# PL@NTNET: HARNESSING THE POWER OF ARTIFICIAL INTELLIGENCE FOR BIODIVERSITY CONSERVATION



***Pierre Bonnet, Ph.D.***
pierre.bonnet@cirad.fr
Permanent researcher (researcher in Biodiversity informatics)
Cirad-Bios, Amap mixt research unit, Montpellier, France

***Alexis Joly, Ph.D.***
alexis.joly@inria.fr
INRIA Research Director (DR 2), INRIA, ZENITH team, France

**Sue Han Lee, Ph.D**
shlee@swinburne.edu.my
Lecturer, Faculty of Engineering, Computing and Science, Swinburne University of Technology

In the age of advancing technology, artificial intelligence systems have become increasingly ubiquitous to many aspects of society. Not only were such technology researched and developed for the benefit and convenience of regular consumers, various initiatives have also been put in motion for the benefit of various societal challenges such as the environment. Pl@ntNet[1] is one such initiative that was launched as early as 2009 as a theoretical research project to experiment image recognition techniques to monitor biodiversity. It was established through an interdisciplinary collaboration between several French research centres in science and technology and biodiversity, namely The French Agricultural Research Centre for International Development (CIRAD), the French National Institute for Research in Digital Science and Technology (INRIA), the French Research Institute for Agriculture, Food and the Environment (INRAE), and the French Research Institute for Development (IRD).

## The History

The project started out with the focus on developing image recognition algorithms for plant species identification and in particular with the search for similarities and more recently supported by deep learning convolutional neural networks technology with a focus on user engagement and collaboration. Between the years 2011 and 2013, Pl@ntNet officially launched what is termed as “Citizen Science Platforms” with the release of the first web application (Goëau et al., 2011) followed by the mobile application (Goëau et al., 2013) respectively. In 2015, with the rise deep learning technology, the researchers’ work has been accelerated and the Pl@ntNet team was among the first one to develop a plant identification system with a scale as large as 8,000 species. The citizen science aspect is in reference to the availability of the platforms to not only botanists, but also free to use by the general public as active users and contributors. The free app

[1] https://plantnet.org/en/

that can be downloaded into mobile devices enables anyone to take a photo of a plant for identification, explore from a list of potential species that might match as well as “vote” or validate the seemingly correct species.

Subsequently in 2018, Pl@ntNet successfully conducted the first ecological study using the data contributed by citizens using the app (Botella et al., 2018). In the study, species distribution modelling of invasive alien plants based on citizen collected data were compared to data inventories made by experts with reasonable predictive effectiveness for some species. As of 2020, Pl@ntNet is also widely used for teaching and raising awareness of biodiversity conservation and agroecology (Bonnet et al., 2020), for instance early prediction of invasive species through species distribution monitoring. Moreover, Pl@ntNet data has been integrated into the Global Biodiversity Information Facility (GBIF) database. In 2021, after more than 10 years from the official launch of the citizen science platform, Pl@ntNet received the Inria – French Academy of Sciences – Dassault Systems Innovation Award which honours research teams that have been active in issues of transfer and innovation in the field of computer science and mathematics. This is in recognition of the research that has supported biodiversity with the collaborative platform based on deep learning for plant identification.

## The Applications

The core focus of the project at the beginning has been the development of image recognition algorithms for plant species identification and in particular with the search for similarities and more recently supported by deep learning Convolutional Neural Network (CNN) technology. This is then integrated into application platforms for ease of use. The approach of the platform is to not only provide the name of the plant to be identified, but also to provide a list of most similar plant observations to the ones submitted by the end users in order to have more engagement with them. The users are therefore involved in the process because they will be presented with choices to select the correct plant if necessary. This in turn supports a continuous improvement of the backend algorithm.

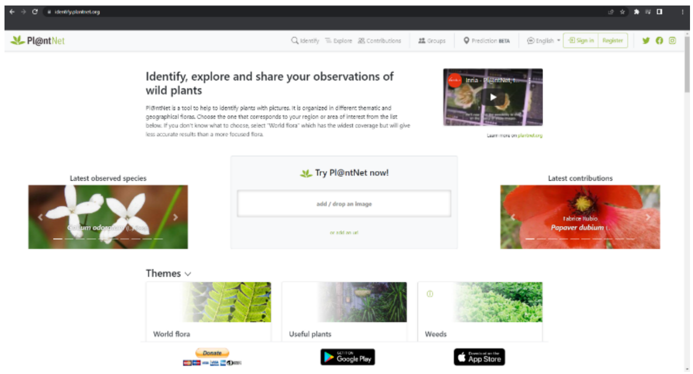


*Fig. 1. Pl@ntNet web app interface for plant species recognition from an image.*

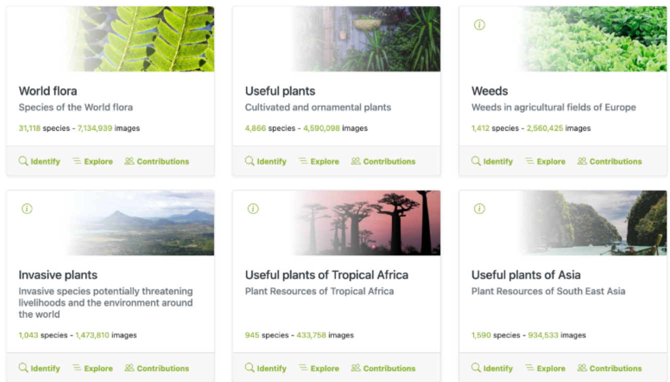


*Figure 2. Graphic interface of Pl@ntNet web app showing the thematic floras covered by the citizen science platform.*

Figures 1 and 2 shows the web application interface of the platform for the recognition as well as exploration. The mobile application as shown in Figure 3, is relatively more convenient on the field whereby users are able to easily conduct identification from their mobile devices on the fly. The recognition can be performed using images of different organs of the plant, such as the flower, leaf, fruit, as well as the bark. The application then engages the user to validate the recognition results among a list similar plants, if possible. On the other hand, other users are also able to validate the contributions of each other in a collaborative manner either in a personal capacity to verify the correctness of the images in the database through exploration, or to participate in groups of similar interests. This collaborative platform fosters the spirit of community among users from different walks of life to exchange knowledge of a common interest in biodiversity. The application has been fast growing, where a few years ago there are up to 20 million users of the app with about 500,000 uses per day during spring peaks, and still increasing.

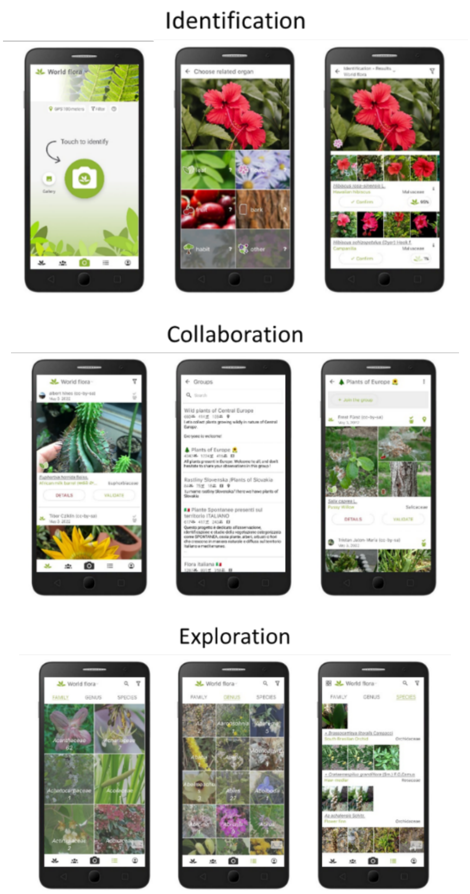


*Figure 3. Mobile application of Pl@ntNet provides an engaging interface for users to perform identification of plant species, explore plants in the database, and collaborate with other users in the community.*

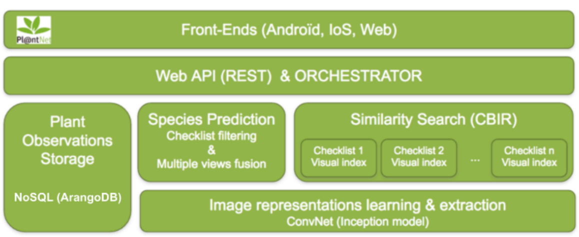


*Figure 4. Pl@ntNet system architecture at the beginning of 2017 (Affouard et al., 2017).*

## The Backend

The Pl@ntNet system architecture can be divided into five main modules as shown in Figure 4 (Affouard et al., 2017). The first is the Plant Observation Storage that contains plant (images of flowers, leaf, etc., species) and provenance (device, user, etc.) data as well as geo-locations of observations, all store within Arango (NoSQL document storage). The Image representation learning and extraction engine is a CNN that is periodically trained using validated observations that were collected from the app users for continuous model improvement. Next is the Species Prediction module that uses the aforementioned CNN for prediction when observations (images) are supplied by the end user through the apps. Other than a single image-based prediction, a weighted average approach has been incorporated for conditions where the user is able to supply images of various organs of a single plant in order to "fuse" the predictions for optimal results of the most probably species. Following that, the feature vector from the CNN is also extracted to support the Similar Search module, specifically Content-Based Image Retrieval (CBIR) operation that uses the compressed binary code of the feature vector from unsupervised hashing for nearest neighbours search. Figure 5 illustrates the concept of the CNN for species classification, and the feature vector extracted to perform CBIR. Finally, the Representational State Transfer (REST)-ful web API is used to manage the data exchanges between the server and front-ends. Users are able to access the rich information such as images available in the database of the plants and species, or descriptive web pages to provide further information.

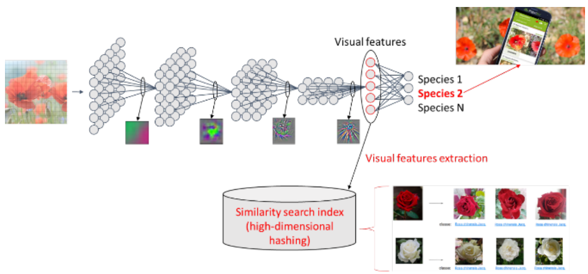


*Figure 5. Conceptual illustration of plant species image recognition technology. Convolutional Neural Network is trained for species classification and visual features from the CNN is extracted for similarity search.*

## Now and the Future

Currently, Pl@ntNet has been adapted to multiple regions including the Americas, Africa, Oceania and Asia, a vast expansion from the initial coverage of Western European flora at the start of the project, and now includes up to 38,045 plant species. To broaden the coverage of the application to remote areas such as dense evergreen forests or high mountain environments, the Pl@ntNet team is currently experimenting with dedicated technologies for offline use of the identification search engine, as people living in remote areas have less access to new technologies (such as recent smartphones, broadband internet, etc.). This is important to mitigate geographical bias in order to ensure a more homogeneous geographical coverage for biodiversity monitoring.

As part of the Cos4cloud[2] European research project, Pl@ntNet is also investing in making its plant species identification service available in the form of an API[3]. This new service has already enabled nearly 5 thousand researchers and app developers to test it and/or integrate it into their own data workflow. These new uses of this service could very soon be available through a wide range of connected sensors or autonomous robots.

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[2] https://cos4cloud-eosc.eu/

[3] https://my.plantnet.org/