End-to-End AI System in Fracture Diagnose Based on CT Scan

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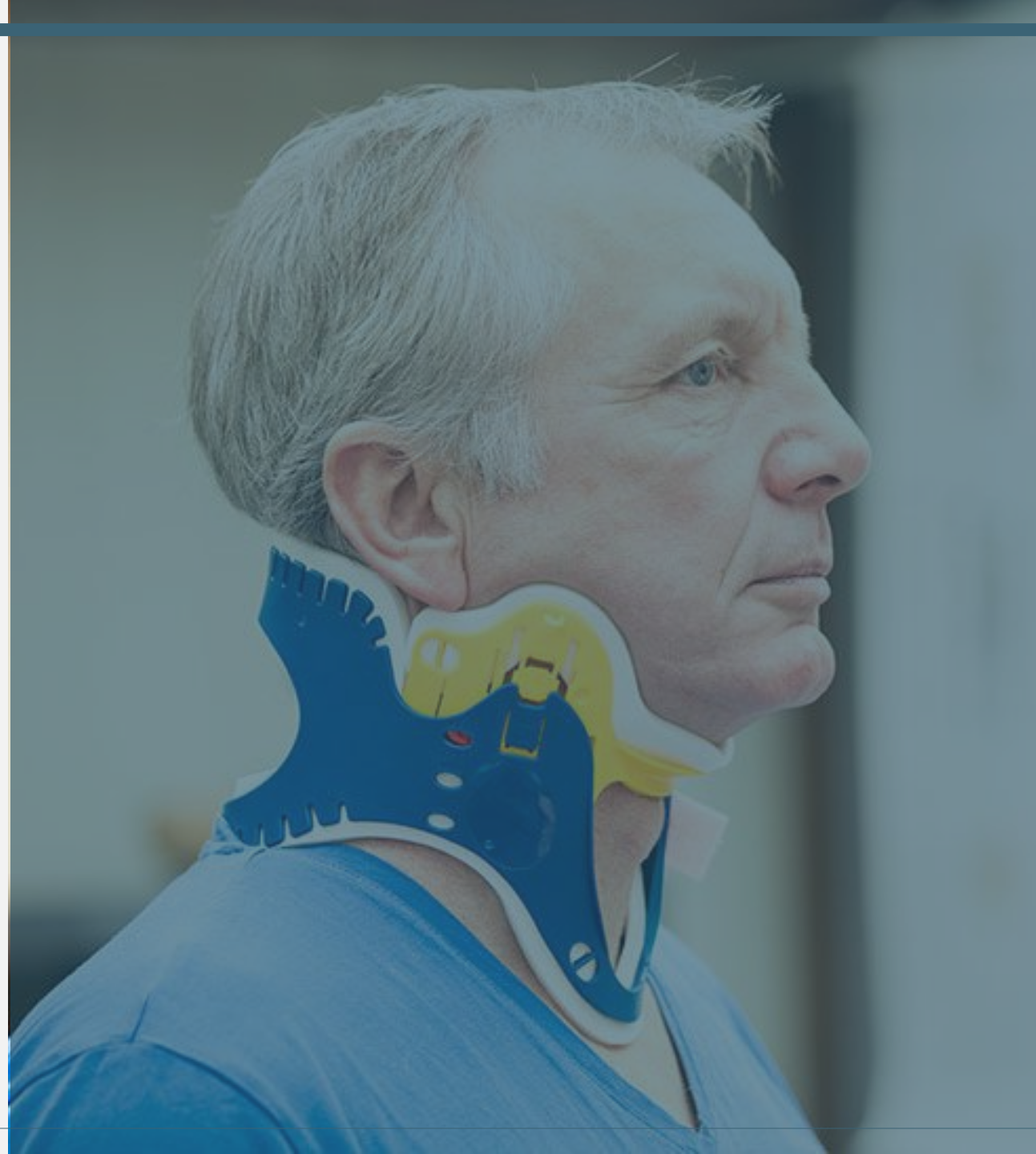
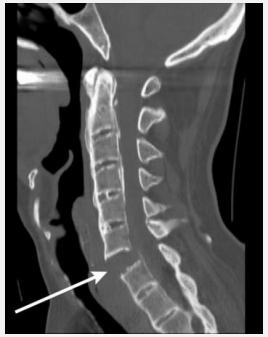


Research-Led Learning

2020

Begin Learning AI

From INT104, one of artificial intelligence courses in XJTLU, we could learn about methods of training AI. We also studied more with online courses: deep learning training with images, as well as the summer research.



Feb. 2022

Real-world Problem

More and more people are getting cervical spine fracture as they are getting older. This is problematic, because it can cause paralysis.

Mar. 2022

Literature Survey

To find solutions, we had literature surveys on image segmentation models: ResNet and EfficientNet. Also, on object detection models: YOLO and fast R-CNN.

Jun. 2022

Solution Testing

Our team has attempted on testing with various solutions and could find that normalizing the images and using EfficientNet with transfer learning improves the performance compared to other solutions.

Aug. 2020

SURF 2022

SURF 2022 learning and researching segmentation and pre-processing algorithms won SURF2022 SAT group award.

Aug. 2022

Better Solution Finding

Proceed with SRLLS for better solution development on the problem. We started group reading on the topic, as well as discussions on each literature reviews

Sept. 2022

Testing Solution

Conclusively, our team began evaluating the model that we finalized.

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Background

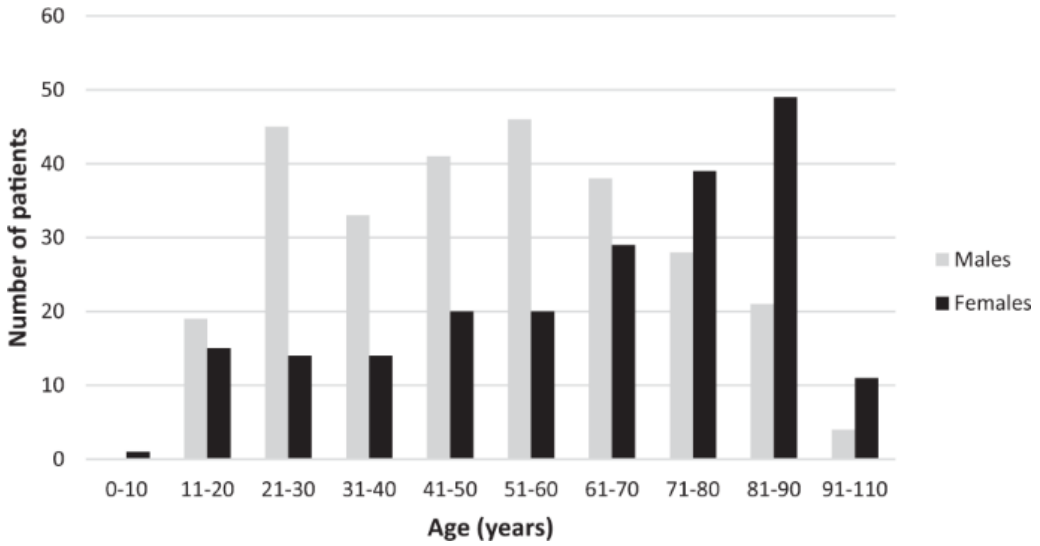
Part 1

Real-world Problem

1. Over 17,730 spinal cord injuries annually,
the most common site of spine fracture
= cervical spine

2. Rise in the incidence of spinal fractures in the elderly.

3. Detection might be more difficult due to:
superimposed degenerative disease
& osteoporosis.



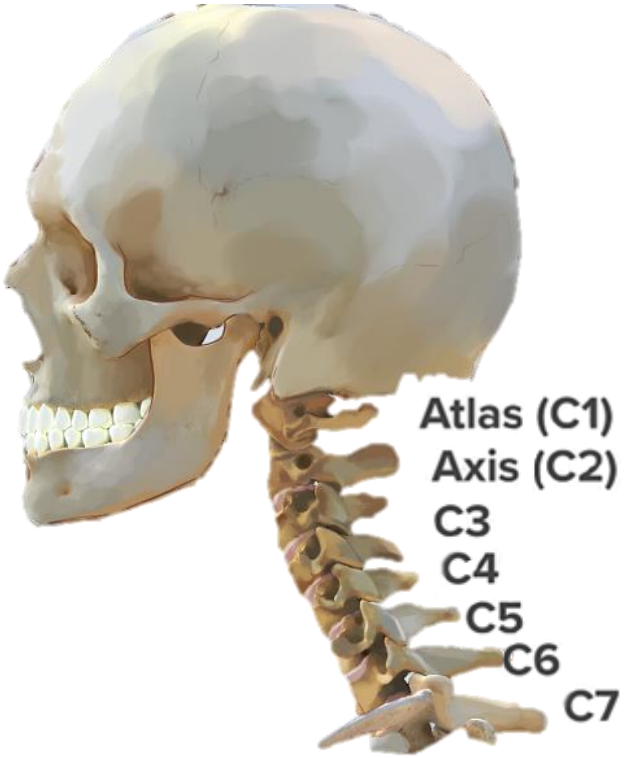
[1] Number of Spinal Fractured Patients by Ages in Iceland

Goal

Detecting and determining the location of any vertebral fractures to prevent neurologic deterioration and paralysis after trauma

Part 1

What do we need to do?



1, Portion of the imaging datasets have been segmented automatically

2, Provided segmentation labels have values of 1 to 7 for C1 to C7 and 8 to 19 for T1 to T12

3, Look for fractures focusing on cervical spine, all scans through C1 to C7 labels

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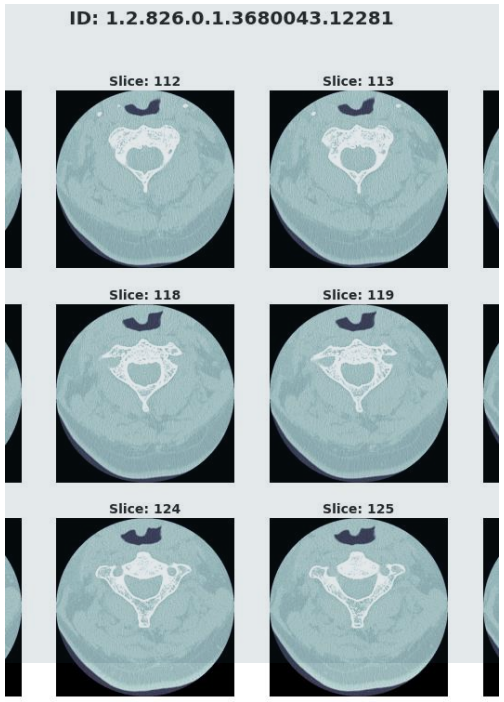
Introduction

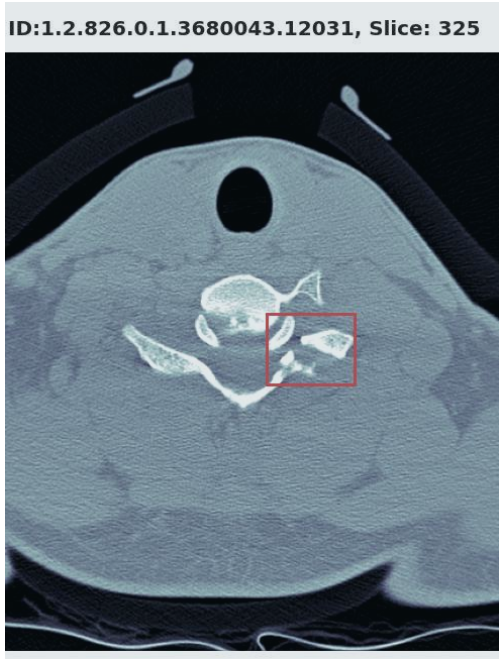
Part 1

Dataset Types



Standard Format

Masked Image

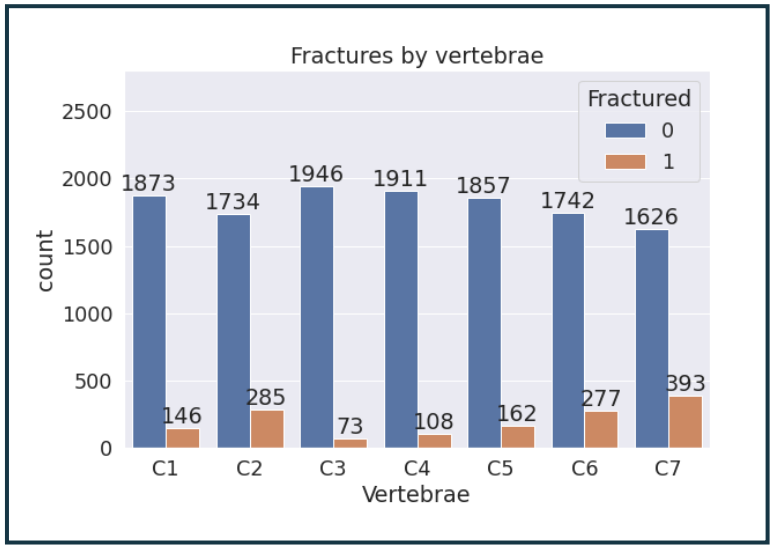


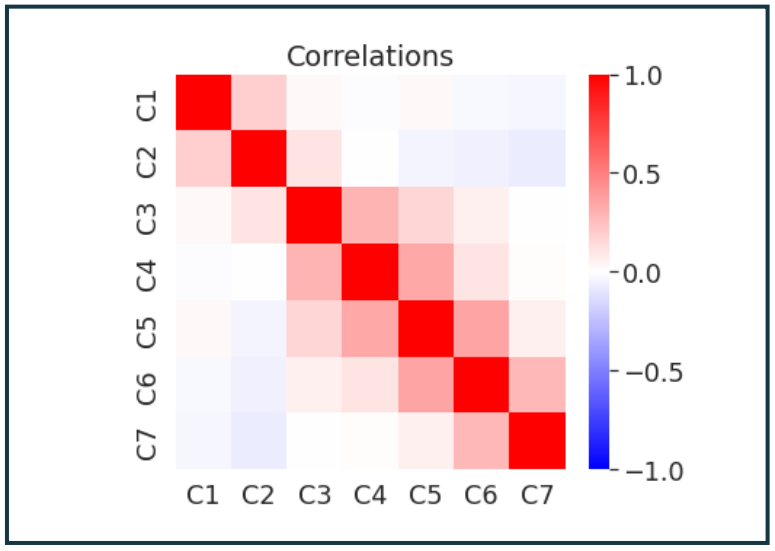
Bounding Boxes

[2] Given dataset: standard format, masked image, and bounding boxes from two different institutes

Part 1

Exploration Data Analysis





- The overall target is roughly balanced (52/48 split)
- C7 has the highest proportion of fractures (19%) whereas C3 has the lowest (4%)
- Several patients have more than one fracture
- If multiple fractures occur on a single patient, they tend to occur in vertebrae close together e.g., C4 & C5 as opposed to C1 & C7

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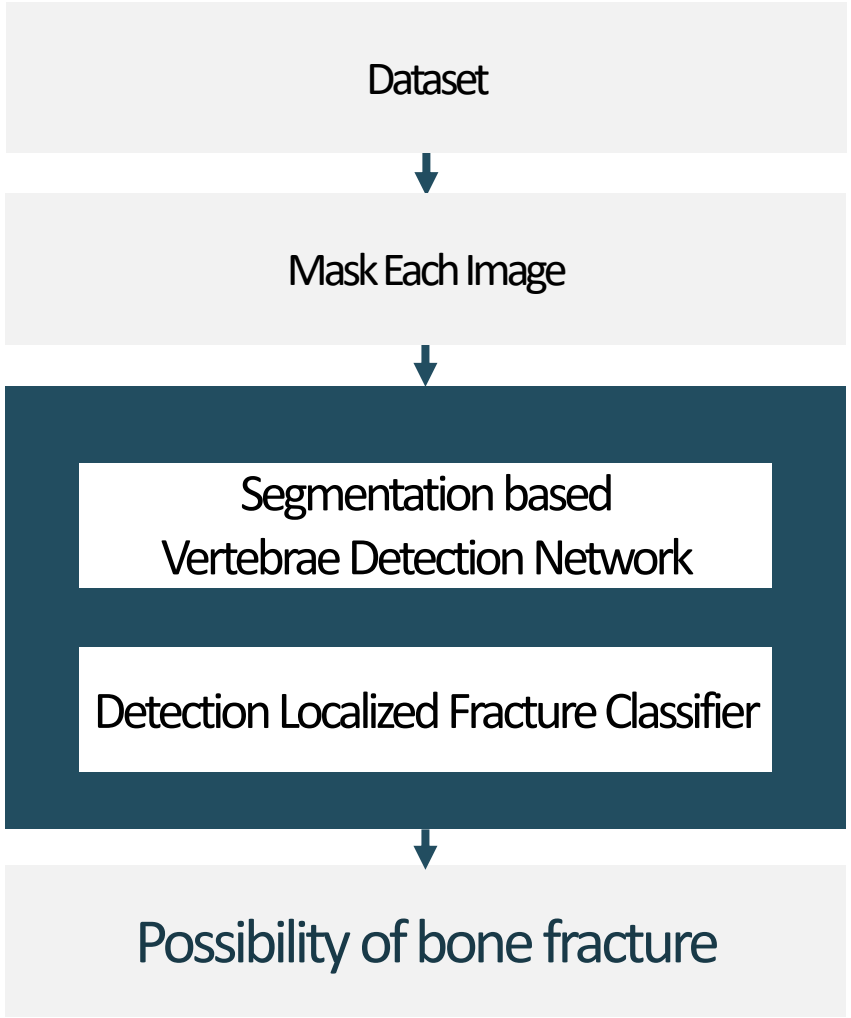
Techniques

Part 2

Techniques



General Process

This experiment aims to evaluate the performance of Detection Localized Classifier (DLC) strategy by developing machine learning models that match the radiologists' performance in detecting and localizing fractures to the seven vertebrae that comprise the cervical spine.

Part 2

Segmentation based Vertebrae Detection Network

Step 1		Step 2		Step 3
Segment metadata before proceeding with model	>>	[3] Iterate Segmentation metadata to the model **EfficientNet V2**	>>	Iterate the trained data to the next process, **classifier**

Part 2

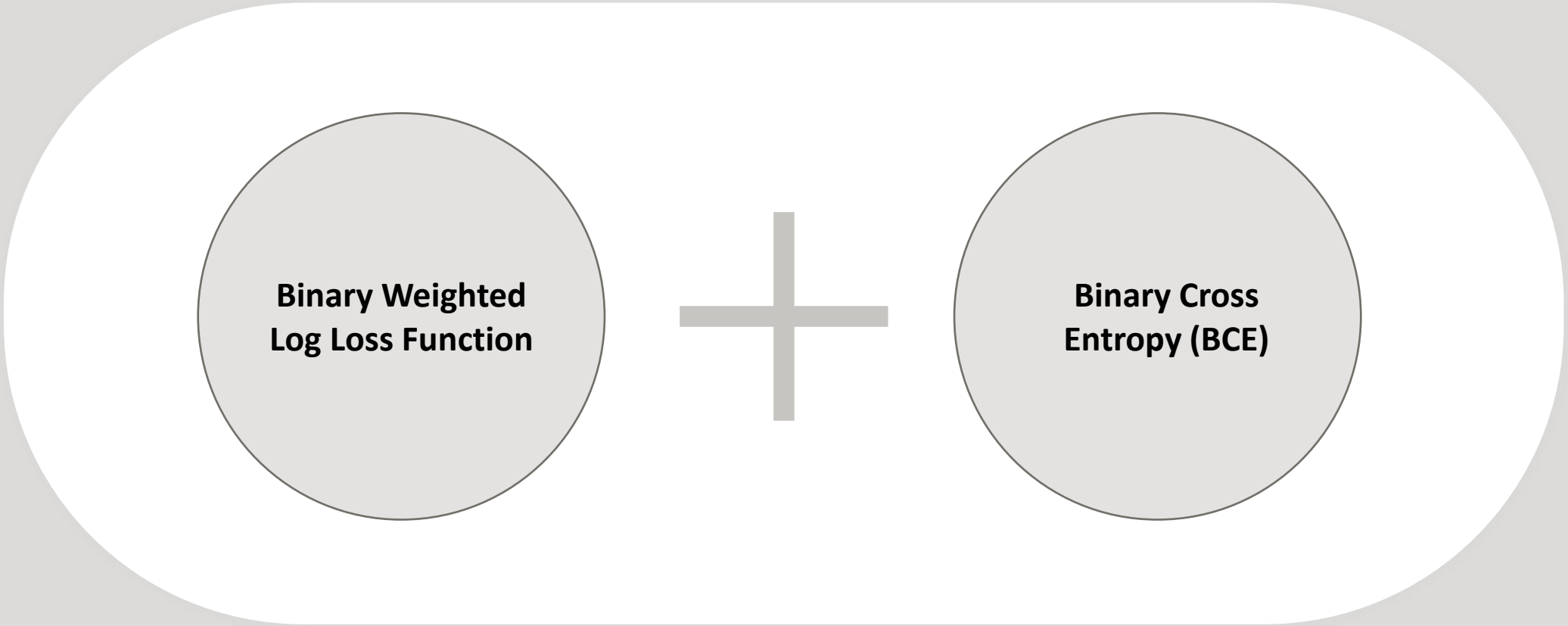
Detection Localized Fracture Classifier

Step 1	Step 2	Step 3	Step 4
Get the trained data from the segmentation network. It **distinguishes vertebrae classes** from each other	**Localize the fracture classifier**. [3] Images are passed to an ensemble of fine-tuned EfficientNet V2 based multi-label classifiers	Produces the **probabilities** of **fractures** and **probabilities** of **existence** of certain **vertebrae** in each slice	**Get a model** that detects fractures and visible C1-C7 vertebrae using a single image

>> >> >>

Part 2

Model Performance Metric



Part 2

Model Performance Metric

$$L_{ij} = -w_j * [y_{ij} * \log(p_{ij}) + (1 - y_{ij}) * \log(1 - p_{ij})]$$

Binary Weighted Log Loss Function

For each test sample id, a set of predicted probabilities are obtained.
Then take the log loss for each predicted probability versus its true label.

$$BCE\ loss = -(ylog(p(x) + (1 - y)log(1 - p(x)$$

Binary Cross Entropy

To optimize the metric better in training process, optimizer BCE is used as the loss function

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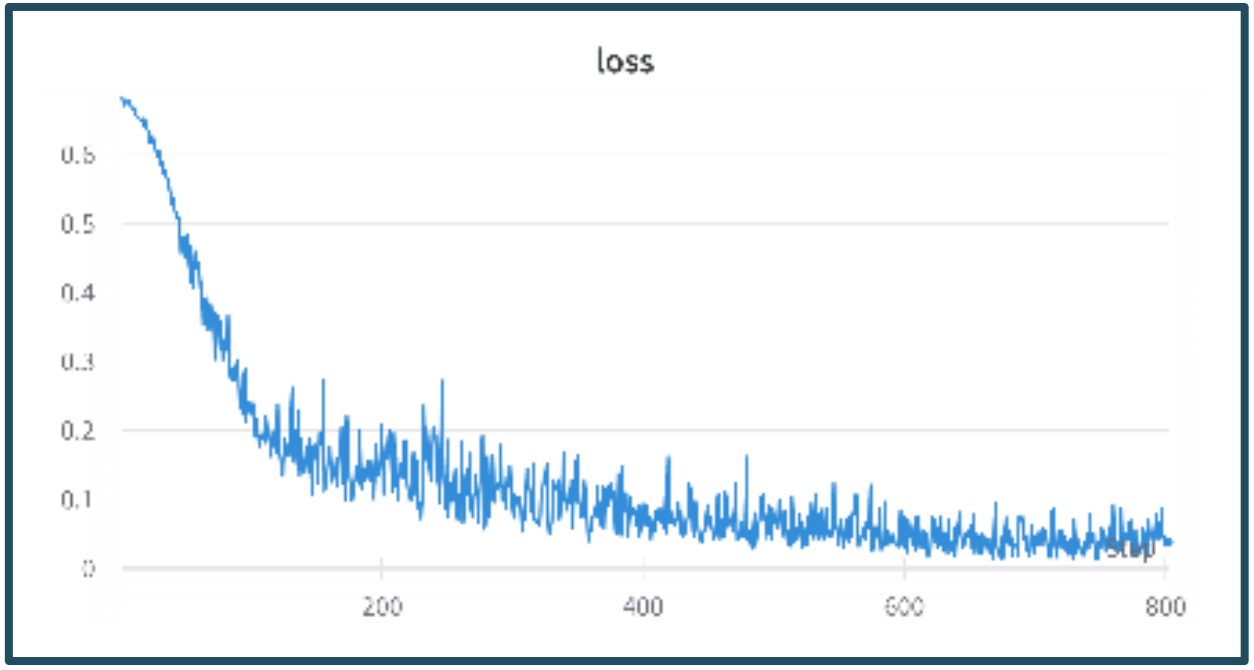
Discussion

Part 3

Discussion

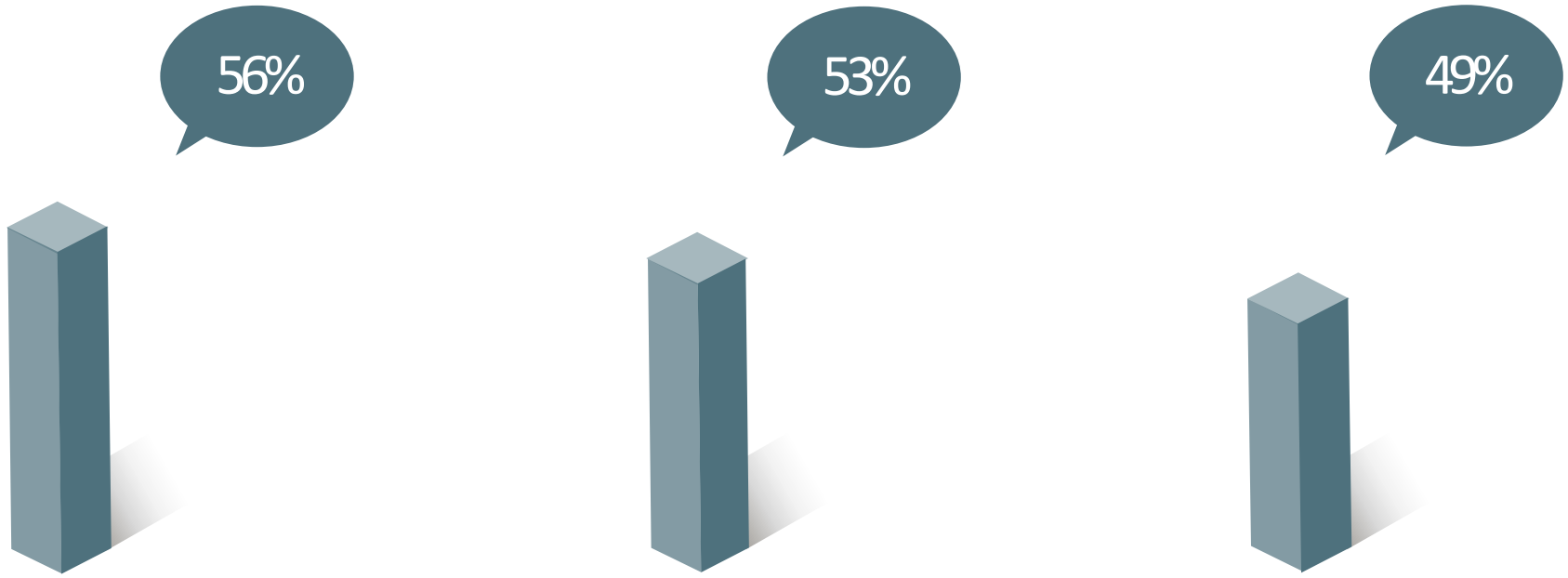


1, The weighted sum of BCE losses in training time

2, Eventually converges for both detection network and the main classifier

Part 3

Discussion



[3] Vanilla EfficientNet V2

[4] Random Forest Segmentation EfficientNet V2

[3] Detection Localized Classifier EfficientNet V2

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Conclusion

Conclusion

1. DLC equipped convolutional classifiers outperforms over the single classifiers & RFS results enhanced classifiers.

2. Further prove that fusion of neural network with multiple purposes would contribute to the improvement on general-purpose aimed models in terms of prediction precision and can possibly lead to easier interpretations of medical deep learning models

Part 4

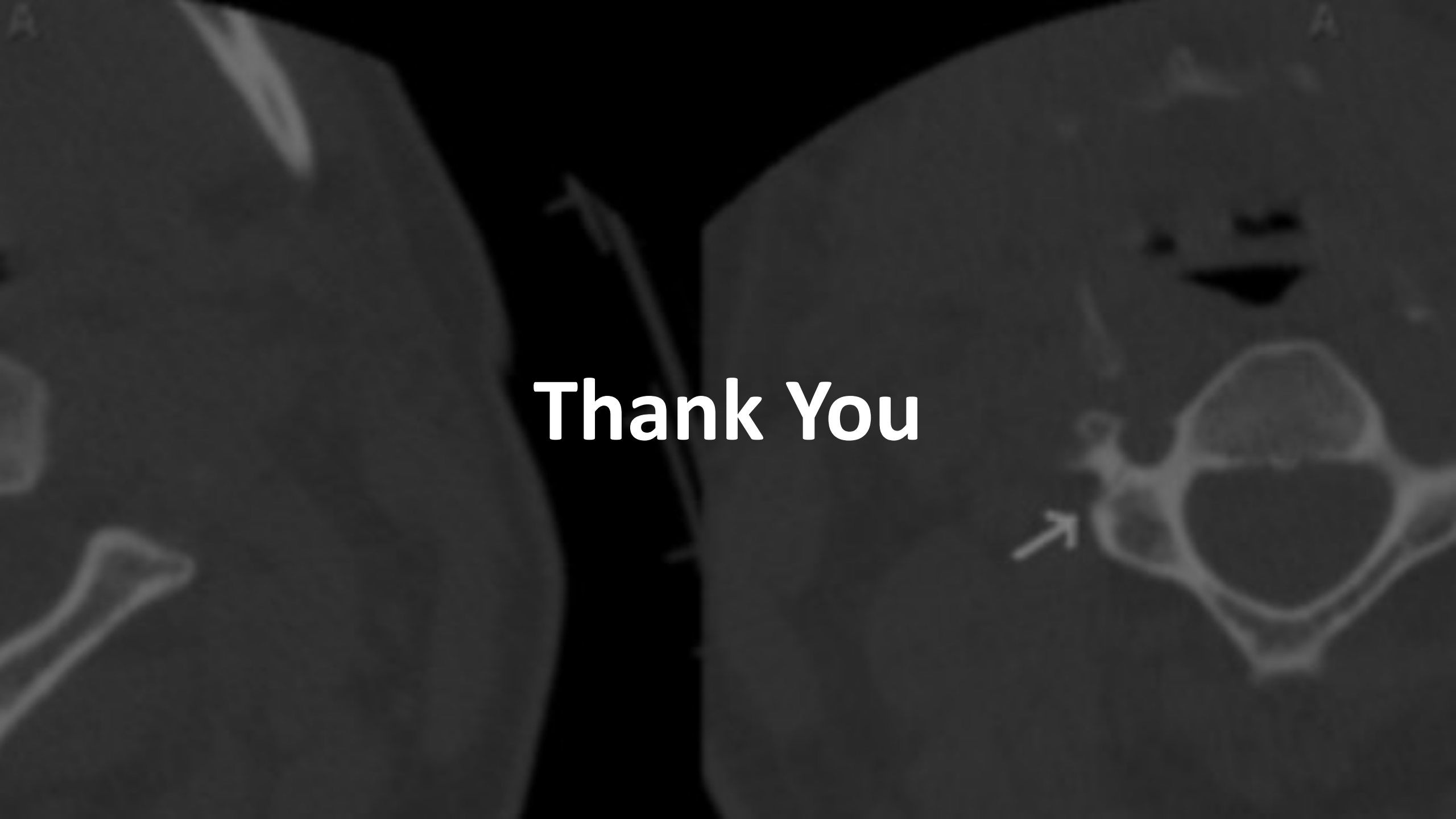
Reference

[1] Eyrun A. K., Sigrun K., Kristinn S., Halldor J. Jr, & Pail E. I. (2018 Aug.). Epidemiology of spinal fractures and associated spinal cord injuries in Iceland. *Spinal Cord Ser Cases* 4, 74. https://doi.org/10.1038/s41394-018-0112-5

[2] RSNA 2022 Cervical Spine Fracture Detection, Identify cervical fractures from scans, https://www.kaggle.com/competitions/rsna-2022-cervical-spine-fracture-detection

[3] Tan M., & Le Q. (2019, May). Efficientnet: Rethinking model scaling for convolutional neural networks. In International conference on machine learning (pp. 6105-6114). PMLR.

[4] Wang, L. et al (2016). Automated segmentation of dental CBCT image with prior- guided sequential random forests. Medical physics, 43 (1), 336-34


Thank You