

# Towards landmarks prediction with Deep Network

Van-Linh LE<sup>1,3</sup>, Marie BEURTON-AIMAR<sup>1</sup>,  
Akka ZEMMARI<sup>1</sup>, Nicolas PARISEY<sup>2</sup>

[linhlv@dlu.edu.vn](mailto:linhlv@dlu.edu.vn), [van-linh.le@labri.fr](mailto:van-linh.le@labri.fr), [beurton@labri.fr](mailto:beurton@labri.fr)  
[akka.zemmari@labri.fr](mailto:akka.zemmari@labri.fr), [nicolas.parisey@inra.fr](mailto:nicolas.parisey@inra.fr)

<sup>1</sup>LaBRI-CNRS 5800, Bordeaux University, France

<sup>2</sup>IGEPP, INRA 1349 Rennes, France

<sup>3</sup>ITDLU, Dalat University, Vietnam

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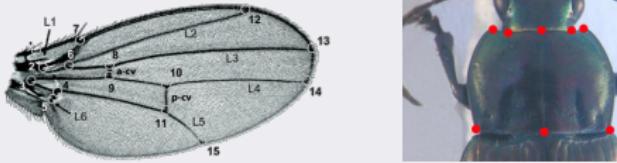


## Morphometry analysis

- ▶ Used to study the complex interaction between the evolution of insect and environmental factors.
- ▶ Characterize the common information of biological shape, such as, shape, sizes, or **landmarks**,....

## Landmark

- ▶ A kind of **point of interest**
- ▶ A specific point defined by biologist. For example, intersection of veins on fly wing, the corner of beetle's pronotum,....



# Dataset



- ▶ Images have been taken from 293 **beetles**, separate into 5 parts (images),
- ▶ Format: 2D in RGB color,
- ▶ Focus on **pronotum** images.



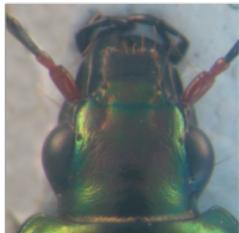
(a) Left mandible



(b) Right mandible



(c) Body

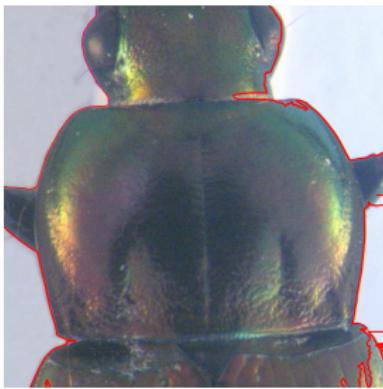


(d) Head

# Problems



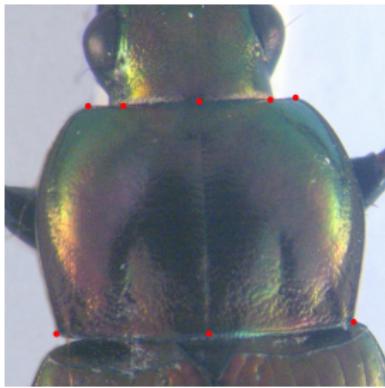
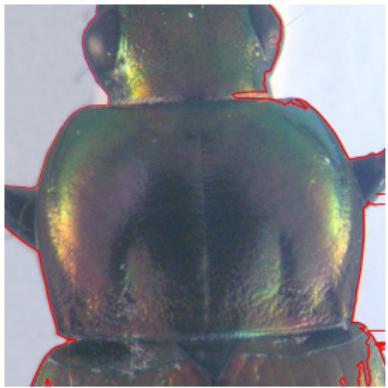
Un-segmentable images:



# Problems



Un-segmentable images:

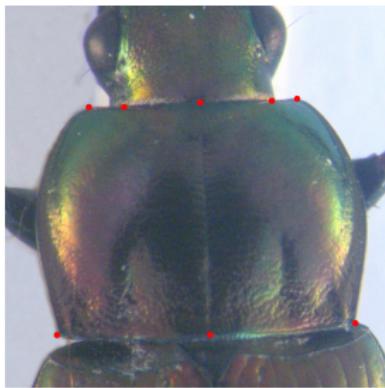
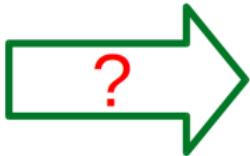
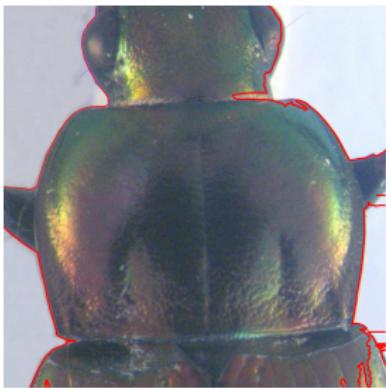


# Problems



3

Un-segmentable images:



**How to predict the landmarks coordinates?**

# Content



## Deep learning and Convolutional Neural Networks

Deep learning

Convolutional neural networks (CNNs)

## Proposed method

Network architectures

Data augmentation

Training from scratch

Fine-tuning

## Results

## Conclusion



## Definition<sup>1</sup>

- ▶ A class of machine learning,
- ▶ Use a cascade of multiple layers for feature extraction and transformation,
- ▶ Learn multiple levels of representation in supervised or unsupervised.

<sup>1</sup> Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," Nature, vol. 521, no. 7553, pp. 436–444, 2015



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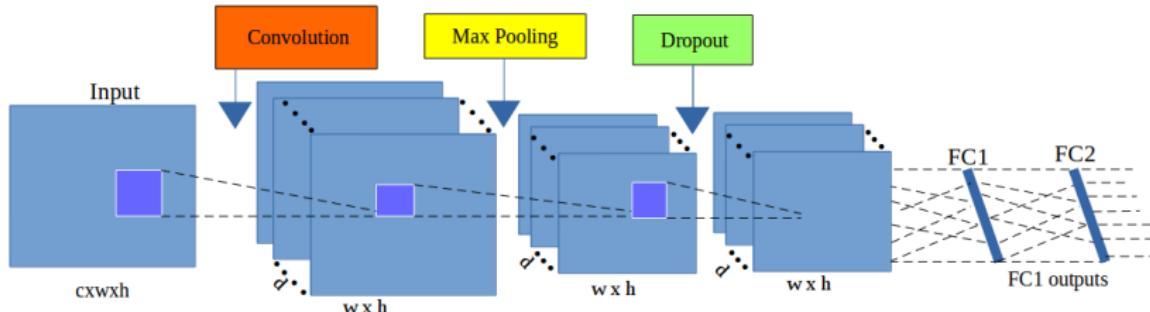
## Applications<sup>1</sup>

- ▶ Computer vision (image recognition and classification)
- ▶ Speech recognition
- ▶ Question answering, language translation

<sup>1</sup> Y. LeCun, Y. Bengio, and G. Hinton, "Deep learning," Nature, vol. 521, no. 7553, pp. 436–444, 2015



- ▶ Consists an input, an output and multiple hidden layers<sup>1</sup>
- ▶ Arranges the data in 3 dimensions: *width, height and depth*
- ▶ Classical layers: convolutional layers (**CONV**), pooling layers (**POOLING**), dropout layers (**DROPOUT**), full-connected layers (**FC**), ...



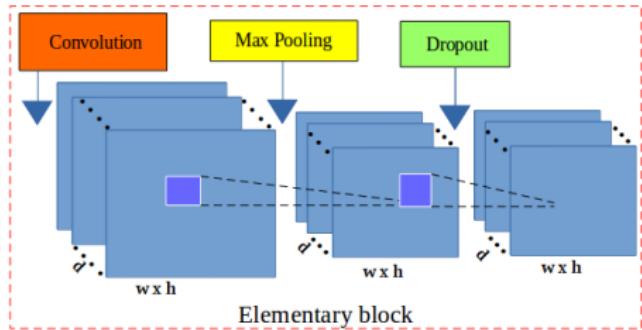
<sup>0</sup> Y. LeCun et al, "Convolutional networks and applications in vision", 2010.

# Network architecture



Elementary block:

- ▶ A CONV layer,
- ▶ A maximum POOLING layer,
- ▶ A DROPOUT layer

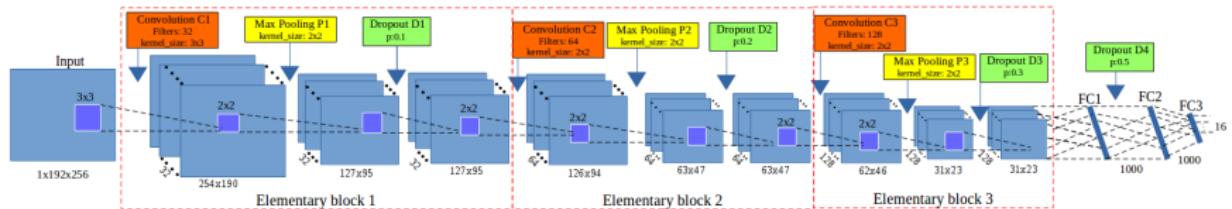


# Network architecture



The proposed model:

- ▶ **Three** elementary blocks,
- ▶ **Three** full-connected (FC) layers
- ▶ A dropout layer was inserted between the first of two FCs



# Data augmentation



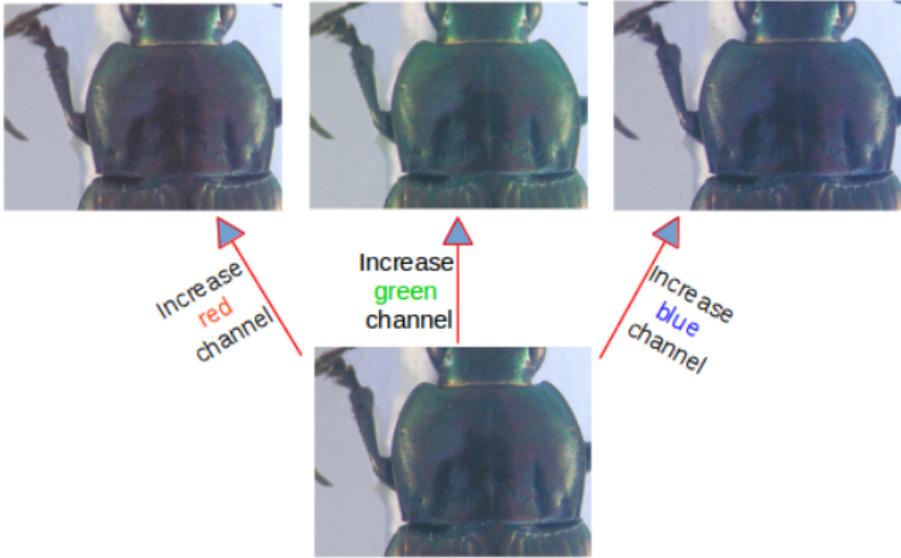
Dataset: 293 pronotum images in RGB format.

# Data augmentation



## Augmentation methods:

- ▶ Increase the value of each channel,

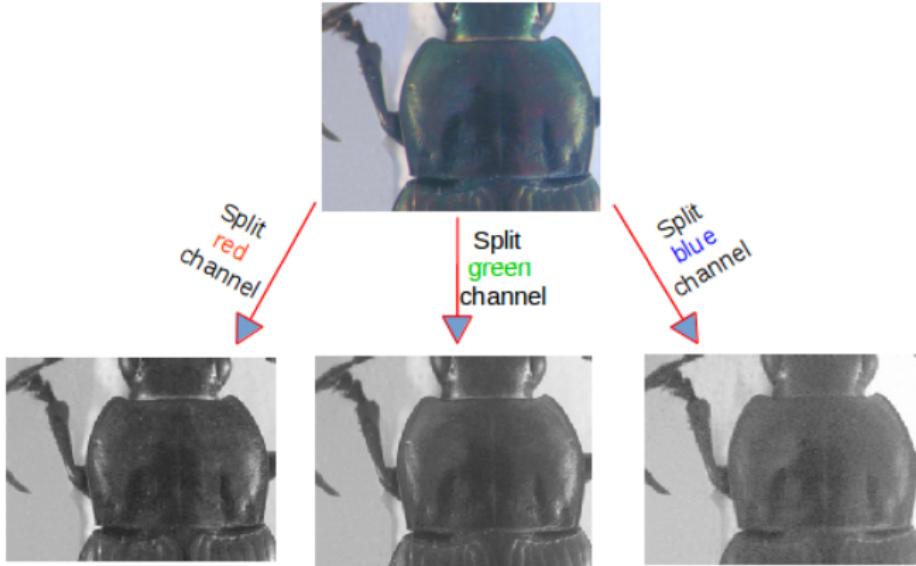


# Data augmentation



Augmentation methods:

- ▶ Split the channels.



# Data augmentation

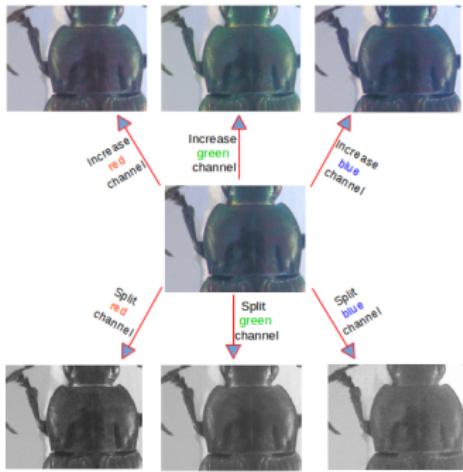


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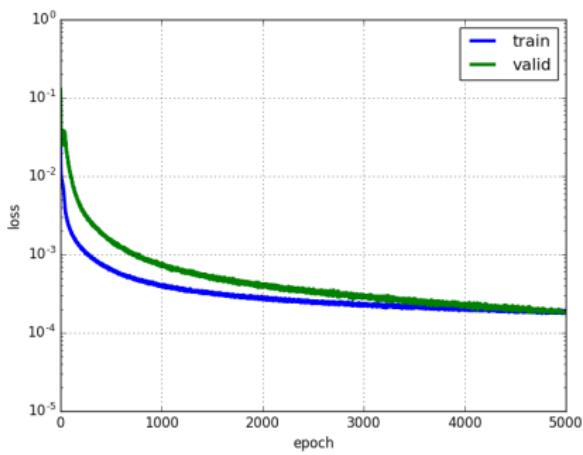
Total:  $293 \times 7 = 2,051$  images



# Training



- ▶ Training parameters: momentum ( $0.9 \rightarrow 0.9999$ ), learning rate ( $0.03 \rightarrow 0.00001$ ), 5,000 epochs<sup>1</sup>
- ▶ Training dataset: 1,820 images ( $260 \times 7$ )
- ▶ Images shows training and validation losses of the models.  
Blue curves are training losses, green curves are validation losses.
- ▶ Training time: 3 hours using NVIDIA TITAN X card.



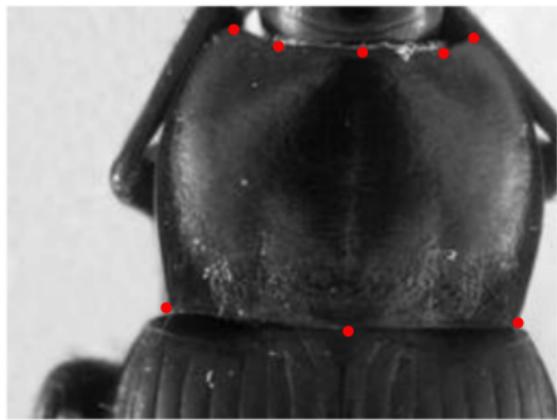
<sup>1</sup>An epoch is a single pass through the full training set.

# First result

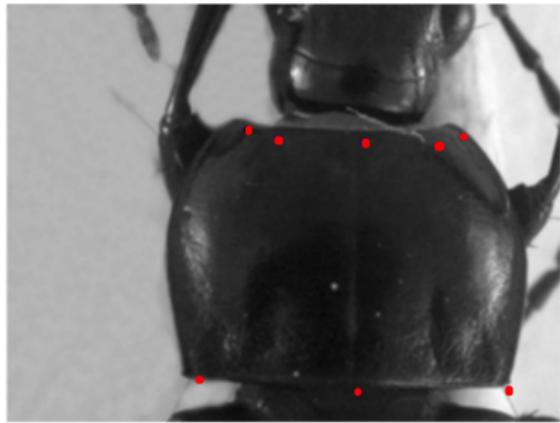
Landmarks on images



- ▶ Run the trained model to predict the landmarks on testing images,
- ▶ Calculate the distance between predicted landmarks and corresponding manual landmarks,



(a)



(b)

# First result

Correlation metrics and average distances



- ▶ Quality metrics: coefficient of determination ( $r^2$ ), explained variance (EV), Pearson correlation.

Metric	$r^2$	EV	Pearson
Proposed architecture	<b>0.9952</b>	<b>0.9951</b>	<b>0.9974</b>

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Correlation metrics and average distances



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Proposed architecture	<b>0.9952</b>	<b>0.9951</b>	<b>0.9974</b>

- ▶ The average distances of all images per landmark.

Landmark	Distance (in pixels)
1	4.002
2	4.4831
3	4.2959
4	4.3865
5	4.2925
6	5.3631
7	4.636
8	4.9363

# Transfer learning



- ▶ Re-uses model developed for a specific task/dataset to lead another task with another dataset
- ▶ **Fine-tuning:** retrain a pretrained model
- ▶ **Model Zoo** (Caffe library): people share their network weights.

**TRANSFER OF LEARNING**



The application of skills, knowledge, and/or attitudes that were learned in one situation to another **learning** situation (Perkins, 1992)

# Fine-tuning our model

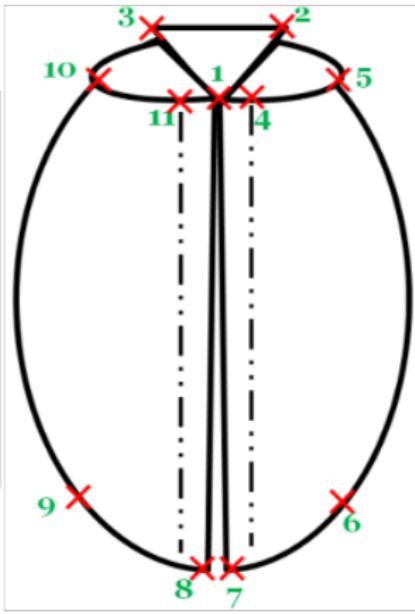
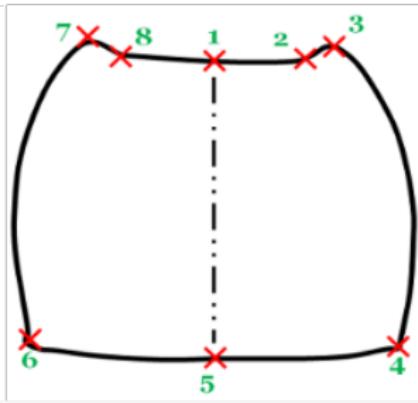
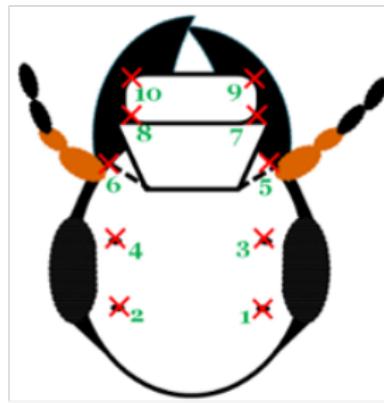


- ▶ Train the model on a dataset including the images of 3 parts of beetles (5,460 images)
- ▶ Fine-tune pretrained model on pronotum dataset

# Fine-tuning our model



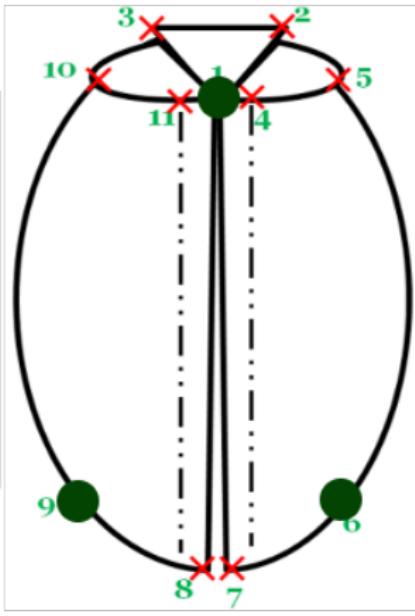
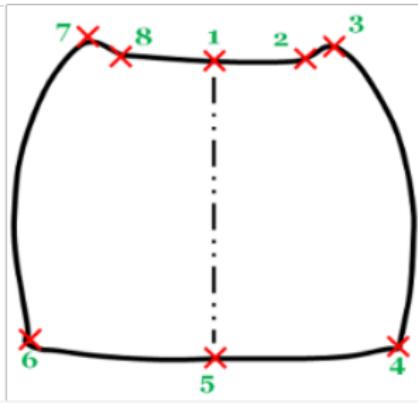
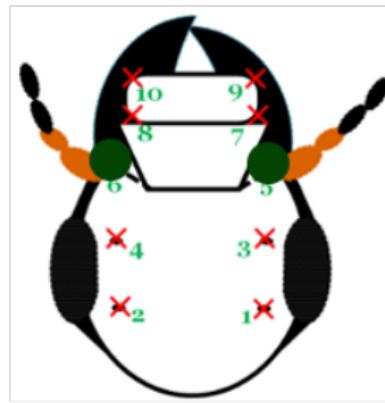
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# Results

Average distance comparing



The average distances of all images per landmark.

Landmark	Distance (in pixels)
1	2.486
2	2.7198
3	2.6523
4	2.7709
5	2.4872
6	3.0492
7	2.6836
8	2.8709

# Results

Average distance comparing



Comparing the average distances between two processes (training from scratch and fine-tuning).

Landmark	From scratch		With fine-tuning	
	Average	SD	Average	SD
<b>LM1</b>	<b>4.002</b>	<b>2.5732</b>	<b>2.486</b>	<b>1.5448</b>
LM2	4.4831	2.7583	2.7198	1.7822
LM3	4.2959	2.7067	2.6523	1.8386
LM4	4.3865	3.0563	2.7709	1.9483
LM5	4.2925	2.9086	2.4872	1.6235
<b>LM6</b>	<b>5.3631</b>	<b>3.4234</b>	<b>3.0492</b>	<b>1.991</b>
LM7	4.636	2.8426	2.6836	1.7781
LM8	4.9363	3.0801	2.8709	1.9662

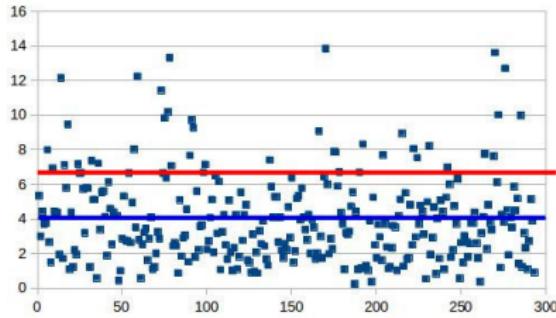
# Results

Distribution of average distances

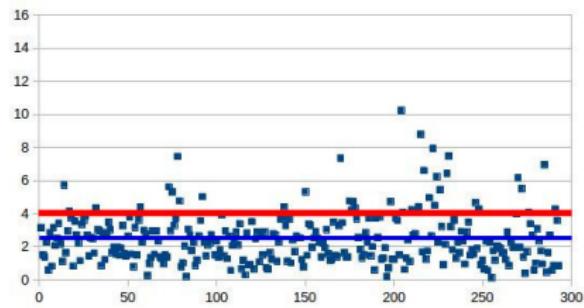


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- The distribution of distance of the best result ( $1^{st}$  landmark)



(a) Training from scratch



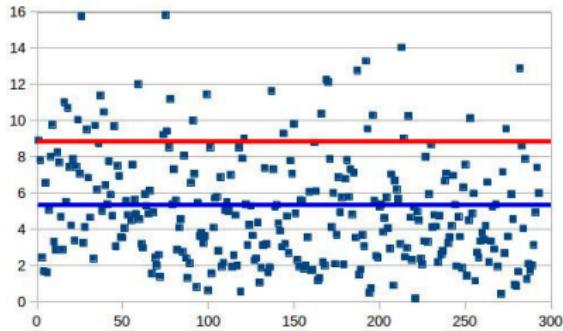
(b) With fine-tuning

# Results

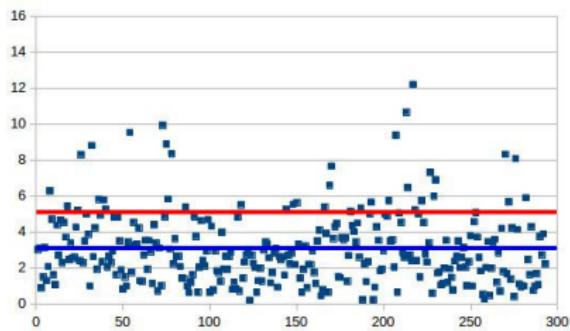
Distribution of average distances



- ▶ The distribution of distance of the worst result ( $6^{th}$  landmark)



(a) Training from scratch



(b) With fine-tuning

# Conclusion



## Conclusion

- ▶ Propose a CNN to predict the landmarks on pronotum images.
- ▶ Propose procedure to augment the dataset.
- ▶ Apply fine-tuning to improve the quality of predicted landmarks.
- ▶ The last of the predicted landmarks leads to satisfying results without a need for segmentation step. It allows replacing manual landmarks.

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## Future works

Continue improving the landmarks coordinates by going deeply how to characterize the learning problem to design the right pre-training set.



**Thank you for attention!**