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# Pl@ntNet Mobile App

Hervé Goëau  
INRIA, ZENITH

Vera Bakić  
INRIA, ZENITH

Souheil Selmi  
INRIA, ZENITH

Nozha Boujemaa  
INRIA, Saclay

Pierre Bonnet  
CIRAD, UMR AMAP

Julien Barbe  
INRA, UMR AMAP

Jennifer Carré  
Tela Botanica

Jean-François Molino  
IRD, UMR AMAP

Aurélien Péronnet  
Tela Botanica

Alexis Joly  
INRIA, ZENITH

Itheri Yahiaoui  
CReSTIC Univ. Reims

Daniel Barthélémy  
CIRAD, BIOS

Grégoire Duché  
Tela Botanica

## ABSTRACT

Pl@ntNet is an image sharing and retrieval application for the identification of plants, available on iPhone and iPad devices. Contrary to previous content-based identification applications it can work with several parts of the plant including flowers, leaves, fruits and bark. It also allows integrating user's observations in the database thanks to a collaborative workflow involving the members of a social network specialized on plants. Data collected so far makes it one of the largest mobile plant identification tool.

## Categories and Subject Descriptors

H.3.3 [Information Search and Retrieval]: Information filtering; Search process; Query formulation

## Keywords

plant, identification, images, visual, retrieval, social network, collaborative, crowdsourcing, citizen science, multi-organ, leaf, flower, bark, fruit, ecology, surveillance, monitoring, multimedia, computer vision, botanist

## 1. BRIDGING THE TAXONOMIC GAP

Building accurate knowledge of the identity, geographic distribution and uses of plants is essential if agricultural development is to be successful and biodiversity is to be conserved. One big challenge, expressed as the *taxonomic gap*, is that identifying plant species is usually impossible for the general public, and often a difficult task for professionals, such as foresters or farmers (who have to deal with weed species). In this context, content-based visual identification tools are considered as one of the most promising solution [4, 2, 12] particularly mobile applications [10, 1] that could help setting-up massive ecological monitoring systems. A noticeable progress in this way has been achieved by the US consortium behind LeafSnap<sup>1</sup> an iPhone application al-

<sup>1</sup><http://leafsnap.com/>

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lowing a fair identification of 184 common American species based on uncluttered images of leaves and shape boundary features [10]. But this is still far from a real-world application that would help a farmer recognizing a specific weed among thousands of potential species. Our claim is actually that more diverse views of the plants, fitting the diversity of much richer floras, should actually be considered to achieve a real ecological impact. The use of leaves alone has actually many practical and botanical limitations. Leaves are typically not visible all over the year for most of the species, or can be intrinsically not enough informative or very difficult to capture (needles, tiny or huge leaves...). Using flowers alone, as suggested in [11, 1], is not a better choice because these limitations are even more accentuated. The iPhone application presented in this demo is the first image-based identification tool dealing with multiple organs of the plants (leaf, flower, fruit and bark) in their natural environment. It allows querying the system at any period of the year and can benefit from the complementarity of the different views to improve identification performances.

## 2. PL@NTNET APPROACH & SYSTEM

The demonstrated iPhone application is built on top of an end-to-end collaborative information system allowing the training data to be continuously enriched and revisited. Complementary to world-wide data integration efforts such as *Encyclopedia Of Life*<sup>2</sup> or crowd-sourced approaches such as ImageNet [3] or NEC flowers dataset [1], our proposal is to rely on thematic social networks to solve data validation issues and produce accurate knowledge. Epistemic communities actually have the advantage to connect experts, enlightened enthusiasts, amateurs and novices around the same topic so that all of them can play complementary roles in a real-world ecological surveillance workflow. Experts can typically animate projects, define observation protocols and teach. Amateurs can collaboratively validate data by interacting together according to their level of expertise, and novice can provide massive sets of observations.

More concretely, our workflow relies on Tela Botanica<sup>3</sup>, a French-speaking network linking 20K members in more than 70 countries (41% *novice* in botany, 30% *with a good practice*

<sup>2</sup><http://www.eol.org/>

<sup>3</sup><http://www.tela-botanica.org/>

and 7% *experts*). Raw image feeds, collected through web crawls, personal collections or the iPhone app itself, are integrated in a collaborative tagging and validation tools and enriched daily by the network. These web applications typically allows managing contradictory determinations that result from the intrinsic complexity of identifying a plant (classical dichotomous keys used by botanists require answering dozens or even hundreds of complex questions related to thousands of often ambiguous morphological attributes). To boost integration, contents with missing organ tags are automatically annotated and can be corrected afterwards. Based on all the produced metadata, only relevant contents are finally inserted daily in the visual index.

The mobile application available on the App Store works at the time of writing on 22,574 pictures representing 957 wild plant species living in France area. Besides, a web beta version of the application includes more than 100K images and 5K species. To our knowledge, there is no other multi-organ database meeting the needs of content-based identification, i.e. with a large number of species, explicit organ tags and a sufficient number of training pictures. Initiatives like EOL provide good illustrations for many plants but must often with only very few pictures per organ and per species. On the other side, crowdsourced datasets such as ImageNet [3] contain thousands of pictures for a lot of species, but still without organ tags and with a very high level of noise for a botanical usage. More generally, most existing data suffer from a *long tail* distribution, i.e. with few species well represented and most species with few images.

### 3. THE IPHONE APP

The iPhone app itself basically contains four functionalities: an image feeds reader to explore the last contributions of the community, a taxonomic browser with full text search options, a user profile and personal contents management screen and the image-based identification tool itself. The user can take up to five pictures of a same plant, and the system ask him to chose for each picture among 4 icons representing a flower, a leaf, a fruit and a bark. The complete set of pictures can finally be submitted as a query plant to the remote visual search engine. Retrieved species with confidence scores and matched images are finally returned to the device and displayed on the the result screen by decreasing confidence. Selecting one of the retrieved species opens a detailed view screen with all matched pictures (classified by organ galleries) allowing a first stage of refinement in the determination process. A second stage of refinement can be achieved by accessing either *eFlora* Tela Botanica fact sheets (the most complete db on France flora) or wikipedia mobile pages. If the user believes having found the right species he can finally share his observation with pictures, date, gps and author's name (in Creative Commons). The observation will then be integrated through the collaborative web tools<sup>4,5</sup>.

### 4. VISUAL SEARCH ENGINE

The generalist CBIR method we are using as the core algorithm of our visual search engine is built from the works of Joly et al. [7, 6, 8] on large-scale matching. It was actually shown in [4, 5] that such object retrieval methods do work surprisingly well on plants although being usually aimed at retrieving rigid objects such as buildings, logos, etc. Concretely, image retrieval is achieved through the following steps: (i) Local features extraction (SURF, HoG,

RGBH and Fourier features around multi-resolution color Harris points) (ii) Hamming embedding and indexing with RMMH [8] (iii) approximate k-nn search with AMP-LSH [6] (iv) voting based on the number of matched features (with or without spatial re-ranking depending on the view type). In the case of leaf scans, an additional boundary descriptor (DFH+Shapes [13]) is used to capture the global shape and has been showed to provide a consistent improvement of the global performances. Thanks to the organ-based tagging paradigm, pictures belonging to a given plant view category can be indexed and searched in a separate visual index. This allows reducing confusion between pictures of different parts of the plant and therefore increases identification performances. At query stage, the  $N^Q$  query pictures belonging to a query plant  $Q$  are searched separately in their respective visual index and the top-K most similar images are returned for each of them (K=20). Identification is then performed thanks to an instance-based classifier computed across all retrieved pictures. It uses a two-stage fusion strategy working first on query images with the same view type (*single-view* level) and then on the produced decision lists at the upper level (*multi-view* level). The single-view fusion level combines a min-rank fusion of the image lists and a classical instance-based classifier to produce a ranked list of species with normalized scores for each type of view. The *multi-view* fusion level consists in a weighted sum of the normalized confidence scores of the *single-view* level, where the weight of each view type reflects its discrimination power for query  $Q$ . More details about the visual search engine as well as extensive experiments on the identification performances are available in [5] and [9]. The iPhone application itself is freely available on the Apple store (*PlantNet*).

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<sup>4</sup><http://www.tela-botanica.org/appli:identiplante>

<sup>5</sup><http://www.tela-botanica.org/appli:pictoflora>

<sup>6</sup><http://www.plantnet-project.org/>