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

\[ ExG = 2 \times G - R - B \]

\[ ExGExR = ExG - (1.4 \times R - G) \]

\[ CIVE = 0.441R - 0.811G + 0.385B + 18.78745 \]
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

\[ \text{Classify } (v) = \arg\max_c P(C = c) \prod_{i=1}^{n} p(V_i = v_i | C = c) \]
• Evaluation method -

\[
\text{Accuracy} = \frac{\text{number of true positives} + \text{number of true negatives}}{\text{Total number of pixels in the image}}
\]

• Test images – 100 images

• Compared against –

\[
ExG = 2 \times G - R - B
\]

\[
ExGExR = ExG - (1.4 \times R - G)
\]

\[
CIVE = 0.441R - 0.811G + 0.385B + 18.78745
\]
ExG

ExG-ExR

CIVE

Proposed technique
CIVE

ExG-ExR

ExG

Proposed technique
ExG

ExG-ExR

CIVE

Proposed technique
ExG

ExG-ExR

CIVE

Proposed technique
• **Accuracy and Processing time** - on 100 images

![Graph showing accuracy and processing time for different algorithms](image)

- Proposed algorithm
- ExG
- ExGExR
- CIVE

- **Accuracy**
- **Processing time (s)**

• **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