Effective segmentation of green vegetation
- A data-driven approach

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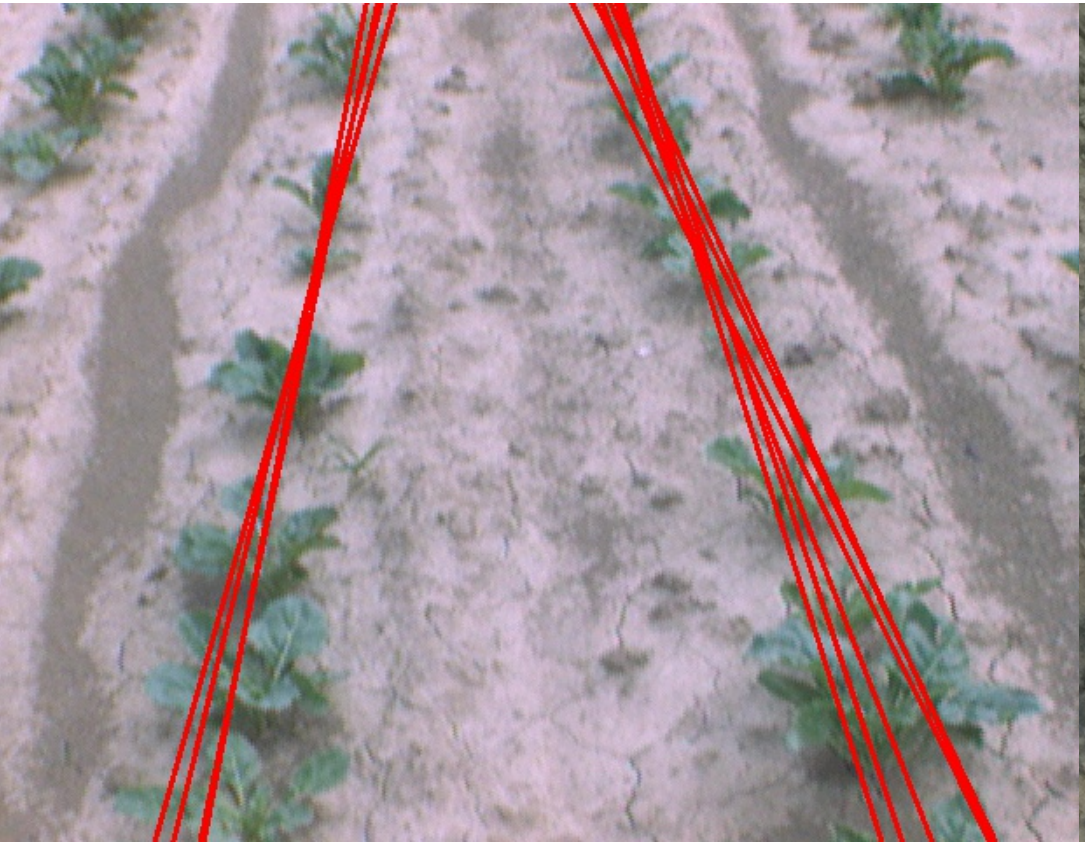
Overview

- Why segmentation?
- Existing segmentation techniques
- Data collection
- A data-driven approach
- Results
- Conclusion

Why segmentation?



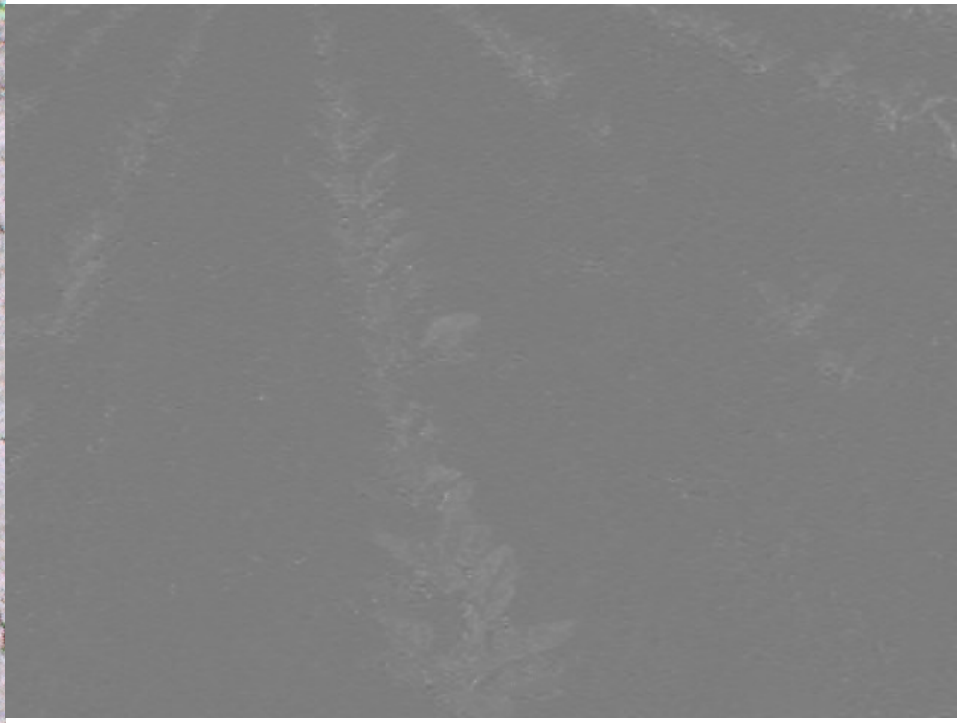
Accurate crop row recognition

Weed detection

What makes segmentation difficult?

Existing segmentation techniques

Vegetation index-based techniques

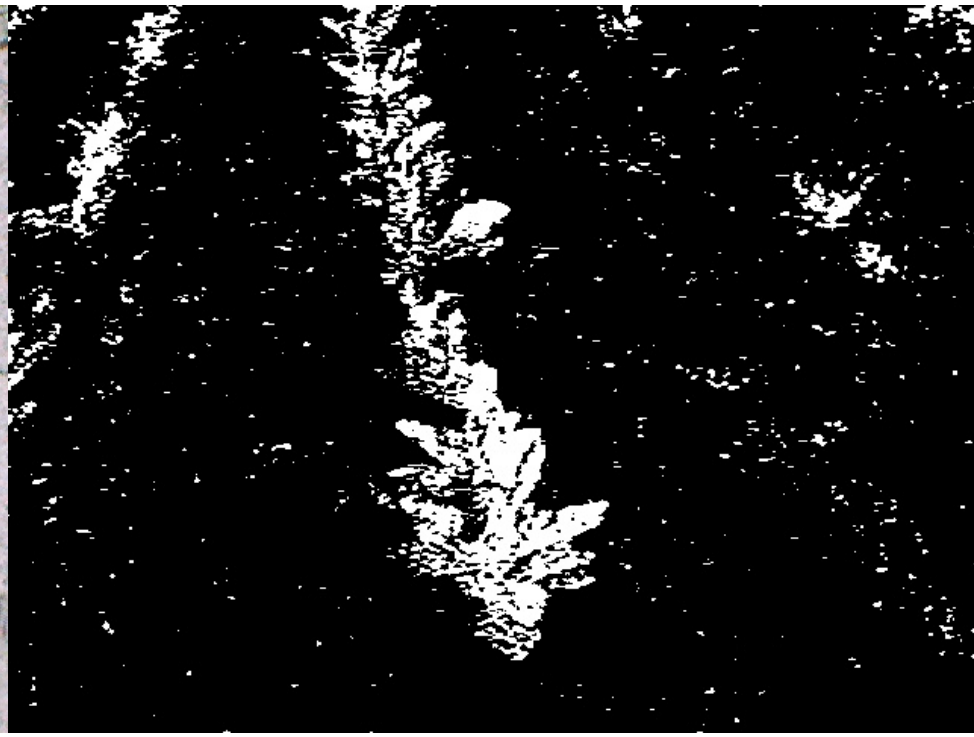


$$ExG = 2 * G - R - B$$

$$ExGExR = ExG - (1.4 * R - G)$$

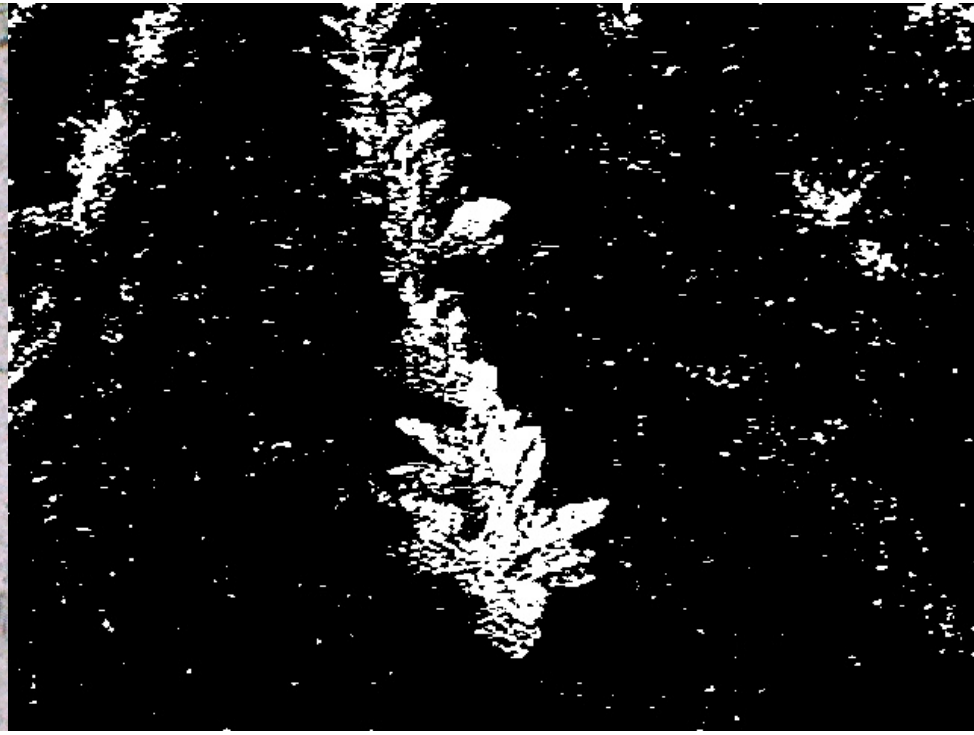
$$CIVE = 0.441R - 0.811G + 0.385B + 18.78745$$

Threshold-based techniques



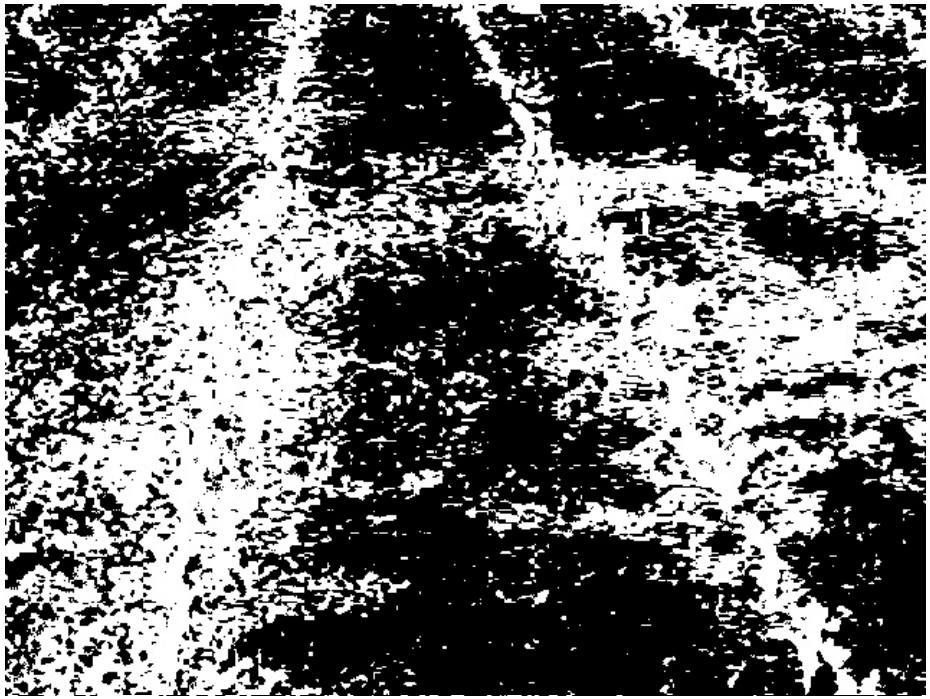
- Ostu-based thresholding technique (Ostu, 1975)
- Dynamic thresholding technique (Rovira-Mas et al, 2005)
- Statistical mean-based technique (Guijarro et al, 2011)

Learning-based techniques



- Unsupervised fuzzy-clustering algorithm (Meyer et al, 2004)
- Mean-shift based segmentation algorithm (Zheng et al, 2009)
- Environmentally adaptive segmentation algorithms (Tian & Slaughter, 1998)

Vegetation index and threshold-based techniques



Learning-based techniques

- Trade off: memory or processing time Vs. performance
- Uses information from only one color space (either RGB or HSV)

Objectives

- A data-driven approach to improve the accuracy of the segmentation algorithm for resource-constrained real-time applications without any compromise on the performance
- Leveraging information from both RGB and HSV color spaces
- Comparison of the performance against state-of-the-art vegetation index-based techniques

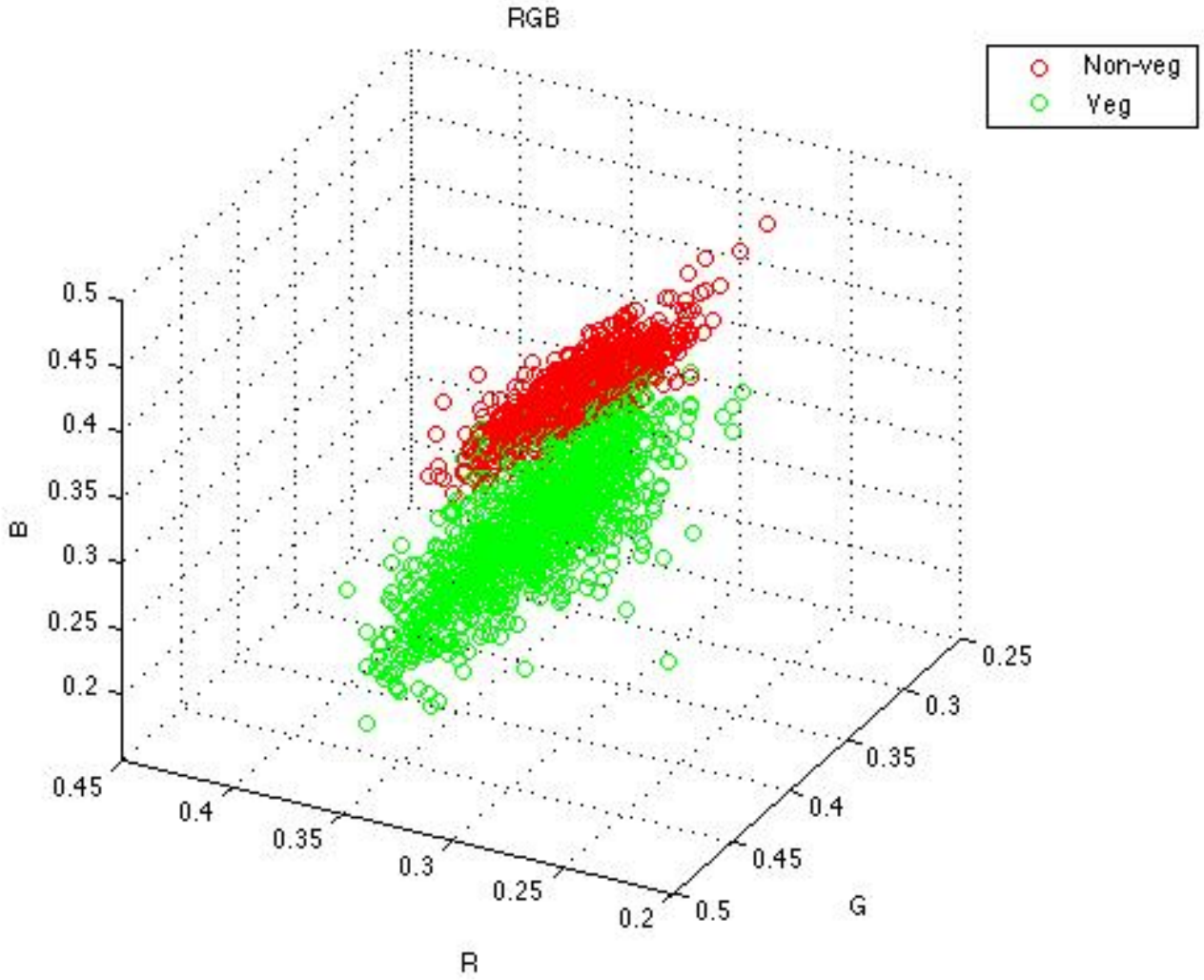
Data collection

- Vision sensor - Fire-i™ 400 industrial camera
- Experimental field - 2.38-ha experimental field of Gembloux Agro-Bio Tech, Belgium
- Types of crops - Sugar beet and Maize
- Acquired period - April to June 2014
- Frequency of acquisition - gap of six to seven days between two consecutive acquisitions for the variability in the growth stage of the plants, illumination conditions.
- Image format - 24-bit RGB color images with a resolution of 640 × 480 in JPEG format

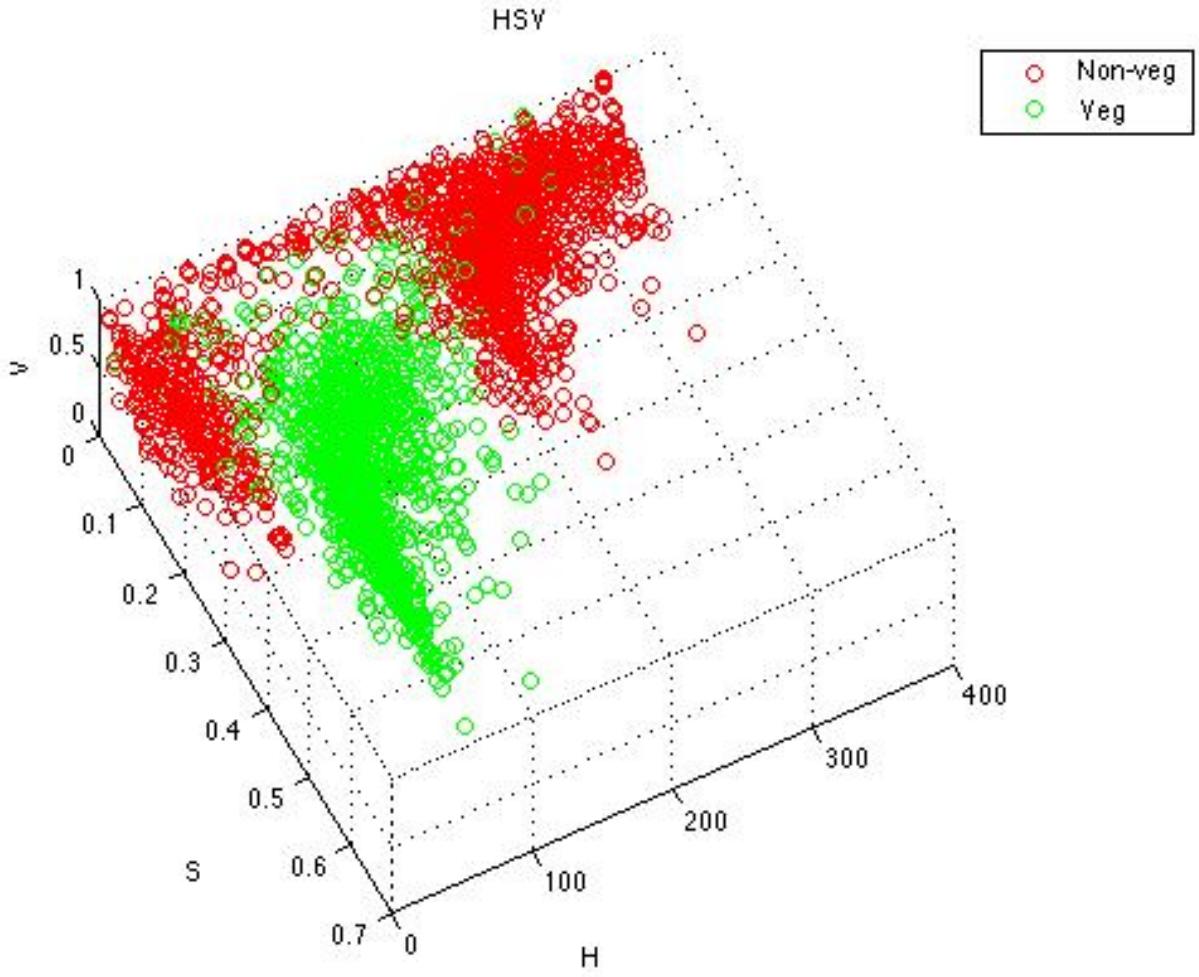
Sample images

Data-driven approach

Normalized-RGB color space



HSV color space



Which color space?

- Linear classifier in original feature space were not enough
- HSV: non-linear transformation of RGB
- Normalized-RGB and HSV: high-dimensional feature space
- A linear classifier in a high-dimensional feature space to improve accuracy

- Image segmentation algorithm - learning and segmentation phase
- Learning phase – Extracting useful features and training the classifier.
- Extracted features - normalized RGB components, Hue (H), Saturation (S) and Value (V) from HSV color space and G-R
- Training images - 3000 data points from 500 images (75% background and 25% green plants)
- Training algorithm - Naïve Bayesian

- Feature selection method - Correlation-based feature selection method
- Selected features – H, S, norm G and G-R
- Learning algorithm - Gaussian distribution of features

$$p(V = v/c) = \frac{1}{\sqrt{2\pi\sigma_c^2}} e^{\frac{-(v-\mu_c)^2}{2\sigma_c^2}}$$

- Segmentation phase - maximum a posteriori decision rule

$$\text{Classify (v)} = \underset{c}{\text{argmax}}\, P(C = c) \prod_{i=1}^{n} p(V_i = v_i | C = c)$$

- Evaluation method -

$$Accuracy = \frac{(number\ of\ true\ positives + number\ of\ true\ negatives)}{Total\ number\ of\ pixels\ in\ the\ image}$$

- Test images – 100 images

- Compared against –

$$ExG = 2 * G - R - B$$

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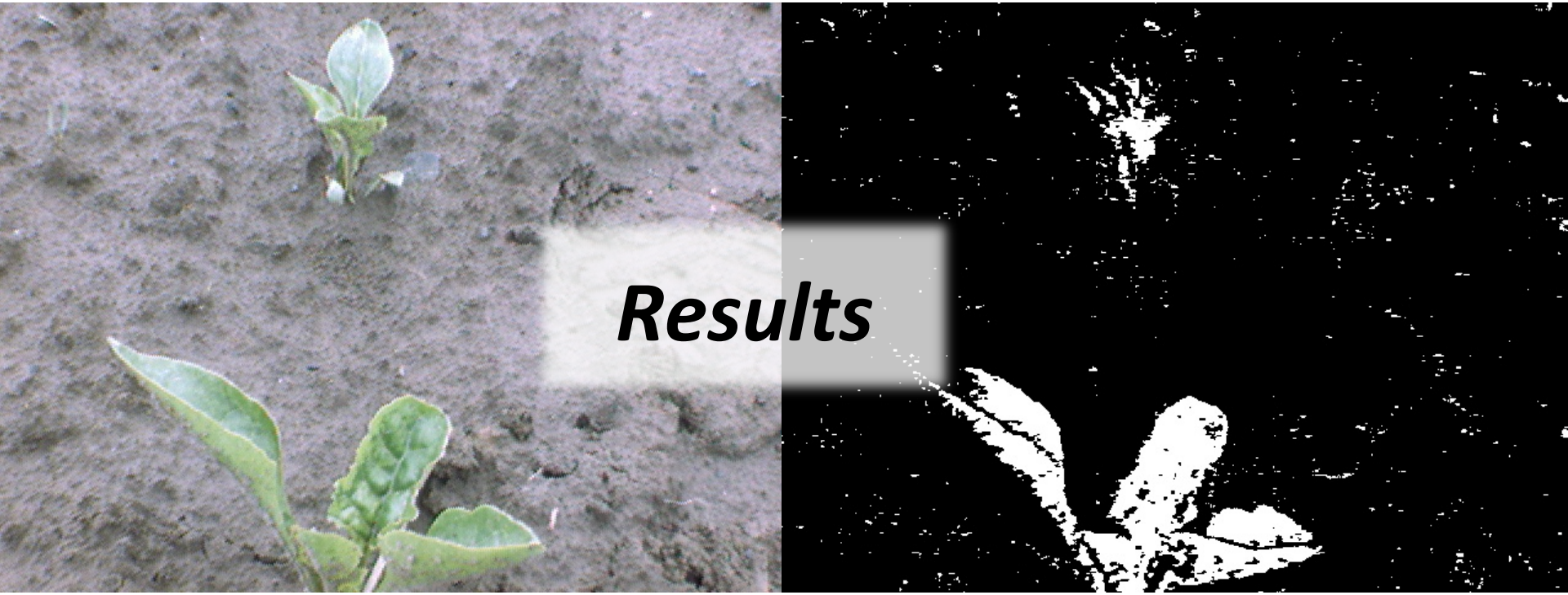
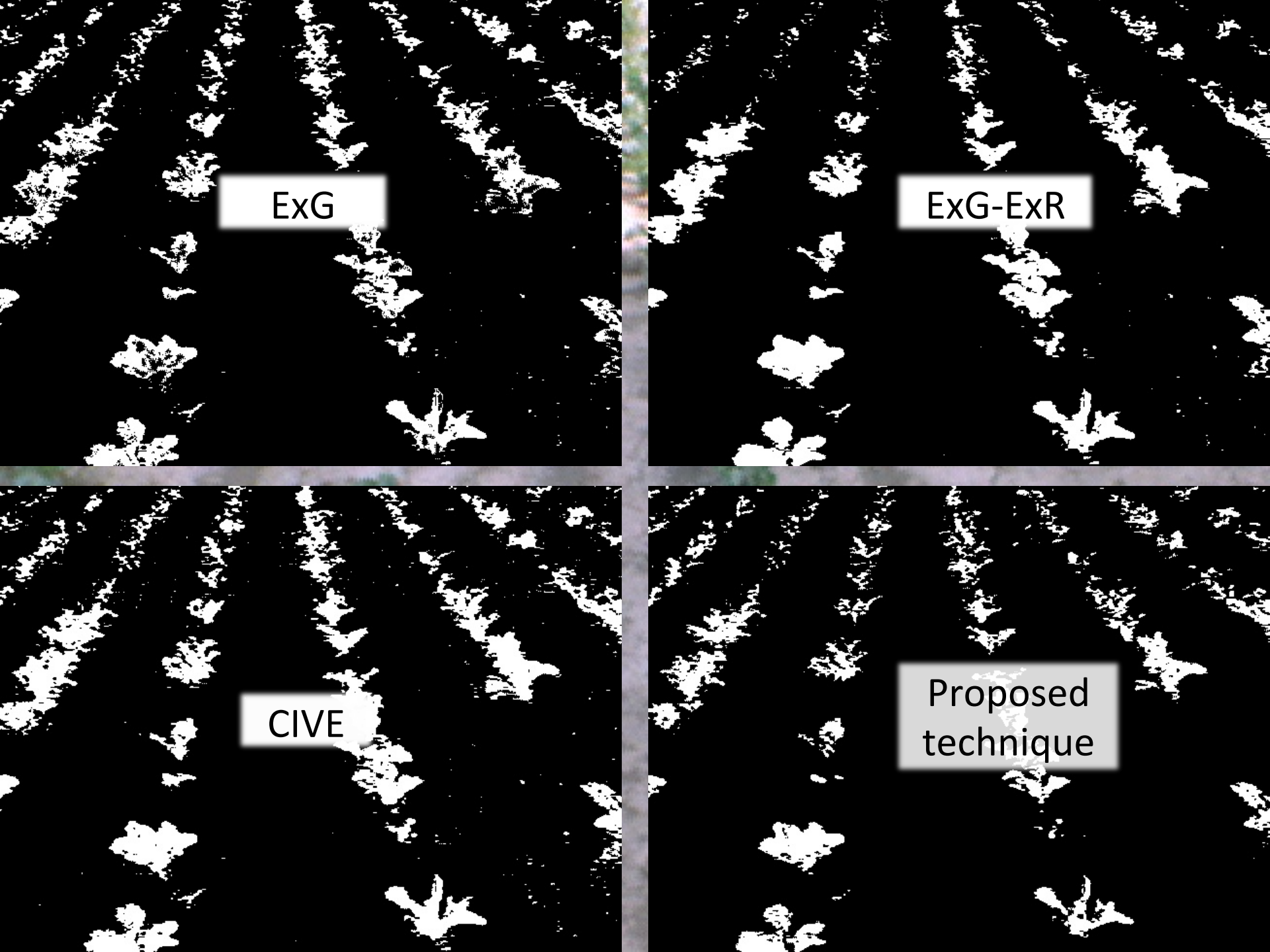
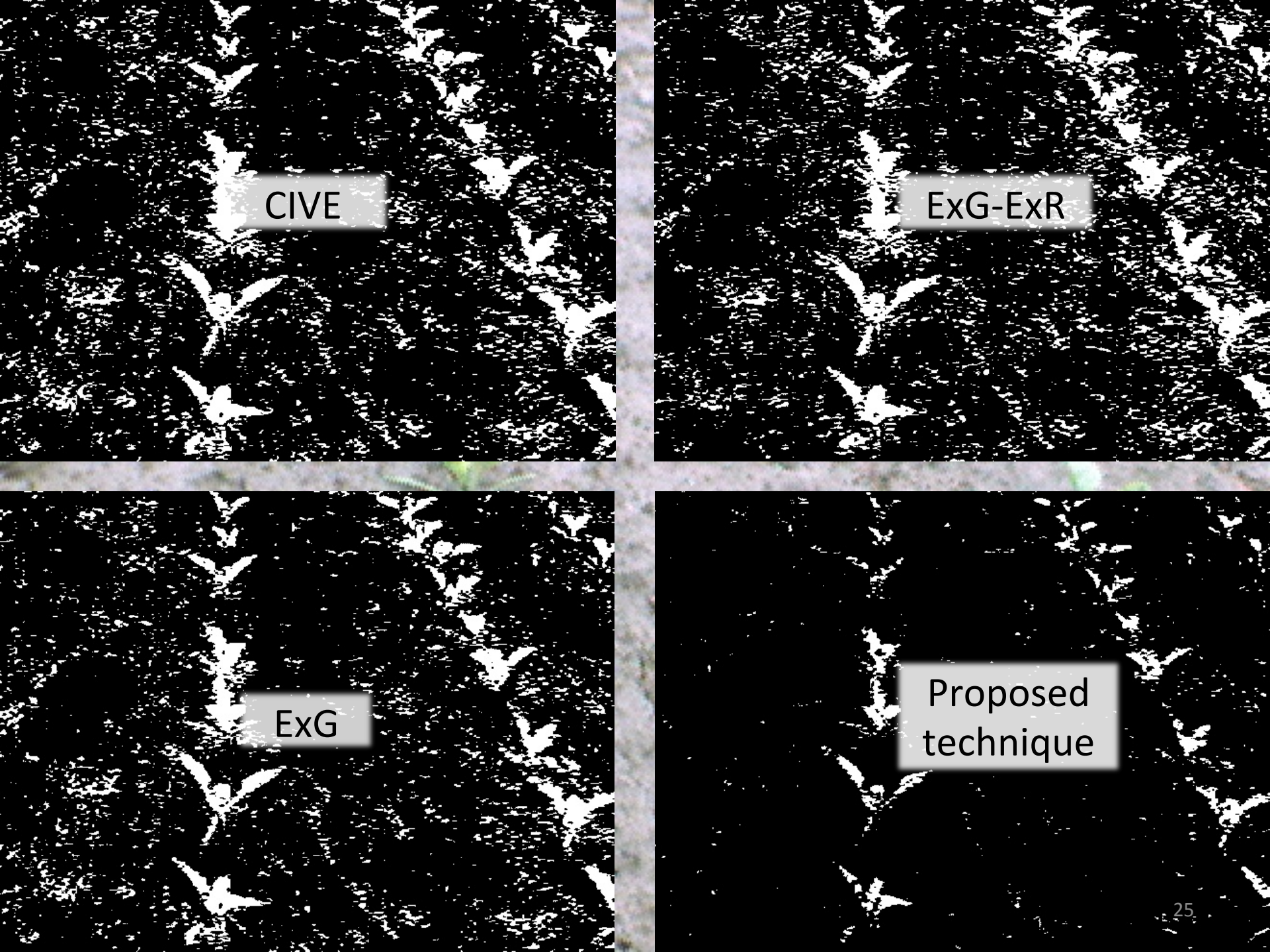

Results


ExG
ExG-ExR
CIVE
Proposed technique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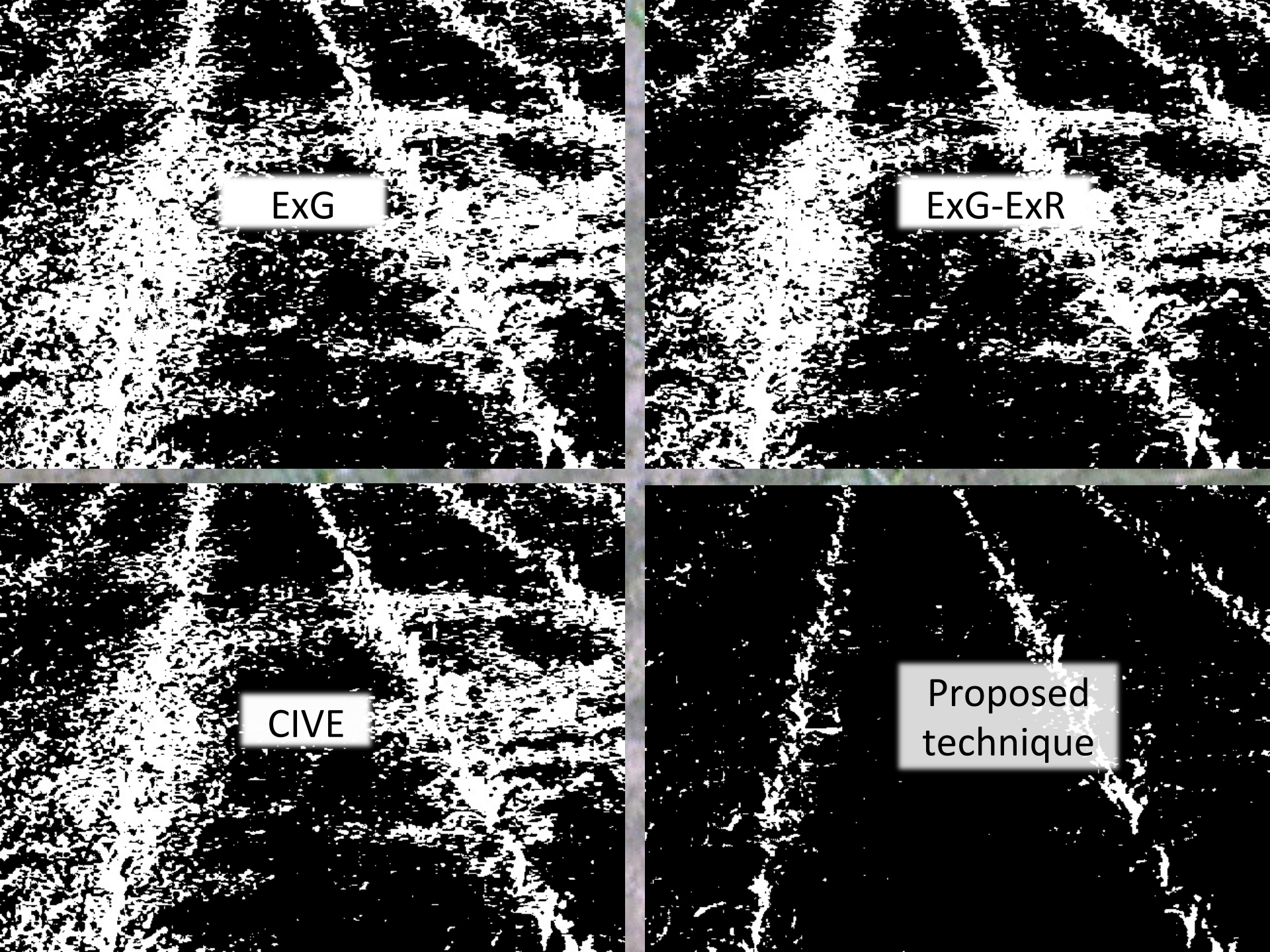
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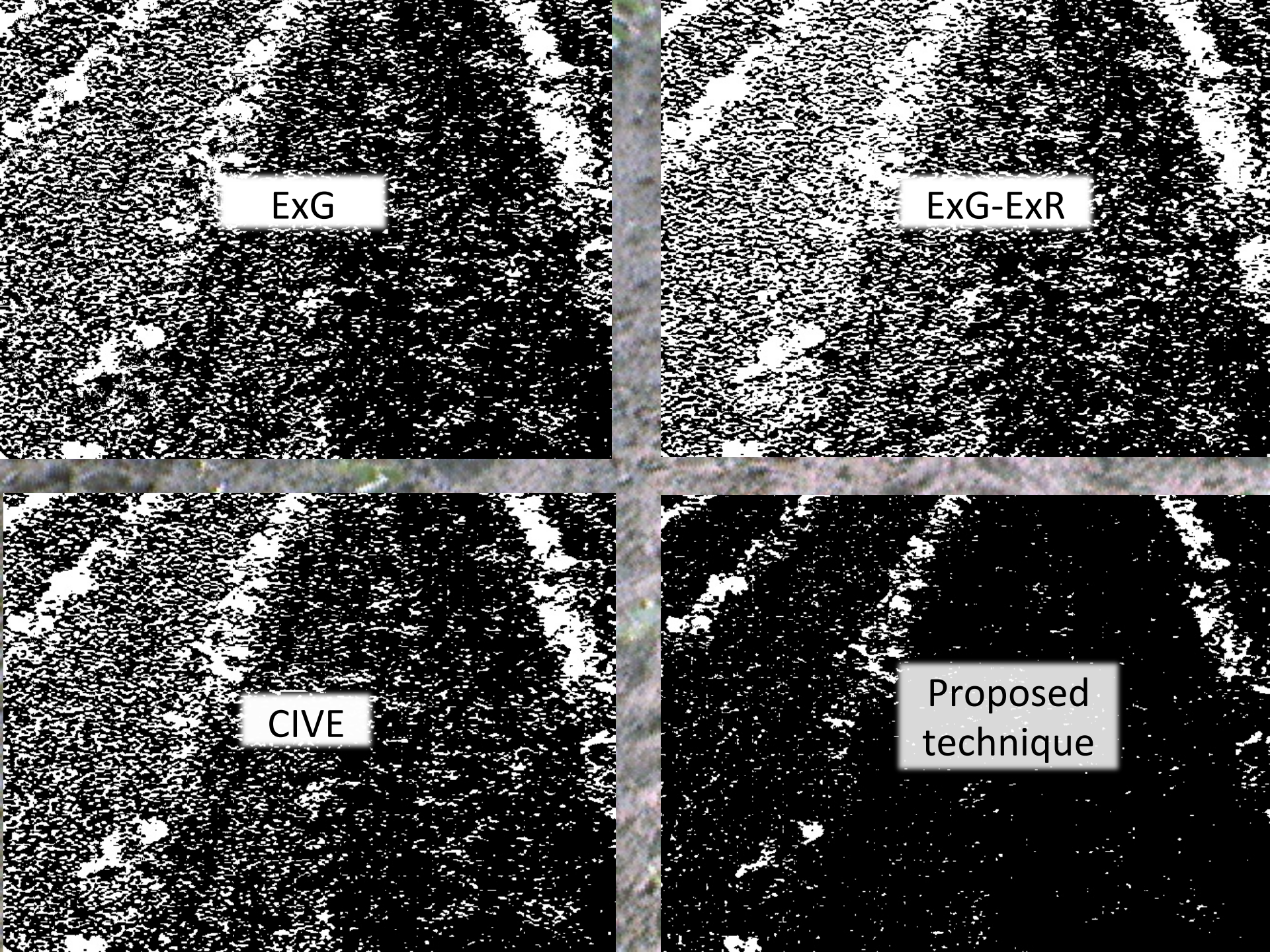
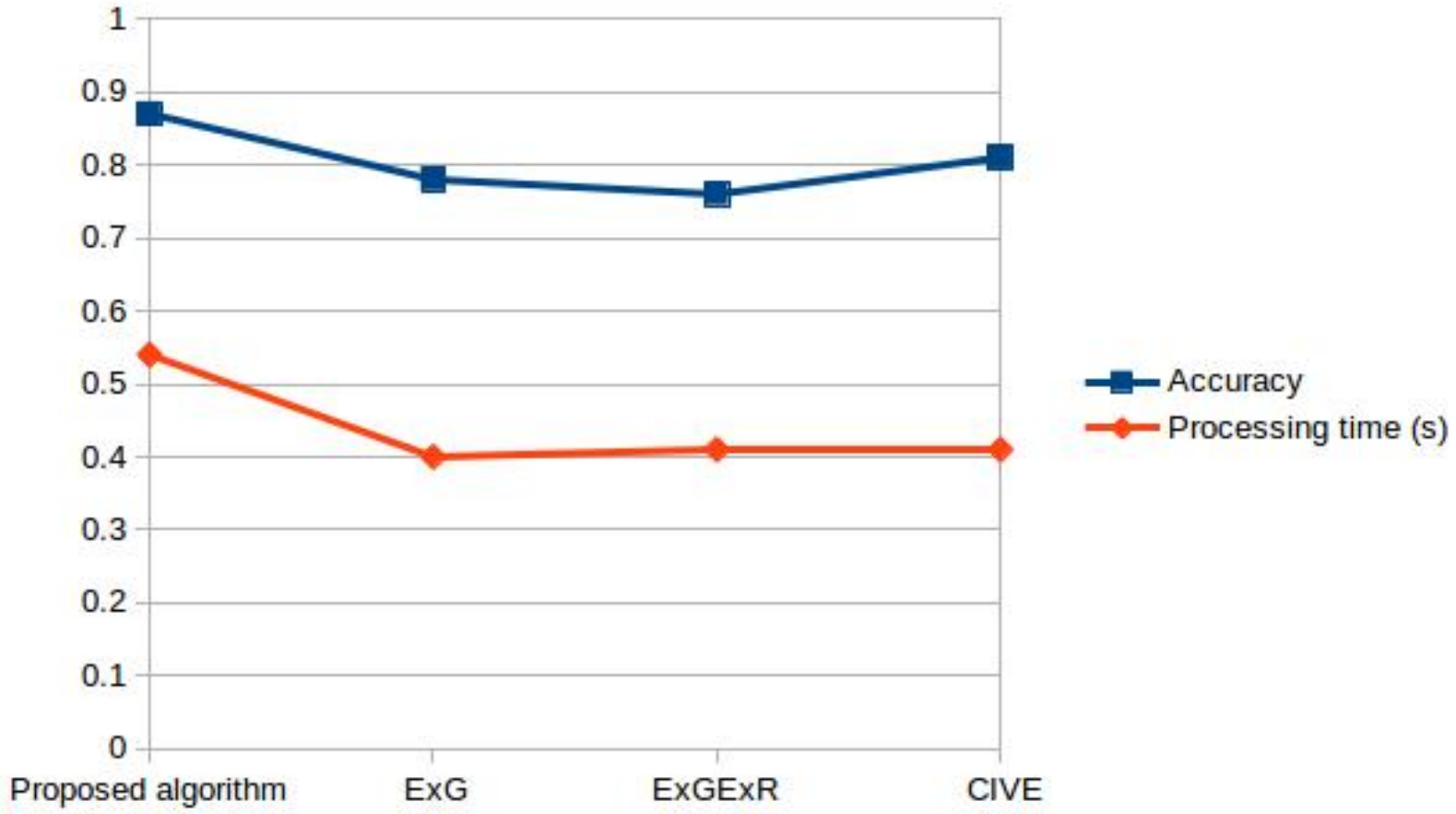

ExG
ExG-ExR
CIVE
Proposed technique

- Accuracy and Processing time - on 100 images



- Memory - only the learned model is stored

Conclusion

- A data-driven approach for accurate segmentation of vegetation under uncontrolled illumination conditions
- Leveraging information from both RGB and HSV color spaces
- Suitable for resource-constrained real-time applications

Future work

- How the proposed segmentation helps to better detect the crop rows and weeds (esp. between rows)?


Thank you for your attention