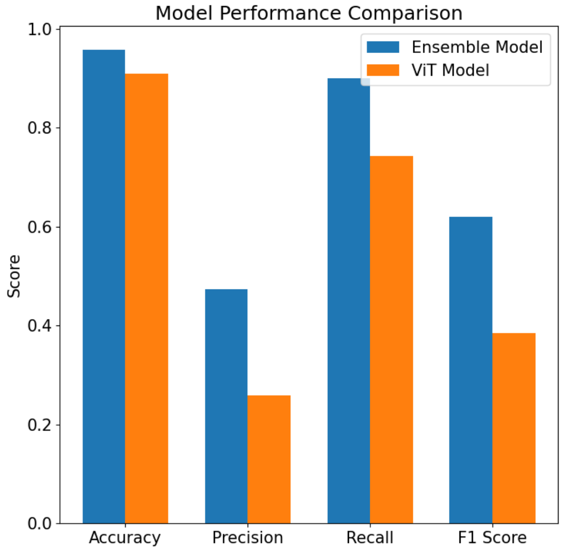
Verification Methods

- Compared Vision Transformer (single model) and an ensemble model
  - We used the relatively new model, the Vision Transformer model, for comparison.
- Results analyzed using sensitivity, specificity and visualizations of confusion matrix, accuracy, precision, recall, and F1 score

Results







Ensemble Model Metrics:
Accuracy: 0.9578
Precision: 0.4731
Recall: 0.8991
F1 Score: 0.6200

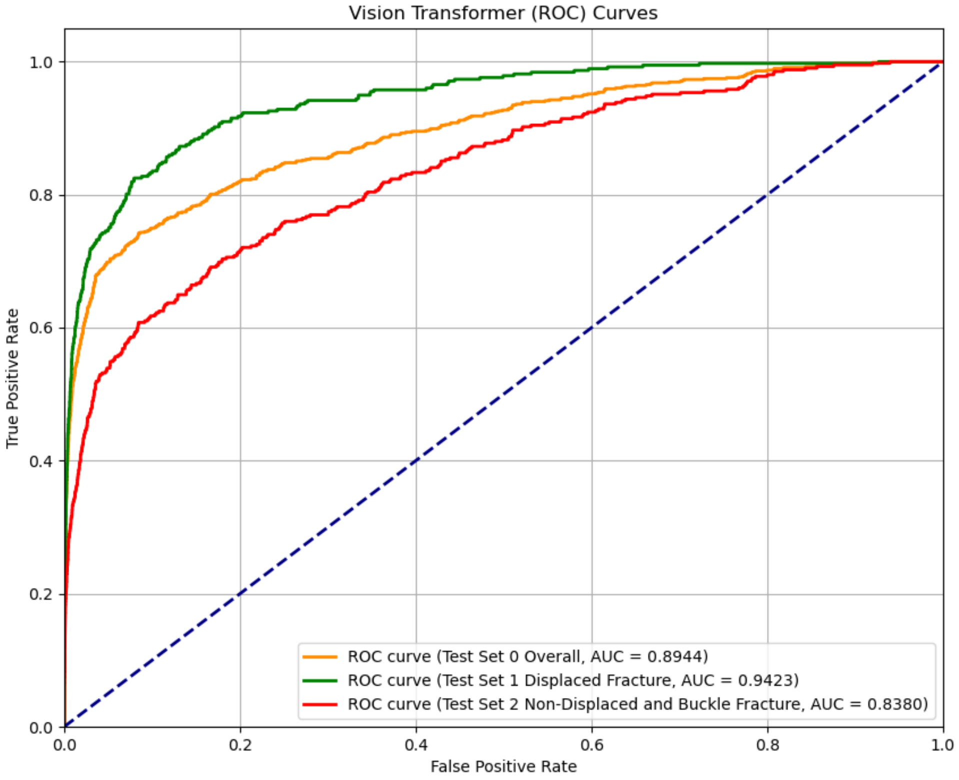
ViT Model Metrics:
Accuracy: 0.9089
Precision: 0.2590
Recall: 0.7420
F1 Score: 0.3840

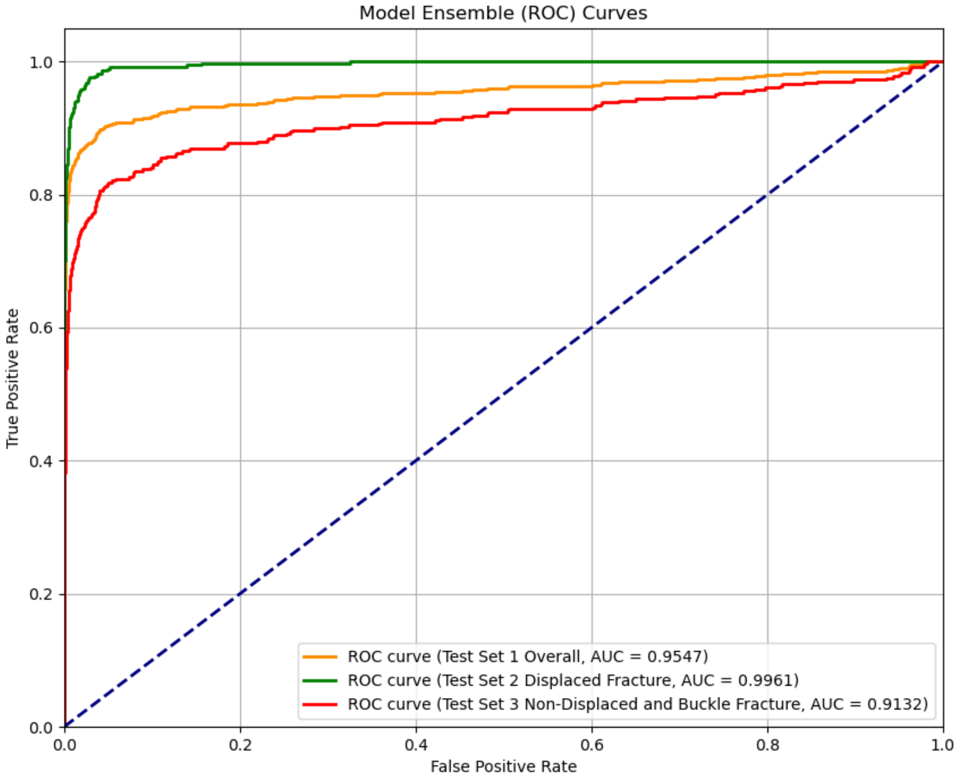
	Sensitivity		Specificity	
Model	ViT	Ensemble	ViT	Ensemble
Overall (n=783)	74.20%	89.91%	91.55%	96.01%
Displaced (n=377)	82.49%	97.61%	92.05%	97.12%
Non-Displaced and Buckle (n=408)	69.12%	81.86%	83.36%	94.93%

Table 1. Vision Transformer and Ensemble Model Results for Fracture Classification.

Results

ROC Curves: A Comparison of ViT and Model Ensemble





Vision Transformer (ROC) Curves

Model Ensemble (ROC) Curves

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Results

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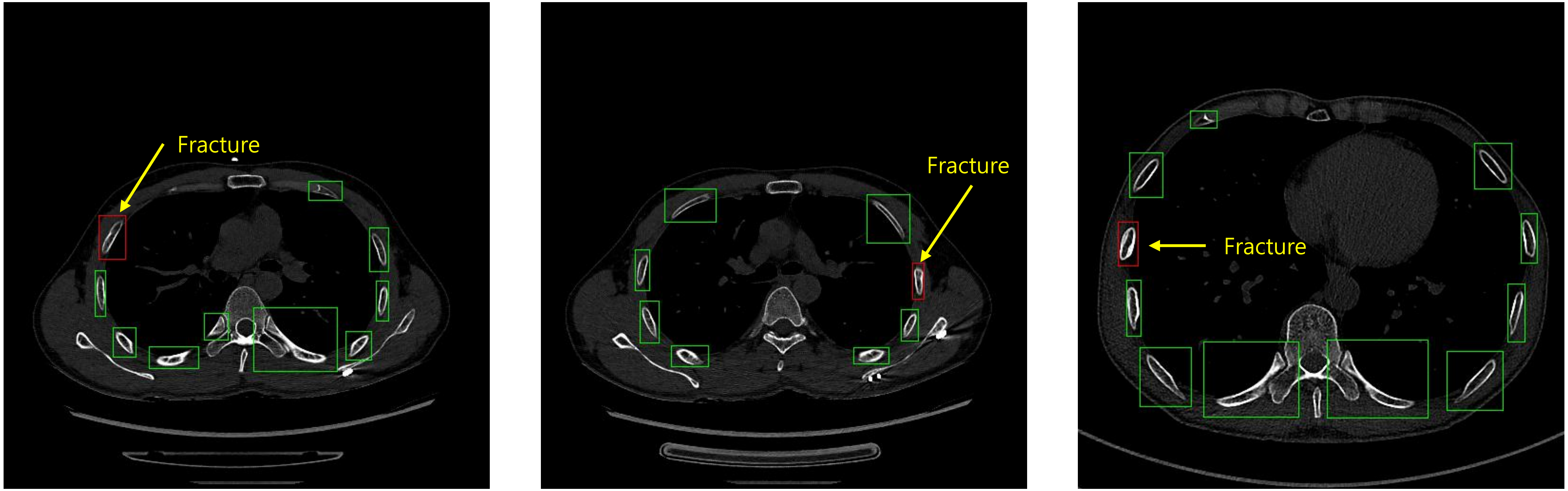

Limitation

- The current model can detection fractures but cannot specify exact anatomical locations of rib fractures.
- The dataset lacked diversity, potentially affecting the model's generalizability to a wider range of fracture types and patient demographics.

Conclusion

- This study employed a two-stage, approach, consisting of detection followed by classification.
- The classification model's performance was maximized through the construction of an ensemble using ResNet50, ResNet101, and EfficentNetV2.
- The ensemble model outperformed individual models in predictions.
- Future work will explore 2.5D and 3D predictions for improved performance.

감사합니다

Thank you for your attention

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