

Prediction of adolescent bone age by hand X-rays

◆
2018.11.1

Linlin Yu(Leader):	515030910078
Xueqi Guo:	515030910103
Zhenglong Wang:	515030910102
Chenyi Wang:	515030910362

Contents



Introduction

1

Idea & Rationale

2

3

Experiments

4

Conclusion

A person is standing on a bright, glowing light source in the center of the frame, appearing to be in space. The light source is a bright, circular glow with a person standing on it, arms slightly out. Below this, the curved horizon of the Earth is visible, showing the dark blue and black colors of the planet's surface. The background is a deep black space filled with numerous small, distant stars.

Introduction

Introduction

Bone age?

Introduction

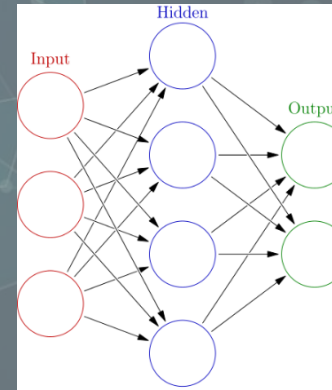
traditional
method

Greulich and Pyle atlas



Deep learning
method

Convolutional
neural network



A conceptual image showing a person standing on a bright, glowing light source in the vastness of space. Below them, the curved horizon of the Earth is visible, showing the outlines of continents and oceans. The scene is set against a dark, star-filled background.

Idea & Rationale

Idea & Rationale

IDEA I: A few specific pieces of bones are primary factors in determination of bone age prediction.

Bones	Weights in CHN		Weights in TW2	Bones	Weights in CHN		Weights in TW2
	male	female			male	female	
radius	9.52	8.39	10	proximal phalanx V	6.96	7.97	2.5
ulna	0	0	10	middle phalanx III	7.69	7.89	2.5
metacarpal bone I	1.97	4.51	3.34	middle phalanx V	1.14	3.83	2.5
				distal phalanx I	10.2	8.61	3.33
metacarpal bone III	7.75	7.76	2.5	distal phalanx III	6.69	7.06	2.5
metacarpal bone V	4.53	6.61	2.5	distal phalanx V	1.61	3.33	2.5
proximal phalanx I	2.09	3.87	3.33	capitatum bone	14.29	10.76	7.1
proximal phalanx III	11.19	9.21	2.5	hamate bone	14.13	10.75	7.1

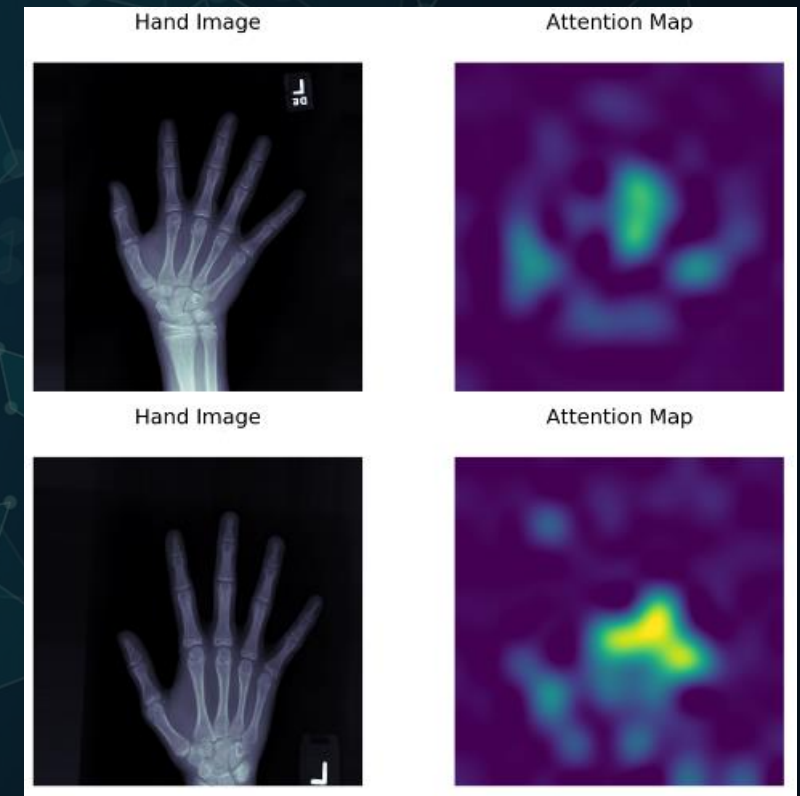
(CHN, TW2: The Standards of Skeletal Maturity of Hand and Wrist.)

Idea & Rationale

Attention mechanism:

1.To reduce the computational burden of processing high-dimensional input data, and to reduce the data dimension by structuredly selecting a subset of inputs.

2.To make the task processing system focus more on finding useful information related to the current output in the input data, thereby improving the quality of the output.



Idea & Rationale

Neural Network Architecture



Input: PNG files (12611 files)

Output: Floating point number

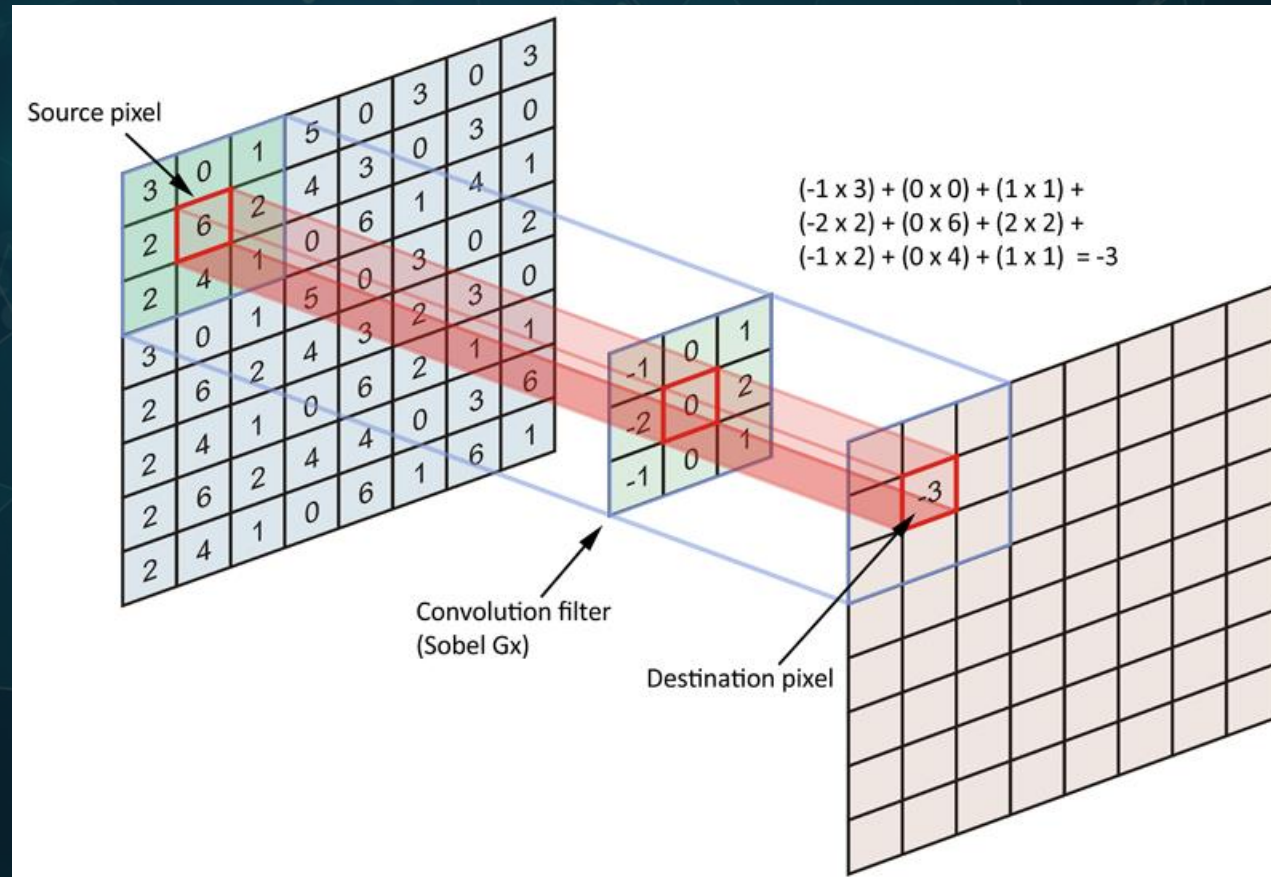
Attention mechanism: Conv2d_1 ~ Conv2d_3

Mean Absolute Deviation: 13.6961 months

(VGG16: Pre-training model)

Idea & Rationale

IDEA II: We wonder whether and how the size of convolution kernel will influence the accuracy of the final prediction.



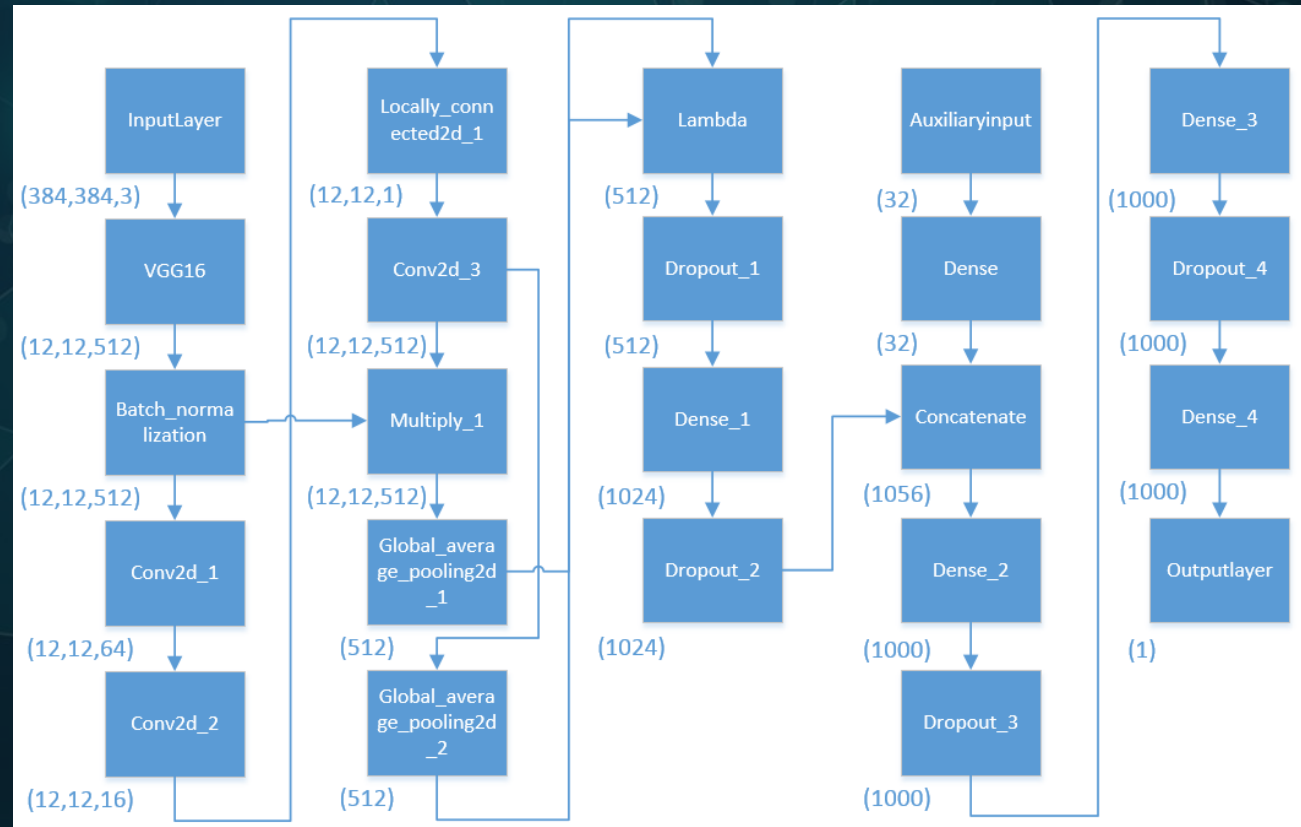
Idea & Rationale

IDEAIII: Gender might be a potential influencing factor on bone age prediction.

Features	Female	Male
Height increase period	Bone age 11-13 years	Bone age 13-15 years
Puberty	Bone age 11 years and about 9 months	Bone age 13 years and about 9 months
Stop growing in height	Bone age 17.3 years	Bone age 18.4 years

Idea & Rationale

- 1、Training male and female X-rays separately.
- 2、Adjusting the convolutional neural network structure to introduce Gender as a new feature.



A person is shown floating in space, positioned directly in front of a bright, glowing light source that creates a large, diffuse halo. The person's silhouette is dark against the intense light. Below the person, the curved horizon of the Earth is visible, showing the dark outlines of continents and the bright blue-white glow of the atmosphere. The background is a deep black space filled with numerous small, distant stars.

Experiments & Discussion

Experiments

Using attention mechanism:

	val_mae_month
Attention	13.6961
No_Attention	16.8528

(Evaluation standard: Mean Absolute Deviation)

Attention mechanism is suitable.

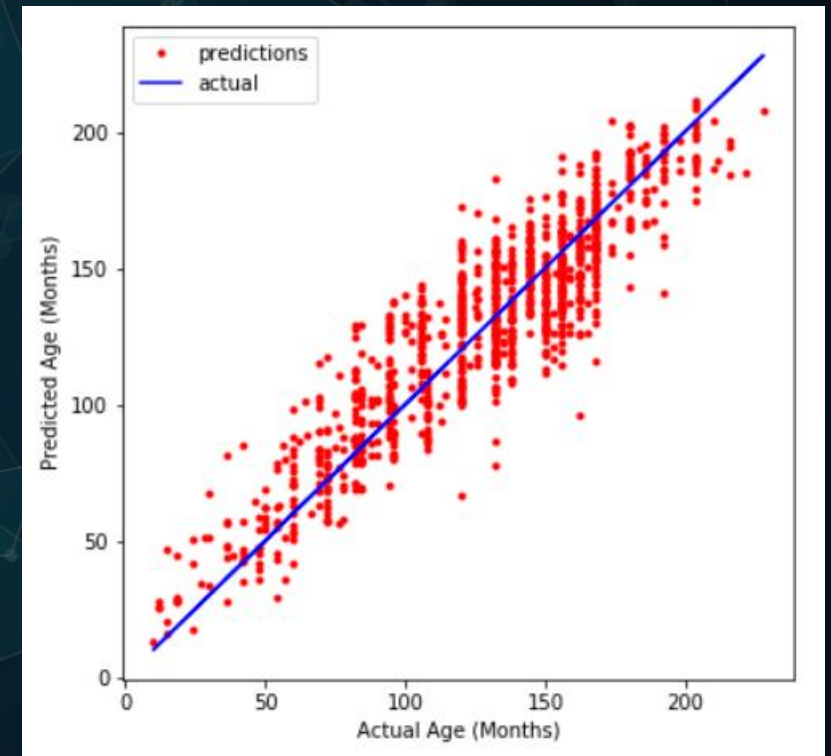
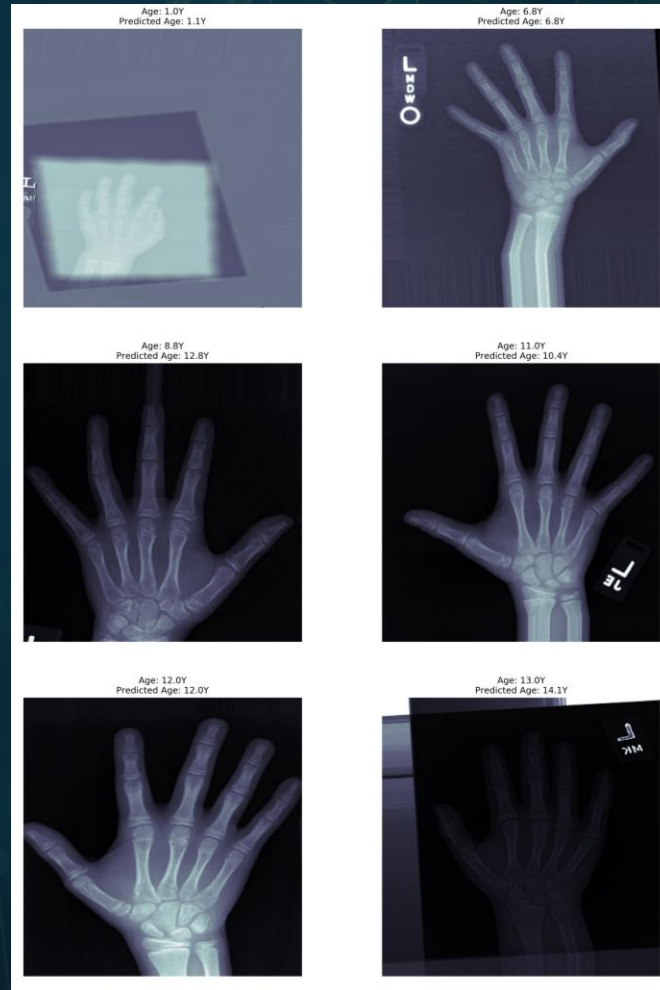
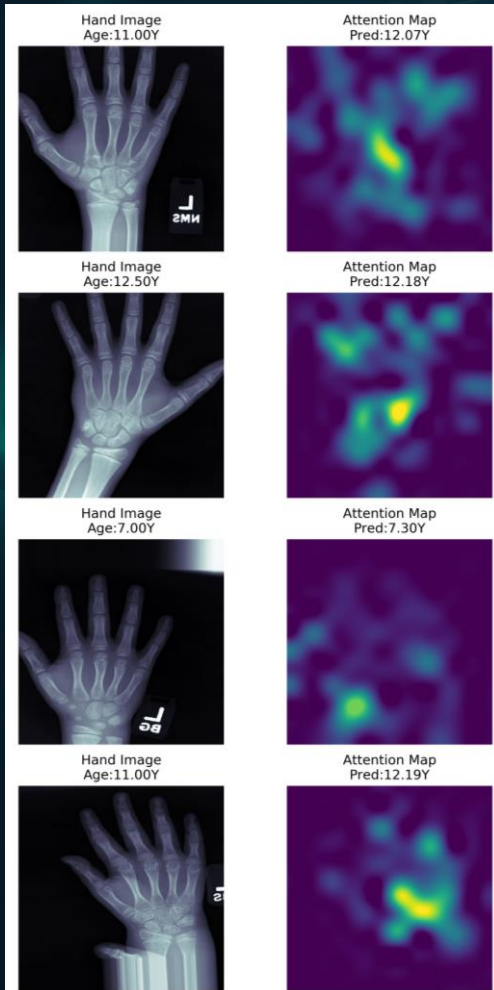
Experiments

The contents of experiments:

Idea I:	pre_train=vgg16
	pre_train=vgg19
	pre_train=resnet
	pre_train=inception_v3
Idea II:	kernel_size=(1,1)
	kernel_size=(3, 3)
	kernel_size=(5, 5)
Idea III:	no_balance
	male only
	female only

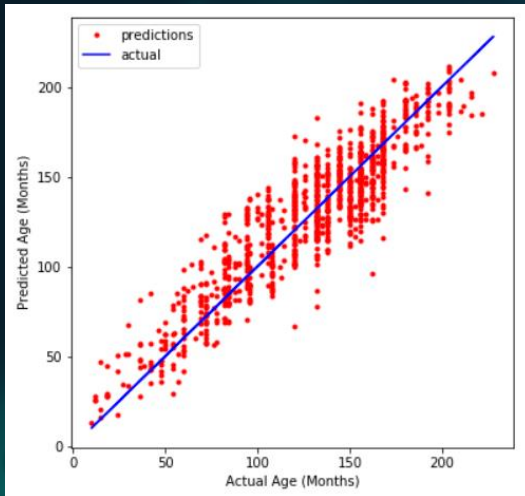
Experiments

Idea I: Using VGG16 as pre-training model.

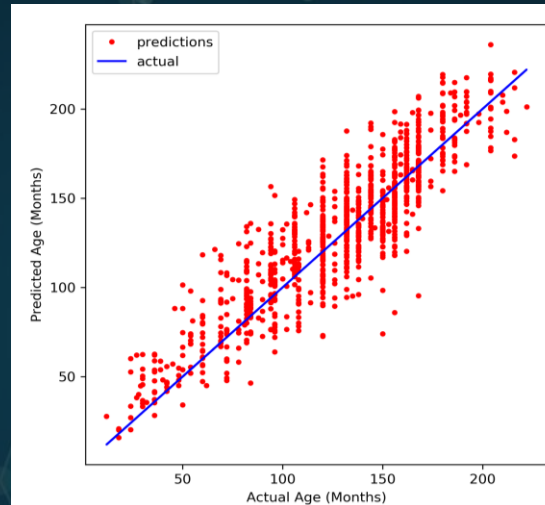


Experiments

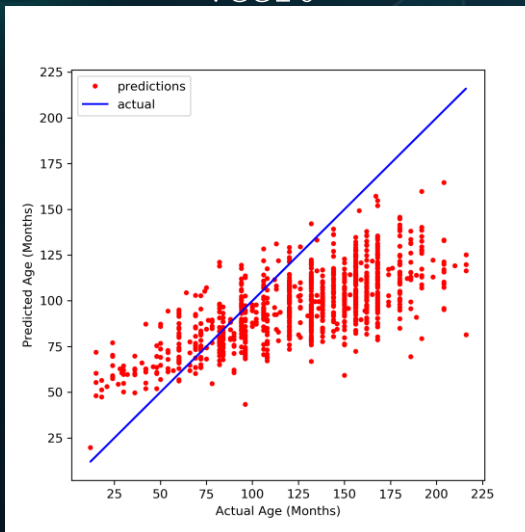
Regressions of 4 different pre-training models.



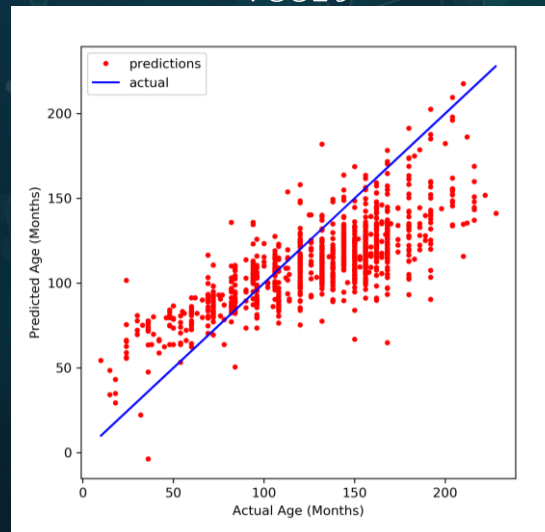
VGG16



VGG19



resnet



inception v3

pre_train_model	val_mae_month
vgg16	13.6961
vgg19	15.2857
resnet	26.9282
inception_v3	35.3809

Discussion

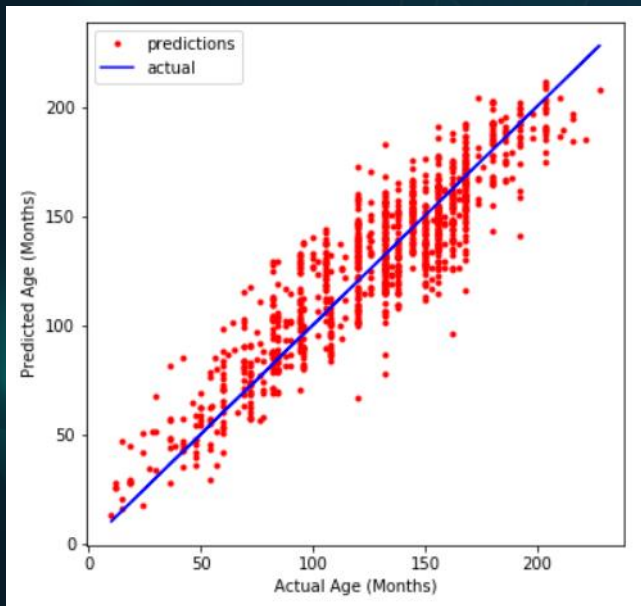
It seems that images pre-trained by VGG16 attain The best performance in bone age prediction.

A possible conjecture is about VGG16's generous parameters and shallow depth.

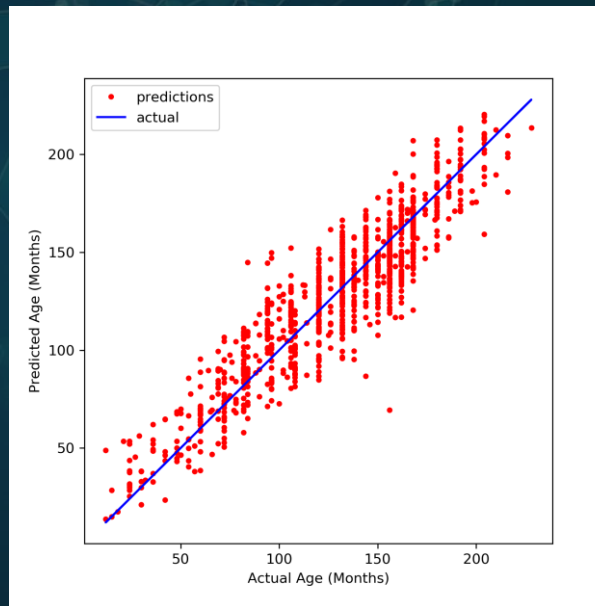
model	size	accuracy of Top1	accuracy of Top5	amount of parameter	depth
Xception	88MB	0.79	0.945	22,910,480	126
VGG16	528MB	0.715	0.901	138,357,544	23
VGG19	549MB	0.727	0.91	143,667,240	26
ResNet50	99MB	0.759	0.929	25,636,712	168
InceptionV3	92MB	0.788	0.944	23,851,786	159
InceptionResNetV2	215MB	0.804	0.953	55,876,736	572
MobileNet	17MB	0.665	0.871	4,253,864	88

Experiments

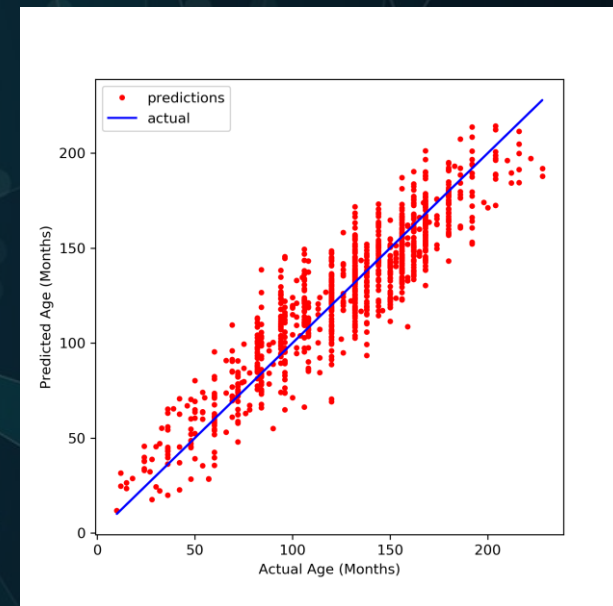
Idea Π : Replacing the original kernel of 1×1 with one of 3×3 and 5×5 .



(1*1)



(3*3)



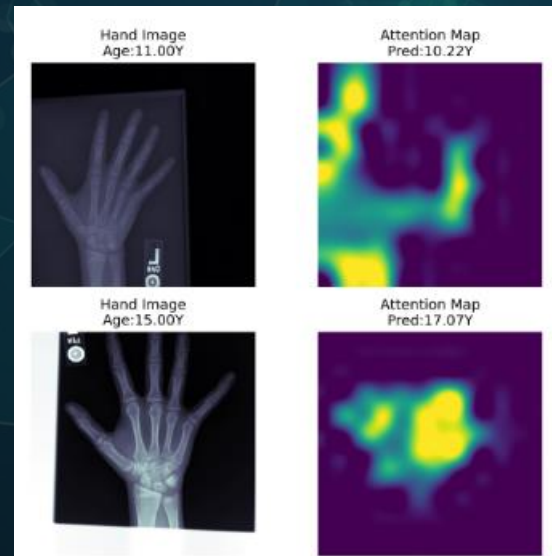
(5*5)

Kernel_size	(1*1)	(3*3)	(5*5)
val_mae_month	13.6961	13.0673	12.9808

Discussion

A 5*5 kernel perform the best compared with a 1*1 kernel and 3*3 kernel in Mean Absolute Deviation but it has an no obvious difference compared to 3*3 kernel.

Guess:Overfitting.



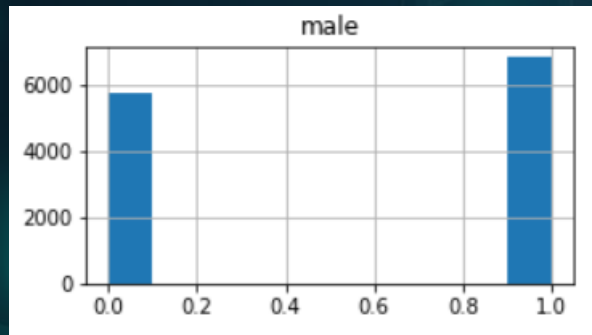
(5*5
)



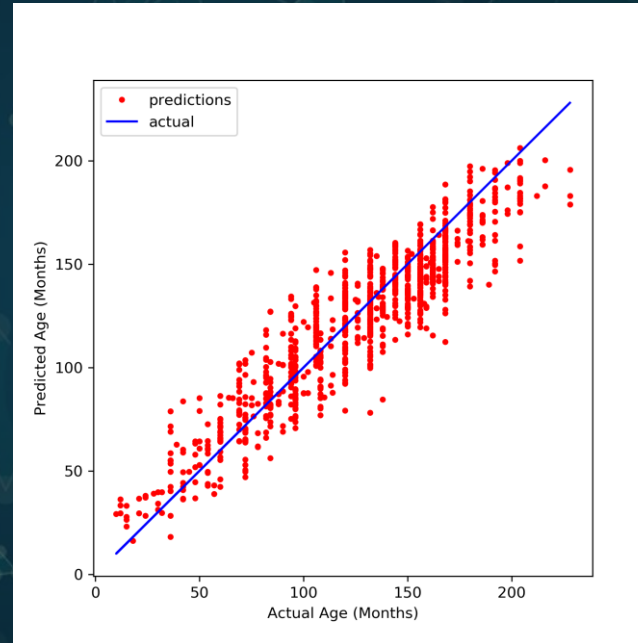
(3*3
)

Experiments

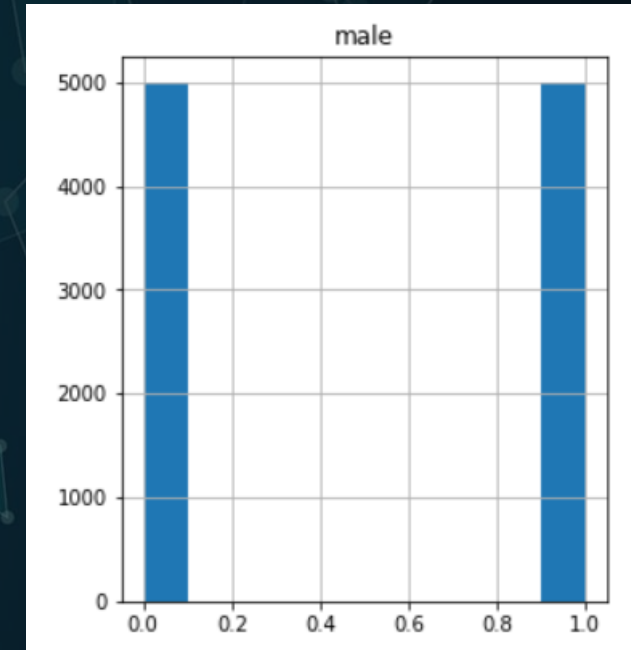
IdeaIII: Using gender as a new feature.



Original data without
balance in gender
information.



No balance

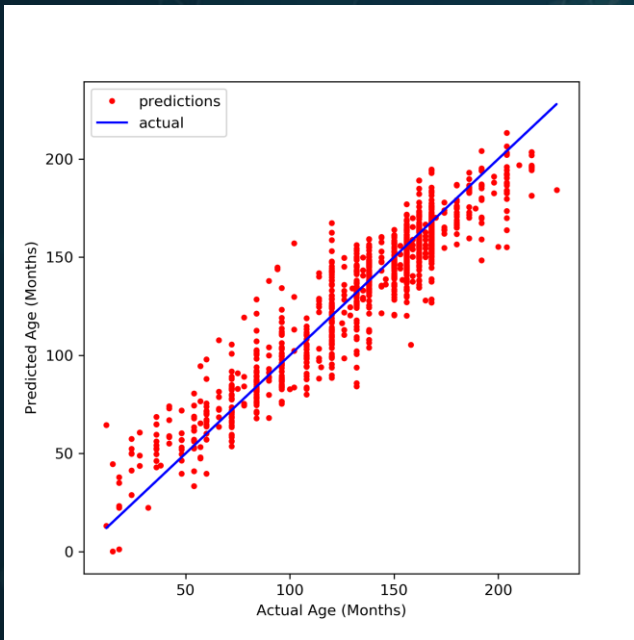


Data with balance in
gender and information.

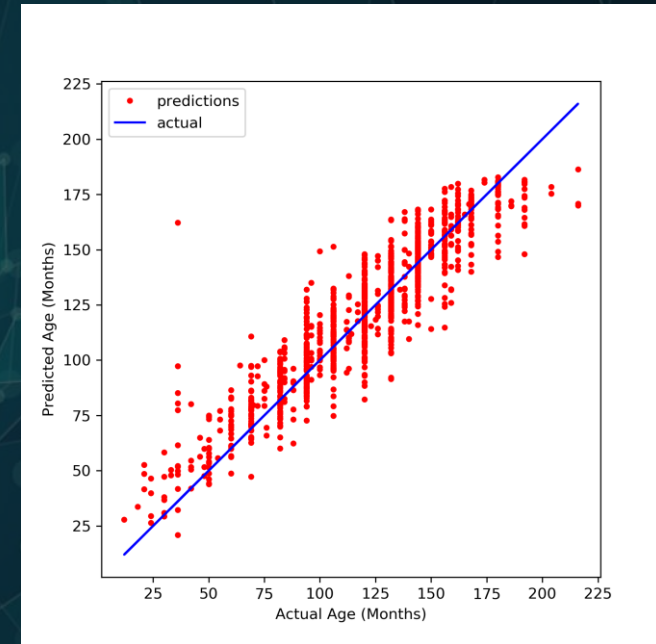
	Convergence time
No_balance	8:27:58
Balance	4:09:50

Experiments

Regressions of male-only and female-only.



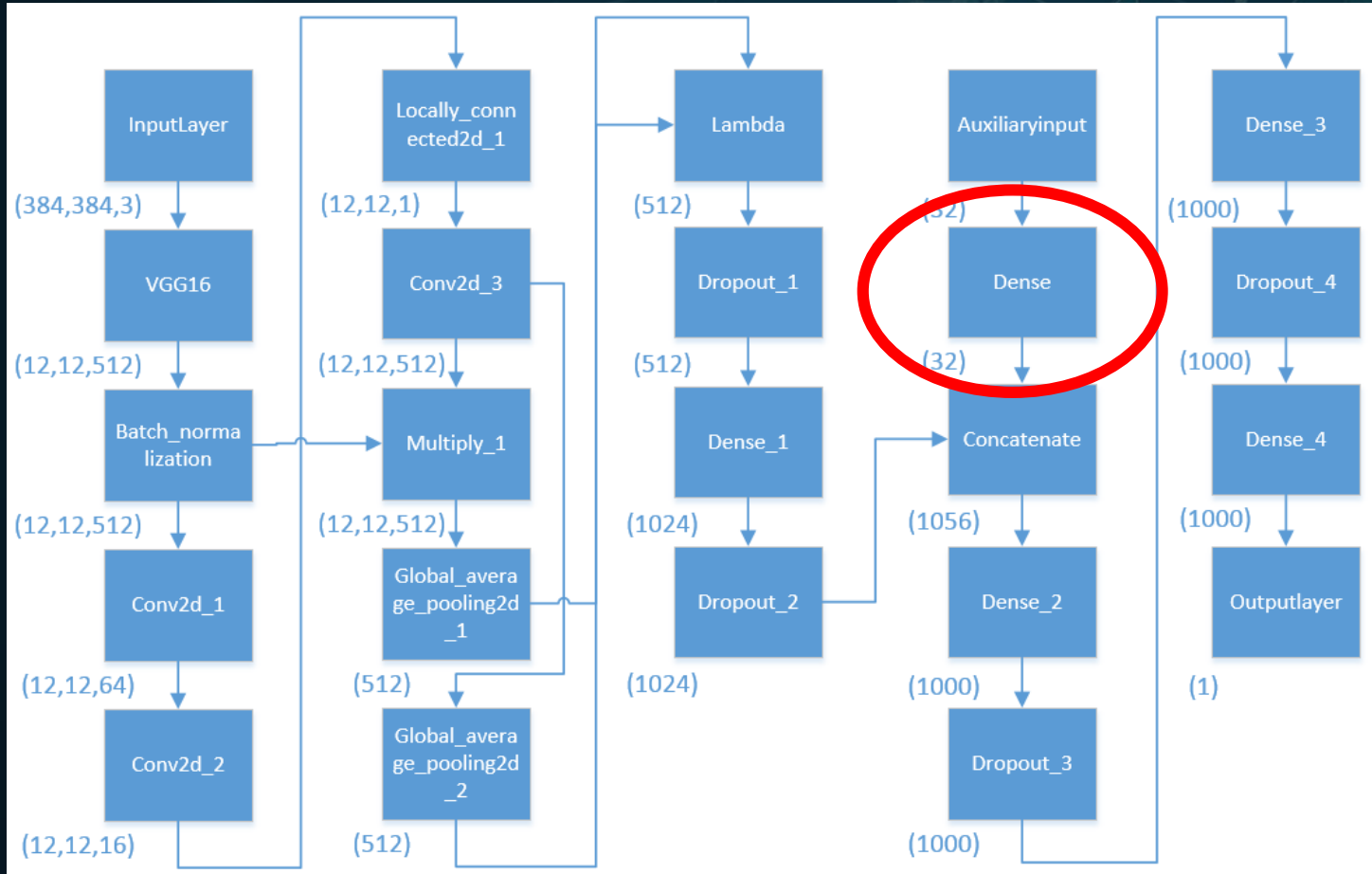
Male-only



Female-only

Gender information	no_balance	male only	female only
val_mae_month	14.1151	10.8182	10.6902

Experiments



shape	val_mae_months
16	11.2869
32	10.969
64	9.7845
128	10.2238
256	10.8532

Discussion

The background of the slide is a dark teal color. It features a complex network of thin, light teal lines connecting small dots, creating a web-like or molecular structure. In the upper right corner, a white line graph is visible, consisting of a horizontal line with several sharp, jagged peaks and valleys, resembling a signal or waveform.

This experiment indicates that there indeed exists difference between male and female in skeletal development.

A person is standing on a bright, glowing light source in the center of the image. The light source is a horizontal band of intense white and blue light, with the person's silhouette standing on it. The background is a deep black space filled with numerous small, distant stars. In the foreground, the curved horizon of the Earth is visible, showing the dark blue and black outlines of continents and oceans. The overall scene is a dramatic, high-contrast image of a person standing on a celestial body or light source, viewed from space.

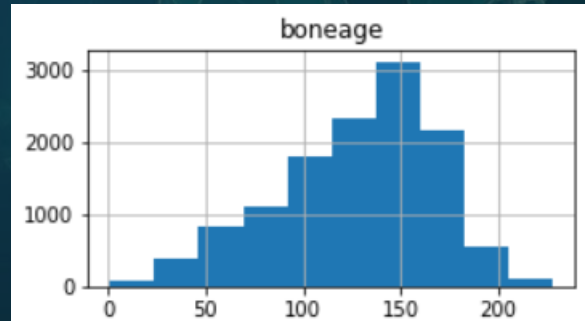
Conclusion

Conclusion

- 1、 Attention mechanism is effective in the task.
- 2、 VGG16 performed best in several pre-training models that had been tried.
- 3、 There indeed exists difference between male and female in skeletal development.
- 4、 3×3 kernel is suitable for this task.

Future work

- 1、 Grayscale graph should be processed by one channel.
- 2、 If we have pre-training weights for medical images, the pre-training model may perform better.



- 3、 The uneven distribution of bone age may have potential effect on prediction.
- 4、 The scanned image is noisy and can be converted to original image.

A person is shown in silhouette, floating in the vastness of space. They are positioned directly in front of a brilliant, glowing light source, which creates a strong lens flare and illuminates the scene. Below the person, the curved horizon of the Earth is visible, showing the dark, cratered surface of the planet. The overall atmosphere is one of isolation and cosmic wonder.

Q & A