

DeepShoot Software

v0.1 – Quick guide

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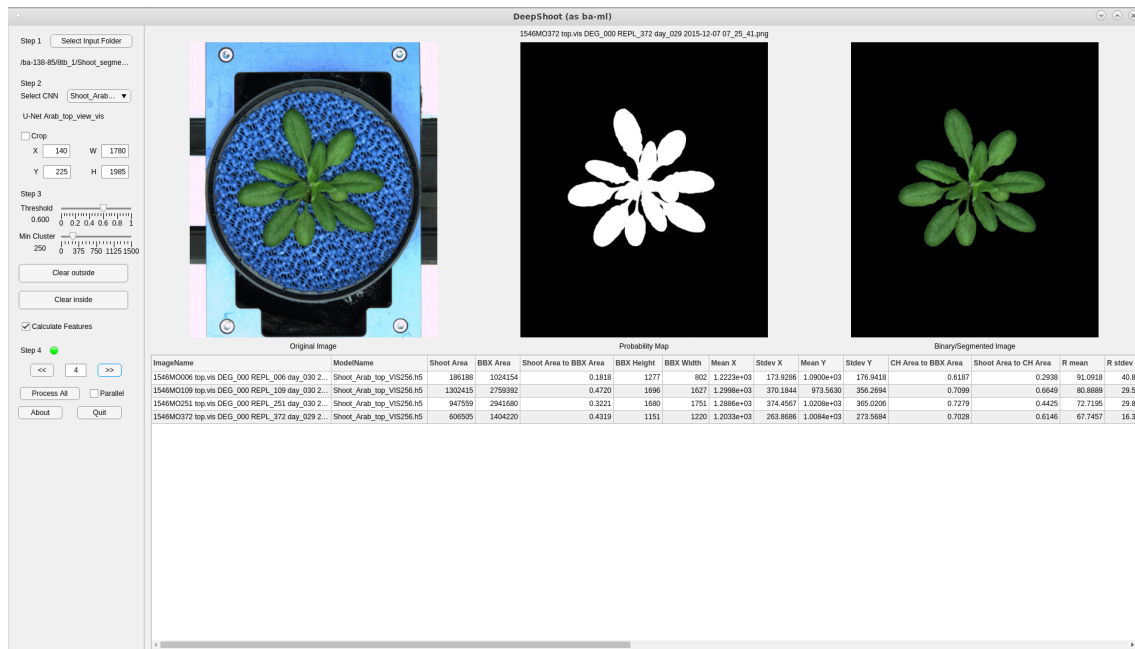
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Deep learning based shoot image analysis tool for visible light RGB images



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1 Introduction

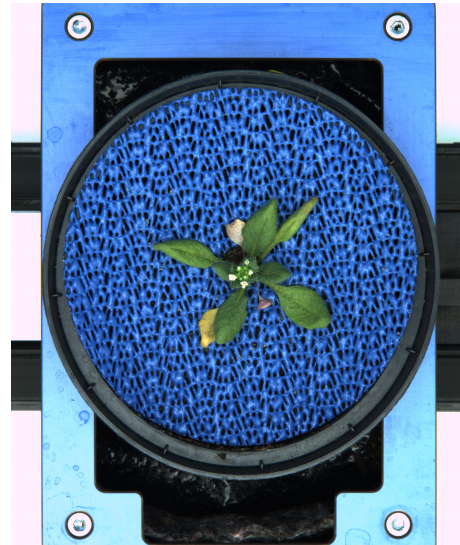
DeepShoot stands for Deep learning based shoot image analysis. DeepShoot is a software tool to automate and facilitate the large-scale of shoot images. It is designed to help scientists or biologists quantify the plant shoot system architecture captured under visible and fluorescence light camera systems in both top and side views, with the help of pre-trained deep learning models.

Like many useful pieces of software, DeepShoot is originated from a question: how DeepShoot is different compared to existing tools? The optimistic answer is quantitatively assess the development of the shoot system in an automated manner for large-scale of images, instead of processing images manually. Since plants exhibit large variability in optical plant appearance and experimental setups, advanced machine and deep learning techniques are required for automated image segmentation and analysis.

The DeepShoot tool was developed within the scope of a PhD thesis aiming to quantify the shoot system architecture in an automated manner. In addition, this tool is capable of extracting shoot traits (like area, width and height) for the plant biomass analysis. The example visible light images of Arabidopsis side view and top view are shown in Fig.1a and Fig.1b respectively.



(a) Arabidopsis side view image



(b) Arabidopsis top view image

Figure 1: Arabidopsis plant grown under visible light

1.1 Key Features

The DeepShoot tool is implemented to automatically process series of shoot (Arabidopsis, barley, maize) images or only one image at a time per user click in order to estimate shoot traits for each image.

- User defined values for image cropping (Crop)
- User defined region of interest with mouse for image cropping (Clear outside)

- Deselection and undo of non-shoot pixels in the segmented image to erase noisy structures (Clear inside)
- The calculated shoot traits as follows:
 - Shot Area: Total number of shoot pixels in the segmented image
 - Bounding box features: Area, Width and Height
 - Colour space features: Statistical analysis of different colour spaces (RGB, HSV, Lab and HSI) of segmented image
 - Convex-hull features: Area
- Calculation and storage of (done for each image):
 - probability, segmentation cleaned, convex-hull feature binary image
 - shoot traits of all images in a CSV file

The user can adjust threshold parameter to influence the behaviour of the calculation.

2 Quick Start

2.1 How to install?

After unpacking the zip archive following two folders will be generated:

```
root
├── DeepShoot
└── quickGuide
```

The DeepShoot tool folder contains the pre-compiled executable of the computer program, example grid layout files, a readme- and a license file. Please, read both text files carefully before starting the program. The *quickGuide* folder contains a copy of this file.

2.2 How to run?

The DeepShoot tool comes compiled in two versions, one for Linux- and one for Windows-based operation systems, respectively. To run the program the user has to install the MATLAB Runtime Environment. Since the DeepShoot tool was developed, tested and compiled under MATLAB 2021a, we recommend to install exactly the same version, i.e. MCR 2021a, which can be downloaded from the official MATLAB side [Install and Configure the MATLAB Runtime](#).

2.2.1 Linux

Under Linux-based operation systems one has to open a terminal and switch to the folder which contains the DeepShoot tool. Then type

```
./run_DeepShoot.sh /path/to/your/MATLAB/Runtime/v910
```

where */path/to/your/MATLAB/Runtime/v910* specifies the path to the locally installed MATLAB Runtime Environment (version 2021a - v910).

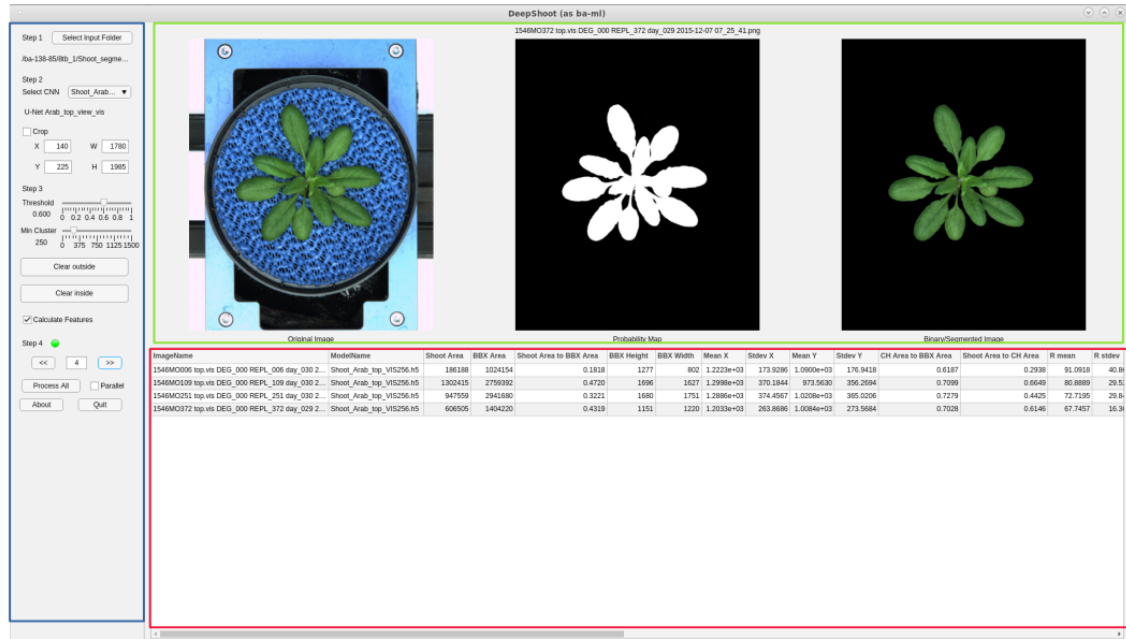


Figure 2: The graphical user interface (GUI) of the DeepShoot tool .

2.2.2 Windows

To run the program under Windows double-click on the icon of the provided executable in the Windows file explorer or start it with its name from the command line.

2.3 The Interface Layout

The major elements of the software interface include an **Input-area** at the extrem left side, **display-area** at upper right side and an **Output-area** at lower right side of the GUI as shown in Fig. 2.

At the input area (Fig. 2 - I, blue color rectangle box), the user can select the folder containing the input images in step 1, then chose the plant corresponding deep learning model and define the underlying crop parameters in step 2. If artifacts exist in the model segmented image then user can remove them by tuning threshold and minimm cluster parameters. Also, user can erase artifacts using clear inside button by drawing a polynomial around the target objects using mouse. In addition, user can select the region of interest in polynomial shape using clear outside button. By checking the "Calculate Fetaures" box DeepSoot calculates some linear features in an automated manner. In step 5, user can process all images at a time or one by one using "Process All" and "« »" buttons respectively.

The example arabidopsis image for shoot segmentation and its probability image and processed binary image are displayed on grid layout in GUI (Fig. 2 - II, green color rectangle box). The calculated shoot traits are displayed on features table in the GUI (Fig.2- III, red color rectangle box).

2.4 First Run

The typical steps to analyse an experiment (a series of images) are:

1. select the related deep learning model in step 2 (select CNN)
2. select an input folder contains images
3. run the analysis
4. define the cut-off values (Threshold and Min Cluster) according to the given preview data (to get rid of false results)
5. (optional) still non-root pixels are present in final segmented image, click on Clear Inside button and select region on image to remove non-root pixels.
6. (optional) preview of input, probability and segmented image can be seen in display window as shown in figure 2
7. Output results like final segmentation and traits with csv file are stored in "Out" folder located at input images folder.

To run the program, the user has to select the input folder of the images. Once the folder was found and successfully imported, the images of the selected folder are automatically analysed to calculate the shoot traits with the used configuration. The user now has the chance to adapt some algorithmic parameters. These parameters are:

Threshold Threshold is an image segmentation parameter which ranges from 0 to 1. Depending on image intensity and noise level, this parameter need to be adapted dynamically for efficient results. The preview of the selected image is automatically updated after every change.

Min Cluster Cluster defines the number of pixels of the binary object. To avoid false detections, the binary objects with more than minimum number of pixels are considered for shoot trait calculation. It ranges from 0 to 1500 on scale.

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B Acknowledgments

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C References

- [1] Narendra N., Henke M., Altmann T., Gladilin E., publication: *in preparation*

D Terms of use

1. The DeepShoot tool and the example image data are distributed for non-commercial usage WITHOUT ANY WARRANTY under the terms described in the EULA license. See the included *EULA.txt* file for details.
2. The user manual is intellectual property of the Image Analysis Group of the IPK Gatersleben. The user may download and use the tool and information available on our web site.

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