# Material and methods

The application is available via a website. The user can upload the picture he want to be identified to this website. The application uses a neural network. A neural network in programs is based on the way biological nervous systems process information [6]. A neural network is something like a program that recognizes a pattern in a series of numbers. When you feed the network a new series of numbers the neural network can tell if it fits in the pattern or not. To make a neural network usable for pictures, the 2D pictures have to convert into series of numbers first. When the neural network in a program works correctly it is possible to teach the computer to identify plant parts from photographs. To identify which particular orchid genus is illegally traded the application should be able to identify which genus of orchids was photographed.

## Requirements for the training pictures

To train the software it is required that the parts of the orchids (flower, tuber and leaf) are always oriented the same way in the pictures. It is also required that the background is one colour, like black or white. The background colour on all the pictures must be the same too. For the flowers, it is the best to frontally take the pictures.

The frontal orientation is also required for the leaves.

The orientation for the tubers is unregulated. It is only required that it is the same for all pictures. For instance, if the first pictures of a hand-like tuber have the spurs on the right, all the other pictures of these tubers must have the spurs on the right. It is also required that the users use the same orientation as the trainer of the software.

At last it is required that there is only one tuber, flower of leaf per picture.

## Look-a-likes

To train the software, well known look-a-likes are also used. This is to check if the application can see the difference between an orchid and a non-orchid. The look-a-likes that are used are adulterants such as *Arum maculatum*, *Asparagus officinalis, Polygonatum verticillatum, Tulipa greigii,* and *Tulipa sp.* [18]. Appendix 1 contains pictures of these tubers.

Table 1 main difference in flowers of different slipper orchid genera [21]

| Species | Colour | Pedicel | Ovary |
| --- | --- | --- | --- |
| *Cypripedium* | Usually showy, concolorous or two-coloured | Obscure to elongate, glabrous, elongating after fertilization in some species | Unilocular, , glabrous, hairy or glandular |
| *Mexipedium* | White, densely brown-pubescent on the outer surface of the sepals | Obscure to short, glabrous | Unilocular, densely covered with multicellular hairs |
| *Paphiopedilum* | Usually showy, concolorous or bicoloured | Obscure to short, glabrous | Unilocular, glabrous or hairy |
| *Phragmipedium* | Usually showy, concolorous or not | Obscure to short, glabrous | Trilocular, glabrous or hairy |
| *Selenipedium* | Concolorous or bicoloured | Obscure to short, hairy | Trilocular, hairy, crowned with a persistent perianth |

Table 2 main differences in leaves of different slipper orchid genera [21]

| Species | Plicate/ conduplicate | # Leaves | Shape | Colour |
| --- | --- | --- | --- | --- |
| *Cypripedium* | Usually plicate | One-several | Lanceolate, ovate, elliptic oblong or cordate, obtuse to acute or acuminate | Green, spotted with blackish maroon in some species |
| *Mexipedium* | Conduplicate | Variable | Ligulate or oblong, obtuse, mucronate at apex | Clear green on upper surface, lighter green below |
| *Paphiopedilum* | Conduplicate | One to several | Ligulate, elliptic, or oblong, obtuse to acute, often tridenticulate at apex | Green, bluish green or chequered or ornamented with dark and lighter green on upper surface, lighter green below, sometimes finely spotted or flushed with purple at base or all over |
| *Phragmipedium* | Conduplicate | Several | Ligulae, elliptic, or oblong, obtuse to acute, often tridenticulate at apex | Darker green on upper surface, lighter green below |
| *Selenipedium* | Plicate | Several-many | Elliptic-lanceolate to linear-lanceolate, acute or acuminate | Green |

Table 3 main differences in tubers of different *salep* orchid genera [22]

| Species | # tubers | Shape | Size |
| --- | --- | --- | --- |
| *Dactylorhiza* | 1 | Digitate, flat, bifid or 5-fid, ovoid, oblong-cylindrical or cylindrical to napiform | mid-sized |
| *Himantoglossum* | 1 | Ovoid or ovate-oblong | Large |
| *Ophrys* | 2 (-3) | Globose or ovoid | mid-sized, one bigger than the other |
| *Orchis* | 2 (-3) | Globose, ovoid or ellipsoid | Small, one smaller then the other |
| *Platanthera* | 2 | Fusiform or ovoid | mid-sized, one bigger than the other |

## Software to be used

At Naturalis Biodiversity Center software is already available that approximately does the same for insects. This software is available via GitHub [25]. GitHub is an online service to share documents. In GitHub every change needs to be committed. After you commit your changes, a new version of the file will be saved. This allows the user(s) to look in a previous version of the file. The software described above is written in Perl. One of the Perl scripts is for training the software. This is only used intern by Naturalis, and can’t be used by the end users of the web application.

The web environment, which is written during this project, is written in Python2.7 using Django1.5.5. The Perl script that will identify the orchids is integrated in this web environment. Although custom officers will mainly use this application, the application will also be useful to foresters. When they find a new orchid species in a natural reserve, they can use the app to identify the orchid as indigenous or foreign species.

# Toekomst

The application can handle different organs of the orchids, which are often traded illegally.

This organs are the flowers, the leaves and the underground tubers.

## Flowers

Sanz *et.al.* [17] identified different slipper orchid species by looking at the colour of the flowers, but this was not always accurate. So during this graduation internship the goal is to make a web application that can identify orchid genera based on pictures more accurately. To do this the software needs to recognise the different species by being trained on pictures of well-identified species. The main goal of this application would be to look at the shape of the flowers. When this give more than one possible result, the colour of the flower and the pattern on the flower can be used to make more distinction.

Table 1 summarizes the main differences in flowers of different slipper orchid genera.

## Leaves

Next to flowers, leaves of slipper orchids can also be used. Because these components look more similar between species this will be harder to use. It is like footprints in the sand. You can see that it comes from a shoe, but you do not know the brand of the shoe. So every little morphological differences needs to be recognised by the software.

Table 2 summarizes the main differences in leaves of different slipper orchid genera.

# Resultaten

## Underground tubers

The colour of two different tubers of *salep* orchids might be the same, so it is not sufficient to only look at the colour. In this case the shape of the tuber is more important than the colour. So the software has to learn to identify different species by shape but also by colour.

During this internship the software is trained on five different genera, which are most often traded as *salep*. The five genera are: *Dactylorhiza, Himantoglossum, Ophrys, Orchis and Platanthera*.

Table 3 summarizes the main differences between these tubers.