

How to use the registration-classification-segmentation (RCS) tool?

The RCS tool has to be run from the command-line using the following syntax:

```
rcs vis_image flu_image background_vis_image background_flu_image vis_seg flu_seg class_model show_figs
```

where rcs is the windows executable (rcs.exe) or, in case of Linux, the executing script (run_rcs.sh) and the eight arguments are

1. vis_image- the name of the original (unsegmented) visible light image incl. the full path
2. flu_image- the name of the original (unsegmented) fluorescence image corresponding to vis_image incl. the full path
3. background_vis_image- the name of the reference (background) vis image (without plant) of the same size as vis_image incl. the full path
4. background_flu_image - the name of the reference (background) flu image (without plant) of the same size as flu_image incl. the full path
5. vis_seg- the name of the segmented vis image which will be written out in output incl. the full path
6. flus_seg- the name of the segmented flu image which will be written out in output incl. the full path
7. class_model- the name of classification model from the "models" folder which will be used for by the algorithm WITHOUT the full path
8. show_figs- is a parameter controlling visualization of the segmentation results (to show figures- yes, otherwise- no)

Input images 1-4 have to be RGB images in the following formats: *.jpg, *.png. The names of images 1-6 have to include full paths if images are stored not in the same folders as RCS executable. If the user does not have background images (3-4), they can be substituted by suitable artificial images. For example, a completely black images of the same size as flu_image can be used to simulated background_flu_images, a completely white, light-gray or light-blue images can be used to simulate background_vis_image of maize, arabidopsis and barley (wheat) images in our examples.

Examples below show application of RCS to example images from the "images" folder. However, the user can apply RCS to any images stored elsewhere as well.

class_model is the name of one of several classification models that can be found in the subfolder "models".

Please note(!):

Differently from image names that have to include the full path, the names of classification models have to consist only of the file name without the full path name. The RCS tool has to be run from the same directory where folders "models" and "model_obj" are stored and not to be displaced elsewhere.

The names of classification models are constructed and can be interpreted as follows

- i. ID of screening facility: LT1, LT2, LT3
- ii. The first letter of the plant species: A- arabidopsis, M- maize, B- barley (wheat)
- iii. ID of the screening experiment images of which were used for model training, e.g. 1546.
- iv. Camera view: side or top
- v. Training scenario: I- juvenile plants, II- mid-stage plants, III- adult plants, or their combinations
- vi. Number of days used for training this model, e.g., 2d, 8d, 20d.
- vii. Image modalities used for training of this model: vis, flu, visflu (combination vis+flu)

In order to appropriately segment a pair of vis/flu plant images a right classification model has to be used. For example, one should select

for arabidopsis side images LT1_A_*_side_* models,
for arabidopsis top images LT1_A_*_top_* models,
for arabidopsis side images LT2_B_*_side_* models,
for arabidopsis top images LT2_B_*_top_* models,
for maize side images LT3_M_*_side_* models,
for maize top images LT3_M_*_top_* models.

Selection of other parameters of classification models such as training set (juvenile, mid-stage, adult plants or their combinations) or image modalities (vis, flu or visflu) is up to user's choice.

Below are examples of RCS usage under Linux und Windows OS:

Linux:

1. Segmentation of a pair of vis/flu arabidopsis top-view images from the folder "images\arab" using the color classification mode LT1_A_1546_top_I+II+III_20d_visflu.mat from the folder "models".

```
./run_rcs.sh /MATLAB_Runtime/v95 images/arab/A_1546_top_vis.png images/arab/A_1546_top_flu.png  
images/arab/background_A_1546_top_vis.png images/arab/background_A_1546_top_flu.png vis_seg.png  
flu_seg.png LT1_A_1546_top_I+II+III_20d_visflu.mat yes
```

where /MATLAB_Runtime/v95 is an example of path to MATLAB 2018b (9.5) run time libraries. Users have to replace it by the location of MATLAB 2018b (9.5) run time libraries on their systems!

For how to install MATLAB 2018b (9.5) we refer to <https://www.mathworks.com/products/compiler/matlab-runtime.html> as well as to our RCS page: <https://ag-ba.ipk-gatersleben.de/rcs.html>.

2. Segmentation of the same images using the same classification model on Windows x64:

Windows:

```
.\rcs.exe "images/arab/A_1546_top_vis.png" "images/arab/A_1546_top_flu.png"  
"images/arab/background_A_1546_top_vis.png" "images/arab/background_A_1546_top_flu.png"  
"vis_seg.png" "flu_seg.png" "LT1_A_1546_top_I+II+III_20d_visflu.mat" "yes"
```

Alternatively to the LT1_A_1546_top_I+II+III_20d_visflu.mat classification model, which was trained on a large dataset including juvenile (I), mid-stage (II) and adult (III) plants using a combination of co-registered vis and flu images (visflu), other classification models can be applied for segmentation of arabidopsis top-view images, for example:

LT1_A_1546_top_I+II+III_20d_vis.mat- classifier trained on the same dataset but only with vis images,
LT1_A_1546_top_I+II+III_20d_vis.mat- classifier trained on the same dataset but only with flu images.

LT1_A_1546_top_II_8d_vis.mat- classifier trained on the dataset of mid-stage (II) arabidopsis plants in top-view using only vis images.

For segmentation of side-view arabidopsis images following classification models can be used

LT1_A_1546_side_III_6d_visflu.mat- classifier trained on the dataset of adult (III) arabidopsis plants in side-view using a combination of co-registered vis and flu images, etc.

Naming and usage of other classification models trained with maize, barley (wheat) images of juvenile, mid-stage or adult plants or their combinations in side or top camera views follows the analog logic.