Towards landmarks prediction with Deep Network

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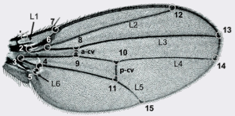
Context

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**,. . . .

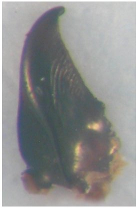
Landmark

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



Dataset

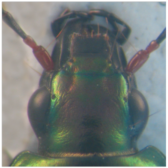
- Images have been taken from 293 **beetles**, seperate into 5 parts (images),
- Format: 2D in RGB color,
- Focus on **pronotum** images.



(a) Left mandible

(b) Right mandible

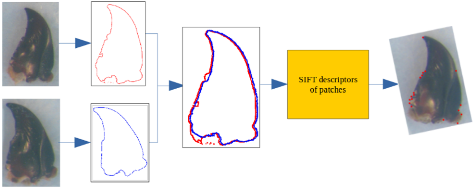
(c) Body



(d) Head

Problems

With segmentable images:[1]



[1] Van-Linh Le, Marie Beurton-Aimar, Adrien Krähenbühl, and Nicolas Parisey. “MAELab: a framework to automatize landmark estimation." WSCG 2017.

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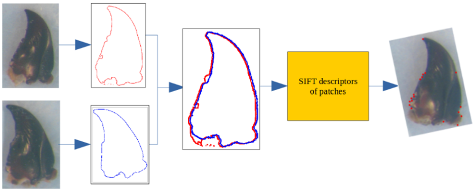
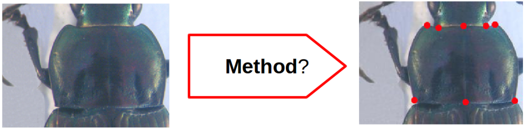


With un-segmentable images:



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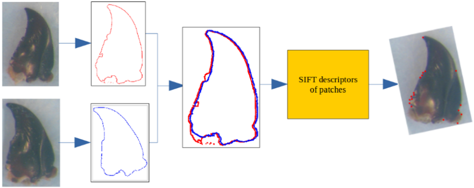

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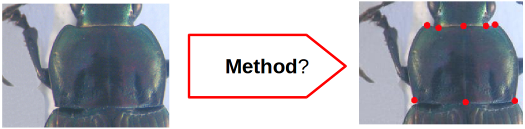

How to predict the landmarks coordinates?

[1] Van-Linh Le, Marie Beurton-Aimar, Adrien Krähenbühl, and Nicolas Parisey. “MAELab: a framework to automatize landmark estimation." WSCG 2017.

Content

Deep learning

Definition

- A class of machine learning[1],
- Use a cascade of multiple layers for feature extraction and transformation,
- Learn multiple levels of representation in supervised or unsupervised.

[1] Y. LeCun, Y. Bengio, and G. Hinton, “Deep learning,” Nature, vol. 521, no. 7553, pp. 436–444, 2015

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Applications

- Computer vision (image recognition and classification)[2]
- Speech recognition[3]
- Question answering [4], language translation[5]

[1] Y. LeCun, Y. Bengio, and G. Hinton, “Deep learning,” Nature, vol. 521, no. 7553, pp. 436–444, 2015

[2] A. Krizhevsky et al, “Imagenet classification with deep convolutional neural networks", 2012.

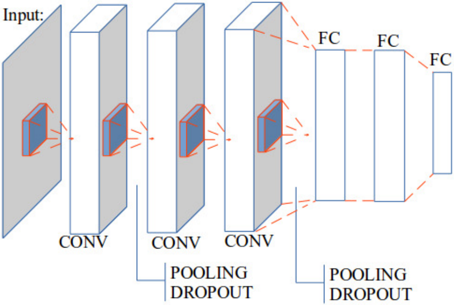
[3] T. N. Sainath et al, “Deep convolutional neural networks for lvcsr", 2013.

[4] A. Bordes et al, “Question answering with subgraph embeddings", 2014.

[5] I. Sutskever et al, “Sequence to sequence learning with neural networks", 2014.

CNNs

- Consists an input, an output and multiple hidden layers[1]
- 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**), . . .



[1] Y. LeCun et al, “Convolutional networks and applications in vision", 2010.

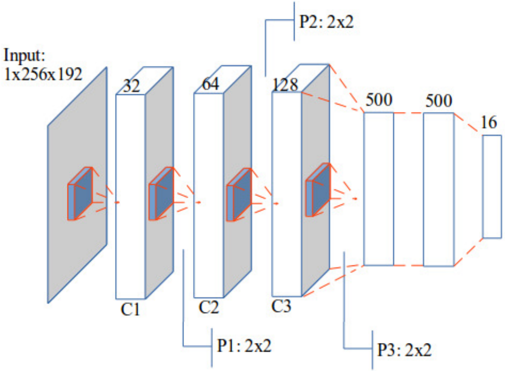
Network architecture

The first model includes:

- An gray-scale input,
- 3 CNN layers (C1, C2, C3),
- 3 POOLING layers (P1, P2, P3),
- 3 FC layers.

Problems:

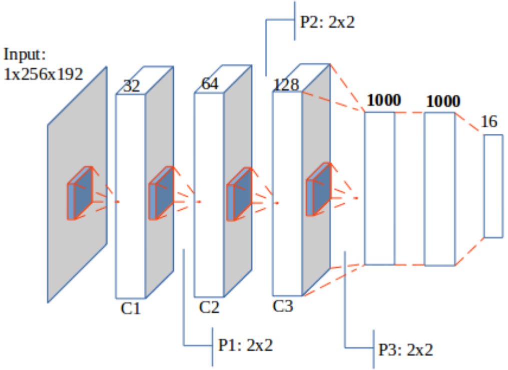
- Output is not good enough,
- Overfitting.



Network architecture

The second model:

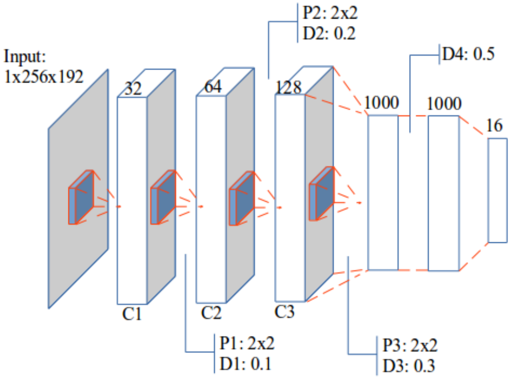
- Same architecture with the first one,
- Modify the output of FC layers (500 -> 1000),
- Result is not improved.



Network architecture

The **third** model includes:

- Keep architecture of the second model,
- Adding 4 **DROPOUT layers** (D1, D2, D3, D4)



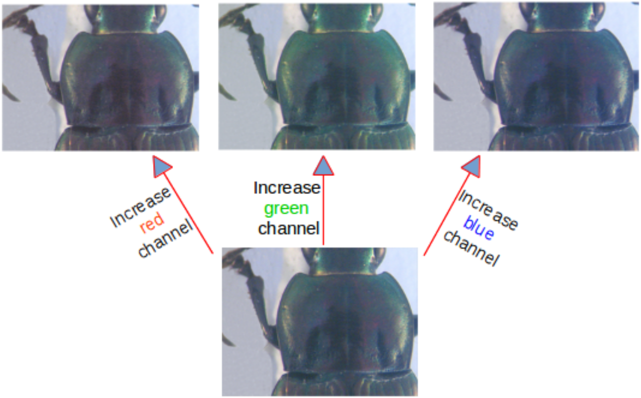
Data augmentation

Dataset: 293 pronotum images in RGB format.

Data augmentation

Augmentation methods:

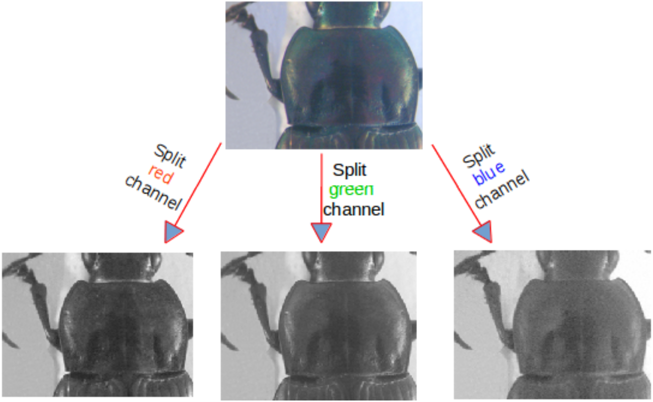
- Increase the value of each channel,



Data augmentation

Augmentation methods:

- Split the channels.

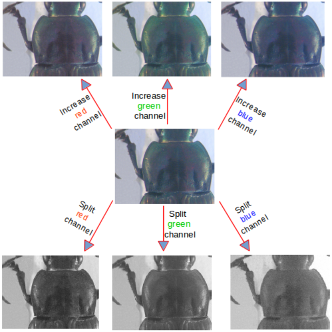


Data augmentation

Dataset: 293 pronotum images in RGB format.
Augmentation methods:

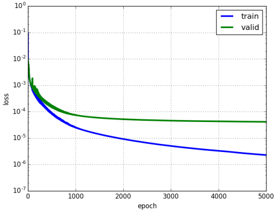
- Increase the value of each channel,
- Split the channels.

Total: $293 \times 7 = 2051$ images

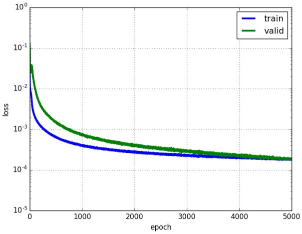


Training

- Model: the third model in 5000 epochs[2]
- Training dataset: 1820 images (260×7)
- Testing set: 33 images
- 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.



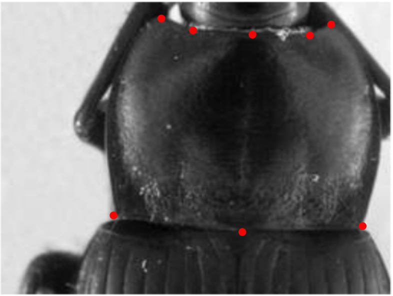
(a) The first architecture



(b) The third architecture

2 An epoch is a single pass through the full training set.

Images show the result on testing images.



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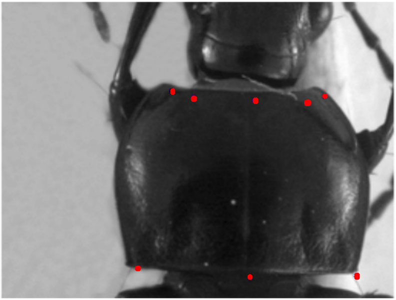


(b)

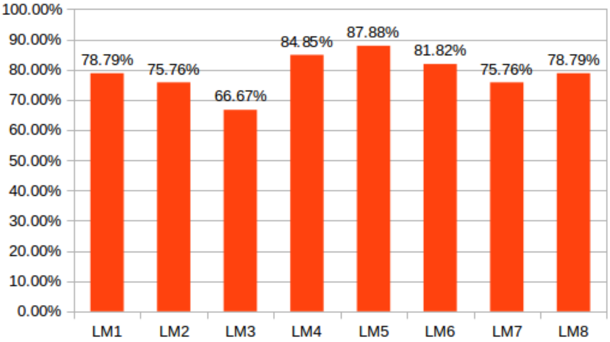
Result
Average distance

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

Chart shows the propotion of acceptable predicted landmarks

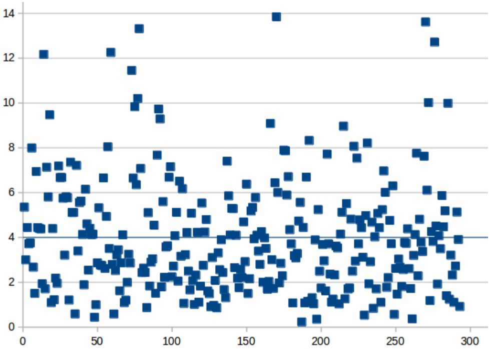
- Average accuracy: $\sim$ 75%
- Highest accuracy: 87.88%
- Lowest accuracy: 66.67%



Result

Distribution of distance on the first landmark

- Good prediction: 56.66%
- Acceptable prediction: 40.27%
- Bad prediction: 3.07%



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

Metric	r^2	EV	Pearson
Cintast et al.[3]	0.884	0.951	0.976
Proposed architecture	**0.9952**	**0.9951**	**0.9974**

[3] Cintas, "Automatic ear detection and feature extraction using geometric morphometrics and convolutional neural networks," IET Biometrics, vol. 6, no. 3, pp. 211–223, 2016

Conclusion

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- Proposed a CNN to predict the landmarks on pronotum images.
- Proposed procedure to augment the dataset.
- The location of the predicted landmarks are acceptable with high accuracy ($\sim 75\%$). It allows to replace manual landmarks.

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Future works

Continue improving the landmarks coordinates by continuing on deep learning, *for example*, using transfer learning.

Thank you for attention!