The CLEF 2011 Plant Images Identification Task

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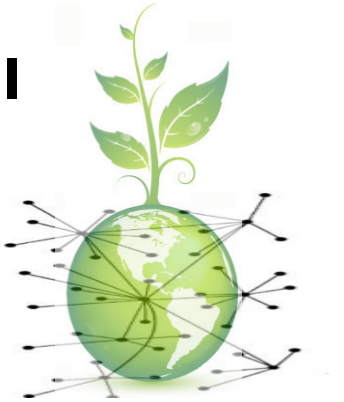
Context

- **Global warming** affects **environment** as well as **agriculture** and food's **safety**

- Accurate **knowledge** about **plants distribution** and **evolution** is essential for **sustainable agriculture** and **biodiversity** preservation

Challenge

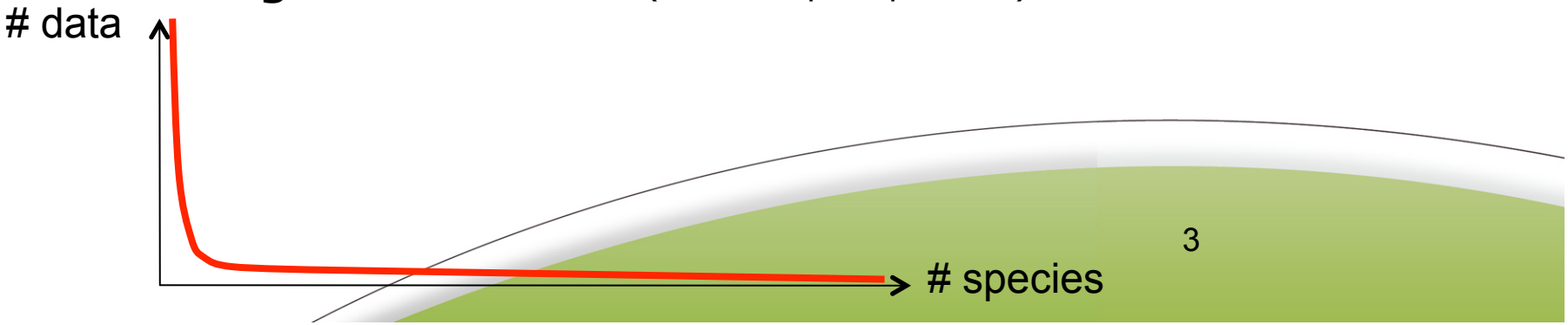
- **Accessing basic information** about plants **is still challenging:**



1. Botanical data is highly **decentralized** and **heterogeneous**
   - Each actor has its own expertise domain, data and format

2. Botanical data is **complex**
   - a single plant's observation includes (un)-structured tags, diverse images, Empirical measurements, Contextual data

3. Botanical data is **sparse** and **incomplete**
   - **Huge** & **Unknown** number of **species** (400K ?)
   - **Long tail** distribution (1 record per species !)



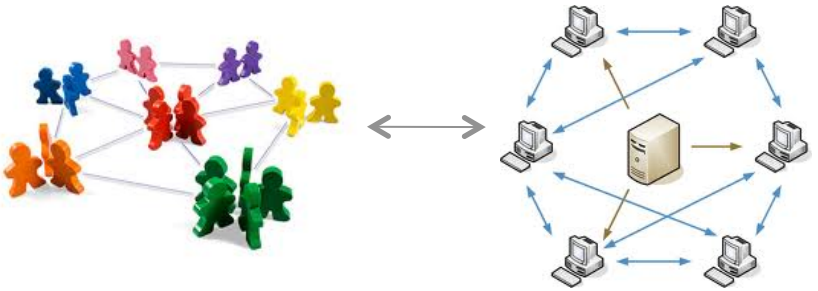
Taxonomic gap

- As a consequence, **identifying plants is very difficult**
  - Large public & professionals: farmers, rangers, etc.
  - Even for the botanists themselves

- And managing ecosystems is problematic
  - How could a farmer select **adapted pesticides ?**
  - How to control **plant's distribution** and **evolution** ?

Towards bridging the gap

- **Collaborative Information Systems**
  - Speeding up integration
  - Sharing knowledge
  - E.g. GBIF, EoL, Pl@ntNet



- **Multimedia IR** & **Identification Tools**
  - Notably **images** are: to acquire by anyone
  - **Visual content** is very informative for caracterisation

- **Image-based identification** (Task motivation)
  - **CBIR** SoA not well studied **on plants**
  - Few **datasets**, biased, narrow

ImageCLEF Plant Id Task

- A **trans-disciplinary** effort towards evaluating **multimedia IR** on **plants**
  - Funded by 

and 

  - Organized in collaboration with **botanists** and **environmental scientists**
- A focused & attractive **pilot task**

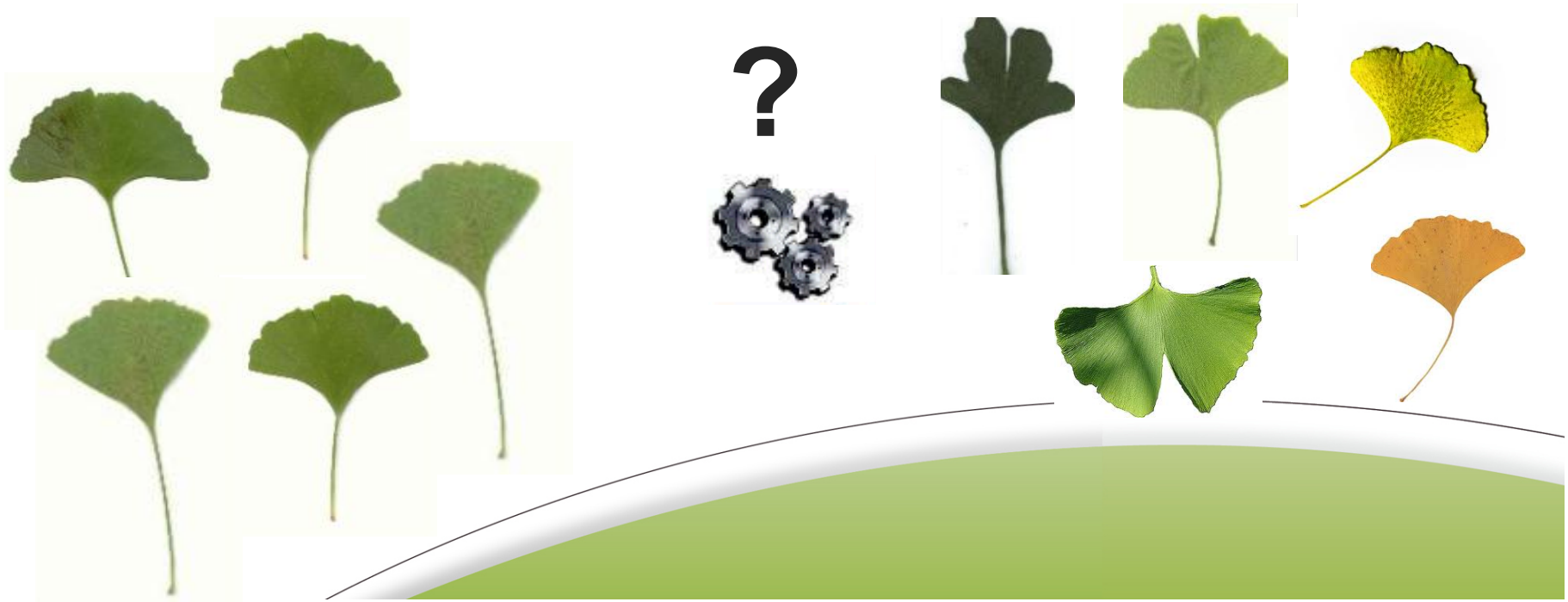
  *as simple as possible **but** as realistic as possible*
  - **Simple**
    - 1 content type = images
    - 1 organ = leaves (most studied)
  - **Realistic**
    - **Collaborative data** with contributors from 1 given climatic region

Data collection & creation

- Problem: How to reduce **bias** beween **training** data and **real user's** data ?

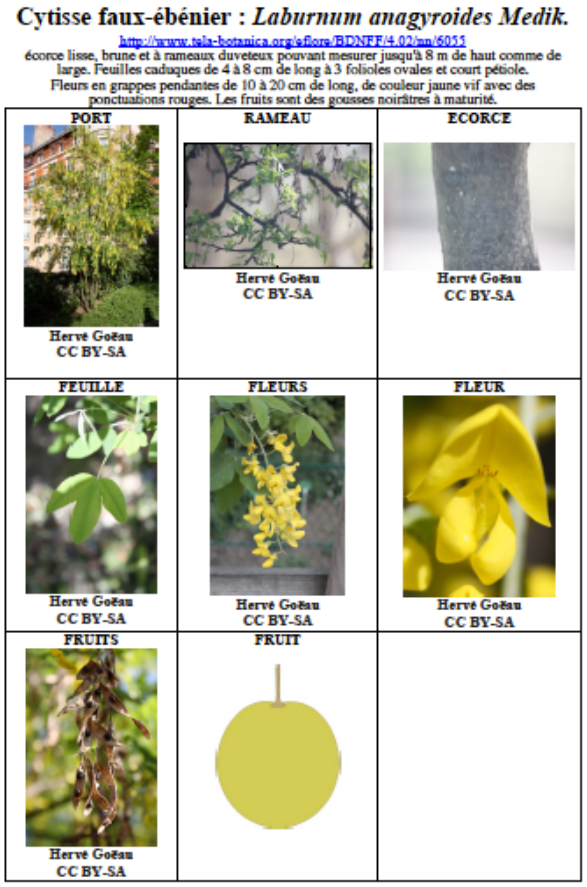
Training data

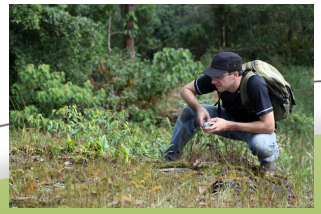
User data



Data collection & creation

- Solution 1: Let **real users collect** training data and botanists validate



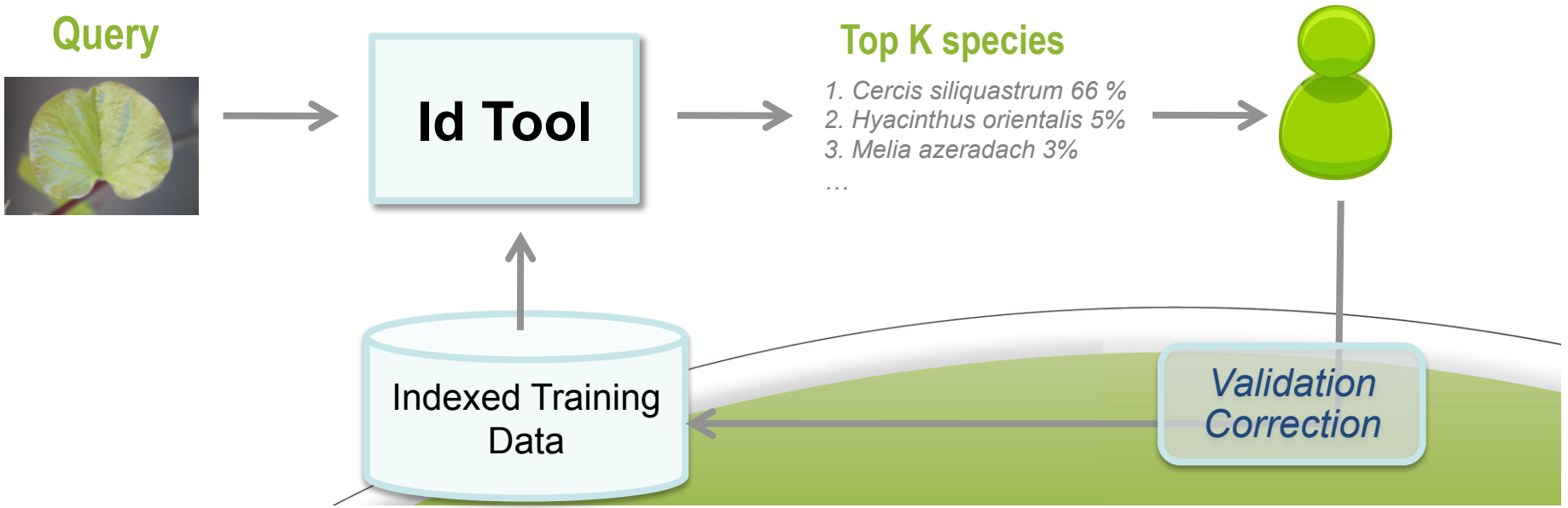


Data collection & creation

- Solution 1: Let **real users collect** training data
- Solution 2: Grow **training data** with **test data**

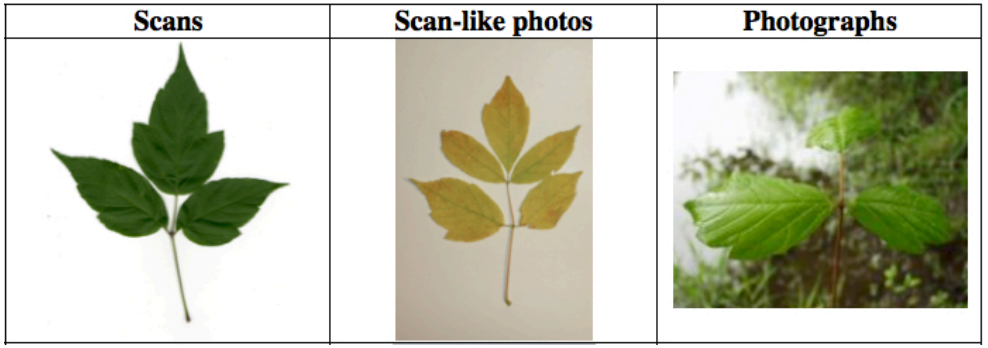
Online Identification Tool — Play

Online Validation & Correction — Contribute



Pl@ntLeaves dataset

- **70** Mediterranean **species**
- 5436 images of **3 types**
  - Scans
  - Photos with uniform background
  - Unconstrained photos



- Metadata (XML)
  - **Type** (scans, photos,...)
  - **GPS**
  - Author
  - Amount of leaves

```
▼<Image>
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   <Date>07/07/10</Date>
   <Type>Scan</Type>
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   <Locality>France - Herault</Locality>
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```
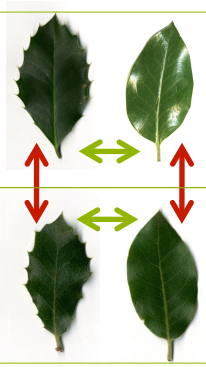
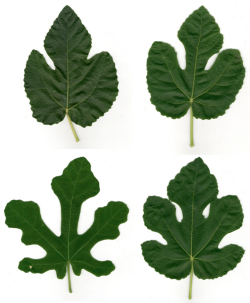

Pl@ntLeaves diversity

Ilex aquifolium L.
(European holly)

Quercus ilex L.
(Holm oak)



Intra-species diversity
versus
visual similarities between species



Lobe number and deep of leaf lobes on *Ficus carica L.* (Common fig)

 # Users = # Localities, # seasons, # environments, # climate, # ecosystems

Leaflets number variability on *Fraxinus angustifolia* Vahl (Narrow-leafed Ash)

Autumnal variability of the lamina color on *Cotinus coggygria* Scop. (Eurasian smoketree)

Growing stage: two compound leaves **from the same tree !** *Gleditsia triacanthos* L. (Honey Locust)

Task description

- A classification task (1 picture vs. 70 classes)
- A **plant-oriented** split strategy

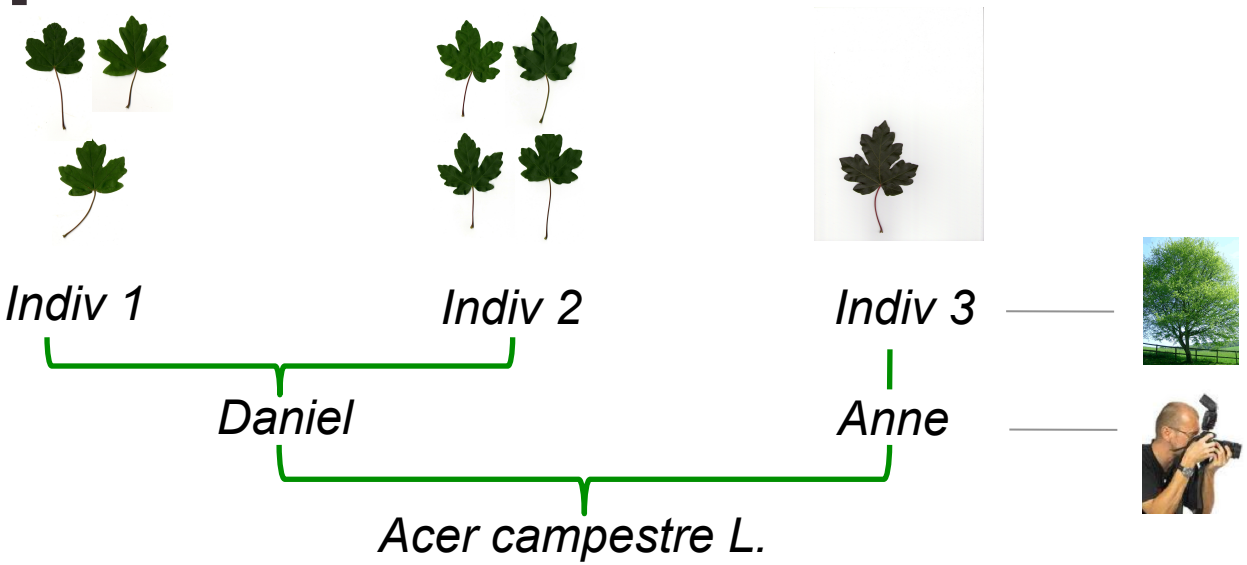
		Nb of pictures	Nb of individual plants	Nb of contributors
Scan	Train	2349	151	17
	Test	721	55	13
Scan-like	Train	717	51	2
	Test	180	13	1
Photograph	Train	930	72	2
	Test	539	33	3
All	Train	3996	269	17
	Test	1440	99	14

- **Separate scores** for the **3** image **types**
  - Scans → plant's diversity study
  - Scan-like photos → real lighting conditions
  - Unconstrained photos → back to the future

- **Free training** strategy (with or without meta-data, photo vs. scans)

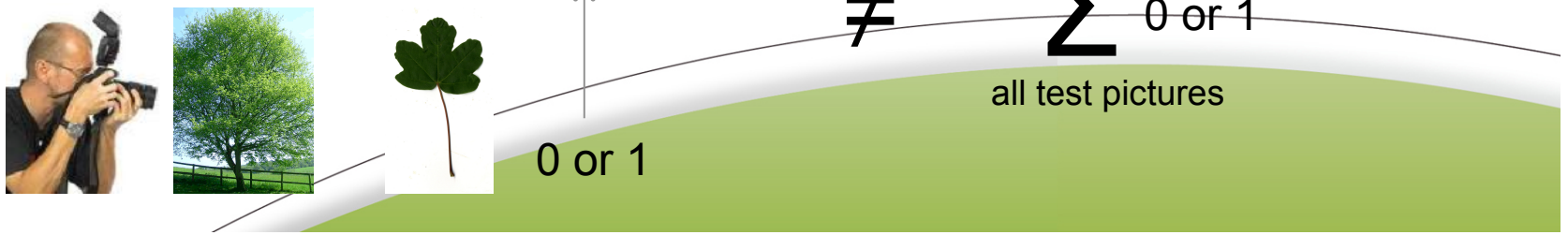
Task description

- **Unbalanced**
  Real-world
  Training data



- **Normalized** Average Classification Score (closer to **any** user's perception)

$$S = \frac{1}{U}\sum_{u=1}^{U}\frac{1}{P_u}\sum_{p=1}^{P_u}\frac{1}{N_{u,p}}\sum_{n=1}^{N_{u,p}} s_{u,p,n}$$



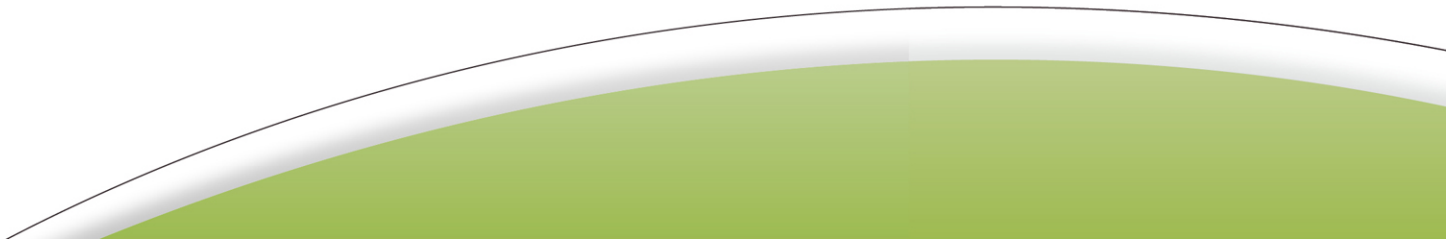
Participation

- About 40 groups registered
- 8 groups submitted a total of 20 runs (max was 4)

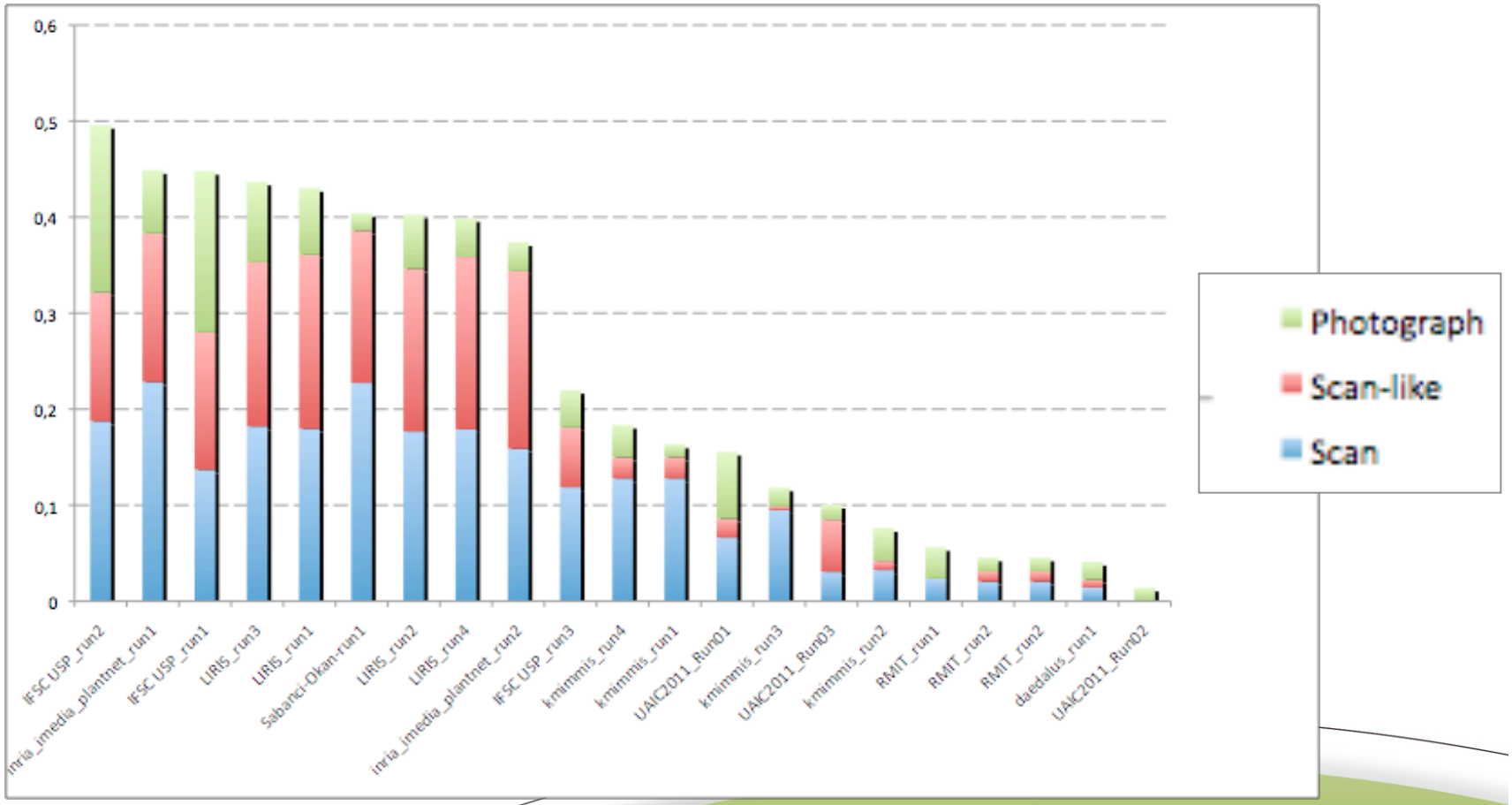
Group	Nb of runs	Methods/focus
DAEDALUS	1	SIFT visual features + NN classifier
IFSC	3	Boundary shape features
KMIMMIS	4	SIFT visual features + NN classifier
INRIA	2	Large scale matching, boundary shape
LIRIS	4	Model-driven boundary shape features
RMIT	2	GIFT visual features, 2 ML approaches
SABANCI-OKAN	1	Global visual features + SVM
UAIC	3	Metadata & visual features

Participation

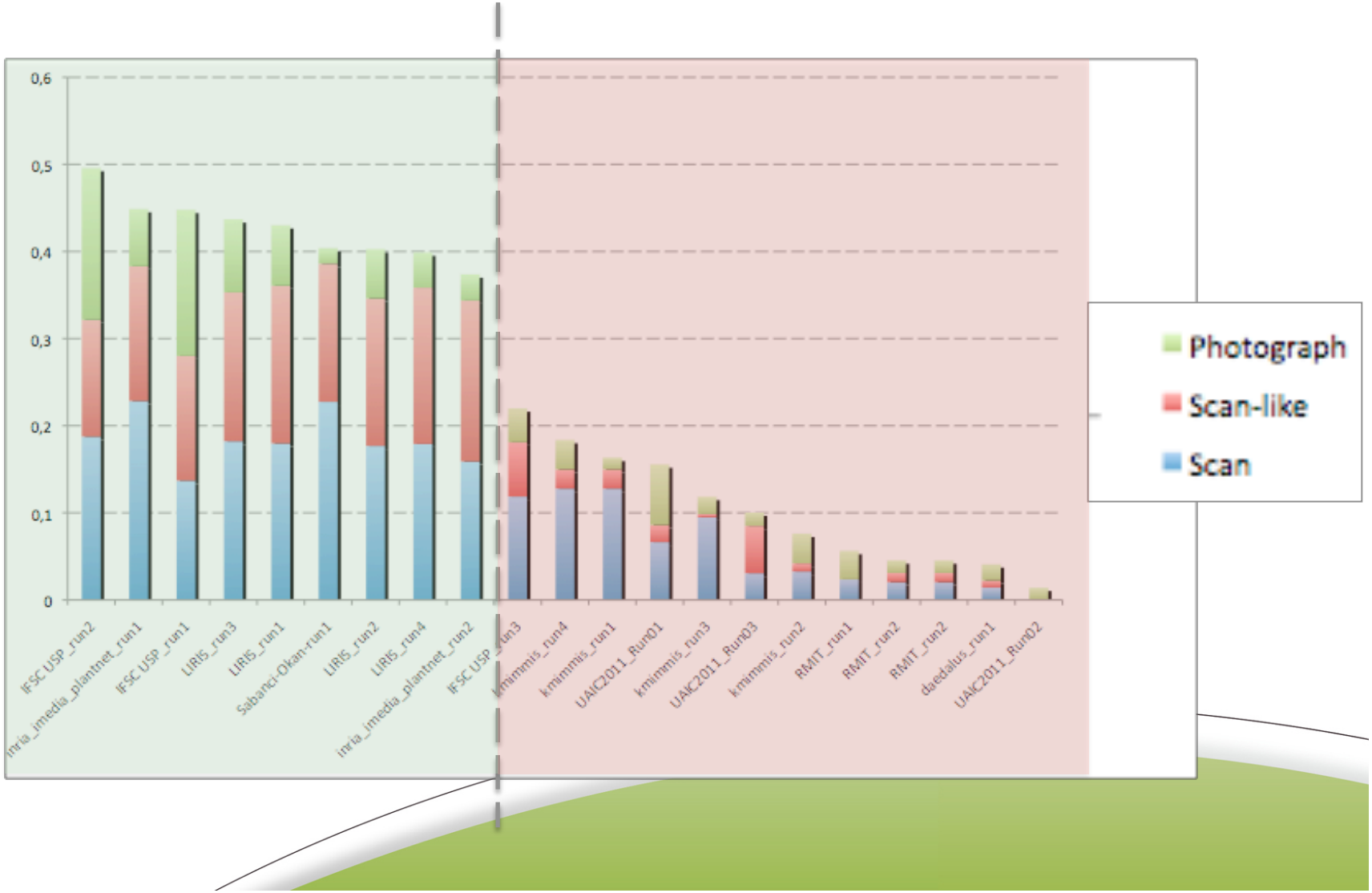
- *Used Media*
  - **Only visual content** — 18/20 runs
  - Using metadata — 2/20 runs
- *Used Visual features*
  - **Leaf boundary features** (SoA for leave's recognition) — 8/20 runs
  - Global visual features — 5/20 runs
  - SIFT features — 5/20 runs
  - Other local features (harris, histograms) — 1/20 runs
- *Classifiers*
  - **NN-classifiers** — 15/20 runs
  - SVM — 4/20 runs
  - Decision tree — 1/20 runs



Results: overview



Results: overview



Results: overview

Using leaf boundary features

No leaf boundary features

Results: overview

Using leaf boundary features

No leaf boundary features

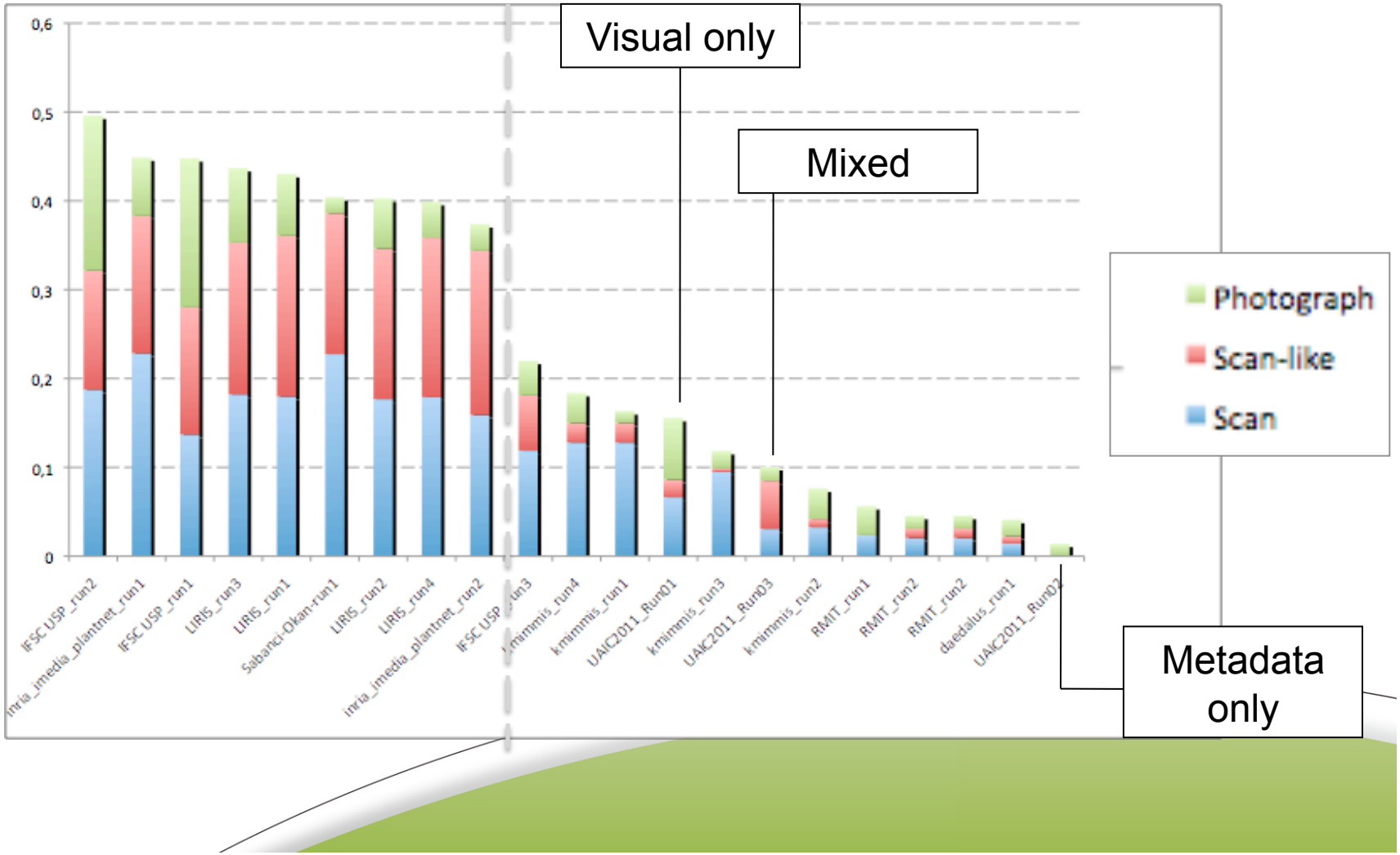
No rigid geometry

Using rigid geometry

Leaf shape is essential !!

Results: metadata

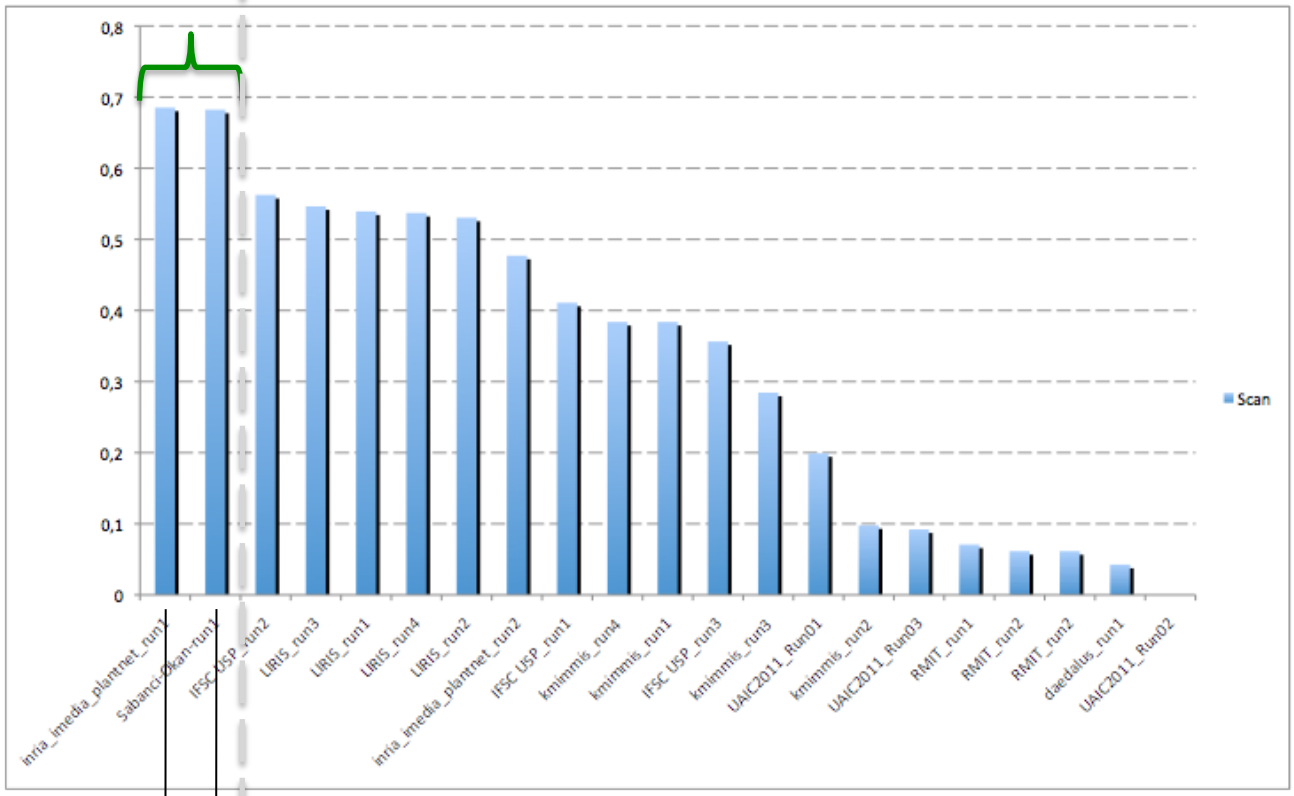
- Geo taggs not so useful in a localized climate region ?
- Relations between metadata are complex



Results: focus on scans

Leaf boundary features alone not sufficient to disambiguate plant's morphologies

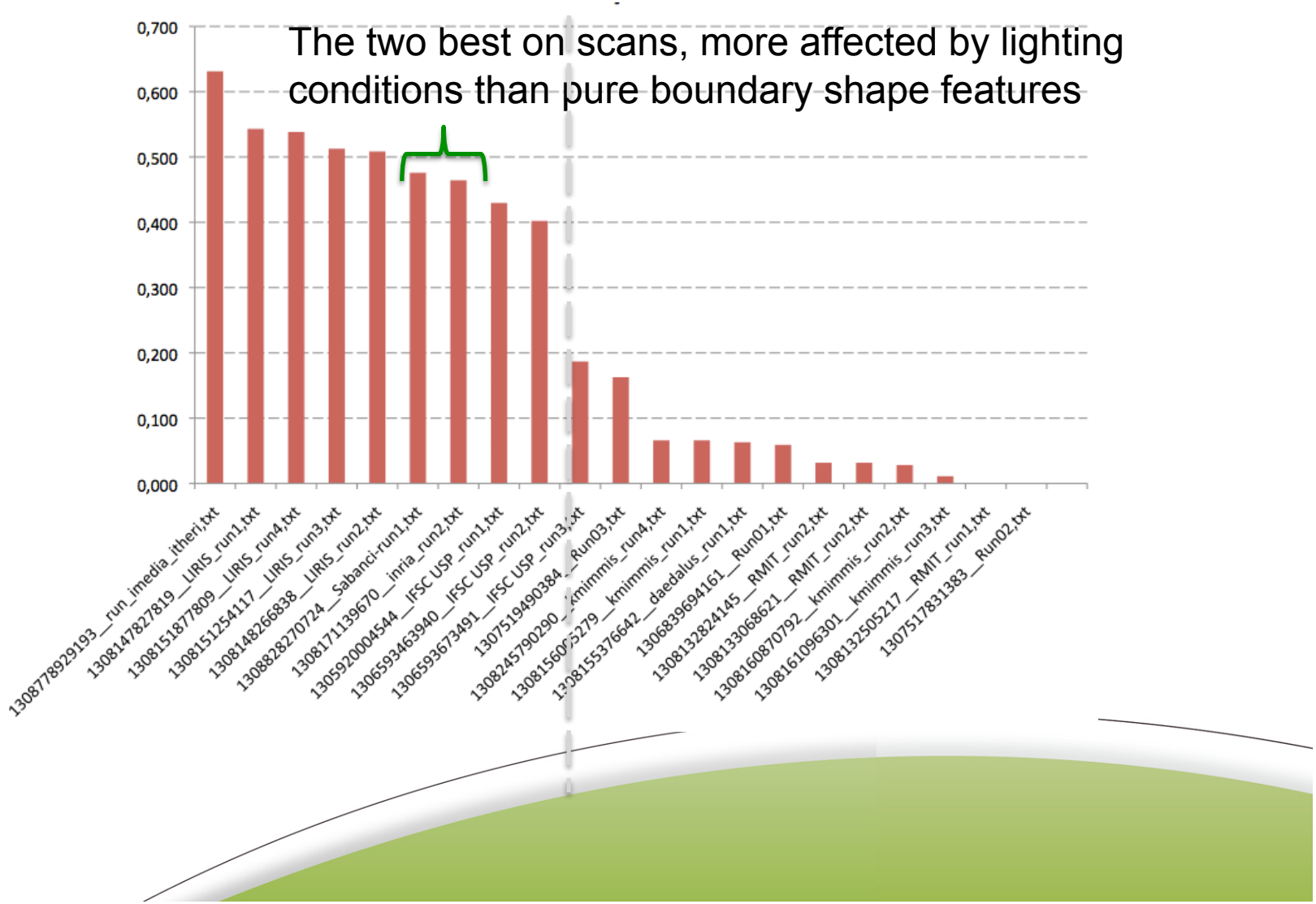
Not pure boundary shape features



Mixed global & shape boundary features
SVM

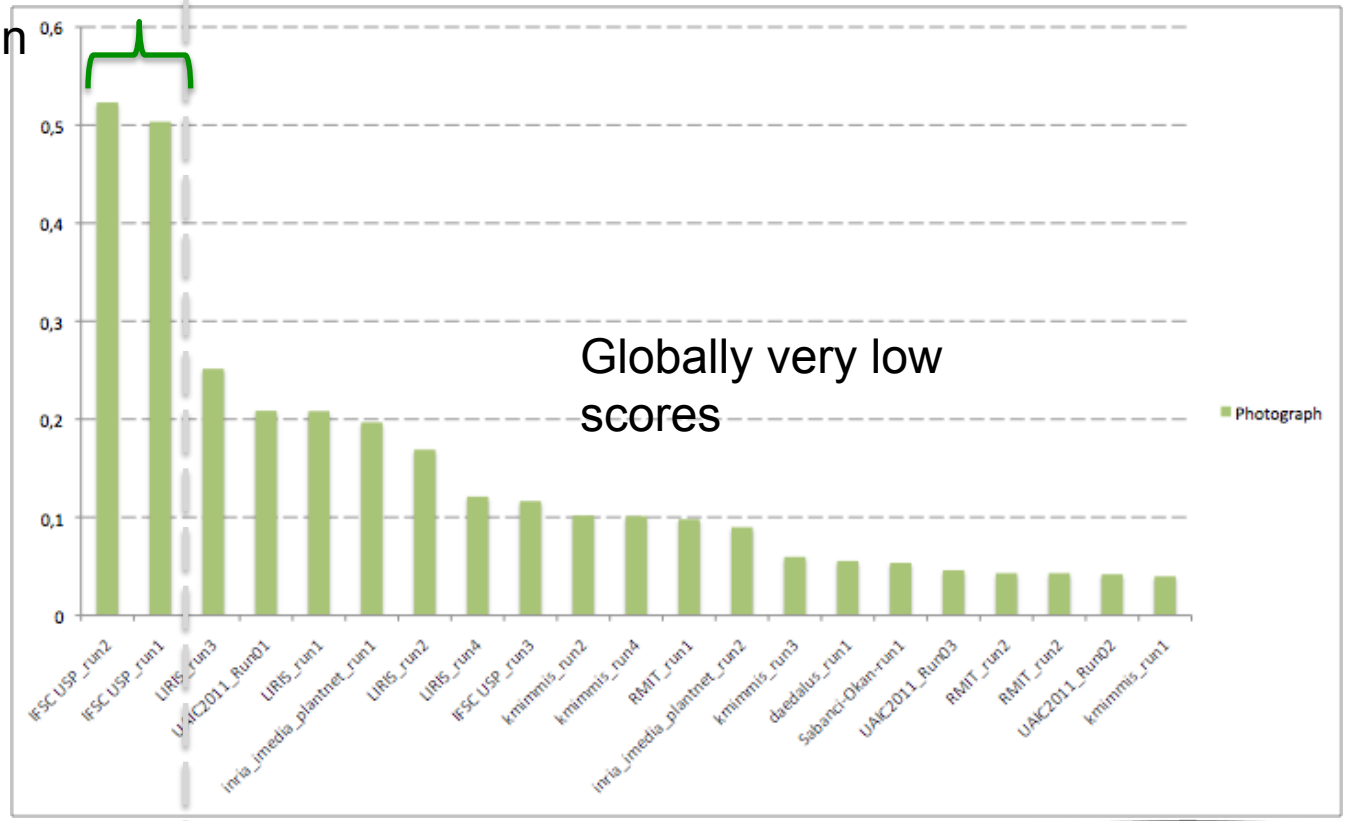
Mixed local features
Rigid object model

Results: focus on scan-like



Results: focus on unconstrained photos

1st, 2nd: with manual segmentation



Results: machine learning concerns

[Yanikoglu et al., Sabanci-Okan univ, ImageCLEF 2011]

- SVM vs. NN classifier: only slight improvements (Crosss-validation scores)

Descriptors	1NN	SVM/SMO
1,3	79.59	80.27
1,2,3	85.02	86.93
1,2,3,4	85.45	87.11
1,2,3,4,5	87.36	89.15
1,2,3,4,5,6	88.59	90.20
1,2,3,4,5,6,7	88.41	**90.57**

- **Crosss-validation (**random splits) vs. **Real test** (plant-based & author-based split)

Cross-valid	Real
90.57	**0.579**

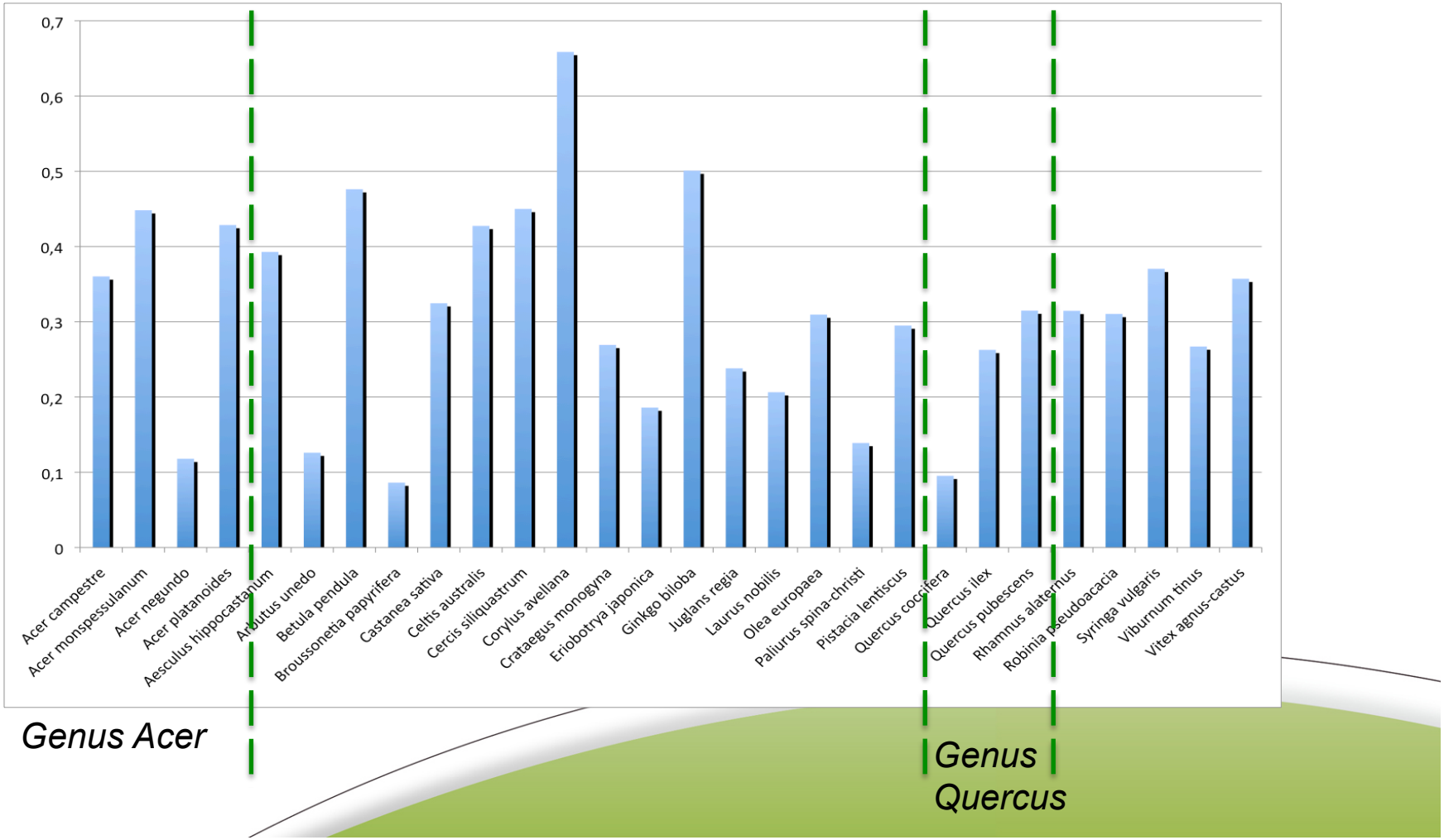
Back to botany

What is difficult across all runs ?

Results by species

High variability

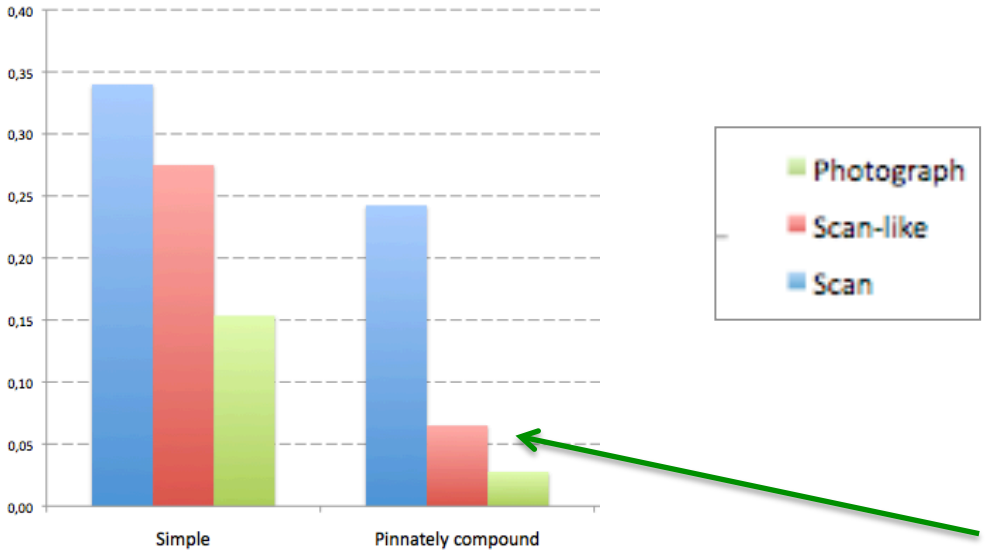
Not interpretable in terms of genus



Back to botany

What is difficult across all runs ?

Results by leaf morphology (based on botanist's manual classification)



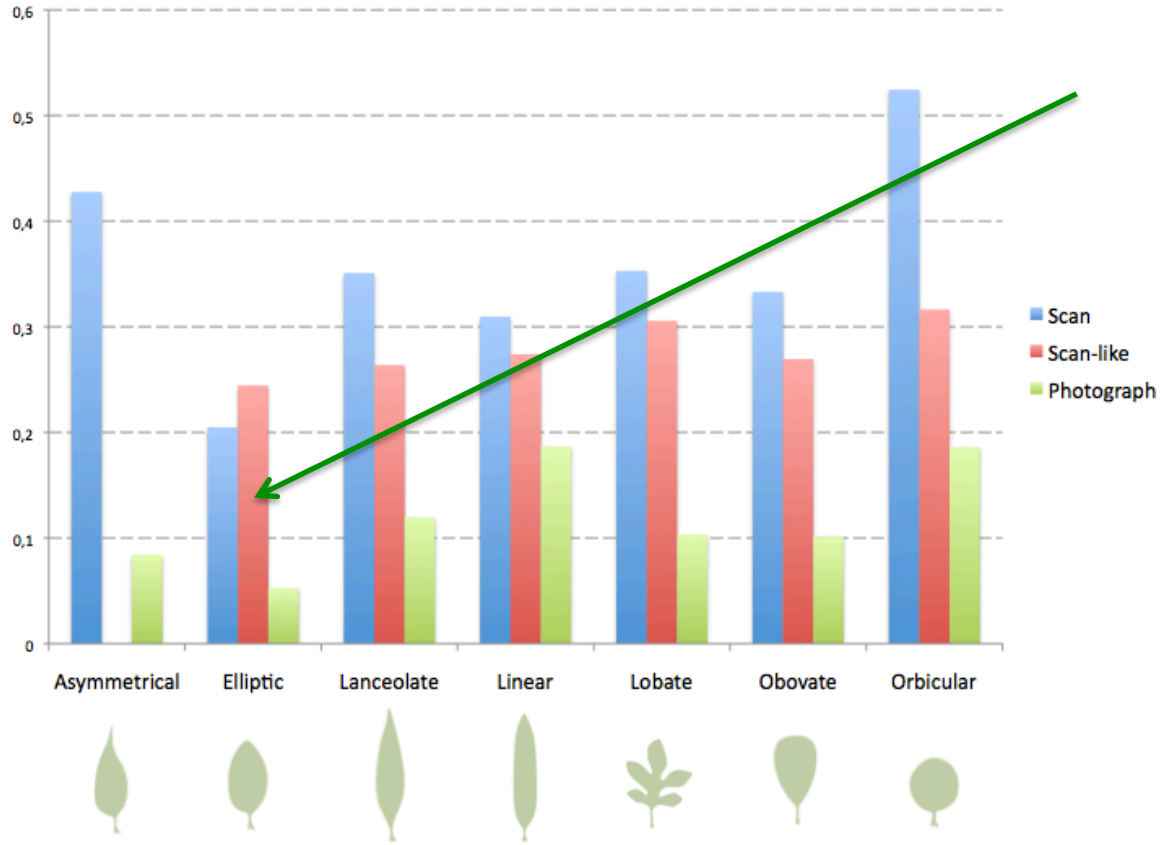
Scan → scan-like :
Shadows ?
Overlaps ?

51 species *16 species*

Back to botany

What is difficult across all runs ?

Results by leaf morphology: simple leaves only



Elliptic shapes:

Most ambiguous category

Most common leaf shape

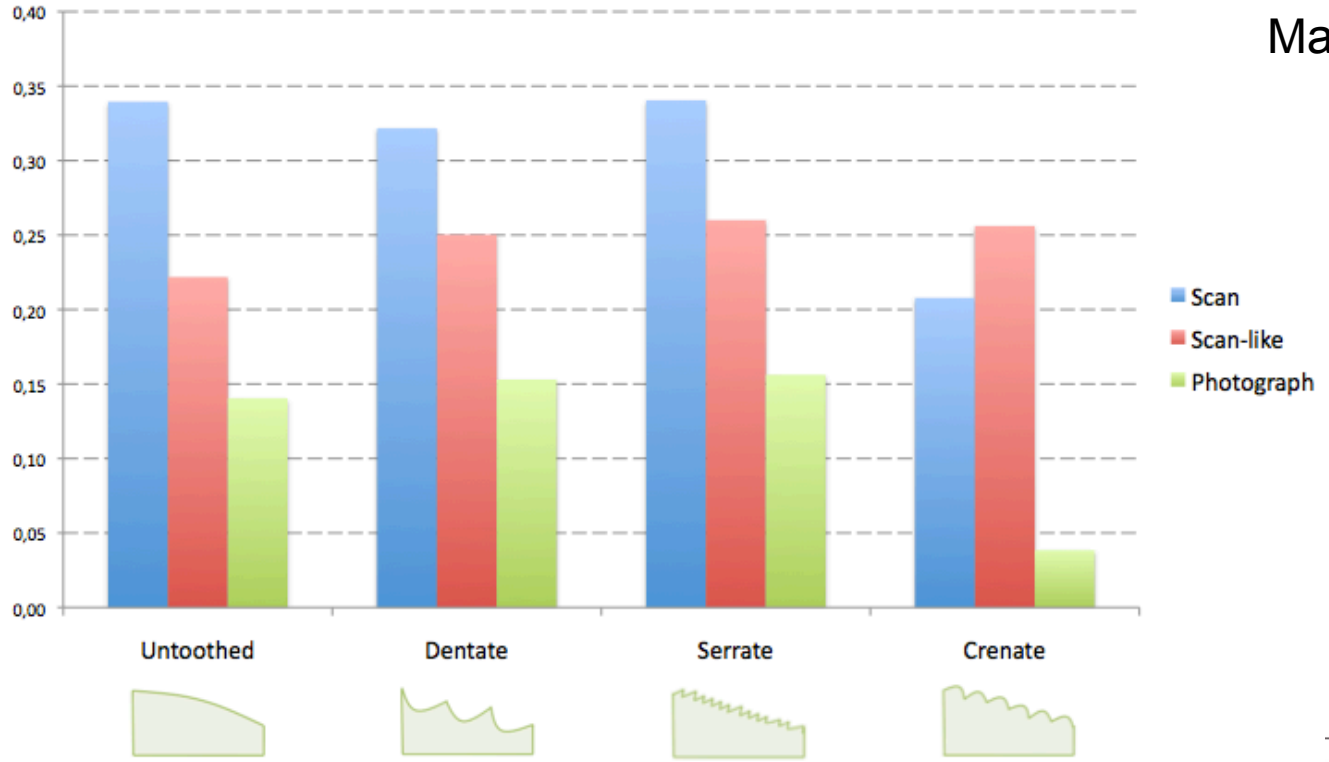
The shape's information itself is poor

 # Species: *1* *31* *15* *2* *13* *18* *10*

Back to botany

What is difficult across all runs ?

Results by leaf morphology: margin type (simple leaves)

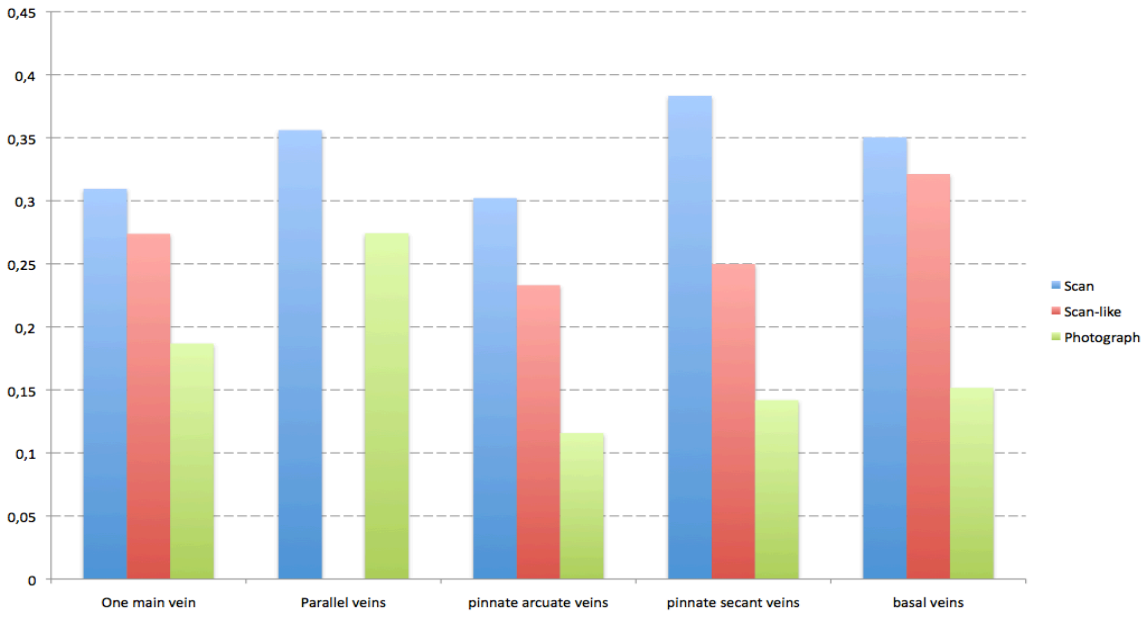


Marginal influence

Back to botany

What is difficult across all runs ?

Results by leaf morphology: vein network type



Marginal influence

Back to botany

What is difficult across all runs ?
Results by individual leaves

Easiest leaves (17/20)

Most difficult (0/20)

→ On the long term, users would probably submit only **easy leaves**
→ So that practical identification rate would increase (professionals, etc.)

Conclusions

- **Good identification scores on scans and scan-like**
  - Not far from mature
  - But high variability across species
  - Mainly due to leaf's morphology (compound leaves…)
- **Unconstrained pictures much more challenging**
- **SoA Shape boundary features are effective but**
  - Outperformed on pure scans when used alone
  - Combining them with other features may improve
- **Local features + geometry effective as well**
  - Best results on scans
  - Most recent recognition methods not tested !!
- **Benefits of advanced Machine Learning techniques is not clear**

Perspectives & issues

- **More species ?**
  - European Trees ≈ 200, European Plants ≈ 2K, Tropical Plants ≈ 200K
  - Pb = existing data too sparse (1 species = 1 image)
  - Depends on collaborative contributions…
- **More organs ?**
  - Fruit, flower, trunk, etc.
  - Pb = existing data even more sparse
  - Depends on collaborative contributions…

- **Beyond identification ?**
  - Towards a real botanical IR system
  - Rank-based task & metric
  - Multi-image & Multi-modal queries
  - Pb: task participation …

Thank you!!

And see you tomorrow morning for CHORUS+ session

AUDIO-VISUAL SEARCH

8:30 – 10:00 Scientific Multimedia Data

- Earth observation
- BioSearch
- Collaborative botany
- Environmental informatics