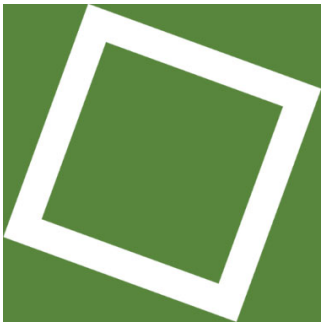


Easy Quadrat

Version 1.0

Easy Quadrat is nothing but the same quadrat traditionally used in agronomy and crop science. Now, it has been brought into the field of modern phenotyping, for cropping and sampling; not from the plants themselves but rather from the images of plants.

Overview

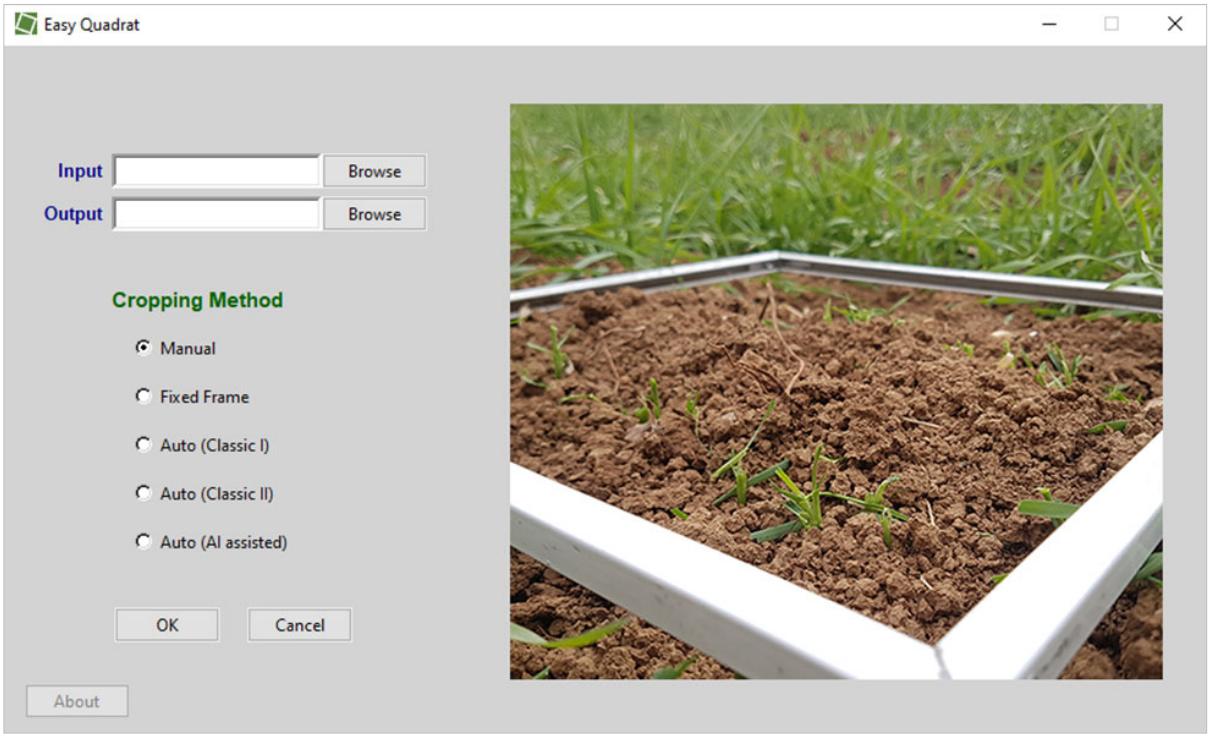
The initial step in RGB image analysis for phenotyping involves segmenting the intended canopy area from the background. Although commercial phenotyping platforms usually employ built-in segmentation algorithms, researchers may opt to supervise the image segmentation process. This can be a time-consuming task, especially when dealing with numerous experimental plots. Easy Quadrat, a Python-based freeware, addresses this challenge by providing a set of simple tools to speed up the determination, segmentation, and cropping of sampling areas in ground-based images captured from crop canopies.

Depending on the study's goals and conditions, the segmentation task can be performed manually or automatically (the latter of which requires a white traditional quadrat to be present in the image). Even in the manual method, efforts are made to streamline and speed up the selection and segmentation processes.

Easy Quadrat offers five image segmentation methods, known as Cropping methods. The three automated methods are designed to find and segment a white sampling quadrat in the image. For detailed information on each method, refer to the relevant section.

Getting Started

1. Download and unpack the Easy Quadrat package
2. Run EasyQuadrat.exe to open the main window.



3. Specify the input path (original images from the canopy) and output path (desired location for saving outputs).
4. Choose the cropping method.
5. Click the Ok button.

Note: *Input images may be standard RGB formats, including JPEG, PNG, and TIFF. Ensure that the output path is an empty directory.*

Cropping methods

1. Manual

The manual method, though basic and time-consuming, is designed to speed up manual segmentation. Use a specific number of points (e.g., 4 points) to draw a single quadrat or other shapes on the image. Clicking the crop button saves segmented images, cropped images, and annotation files in the output path. The next image is loaded automatically.

Buttons and shortcut keys:

Reset (Esc): Cancels the current selection.

Skip (Space): Skips the current image.

Jump: Jumps to a specific image number in the list, useful for processing images in distinct rounds.

Crop (Enter): Confirms the selection and saves the image.

Points: Specifies the number of points for drawing the selection shape (default is "2-Sq." for two points as opposite vertices of a square).

Point Color: Sets the color of selection points and lines.

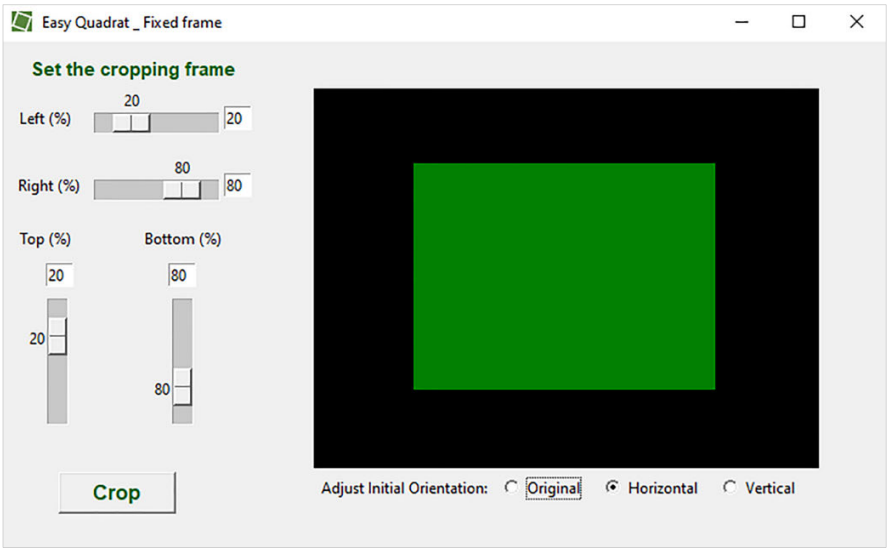
BG Color: Defines the background color of the output image (segmented image).

HLO (Handle Labeling Orientation): Attempts to correct potential orientation-based inconsistencies in the coordinates saved in the label files. Check this box if you plan to use the annotations (label files) later for modeling purposes, but your images lack consistent orientation.

> **Tip:** As a more efficient alternative to using HLO, and to ensure the validity of annotations, it is highly recommended – if possible – to rotate all input images to landscape orientation before starting the segmentation using the Manual method. For this purpose, consider using the Fixed Frame method (as described in the next section): within the window of the Fixed Frame method, select the 'Horizontal' option and click 'Crop', without altering the frame dimensions. Subsequently, use the images saved in the output path as the input images for the Manual method.

Zoom (Ctrl + Mouse Scroll): Zooms in or out of the image. Also use the right-click to navigate the zoomed image.

2. Fixed Frame



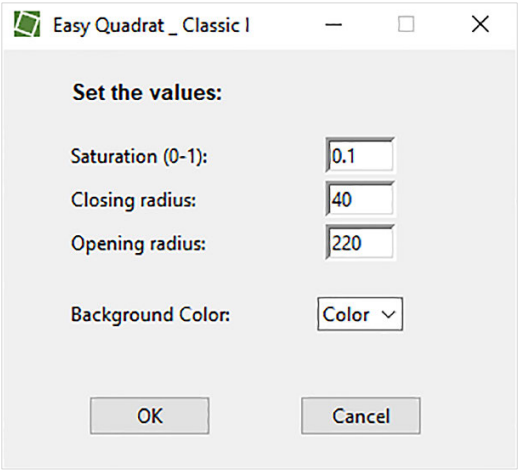
The Fixed Frame method serves as an image trimming tool, requiring you to set the cropping frame and click the Crop button. If the input images lack a consistent orientation (i.e., landscape or portrait), you can adjust the initial orientation to make all images either landscape or portrait before cropping.

The Fixed Frame method proves particularly useful when images are taken in a regular and precise manner. Removing marginal parts with specific percentages allows you to obtain the intended experimental sample from the canopy. Ground-based images of mini-plots (e.g. in breeding programs) often include unwanted background, such as marginal areas or even adjacent plots, which should be removed before image processing for phenotyping purposes. In such situations, the Fixed Frame method becomes an ideal trimming tool.

3. Auto (Classic I)

This method aims to recognize and segment a white quadrat in the image by employing classic image processing techniques, such as image opening and

closing. For a more in-depth understanding, refer to the literature on mathematical morphology.



Variables:

Saturation: Adjusts the saturation level, influencing the intensity of colors in the image. Higher values may enhance the visibility of the white quadrat.

Closing Radius (pixels): Determines the radius of the closing operation, which involves dilating the image and then eroding it. This parameter affects the size of gaps that are filled in the image.

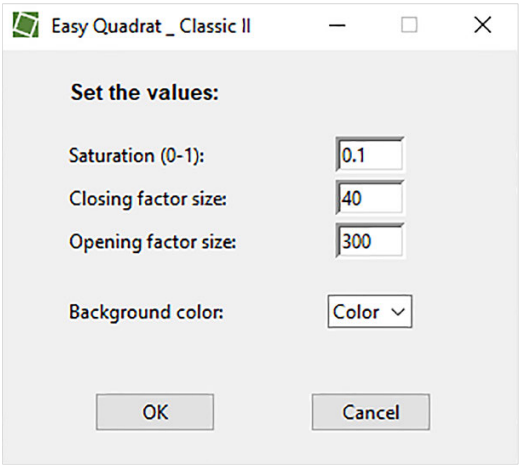
Opening Radius (pixels): Sets the radius for the opening operation, which consists of eroding the image and then dilating it. This parameter influences the removal of small objects from the image.

> ***Note:*** *The optimal values for these parameters may depend on factors such as imaging height, size, and color of the quadrat, as well as light conditions. Adjust these values accordingly to achieve the best segmentation results for your specific imaging setup and conditions.*

Background Color: Defines the background color of the output image (segmented image).

4. Auto (Classic II)

Similar to the *Classic I* method, this approach also utilizes image opening and closing techniques. However, there are some differences. Here, the main technique involves segmenting the image based on saturation, performing morphological operations (opening and closing) with horizontal and vertical factors, creating convex hulls, and finally selecting the mask with the smaller convex hull area for cropping.

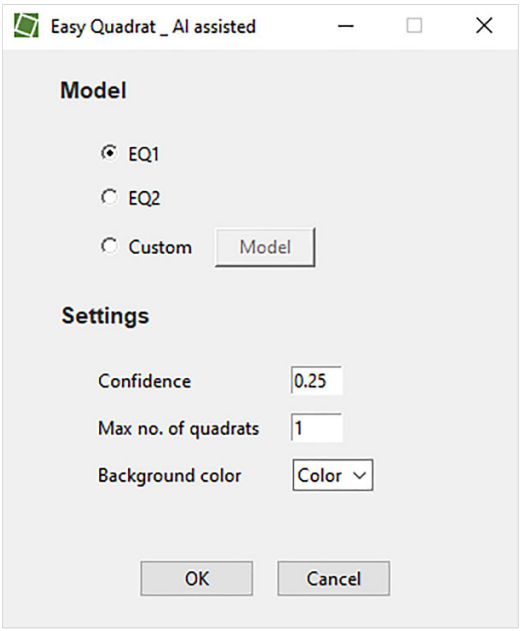


The optimal values (i.e. number of pixels) for opening and closing parameters may vary depending on the characteristics of your image archive, such as imaging conditions, size of the sampling quadrat, and lighting conditions. It is recommended to test various opening and closing values to achieve the best segmentation results for your specific dataset.

5. Auto (AI-assisted)

Leveraging state-of-the-art machine learning models (YOLOv8n-seg and YOLOv8m-seg models), the 'AI-assisted' method stands as the most advanced

technique offered by Easy Quadrat. These models have been trained and validated on a diverse set of images taken from a wheat field in the booting phase. This method is designed to successfully detect and segment white quadrats in various canopy images. To use this technique, follow these simple steps: set your preferences in the respective window and click the "Ok" button.



Variables:

EQ1 model: An exclusive model of Easy Quadrat trained to detect white quadrats using the YOLOv8n-seg model.

EQ2 model: Another exclusive model of Easy Quadrat trained to detect white quadrats using the YOLOv8m-seg model. Generally, ‘m’ models are more powerful and accurate but may be slower than the ‘n’ models.

Custom model: If you wish to train and use your own YOLO models, you can upload them into Easy Quadrat using this option.

Confidence: This represents the lower threshold of confidence in quadrat detection and ranges between 0-1. Higher confidence values result in stricter predictions, only returning objects more similar to a white quadrat. For instance,

the default value of 0.25 segments and saves objects recognized as white quadrats with probabilities higher than 0.25 (25%).

Max no. of quadrats: Specifies the maximum number of quadrats expected to be recognized and segmented by Easy Quadrat.

Background Color: Defines the background color of the output image (segmented image).

Note:

- *To preserve the original color properties of the input images and avoid interpolation and other manipulations, which are generally undesirable in phenotyping analyses, Easy Quadrat refrains from rotating the images, except when a 90-degree rotation is needed (i.e. in the Fixed Frame method). Therefore, if the sampling quadrat is positioned obliquely in the field, some marginal parts outside the quadrat may be included in the Cropped image outputs. In such instances, and if the study objectives permit, it is advisable to utilize the Segmented images output for subsequent image processing tasks in phenotyping.*

- *The classic I method is suggested by Peter Suter (for more information on this specific method, see: https://discuss.python.org/t/how-can-i-detect-and-crop-the-rectangular-frame-in-the-image/32378/25).*

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