# Data simulation to improve supervised segmentation of apple scab images

## Clément DOUARRE

*Supervisors : Laure TOUGNE, Carlos CRISPIM-JUNIOR, David ROUSSEAU, Anthony GELIBERT*

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EXPÉRIMENTATION
INNOVATION

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Légumes
Ornement
Plantes aromatiques
et médicinales
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Cidriculture
Viticulture
Paysage

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# Apple scab

- Infection of fruit by a fungus which can cause major production loss for farmers.

*Source image : Wikipedia*

# Apple scab

- Infection of fruit by a fungus which can cause major production loss for farmers.
- Early and automatic detection would be of major interest.



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# Apple scab

- Infection of fruit by a fungus which can cause major production loss for farmers.
- Early and automatic detection would be of major interest.
- Use of infrared imaging. [1]



*Source image : Wikipedia*



RGB                    IR

[1] Belin *et al*, "*Thermography versus chlorophyll fluorescence imaging for detection and quantification of apple scab.* ", 2013
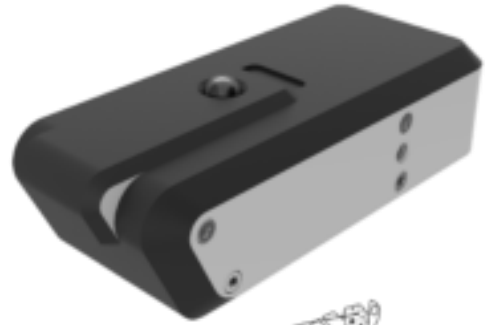
# Image acquisition

# Image acquisition

Carbon Bee sensor

# Image acquisition



RGB

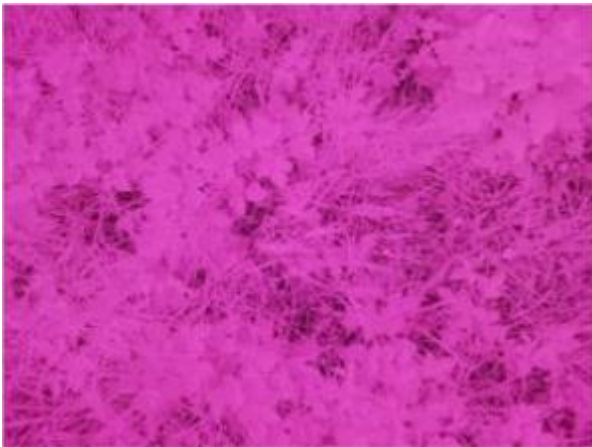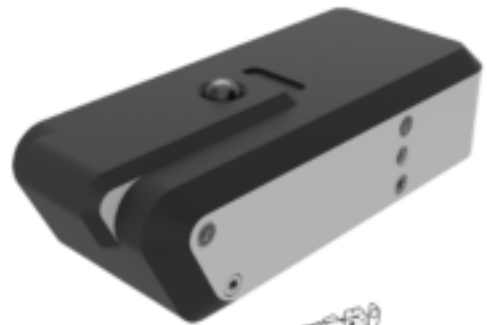Carbon Bee sensor

# Image acquisition
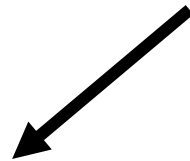


RGB

Carbon Bee sensor
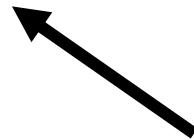
IR
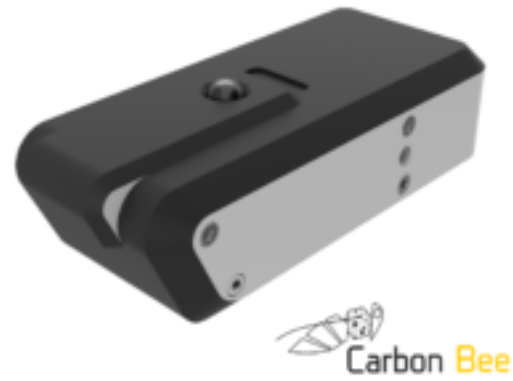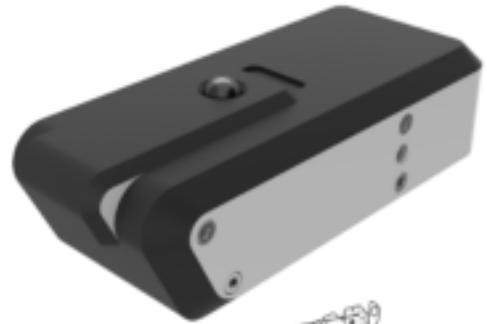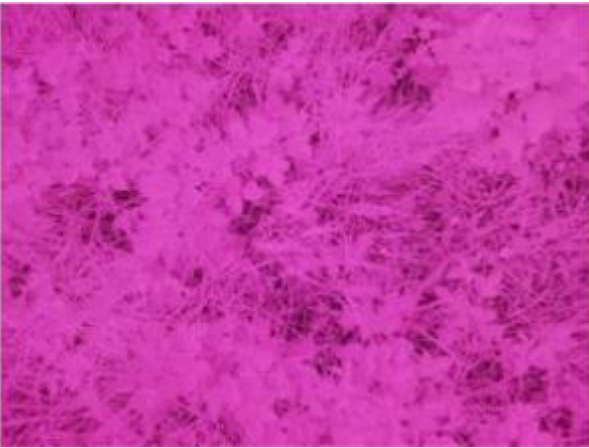
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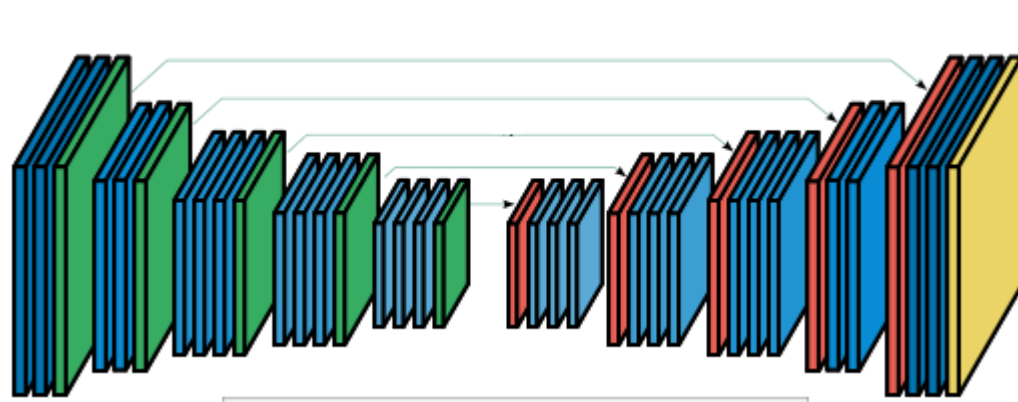
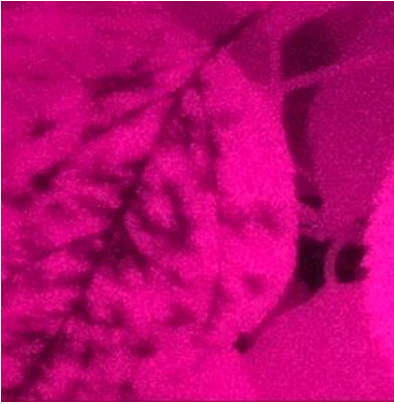

RGB

IR

Carbon Bee sensor

Hyperspectral

# Segmentation by neural networks

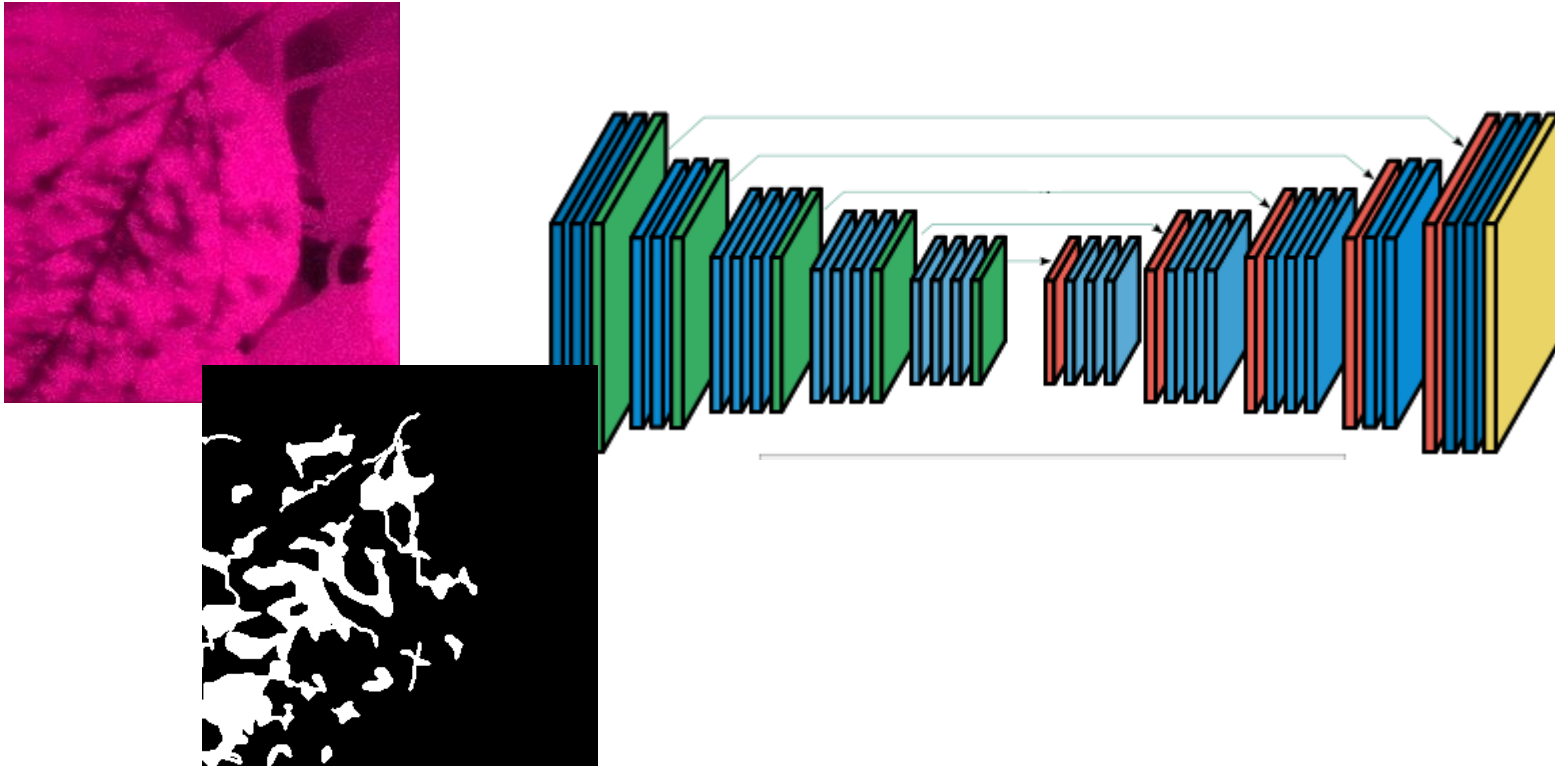- Segmentation of apple scab : localization of scab pixels on an image.

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- Segmentation of apple scab : localization of scab pixels on an image.
- Done here by Convolutional Neural Networks (SegNet).
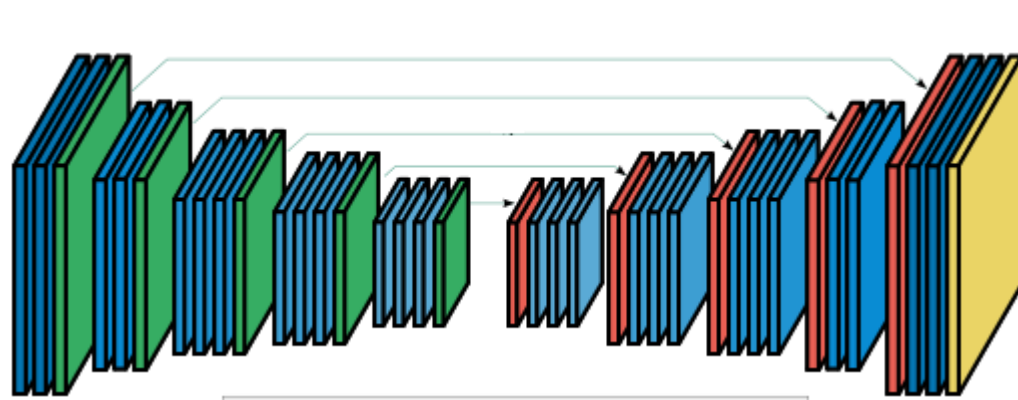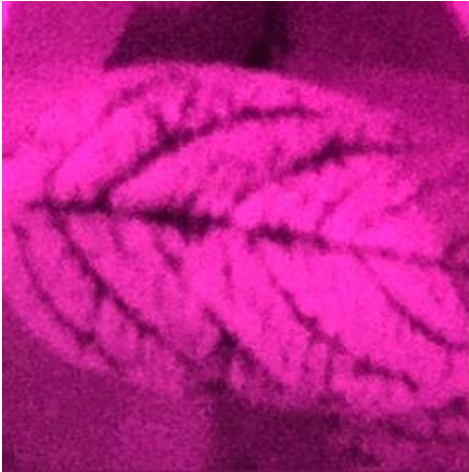
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Source network image : Badrinarayanan *et al*, "*Segnet: A deep convolutional encoder-decoder architecture for image segmentation.* ", 2016
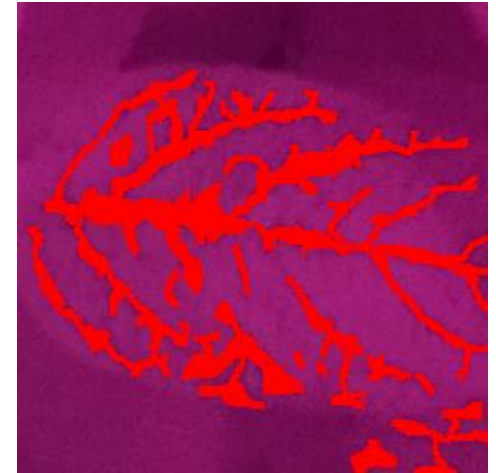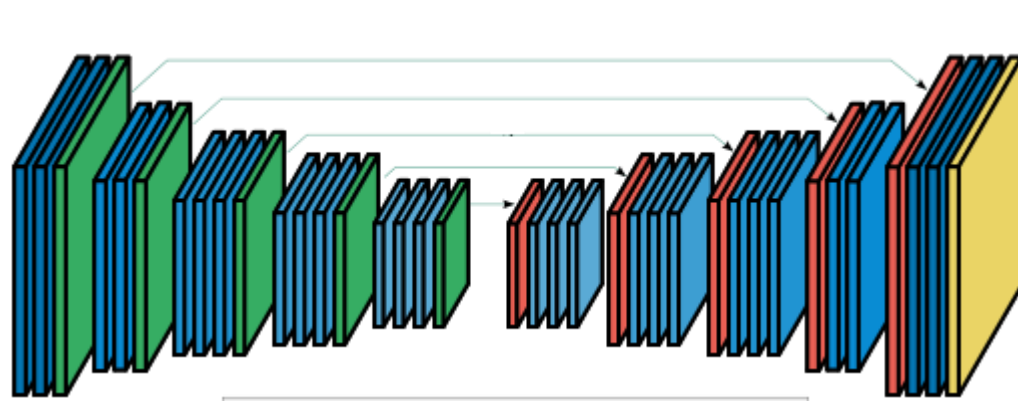
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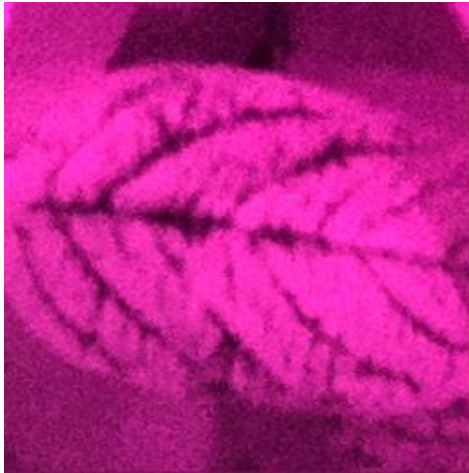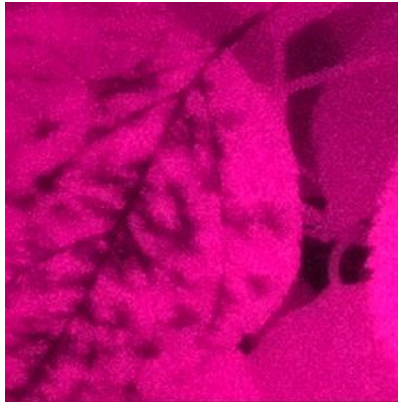
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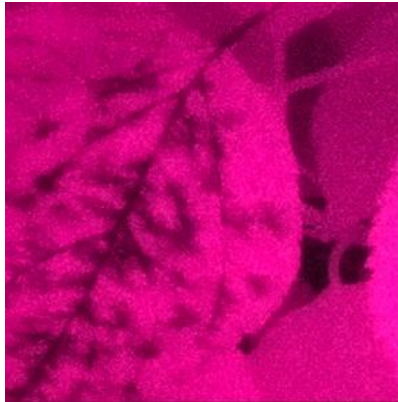- Done here by Convolutional Neural Networks (SegNet).

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- Annotation for segmentation is done pixelwise.
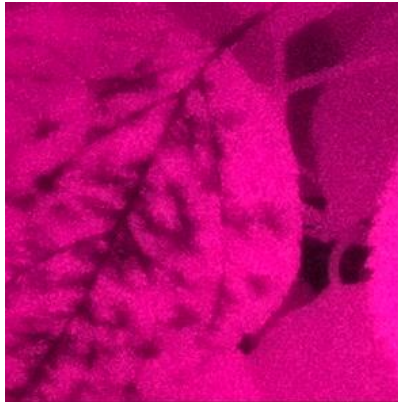
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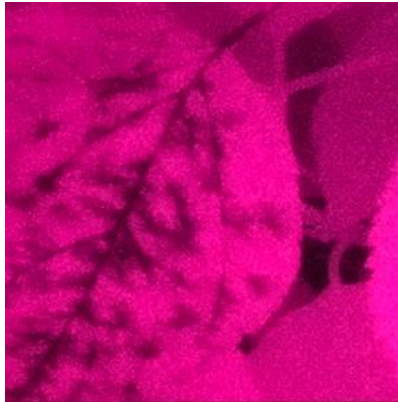
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- >> training databases are usually quite small.
  Our database is 10 images, which we tile in 887 sub-images.
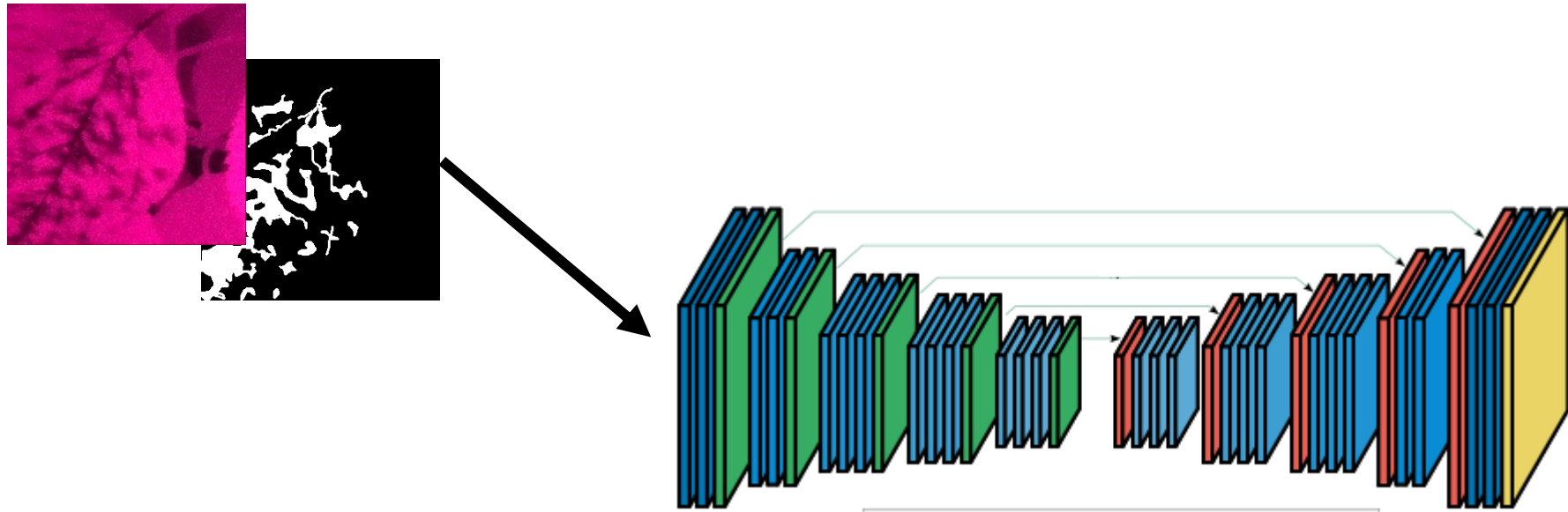
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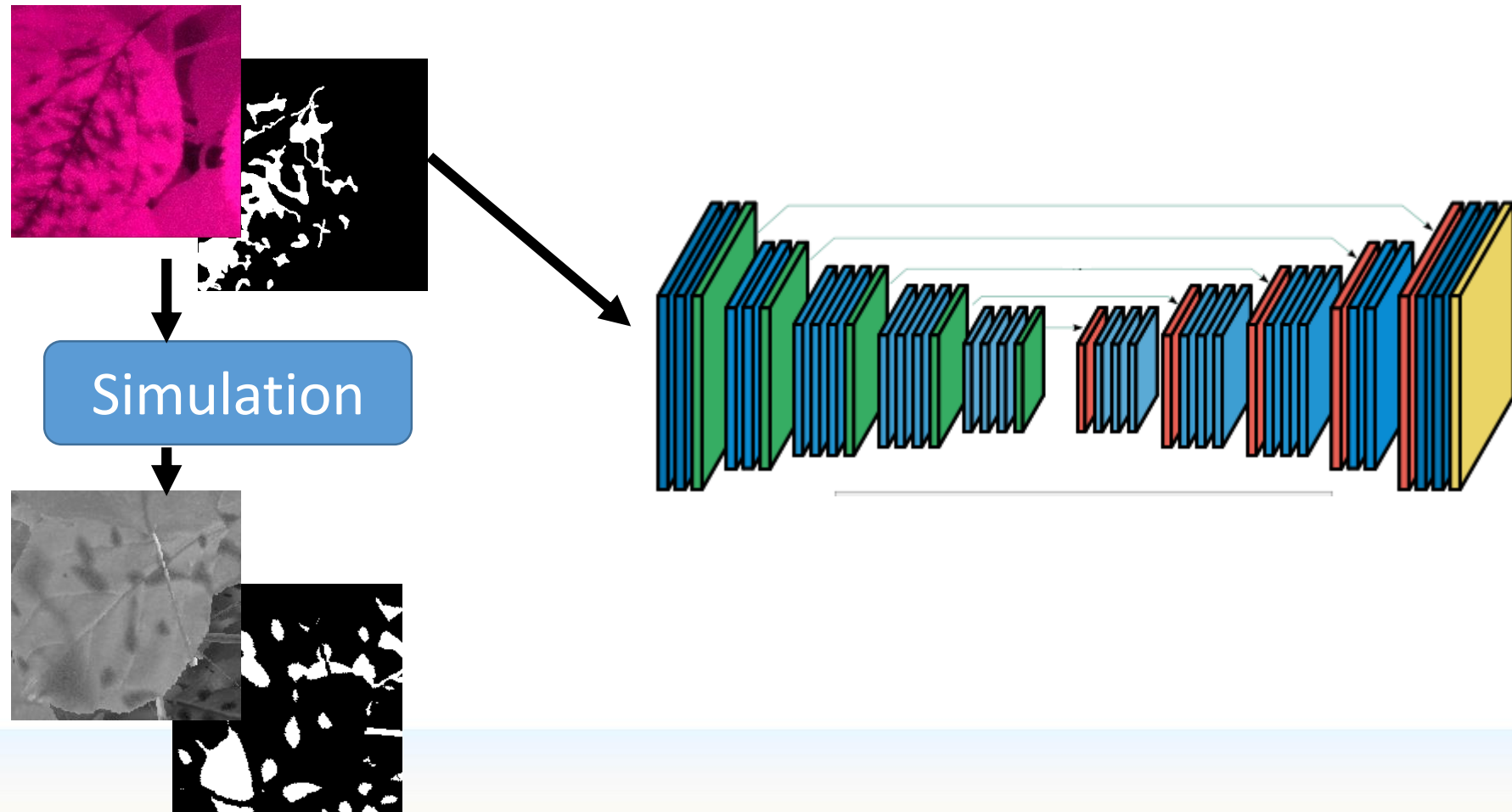
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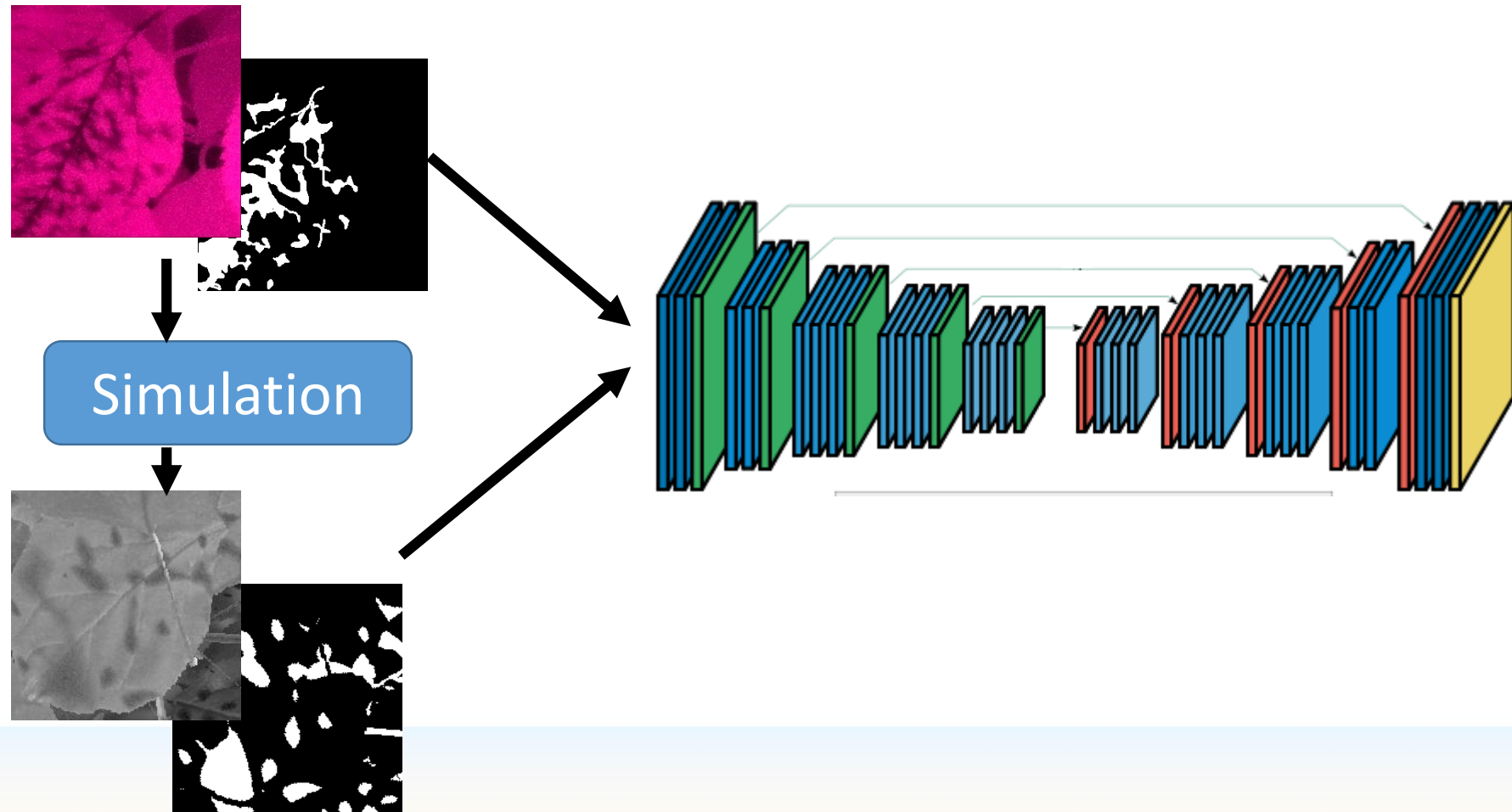# Simulating annotated data

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# Simulator : goal

# Apple scab simulator

- Build apple plant scenes from isolated leaves and information of real images.

Leaf images

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Real images



Leaf images

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Real images

White noise

Leaf images

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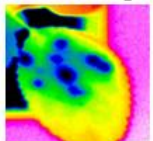


Real images
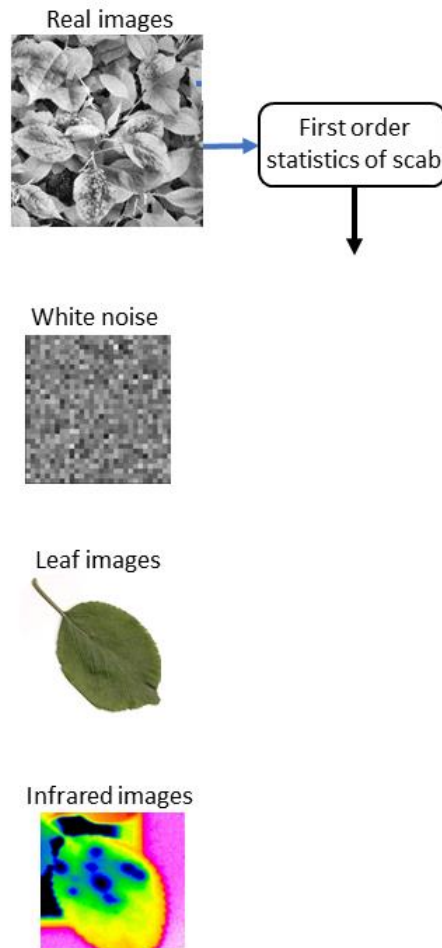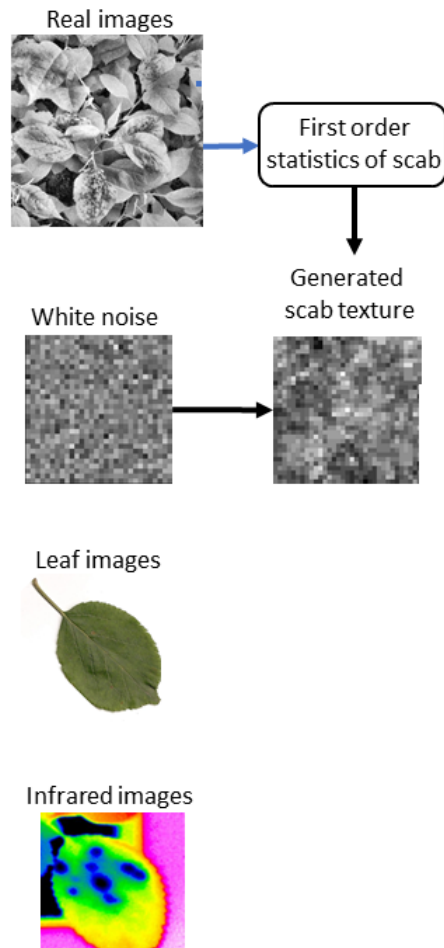
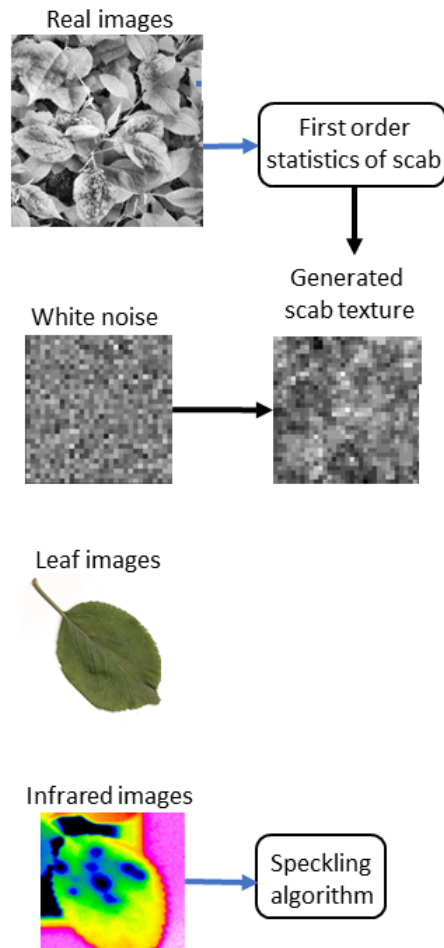White noise

Leaf images

Infrared images

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Real images

First order statistics of scab

White noise

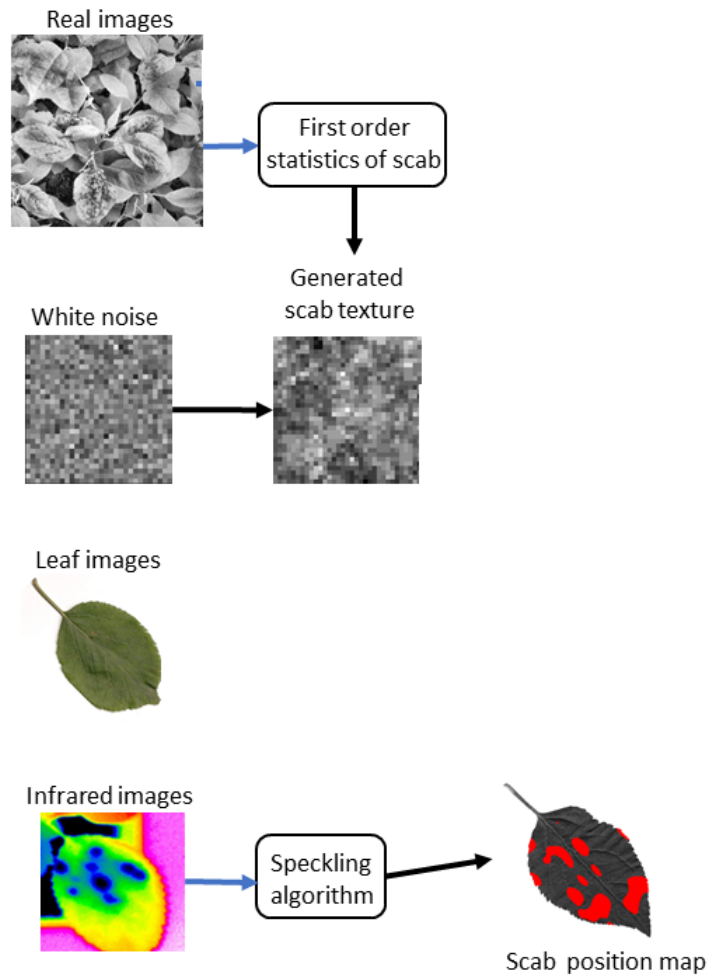Generated scab texture

Leaf images

Infrared images
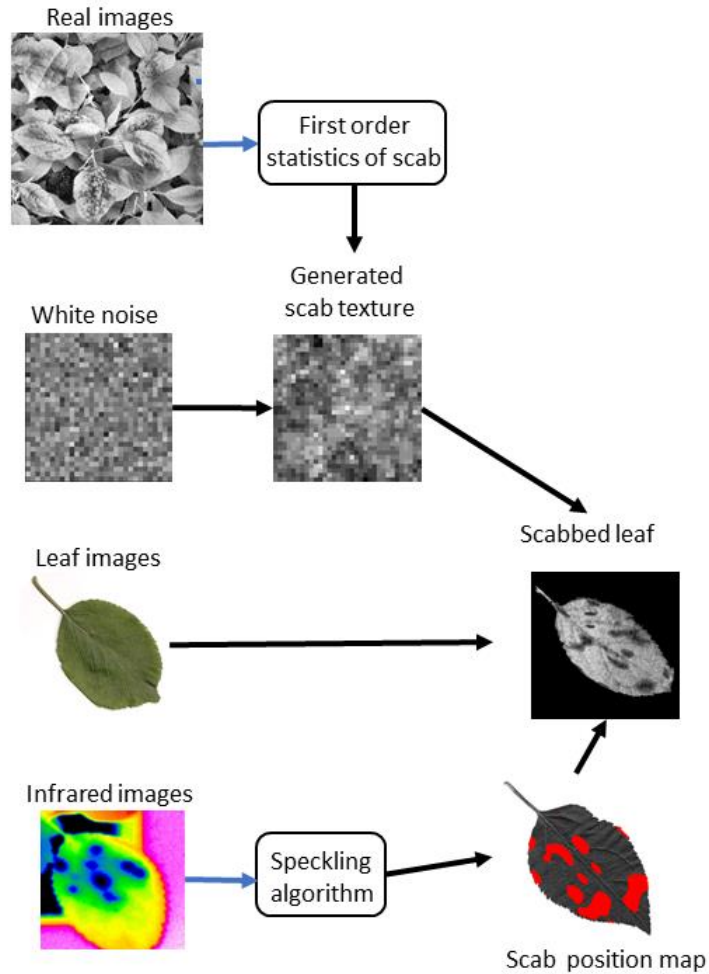
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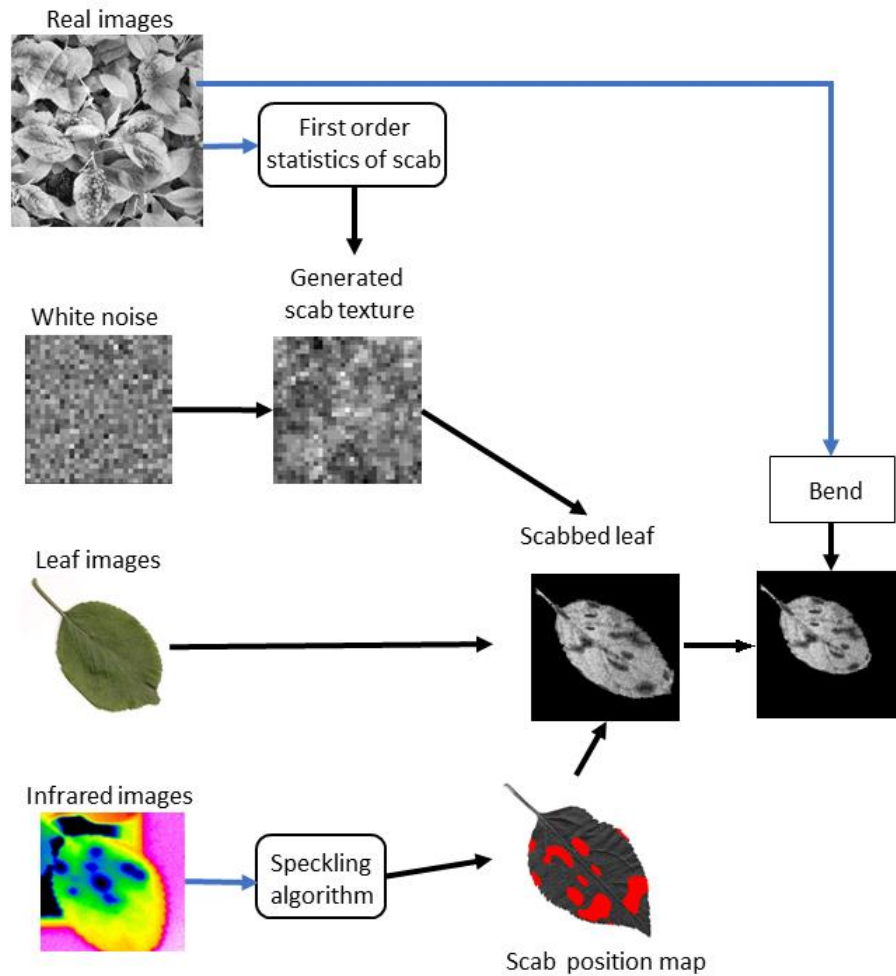- Build apple plant scenes from isolated leaves and information of real images.

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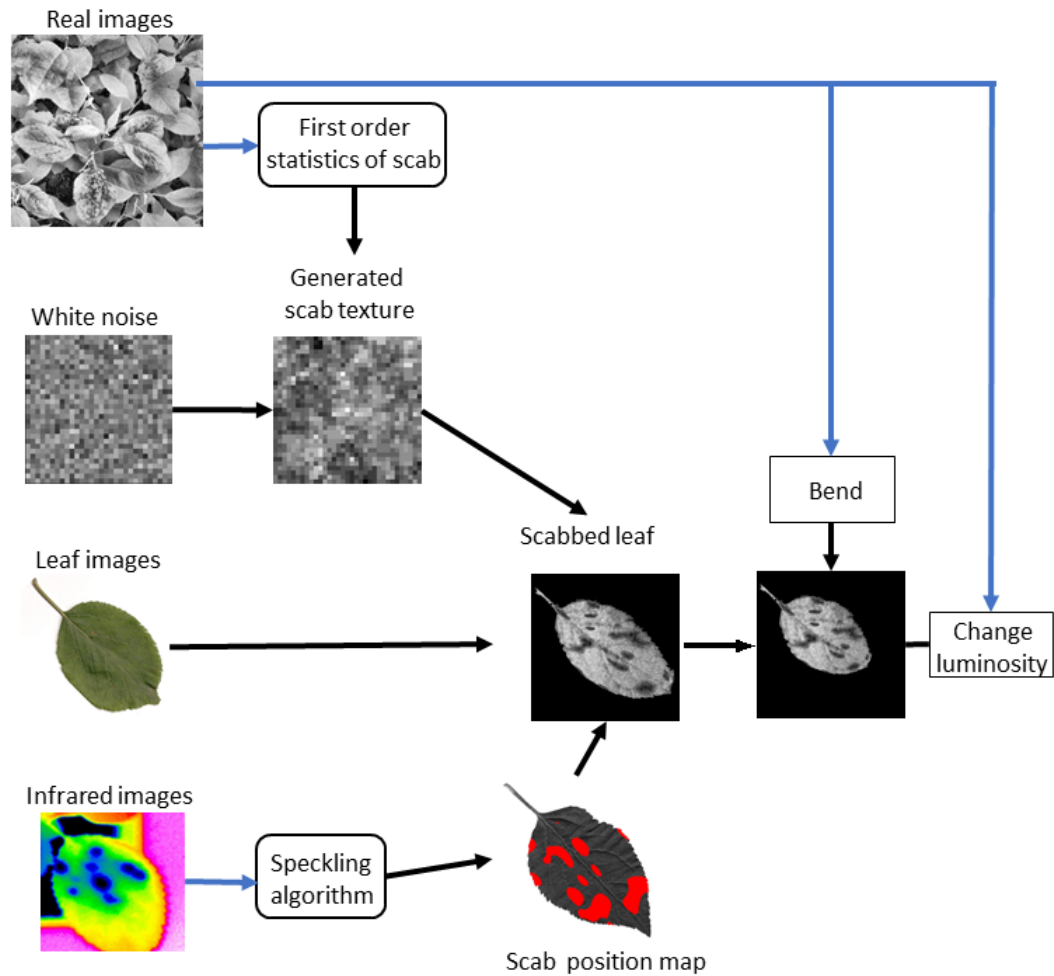- Build apple plant scenes from isolated leaves and information of real images.

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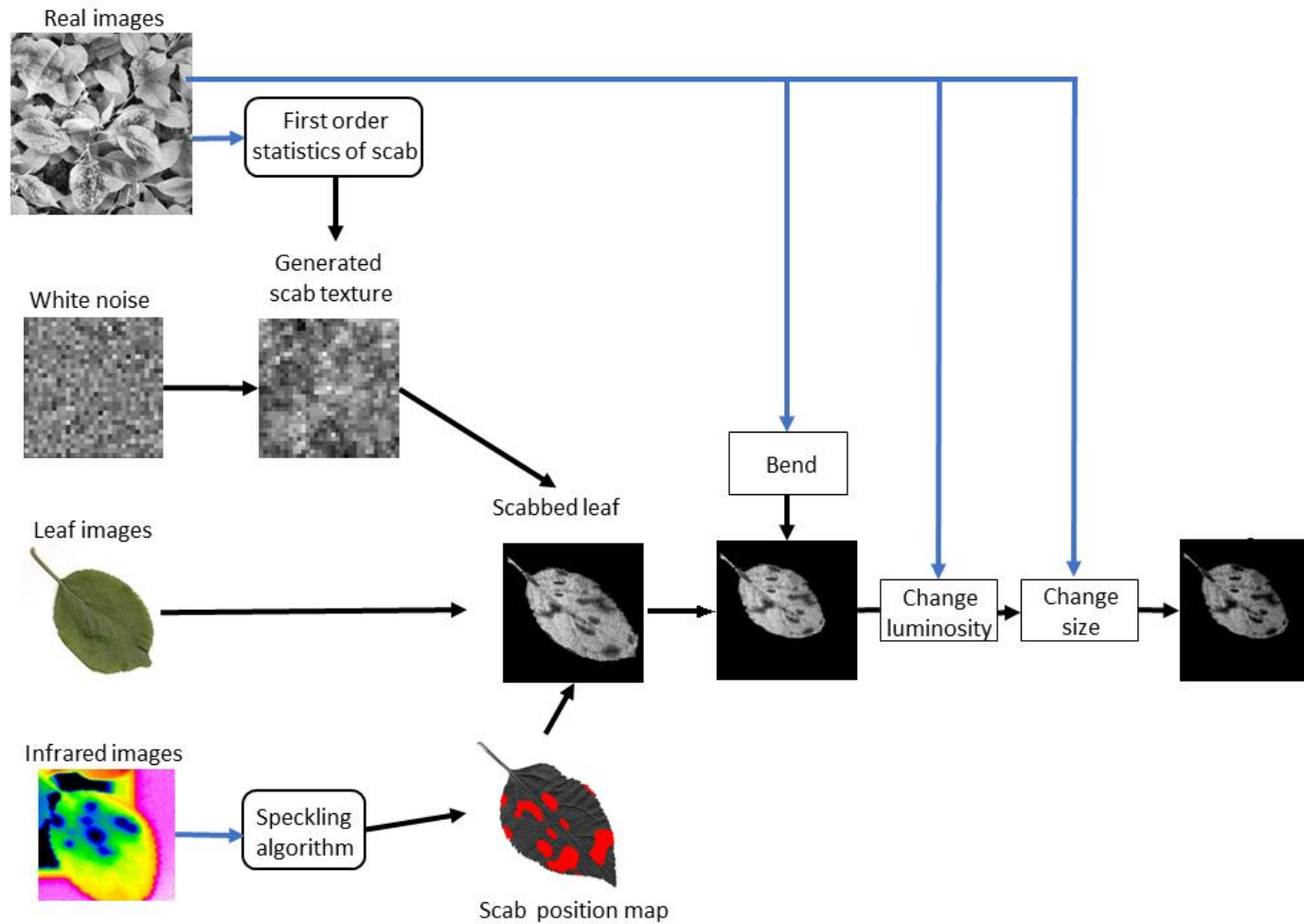- Build apple plant scenes from isolated leaves and information of real images.

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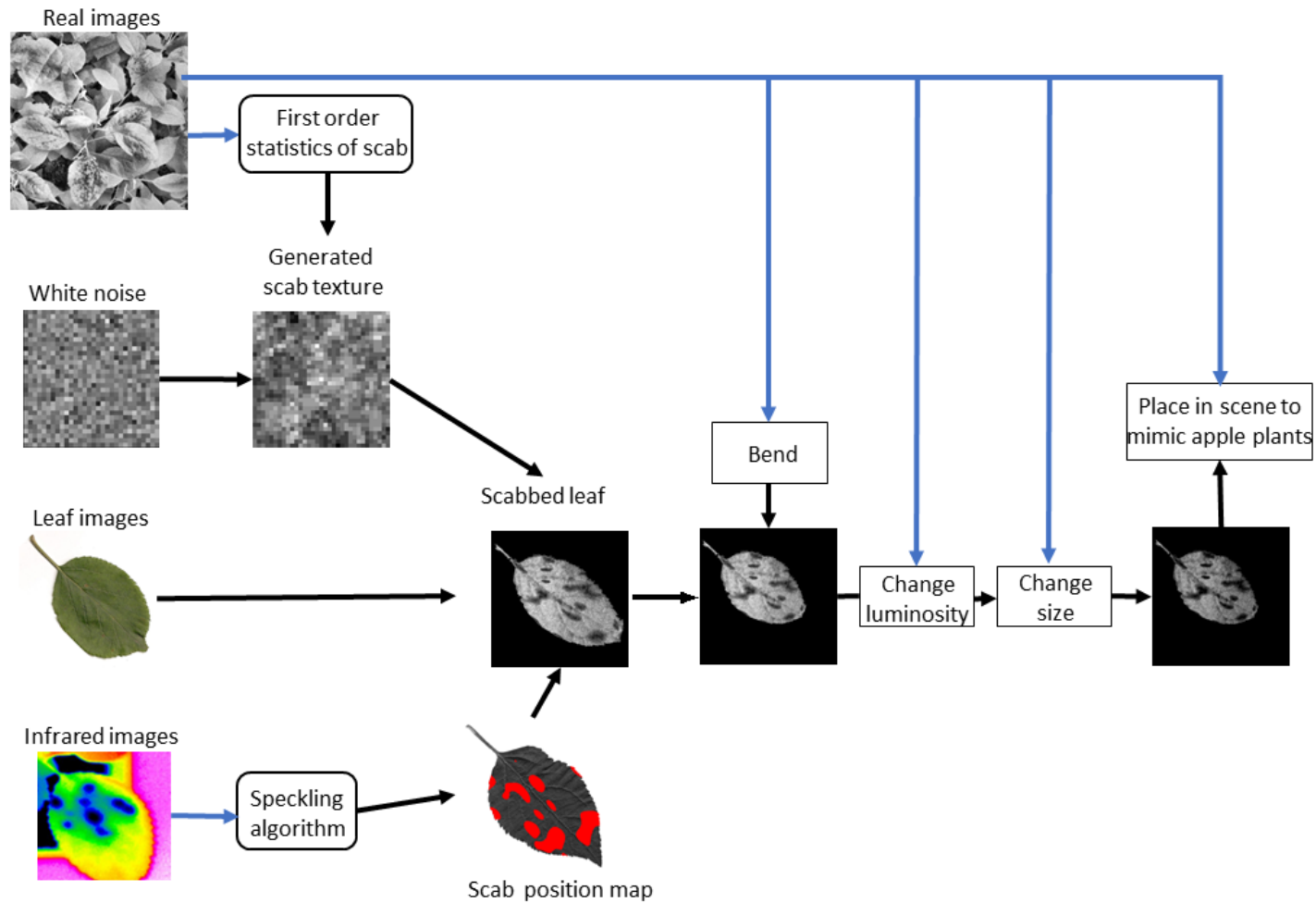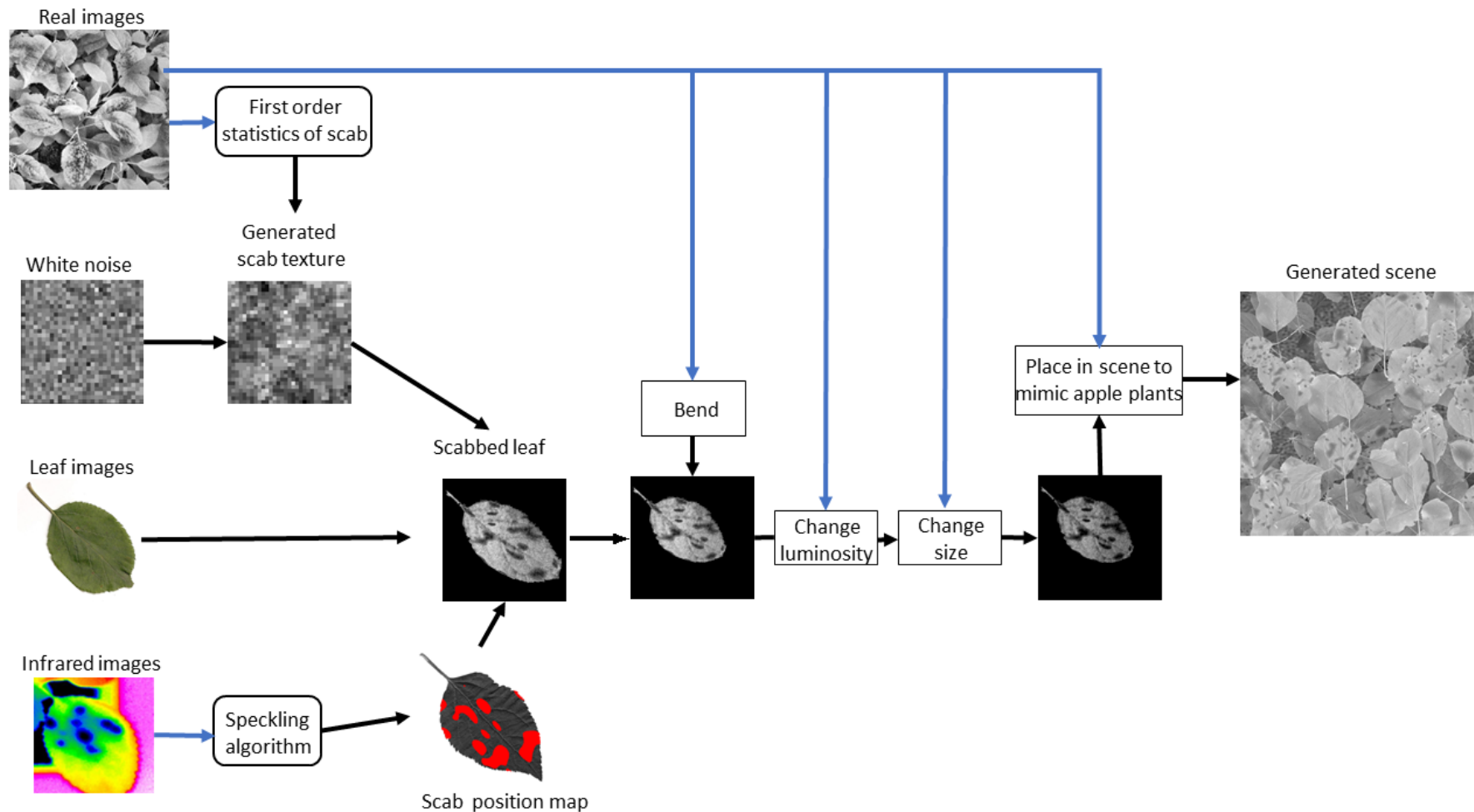- Build apple plant scenes from isolated leaves and information of real images.

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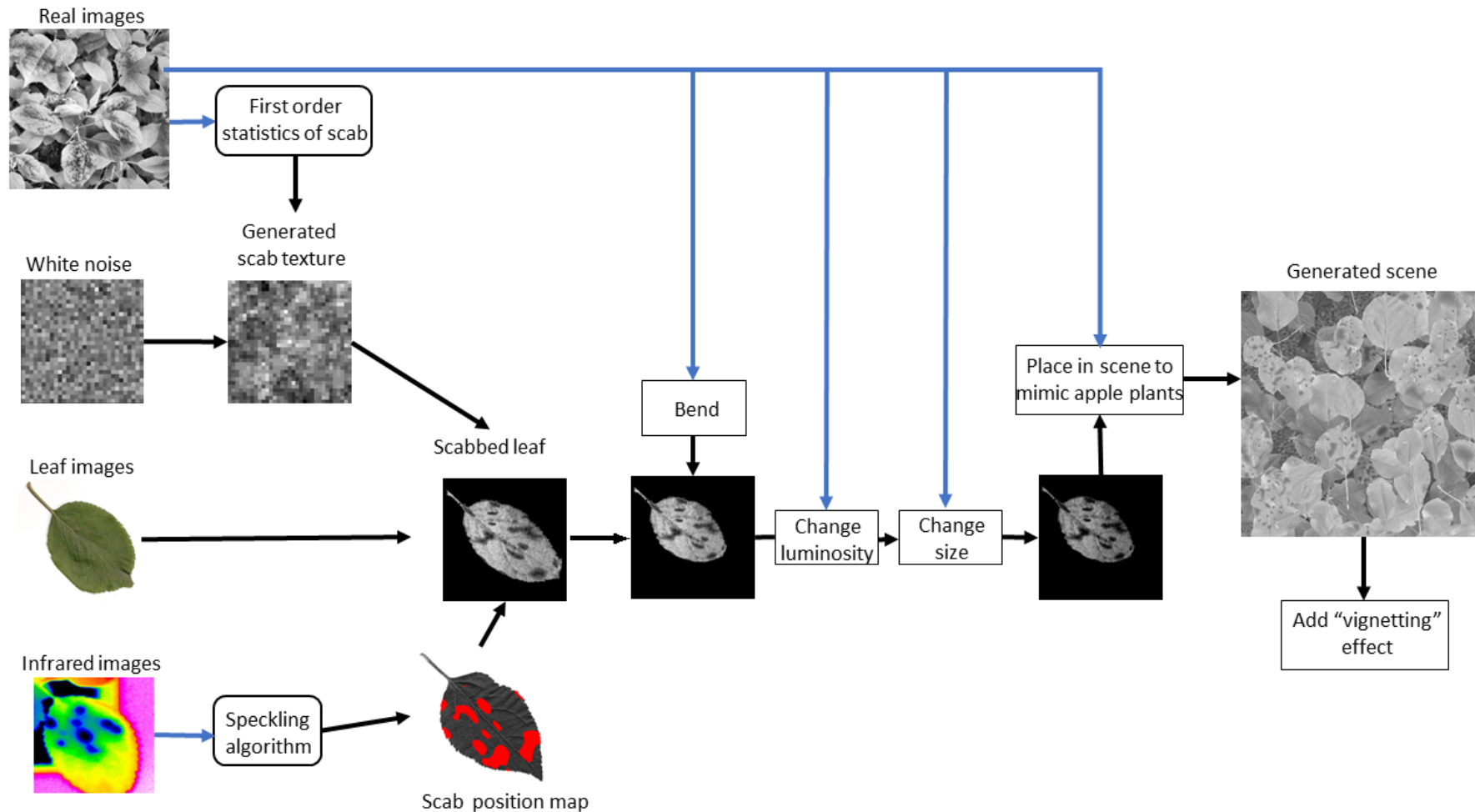- Build apple plant scenes from isolated leaves and information of real images.

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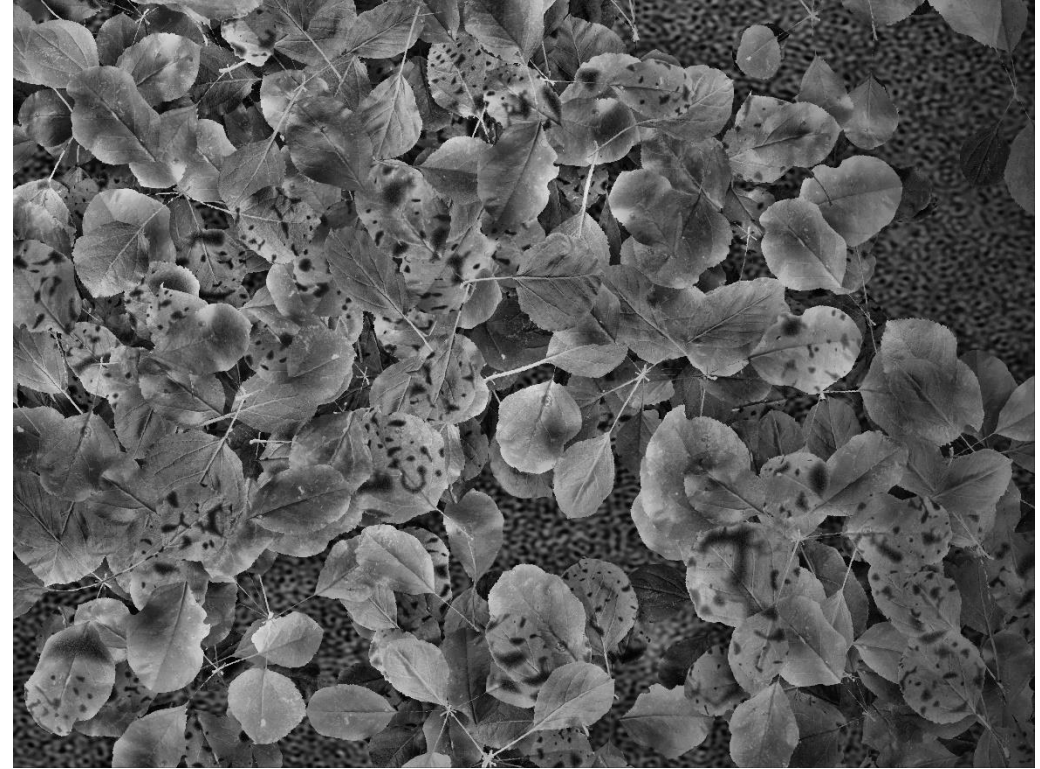
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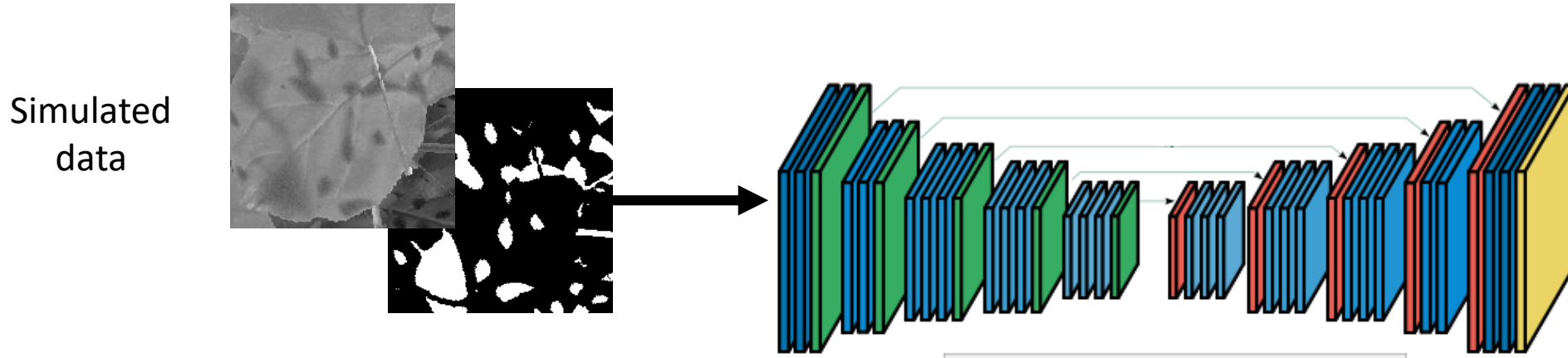
# (Visual) results



Real



Simulated

# How to use simulated data ?

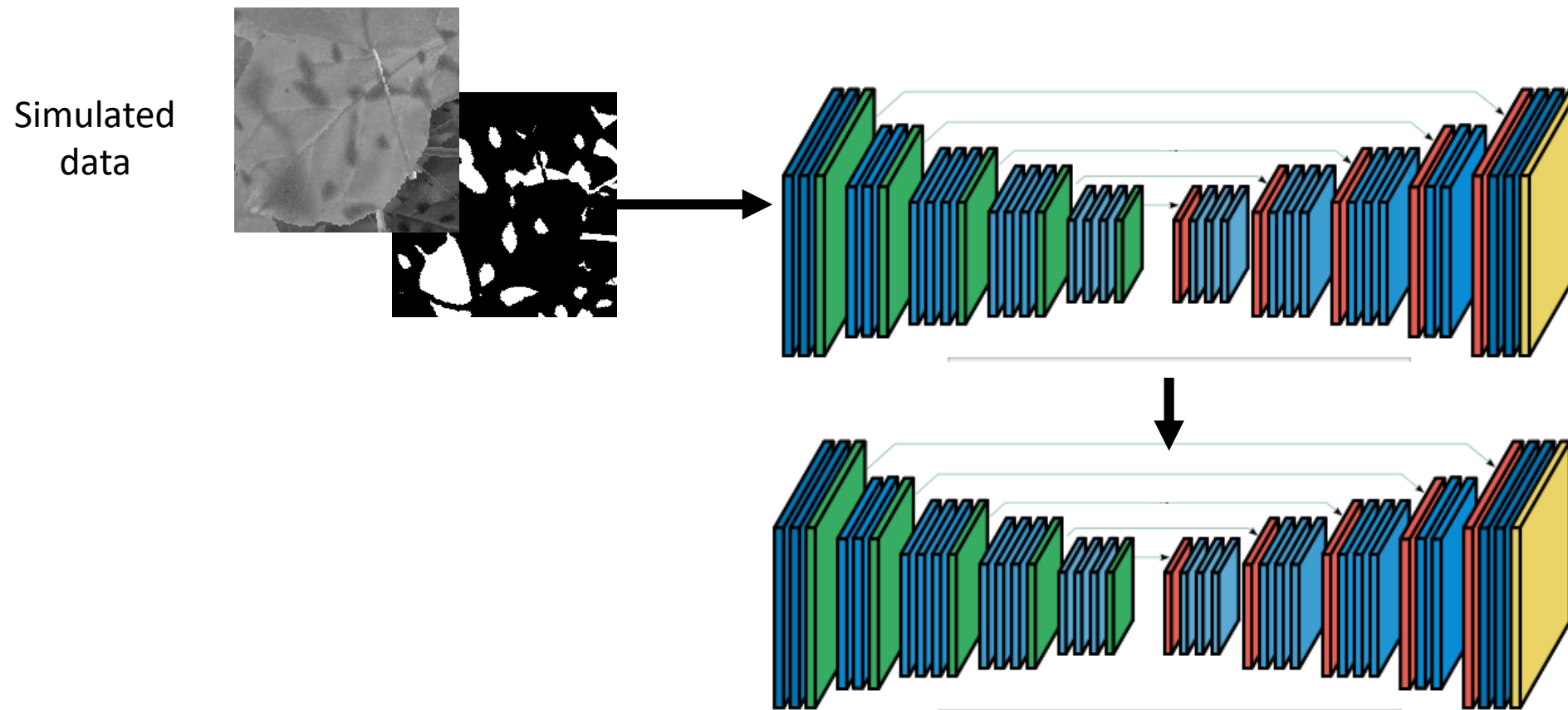We'll use simulated data as pretraining.

# How to use simulated data ?
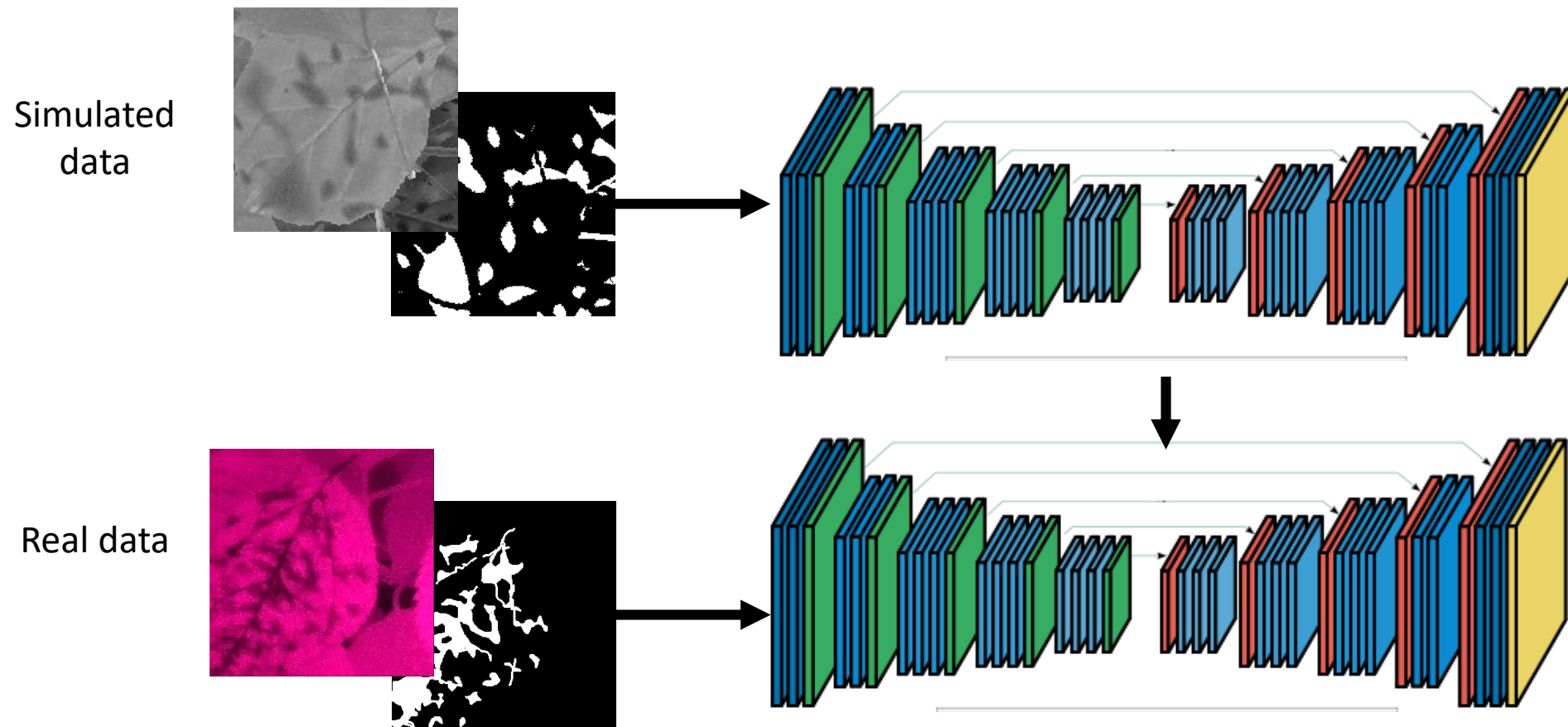
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Simulated
data

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Simulated data

Real data

# Results

Training was done on train set until convergence was reached on validation set.
Score was then computed on test set.

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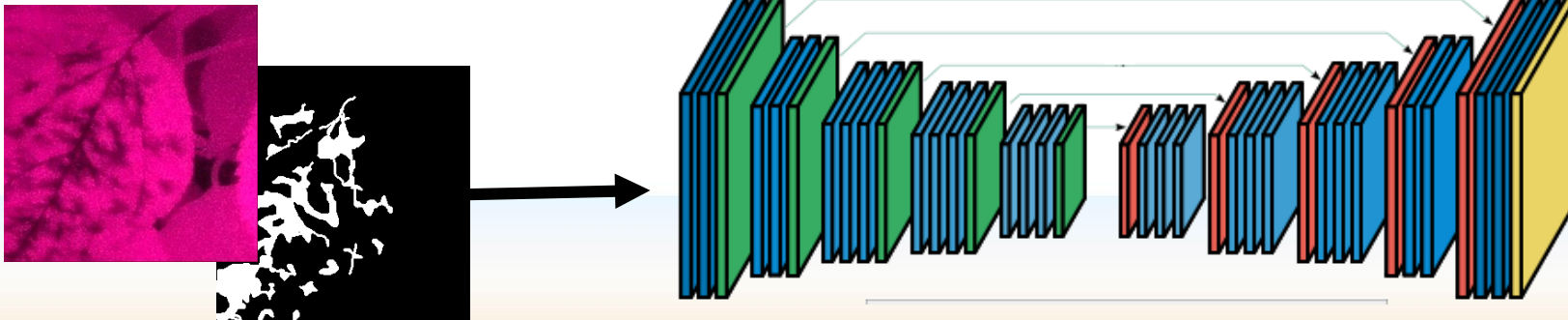Score was then computed on test set.

Scoring used was F1 score = $2 \frac{precision \cdot recall}{precision + recall} \in [0,1]$

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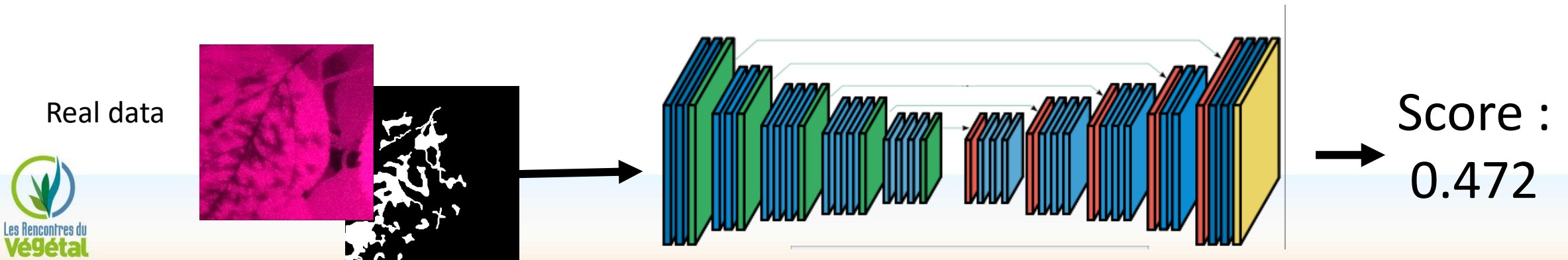
Real data

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Real data

Score : 0.472

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Real data
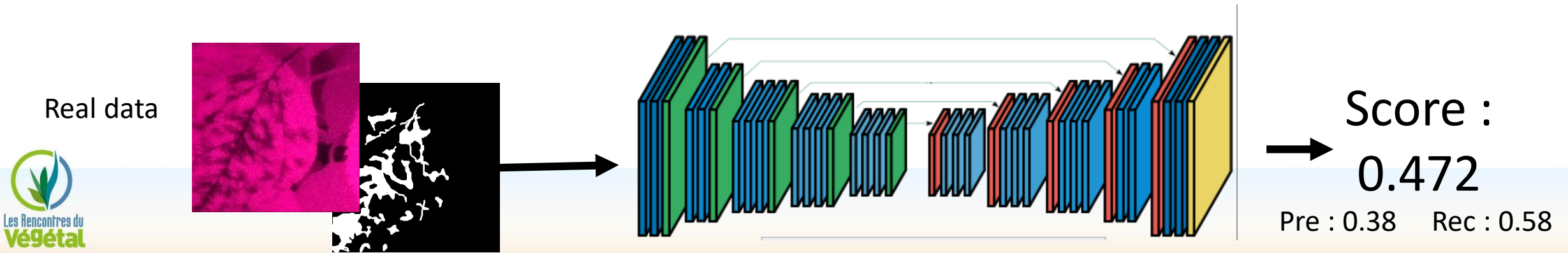
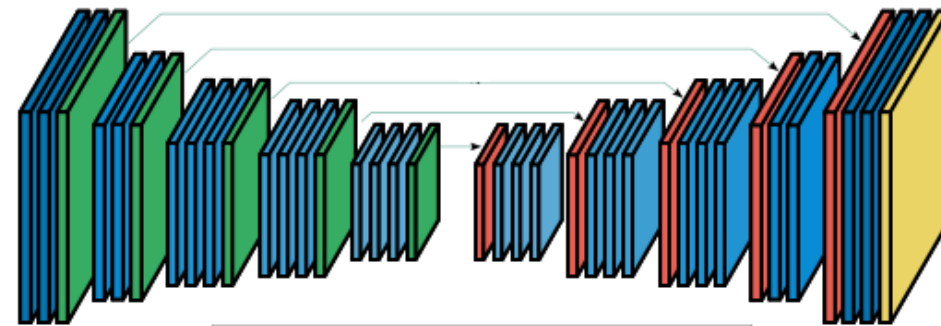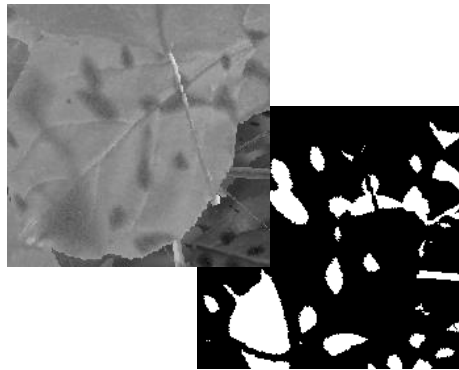Score :
0.472

Pre : 0.38    Rec : 0.58

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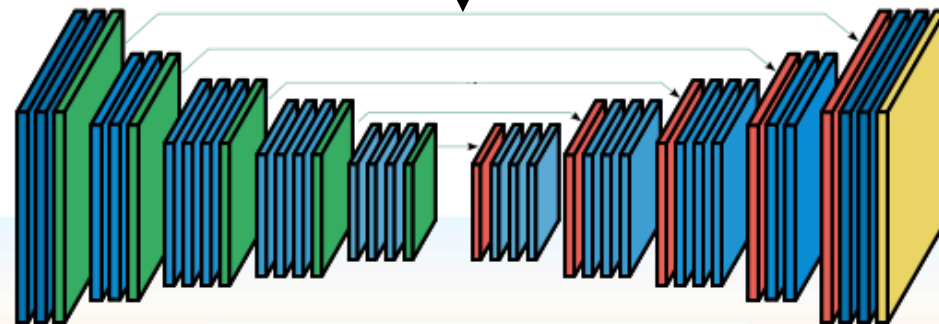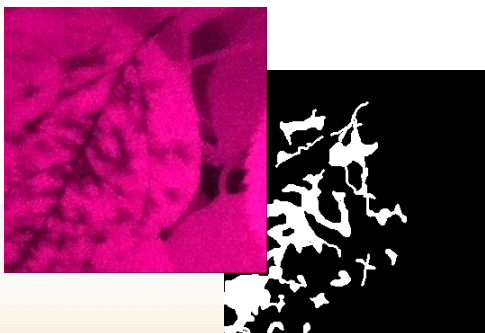Score was then computed on test set.

Scoring used was F1 score $= 2 \frac{precision \cdot recall}{precision + recall} \in [0,1]$



Simulated data

Real data

Score : 0.597

Pre : 0.65     Rec : 0.55

# Ablation study

- What was useful in our simulator ?

# Ablation study

- What was useful in our simulator ?
- Generate images while "knocking out" some of the simulator's functions.
  - Light variation
  - Size variation
  - Plant position …
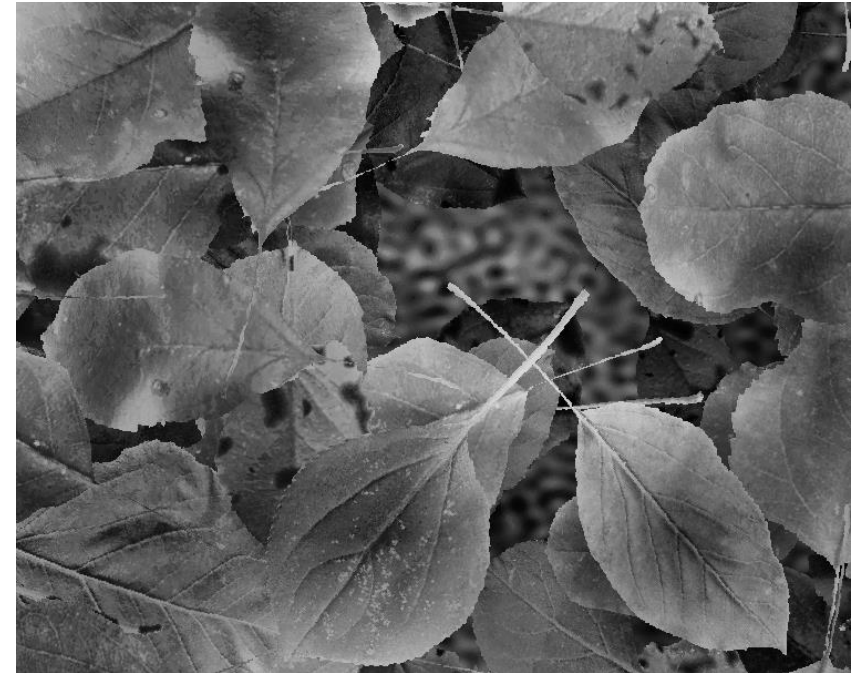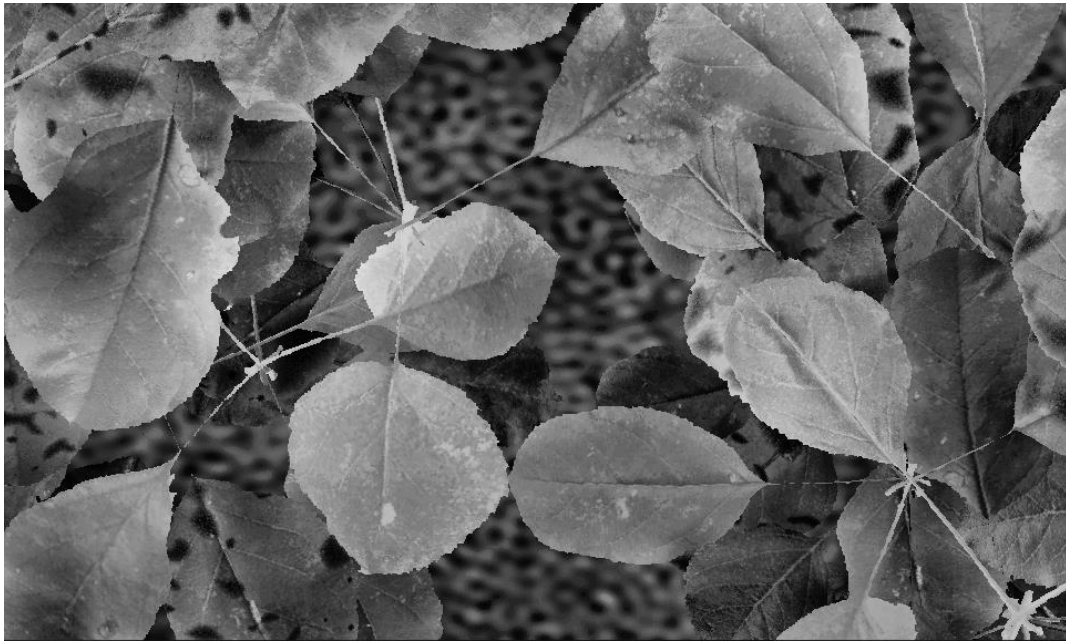
# Ablation study

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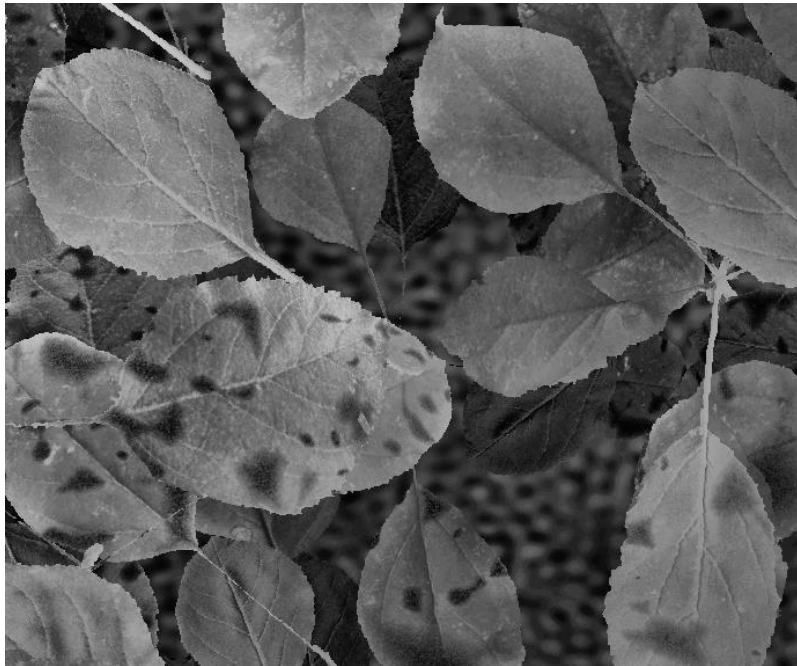Then pretrain with these new images, and compute score on real database.

# Ablation study : examples
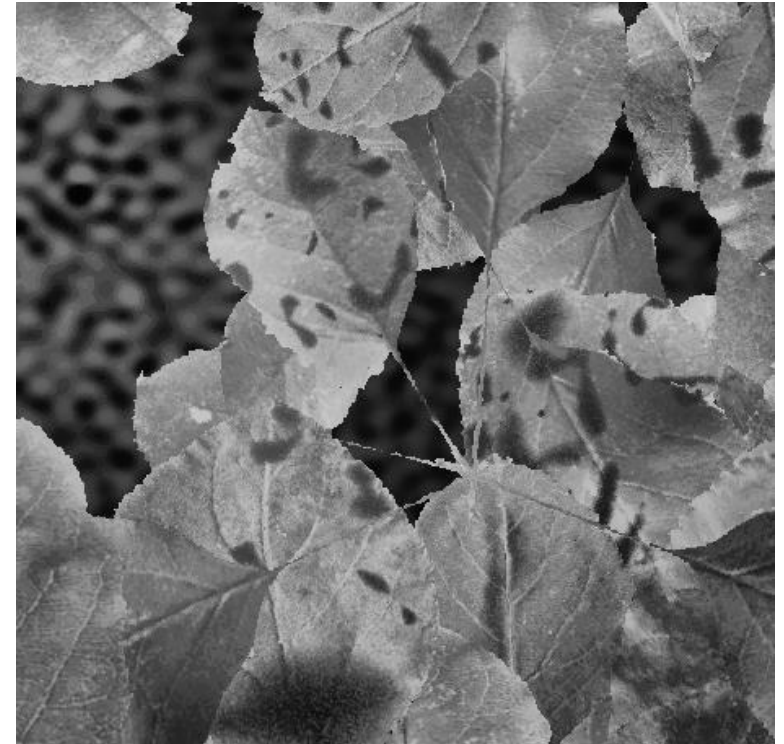
Taking out structure.

# Ablation study : examples

Taking out size variation.

# Ablation study : examples
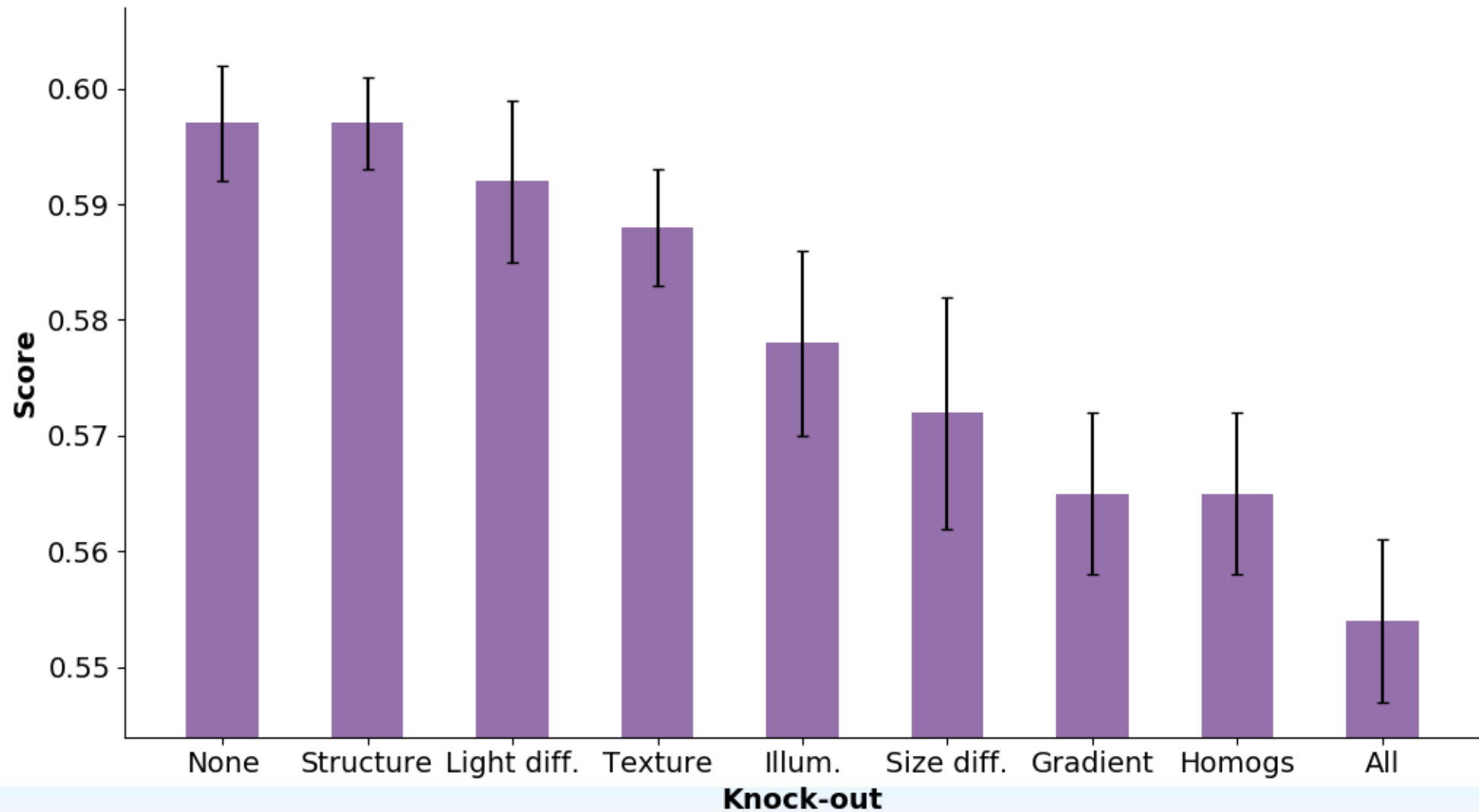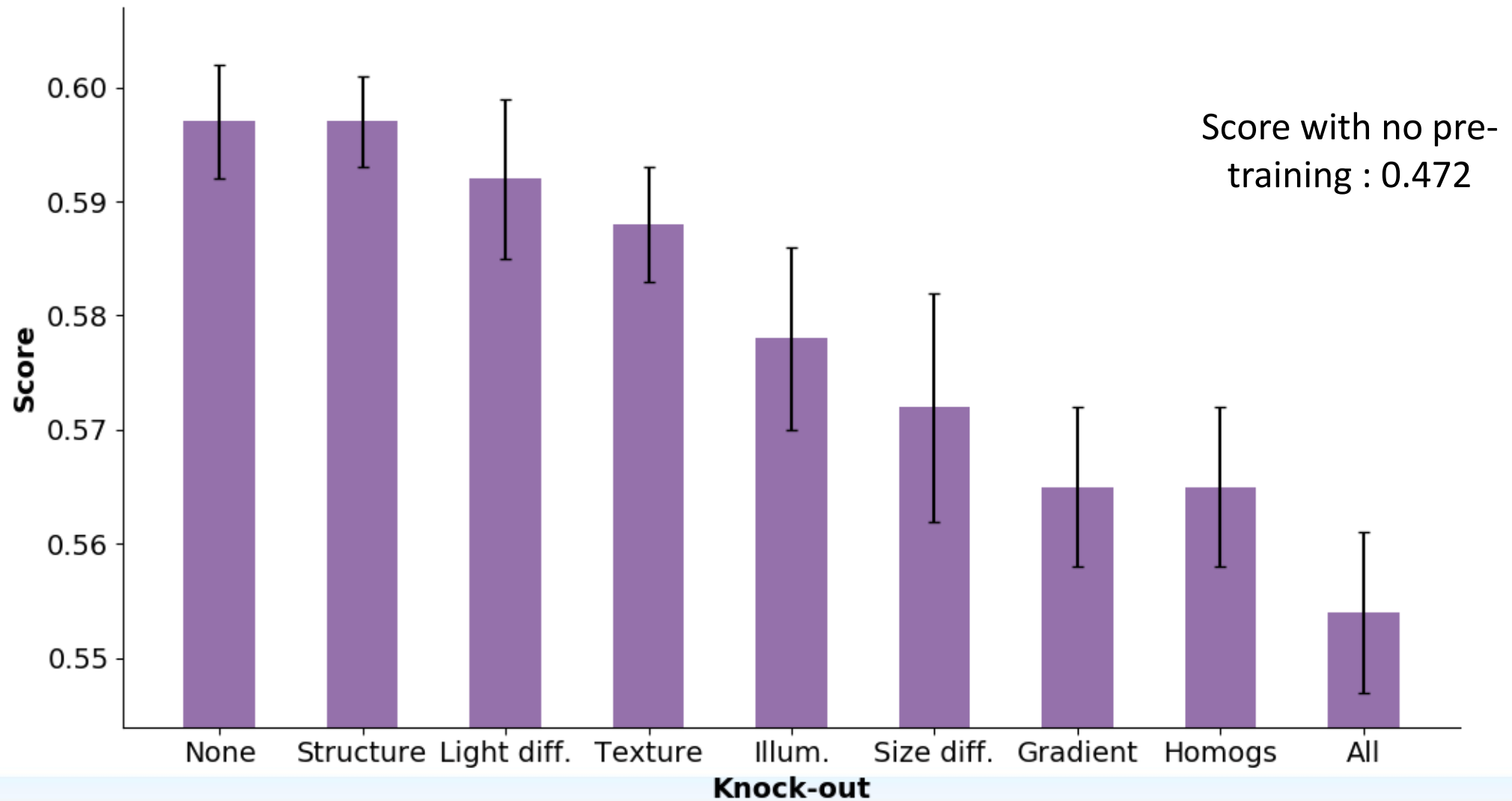
Taking out luminosity variation.

# Ablation study : results

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Score with no pre-training : 0.472

# Conclusions

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- We've studied a difficult case of image segmentation : apple scab disease on plant leaves in IR.

- We've successfully augmented the small database by a simulator which we've used to pre-train a CNN.

- F1 score on test set **was increased by 12%.**

# Perspectives

- Compare this kind of augmentation with other kinds of augmentations.

- Compare pre-training vs directly adding generated images into database.

- Apply same kind of generator to other variety of plant disease.