Bone Age Detection from X-ray

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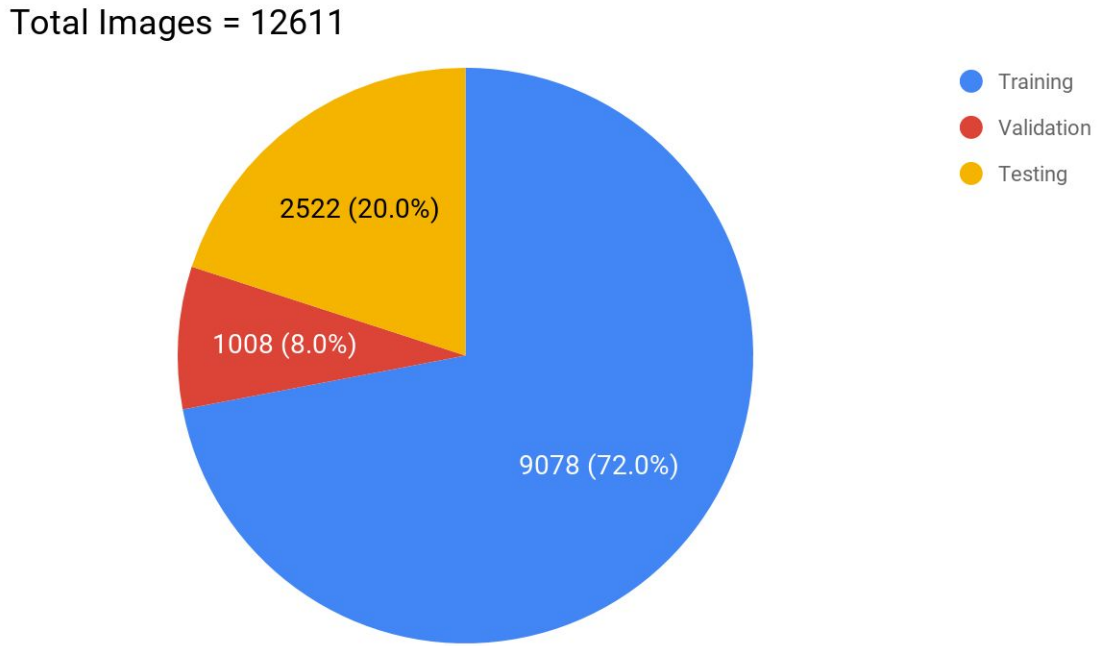
Introduction

1. Radiologists manually find skeletal age with help of atlas.
2. Compare skeletal age with actual age to ensure normal growth in children.
3. RSNA held competition to automate the process.

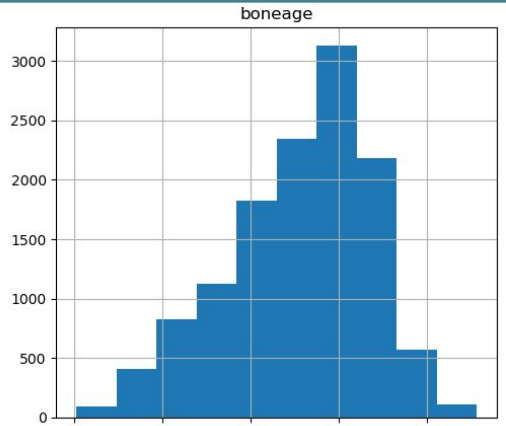
Dataset

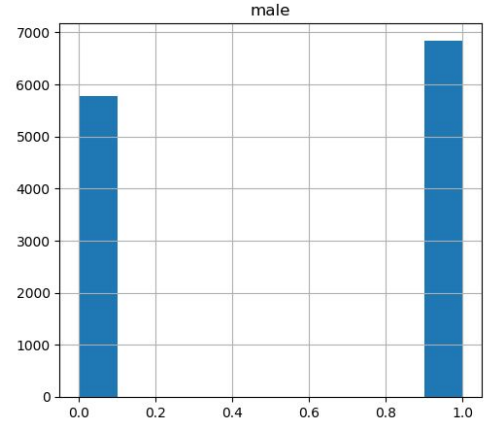
1.png

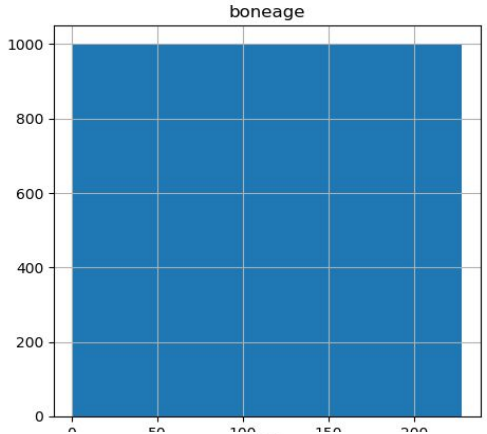
id	boneage	male
1	180	False
2	12	True
...	...	...

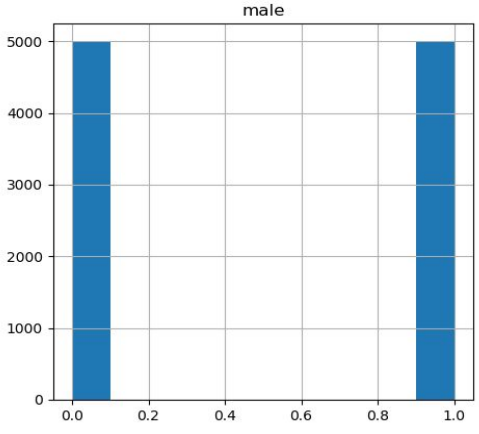


Balancing Dataset







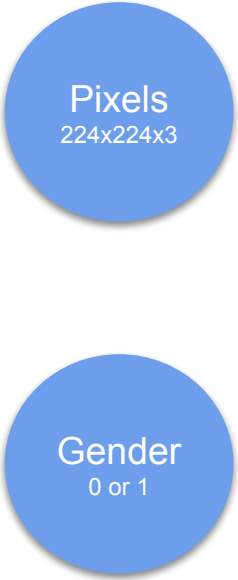


Preprocessing

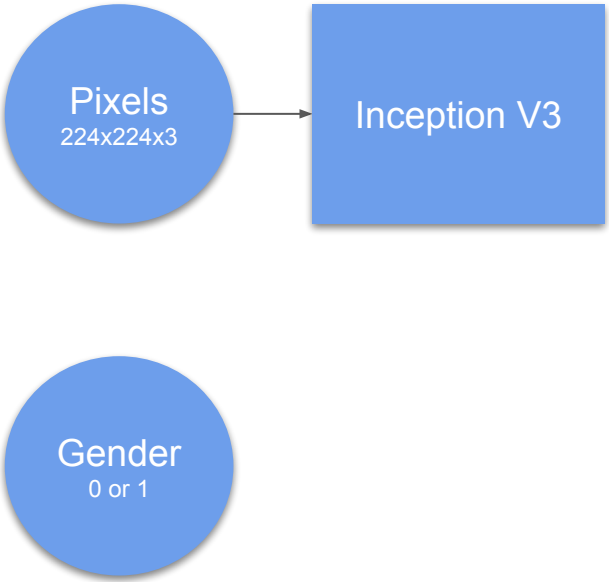
1. Age normalization $(x - \mu)/\sigma$
   - Reduces effect of outlier data points
2. Reduce Image Resolution 2000x1500 $\longrightarrow$ 224x224
   - Reduce redundant pixels while retaining information.
3. Rotation 5°
4. Horizontal/Vertical Translation 15%
5. Zoom 25%
6. Horizontal Flip

} For better generalization

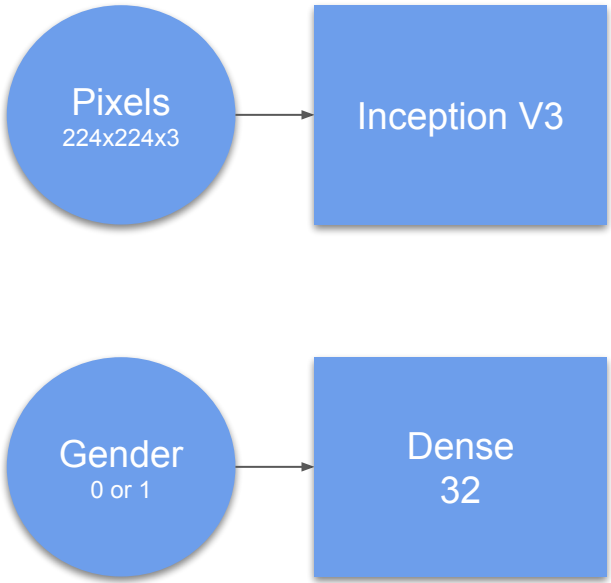
Architecture



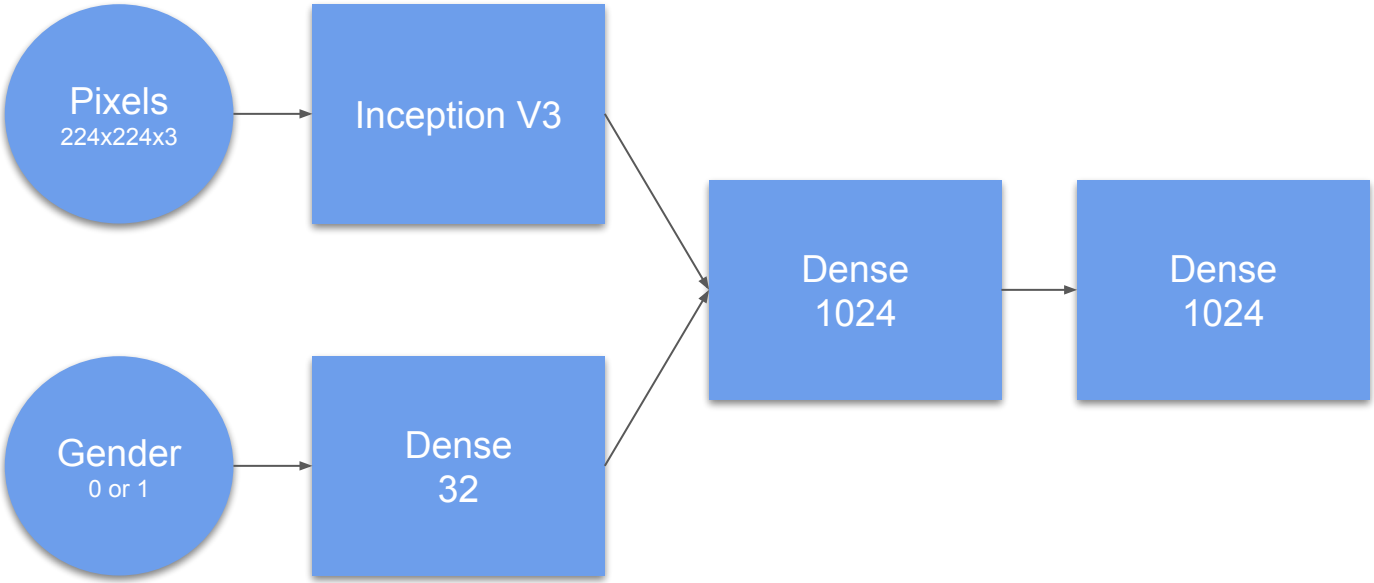
Architecture



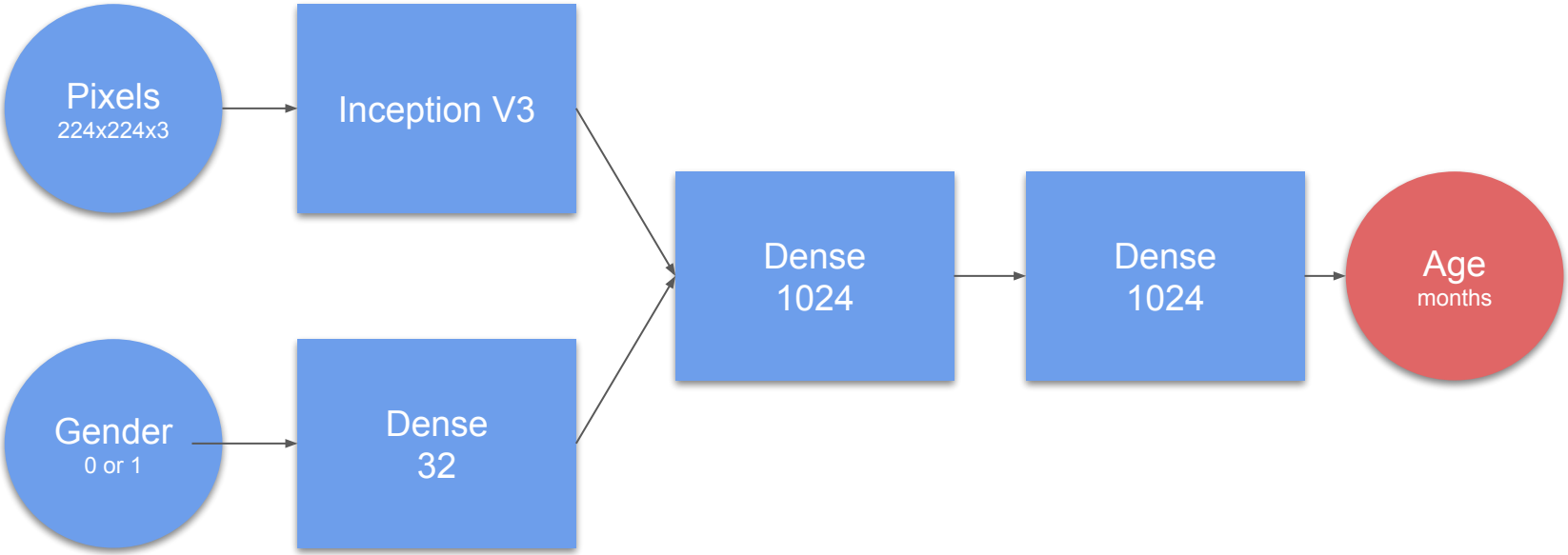
Architecture



Architecture



Architecture



Hyperparameters

Optimized over these parameters

- Pooling : Average pooling / Max pooling
- Dropout : 0.2 / 0.5
- Activation function : ReLU / tanh
- Gender : Use or not
- Image Size : 224x224, 500x500
- Pretrained models : Inception V3, VGG16, MobileNet

Training

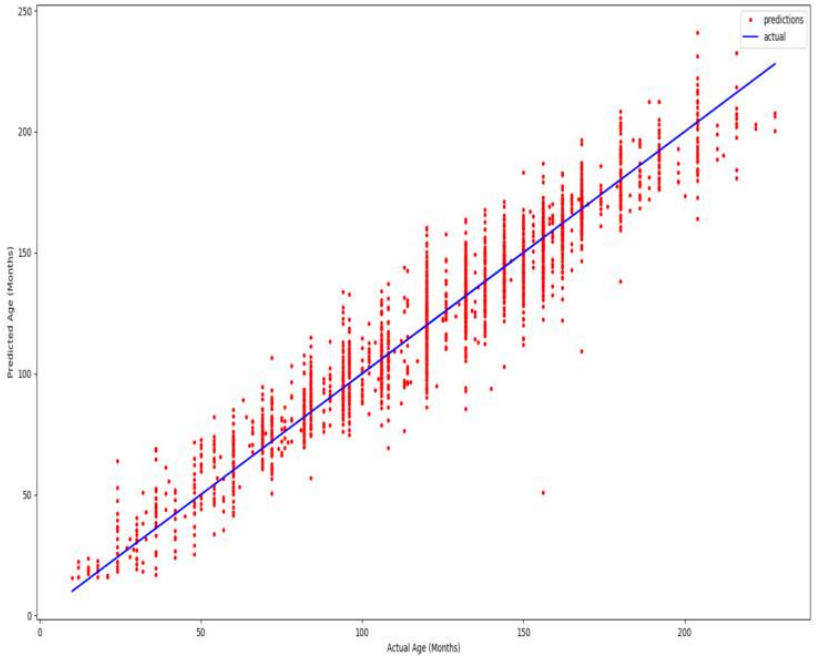
- Batchsize of 10
- Trained over 50 epochs (early stoppage with patience 10)
- Adam optimizer
- Mean Square Error as loss function
- Reduce Learning Rate on Plateau

Results

For the best model,

Test Mean Absolute Error = 8.615 months

- train_loss = 0.0809
- train_mae_months = 9.0737
- valid_loss = 0.0709
- val_mae_months = 8.1923



Code is uploaded on Github
https://github.com/chiragiitp/Bone-Age-Detection-From-X-Ray

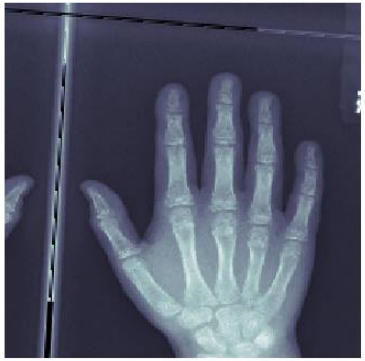
Results

Performance Metrics of various models					
Model No.	Train Loss	Train MAE	Valid Loss	Valid MAE	Test MAE
Model 1	0.4827	21.9844	0.3689	19.1613	19.449
Model 2	0.2349	15.4782	0.1865	13.7690	26.3639
Model 3	0.3227	17.8639	0.1702	12.7672	13.083
Model 4	0.0889	9.4319	0.0736	8.4977	8.842
Model 5	0.2878	16.2868	0.1143	10.8331	11.2478
Model 6	2.4902	56.4327	1.1138	36.9110	35.309
Model 7	0.1609	12.7924	0.1073	10.6136	11.0849
Model 8	**0.0809**	**9.0737**	**0.0709**	**8.1923**	**8.615**

Age: 10.0
Predicted Age: 15.6
Gender: Female

Age: 82.0
Predicted Age: 81.3
Gender: Female

Age: 106.0
Predicted Age: 110.1
Gender: Female



Age: 126.0
Predicted Age: 129.8
Gender: Female

Age: 144.0
Predicted Age: 121.9
Gender: Male

Age: 156.0
Predicted Age: 146.3
Gender: Male

Age: 168.0
Predicted Age: 170.0
Gender: Male

Age: 228.0
Predicted Age: 200.3
Gender: Male

Conclusion

1. Gender information is vital for the network.
2. Mean Average Deviation (MAD) between different human observers 0.61 years. MAD with the winning model is 0.36 years.
3. Deep CNN can surpass human level efficiency.

Should we stop training Radiologists now?

References

- Kaggle
- RSNA challenge
- Performance of a Deep-Learning Neural Network Model in Assessing Skeletal Maturity on Pediatric Hand Radiographs
- Lee, H., Tajmir, S., Lee, J. et al. J Digit Imaging (2017) 30: 427. Fully Automated Deep Learning System for Bone Age Assessment

Thank you