New Technologies for Plant Phenotyping
Unidad Integrada Balcarce (INTA-UNMDP)
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Low cost computer vision implementations for plant phenotyping/identification problems

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Outline

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- Our path here:
  - Weed seeds
  - Green seeds
  - Plant identification using veins
  - Counting seeds in pods
  - Stripes in apples
- Conclusions
- The Future

The beginning: Weed seeds identification (~2000)

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Colaboration:

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Weed seeds identification: Hardware

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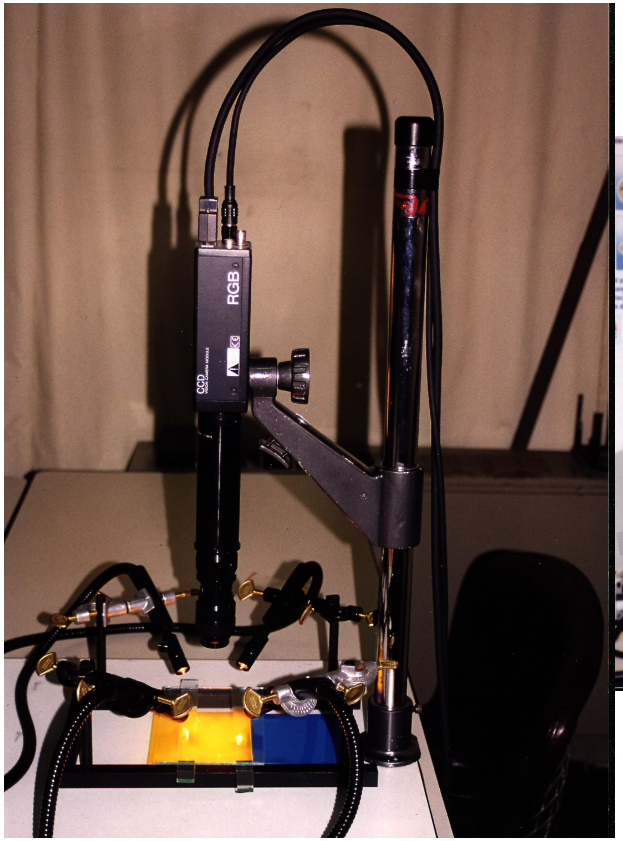
- High-End Equipment
  - Frame grabber
  - Special camera
  - Light source
  - Etc.
- Pro: High Performance
- Con:High cost!



Weed seeds identification: Software

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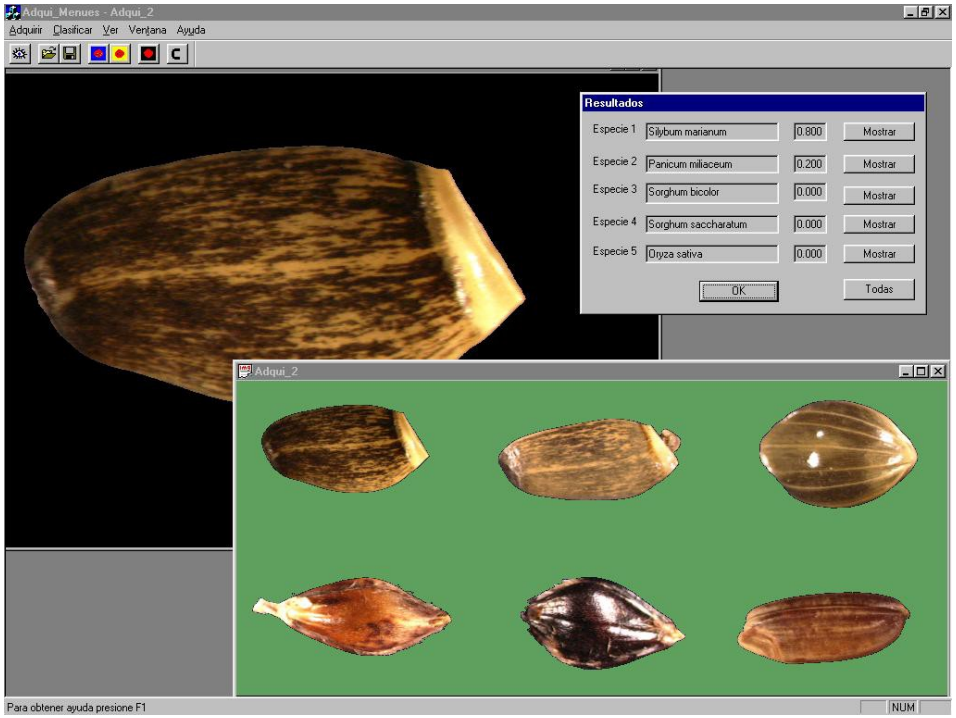
- Imaging + segmentation
- Measurement of diverse features:
  - Morphological
  - Textural
  - Color
- Classification with Neural Networks ensembles



- Very good results:
  - +95% correct recognition on 250 species
  - +99.5 accuracy using the 5 most probable species

Weed seeds identification: The problems

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- Nobody was willing to pay the cost of the equipment!
- High-End video equipment also have problems
  - Drivers
  - Replacements
  - Aging of lamps (COLOR!)

Second attemp: Green levels in soybeans (~2008)

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Green levels in soybeans: How to measure color?

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- We gave up on special hardware!
- Low cost solution:
  - Of-the-shelf imaging device with calibration standard
  - Software implemented as a web service

Green levels in soybeans: Software

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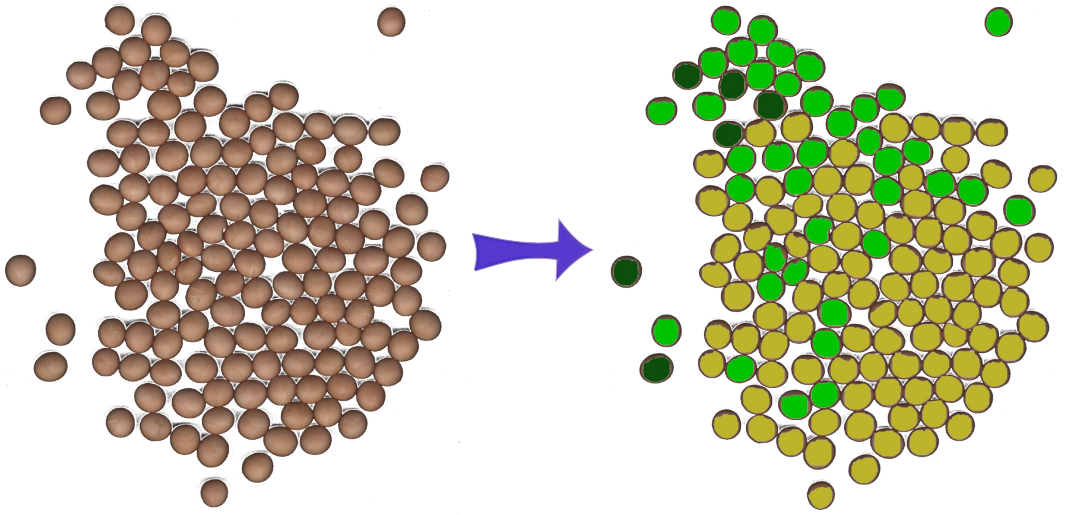
- Calibrated Scanner + Segmentation
- Feature extraction
  - Morphological
  - Color
- Clasification with Random Forest (Ensemble of classification trees)

- All project based on Open Software (Open CV - R)



Green levels in soybeans: Problems!

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- Color is really difficult!
- Even for us!
- We can control the ilumination easily with a flatbed scanner, but translating colours from diverse equipments with high accuracy is very difficult

Green levels in soybeans: Results

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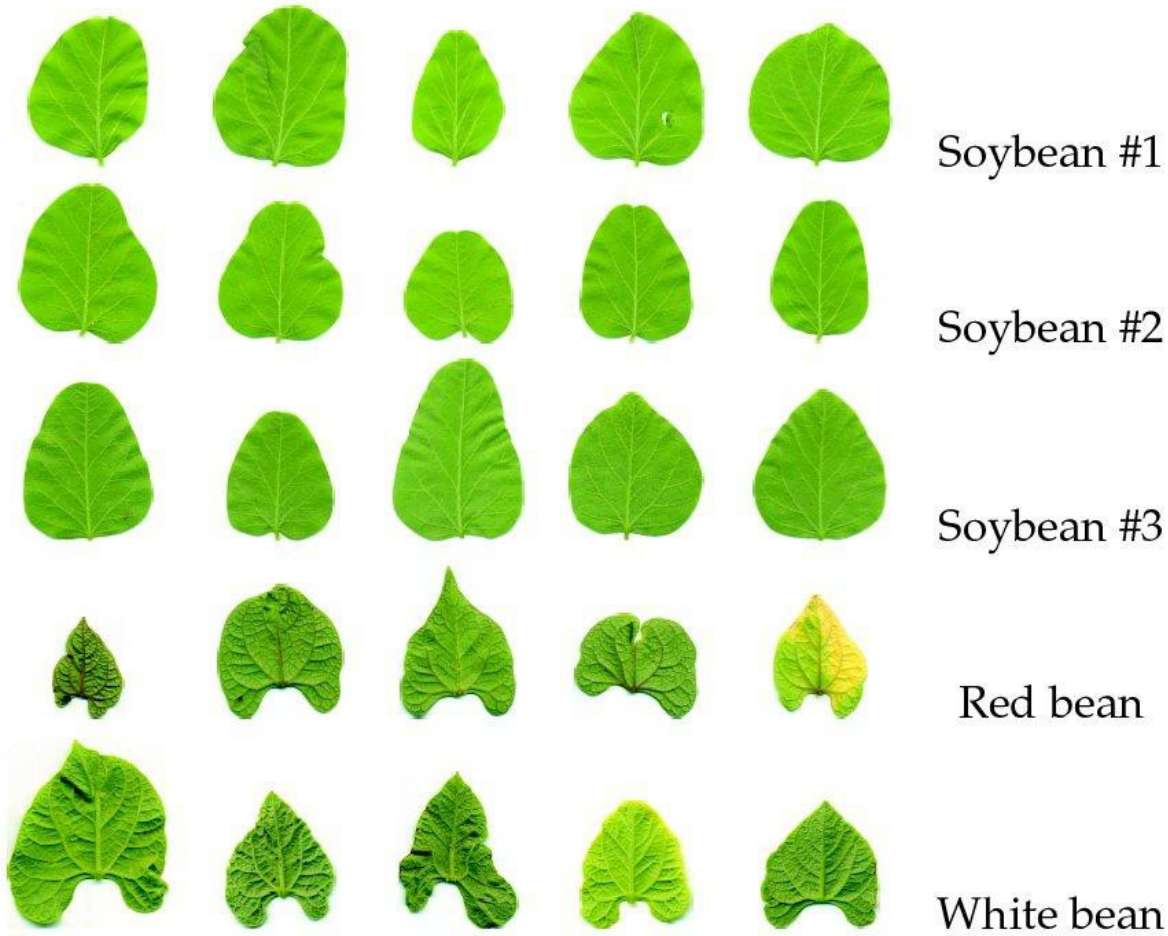
- Average human accuracy: 65%
- Best result for automatic system: 85%

- But:
  - Using a single scanner
  - Translating from other scanners decrease accuracy to near random results

Cultivar identification using leaf veins (2012)



Colaboration:

Cultivar identification using leaf veins

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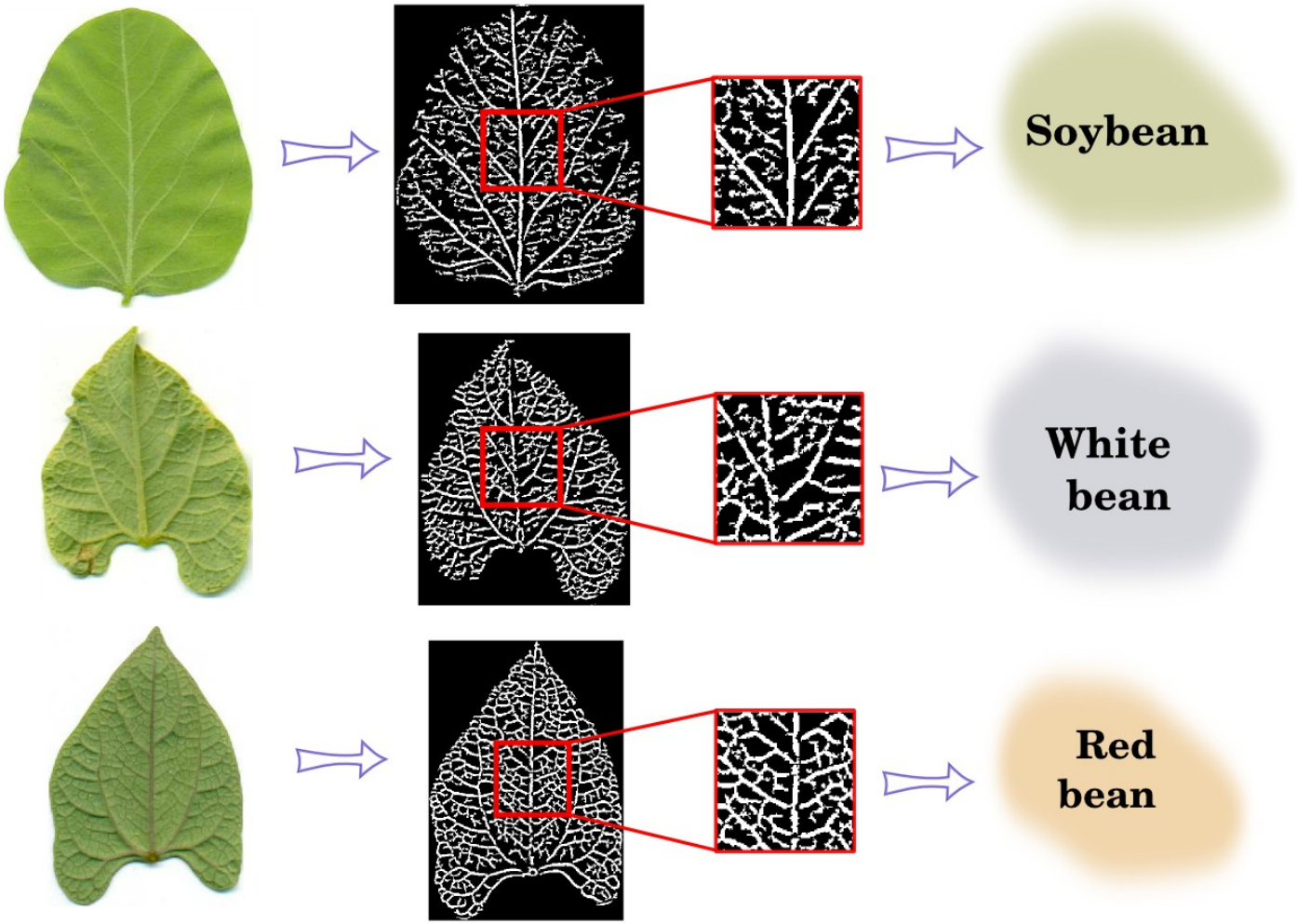

Cultivar identification using leaf veins: pipeline

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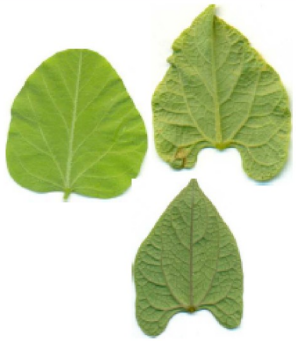
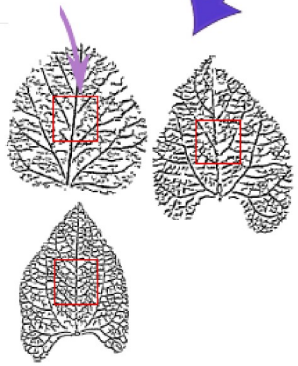


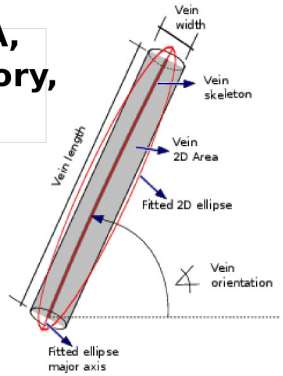
Grayscale conversion

Segmentation

Patches extraction



Segmented veins



Feature extraction

SVM, RF, PDA, Consensus theory, etc.

Soybean #1

Soybean #2

Soybean #3

Red bean

White bean

Cultivar identification using leaf veins: results

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- Average human accuracy: 45%
- Best result for automatic system: 60%

- Automatic methods outperforms humans (on cultivars and species)
- But results are not good enought as to develop a portable device

Cultivar identification: can we improve? Deep learning

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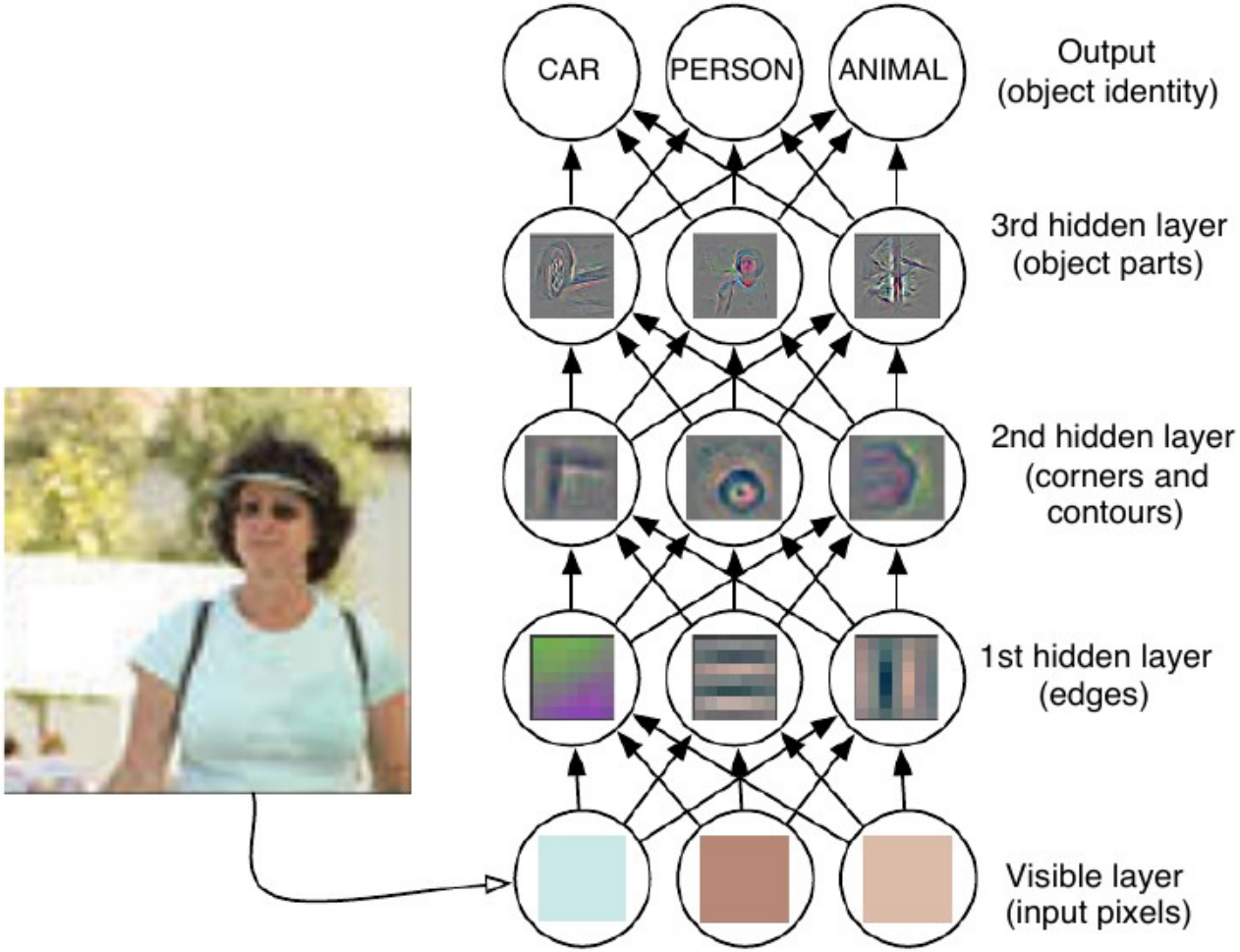

Cultivar identification with Deep learning

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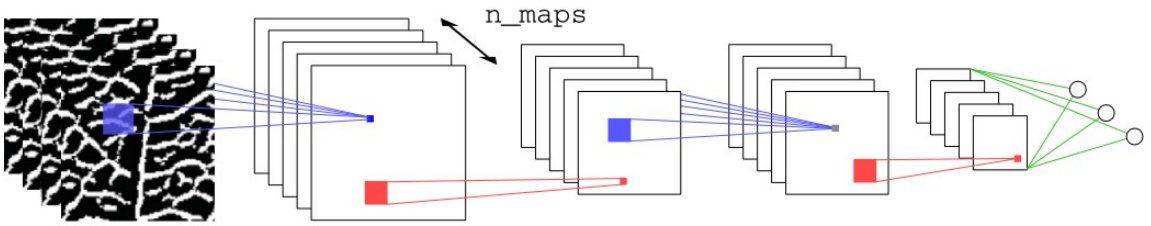
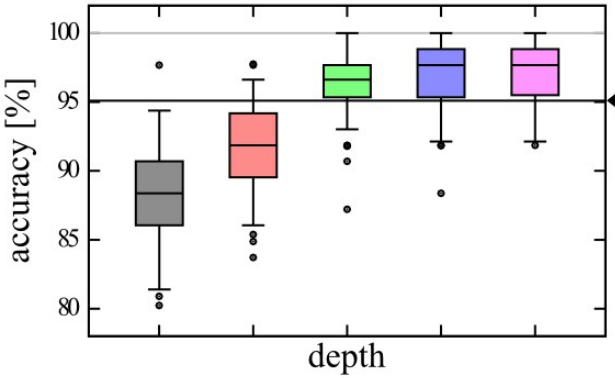
original image

vein segmentation



central patch

convolutional neural network



dataset's state-of-the-art accuracy

improved accuracy

relevant patterns visualization

Phenotyping: counting seeds in pods (2015)

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- Semi-automatic procedure: pods are colected from the plant by hand and counted automaticaly with a vision system
- Regular camera, cheap ilumination device and a computer
- Segmentation + feature extraction
- Classification with SVM

Phenotyping: counting seeds in pods

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Phenotyping: counting seeds in pods

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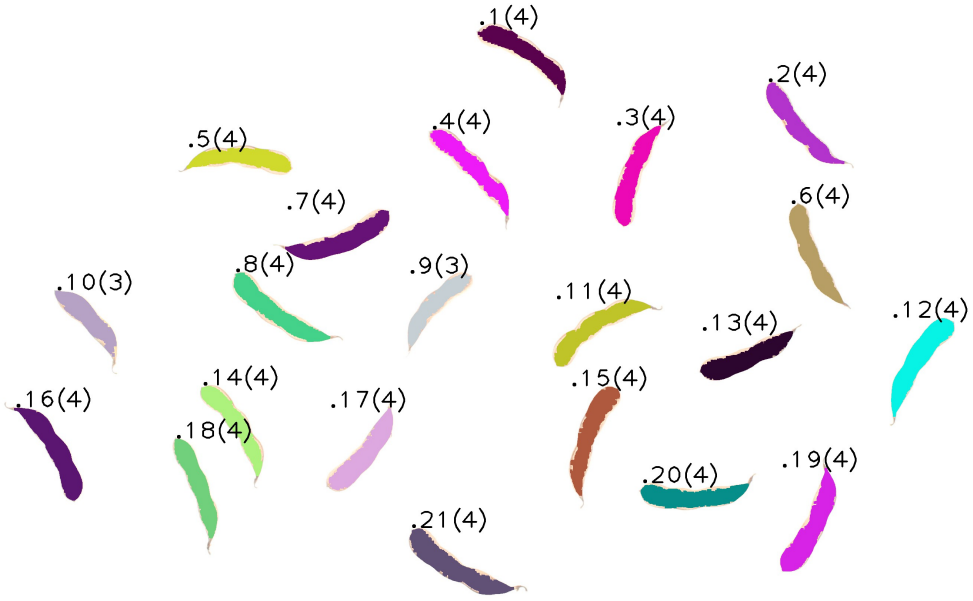

Phenotyping: counting seeds in pods

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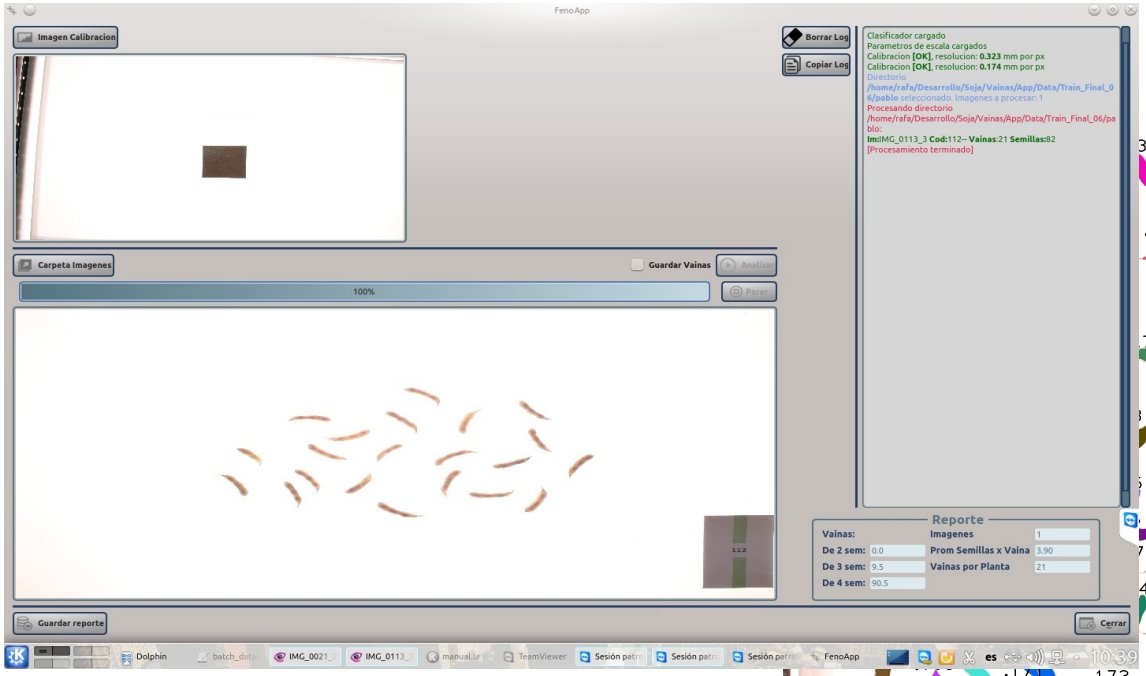

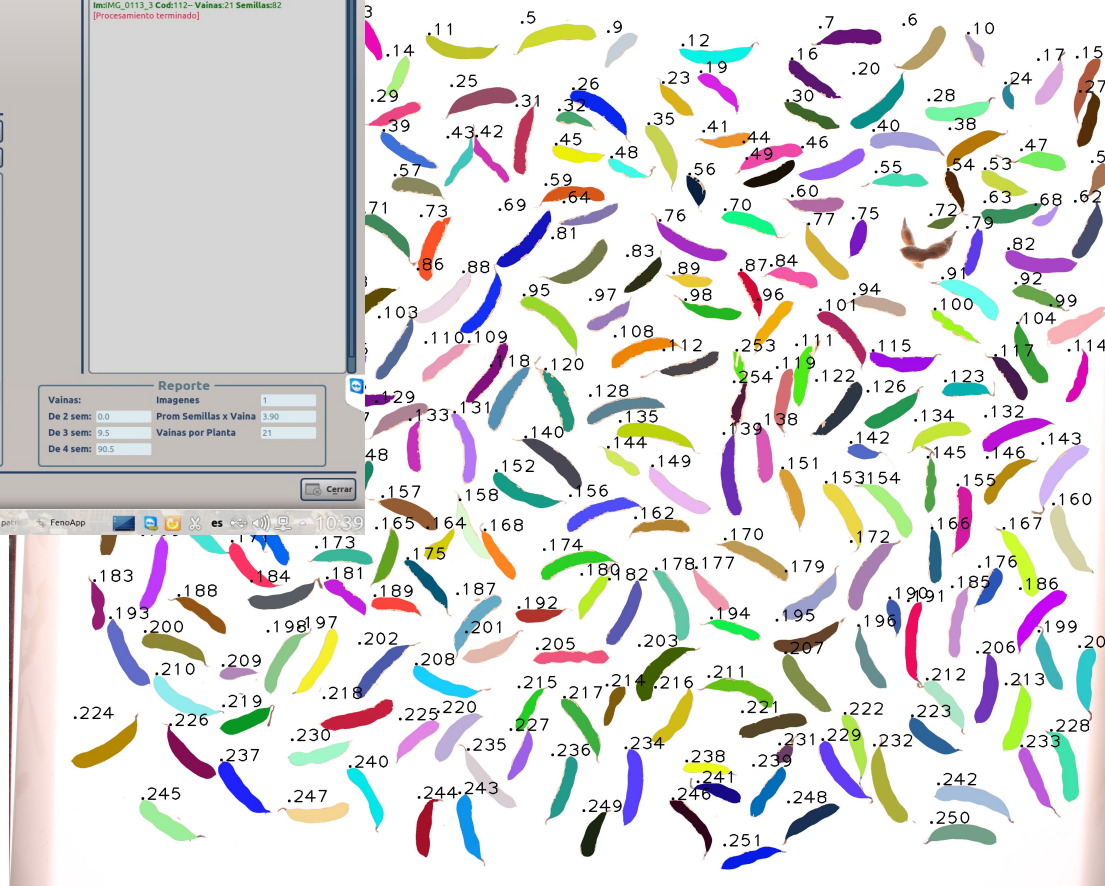

Phenotyping: Results

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- Accuracy +90%
- Limits: pods with “new” shapes and size lead to errors

- Proposed solution: using deep learning (working now...)

Phenotyping: stripes on apples (2015)

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- Work in progress with FEM (Trento, Italy)
- Goal: develop a low cost device to grade apples according to stripes quality

Conclusions

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- Machine vision systems based on low cost hardware are useful and easy to develop
- Many agricultural applications known
- Measuring color in practice is difficult
  - But you hardly need color in phenotyping
- Lots of potential phenotyping applications

The (near) future

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- Phenotyping
  - Counting seeds (pods) in live plant
- Identification
  - Identifying weeds in real time video
  - Collaboration in the development of a weed control autonomous robot

The team

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- Dra. Mónica Larese
- Dr. Rafael Namías
- Dr. Pablo Verdes
- Dr. Guillermo Grinblat
- Dr. Lucas Uzal
- Dr. Ariel Baya
- Dra. Belén Bernini (former)
- Dr. Alejandro Ceccatto (former)
- Dr. Hugo Navone (former)
- Dr. Roque Craviotto and gruop (INTA OLIVEROS)
- Dr. Eligio Morandi and group (UNR – Zaballa)
- Dr. Eugenio Aprea (FEM – Trento - Italy)