Abnormality detection in musculoskeletal radiographs

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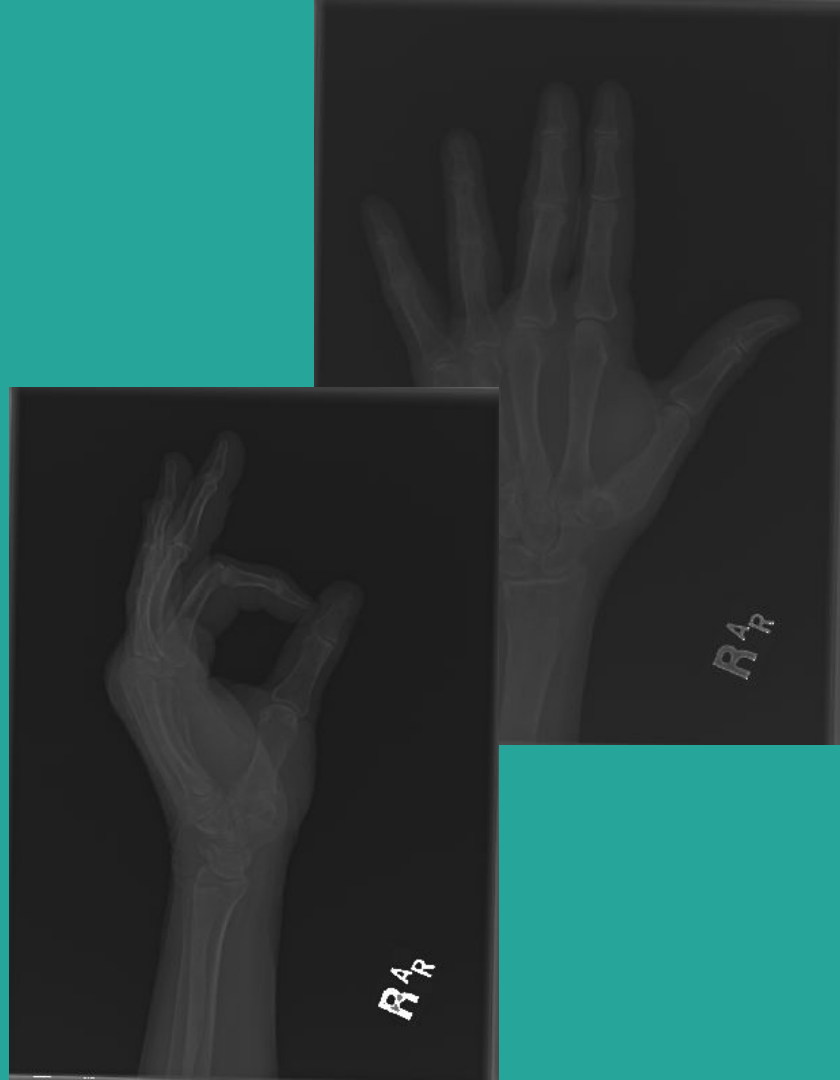
The problem

Does this study show an abnormality?



30 M

Annual number of visits to hospital emergency departments.

90% treated and released, 10% hospitalized [1]

[1] The Burden of Musculoskeletal Diseases in the United States (BMUS) 3rd Edition

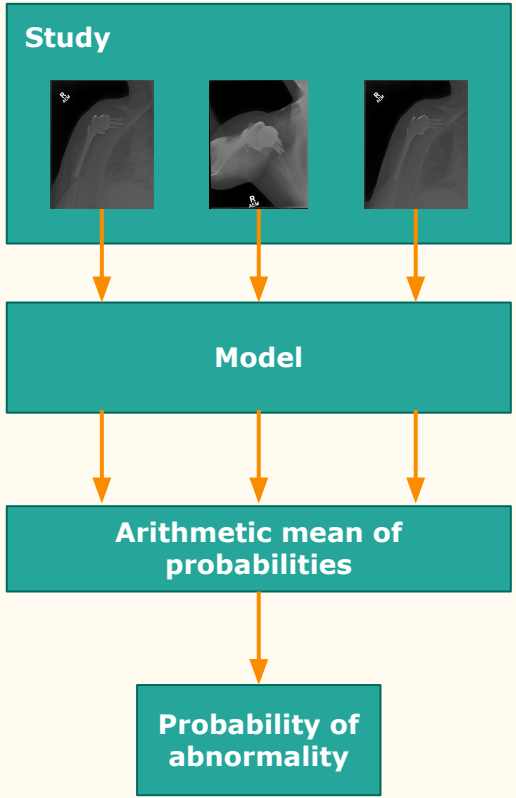
Problem characteristics

2 class classification (binary crossentropy as a loss)

Accuracy metric as a benchmark, we also look at precision, recall and AUC-ROC

MURA dataset (15k studies, unbalanced class weights)[2]

Difficult to label, even for professionals



[2] Pranav Rajpurkar, Jeremy Irvin, Aarti Bagul, Daisy Ding, et al. MURA: Large Dataset for Abnormality Detection in Musculoskeletal Radiographs

The network

DenseNet[3]

An evolution of ResNet[4]

- Extends the concept of skip connections
- Strengthen feature propagation
- Encourage feature reuse
- Deals with vanishing gradients
- Memory efficient: reduces number of parameters

[3] Gao Huang, Zhuang Liu, Laurens van der Maaten, Kilian Q. Weinberger. Densely Connected Convolutional Networks.
[4] Kaiming He, Xiangyu Zhang, Shaoqing Ren, Jian Sun. Deep Residual Learning for Image Recognition

ResNet v DenseNet

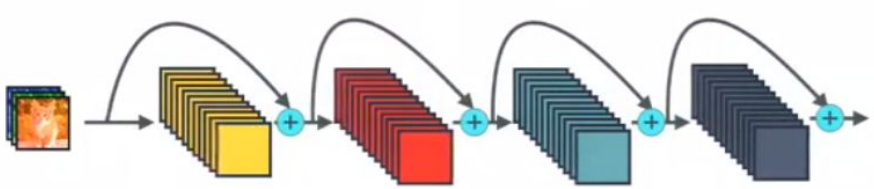
Traditional ConvNet: input goes through several convolutions to extract features

ResNet: identity shortcut connections skipping layers.

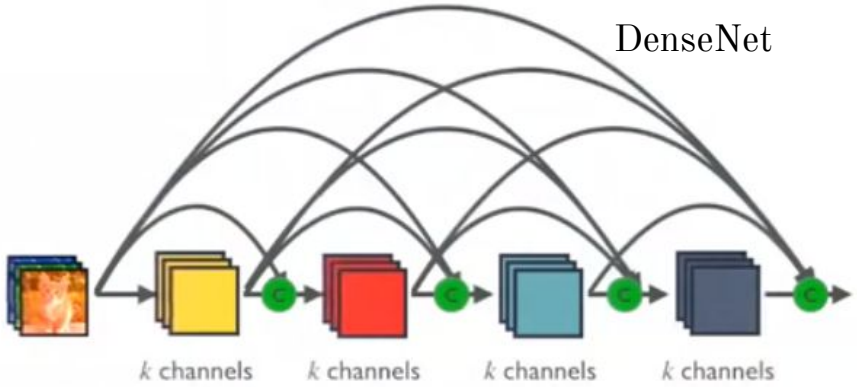
DenseNet: shortcuts connect all layers in a block directly with each other.

Several possible depths. We use 169 layers.

ResNet



DenseNet



Training method

Densenet: 169 layers for feature extraction (ImageNet[5] weights)

Final fully connected layer for classification

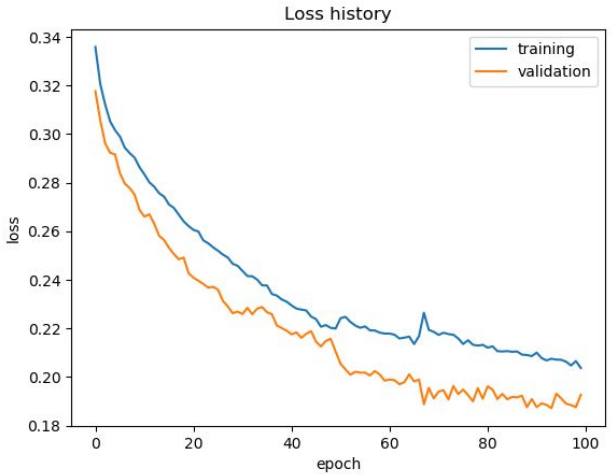
Data normalized to [0-1] range

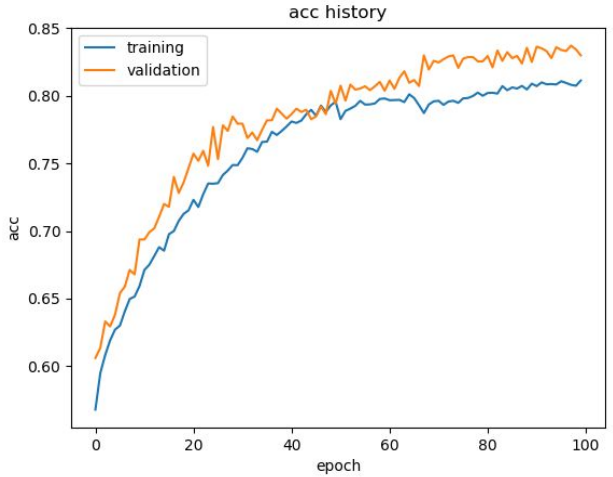
Data augmentation (lateral inversions, rotation of up to 30º)

Modify loss to account for class imbalance

Results

Training history



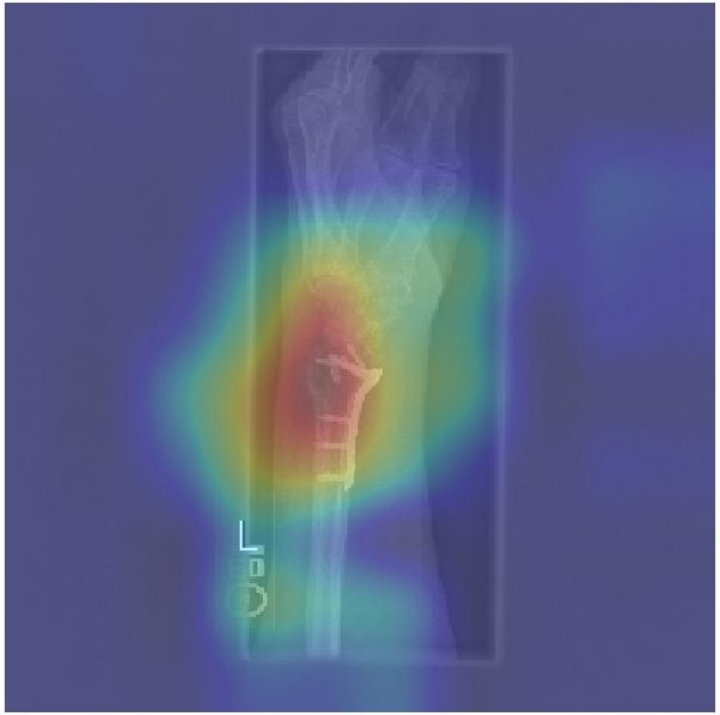


Accuracy	**Recall**	**Precision**	**AUC**
83.1%	63.9%	92.5%	88.9%

An abnormal study

Input Image

Activation Map



An abnormal study

Input Image

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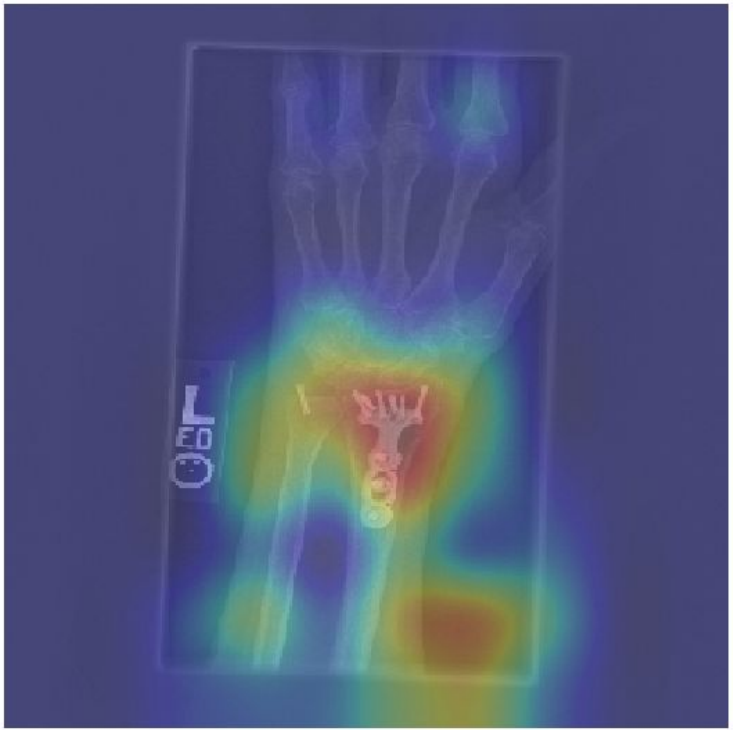

Conclusion

Conclusion and improvements

Metrics similar to [2]

High precision, Lower recall

Clear and insightful visualization

Limited sections

Ensemble classifier

Color image as input, oversized model

Image preprocessing (watermark clean-up)

[2] Pranav Rajpurkar, Jeremy Irvin, Aarti Bagul, Daisy Ding, et al. MURA: Large Dataset for Abnormality Detection in Musculoskeletal Radiographs

Thank you

References

[1] “BMUS: The Burden of Musculoskeletal Diseases in the United States,” BMUS: The Burden of Musculoskeletal Diseases in the United States. [Online]. Available: https://www.boneandjointburden.org/. [Accessed: 23-Apr-2019].

[2] P. Rajpurkar et al., “MURA: Large Dataset for Abnormality Detection in Musculoskeletal Radiographs,” ArXiv171206957 Phys., Dec. 2017.

[3] G. Huang, Z. Liu, L. van der Maaten, and K. Q. Weinberger, “Densely Connected Convolutional Networks,” ArXiv160806993 Cs, Aug. 2016.

[4] K. He, X. Zhang, S. Ren, and J. Sun, “Deep Residual Learning for Image Recognition,” ArXiv151203385 Cs, Dec. 2015.

[5] O. Russakovsky et al., “ImageNet Large Scale Visual Recognition Challenge,” ArXiv14090575 Cs, Sep. 2014.

[6] Raghavendra Kotikalapudi, keras-vis Neural network visualization toolkit for keras. 2017.