WeedOut: An Autonomous Weed Sprayer in Smart Agriculture Framework using Semi-Supervised Non-CNN Annotation

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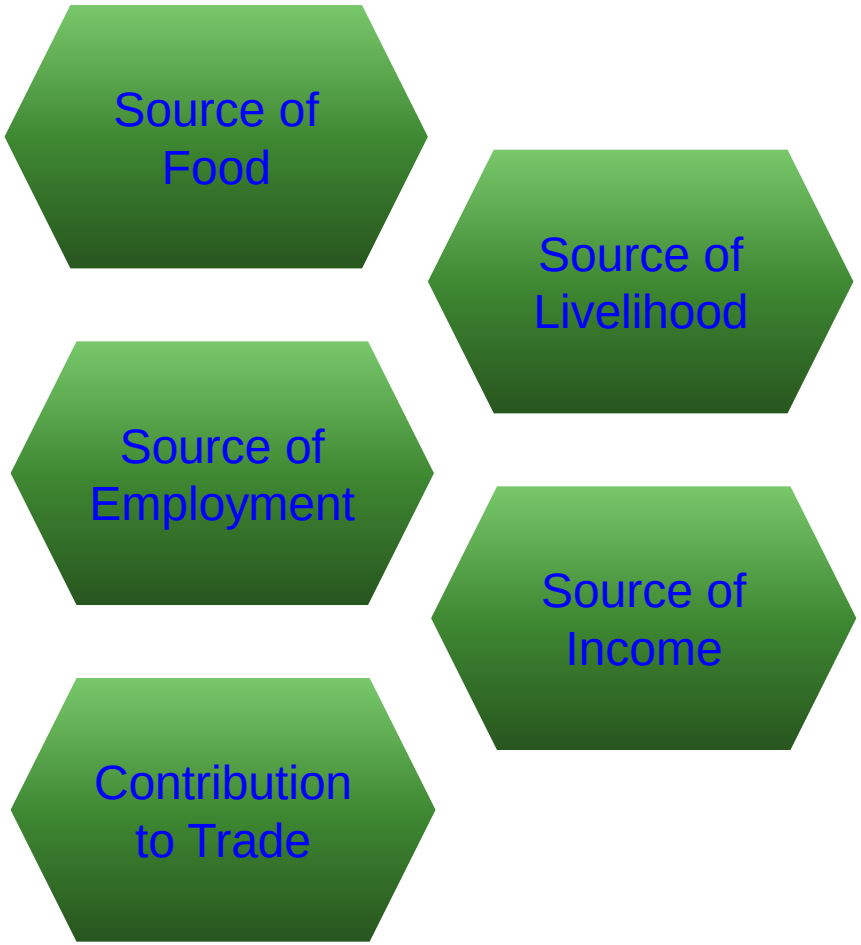
Outline

- Why This Matters
- Novel Contributions
- Related Works
- Working of WeedOut
- Implementation and Results
- Conclusion and Future Work

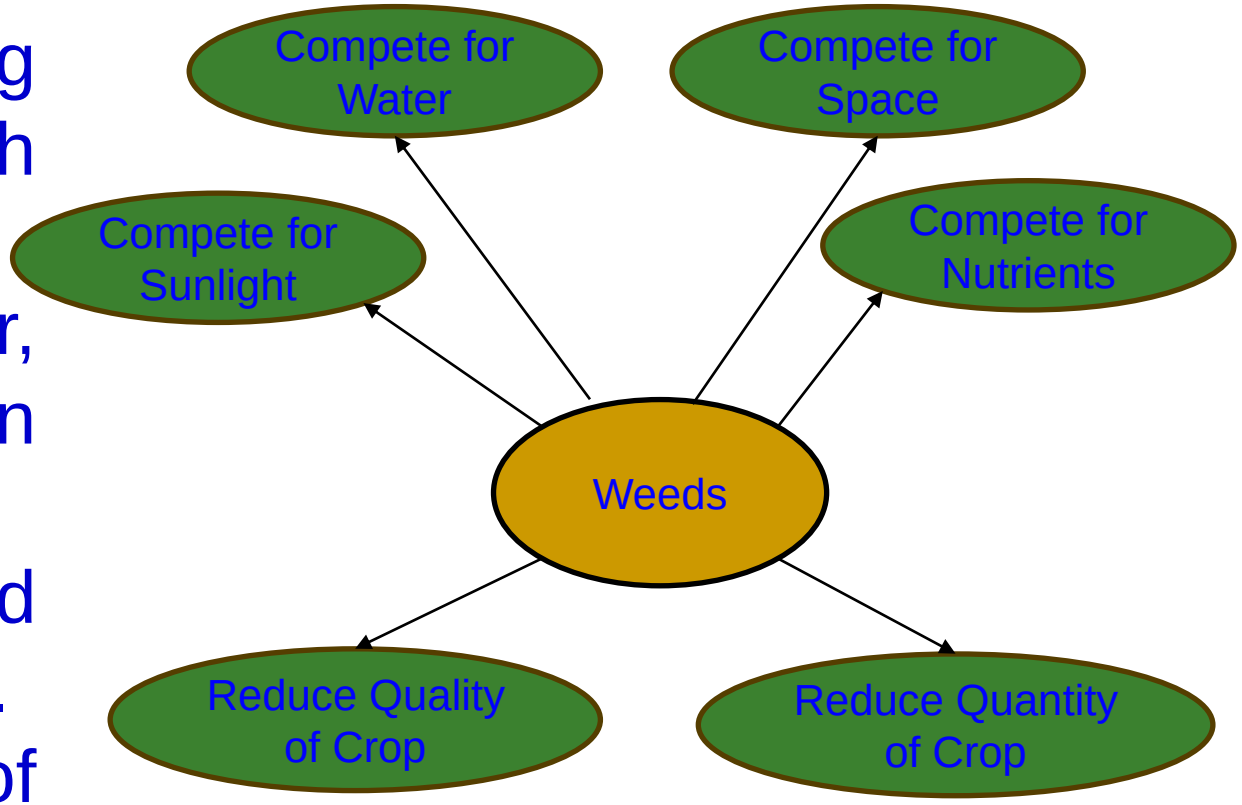
Why This Matters

- Agriculture is the foundation of the food system, providing the food that we eat.
- Agriculture is a major contributor to the global economy.
- The global human population is projected to reach 9.7 billion by 2050 and 10.9 billion by 2100.
- Food security and food safety must be ensured to everyone.



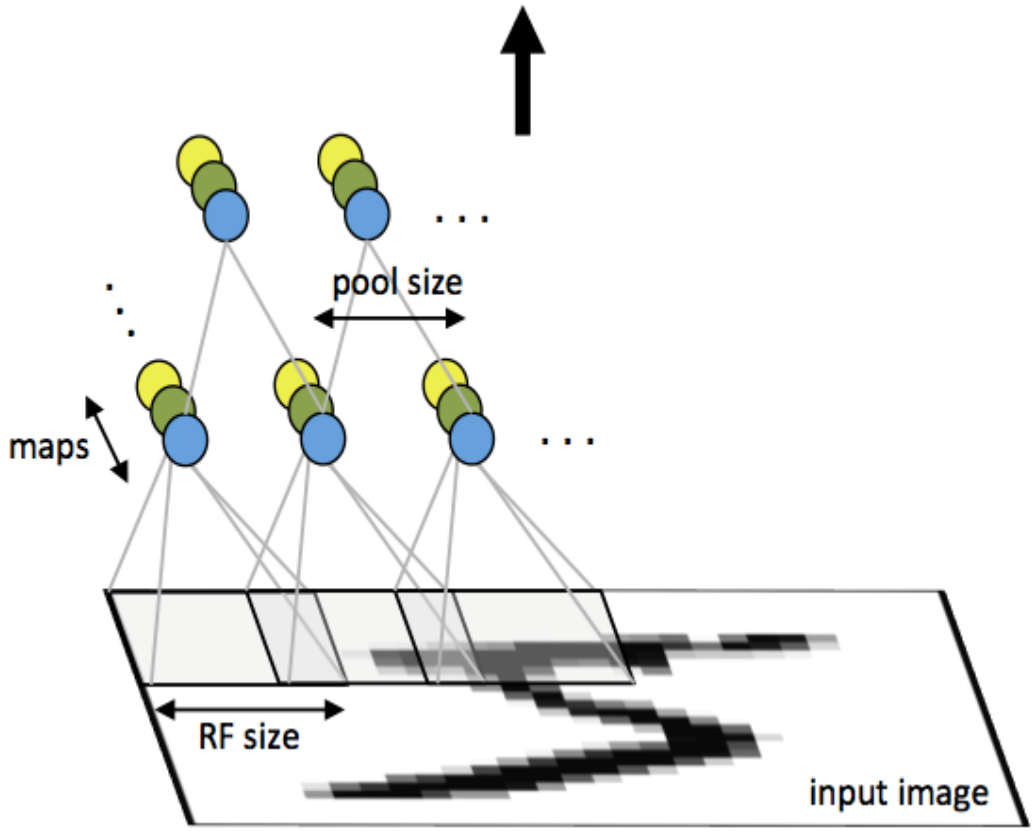
Why This Matters

- Weeds are unwanted plants that grow along with the crop being cultivated and compete with primary crops for resources.
- Weed competition for water, nutrients, sunlight, and space can reduce crop yields by up to 40%.
- Weeds can harbor pests and diseases that can damage crops.
- Weeds can reduce the quality of agricultural products.



Why This Matters

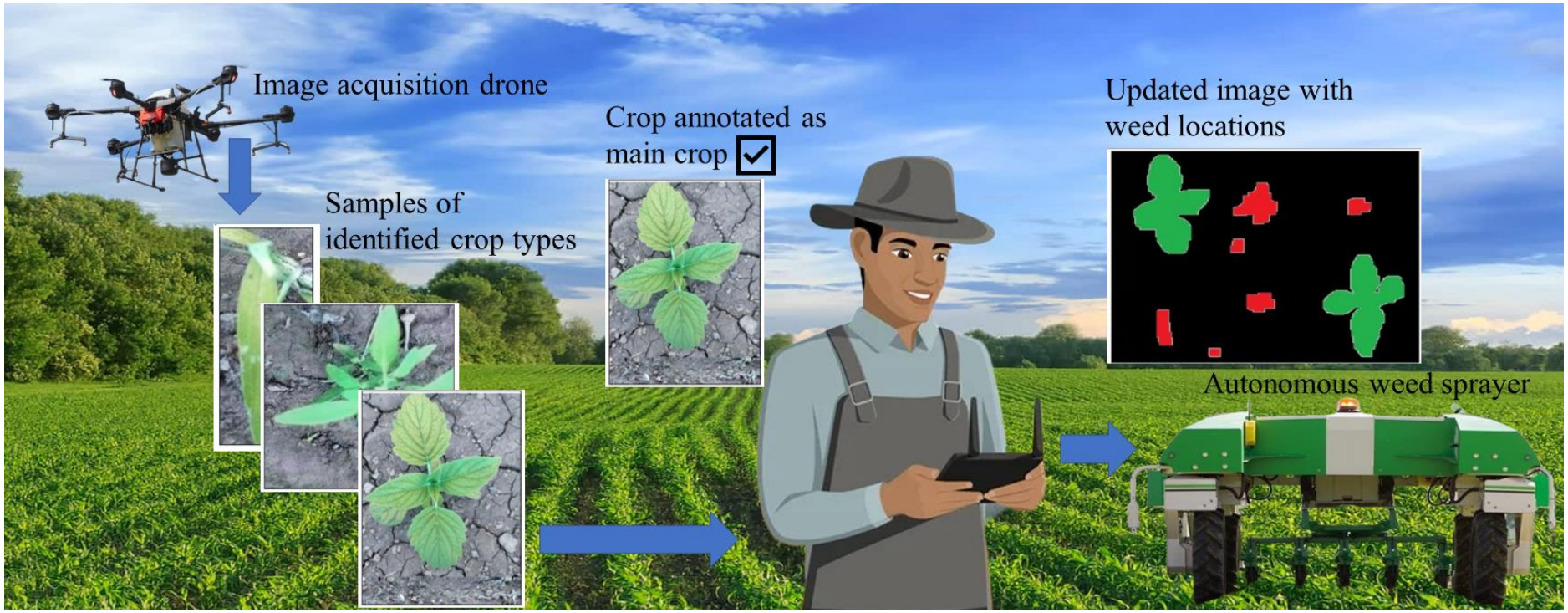
- Various A-CPS solutions have been developed using CNN to detect and manage weeds.
- CNN can only detect images with features presented while training.
- Appearance of same crop varies with growth cycle and geographic locations due to various factors.
- Needs lot of annotated images to train.



Source: UFLDL Tutorial, Convolutional Neural Network (UFLDL Tutorial)

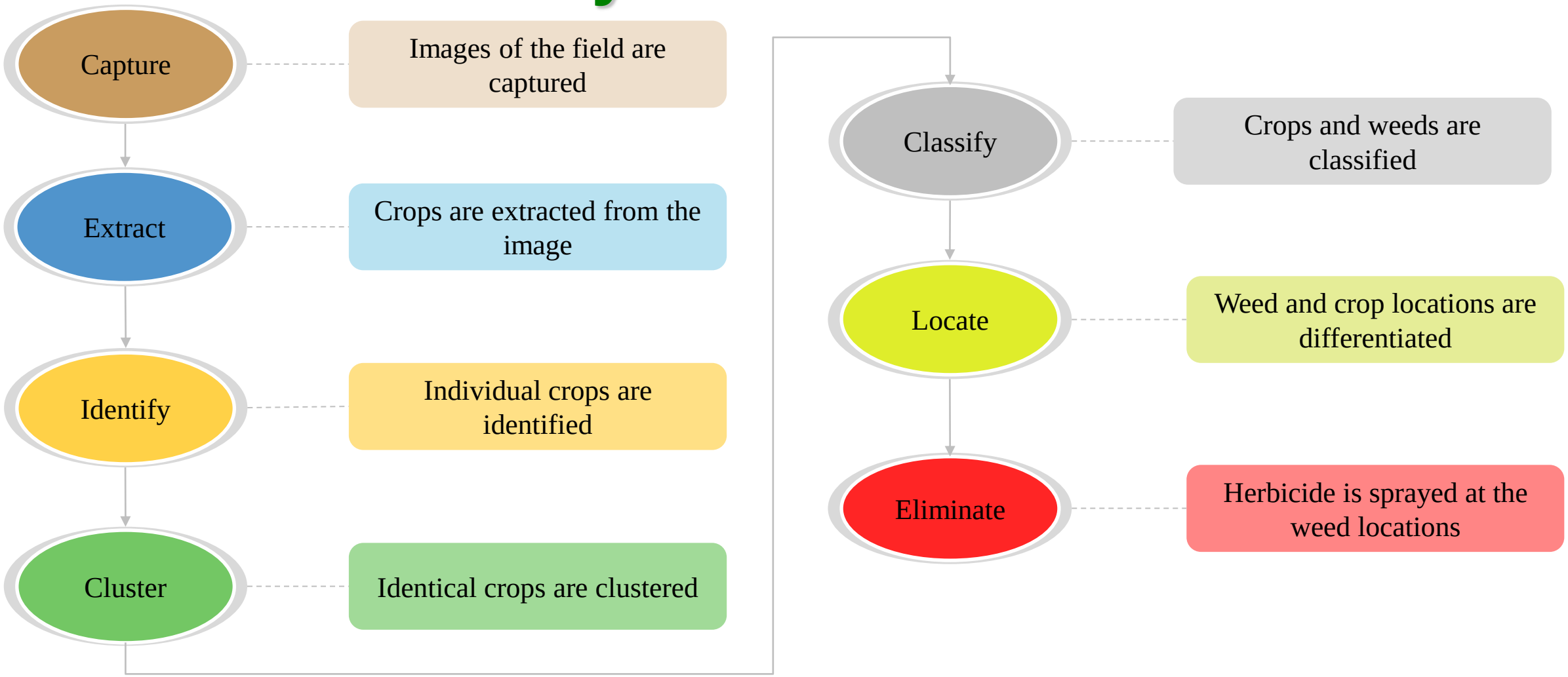
Why This Matters

- Instead, proposed A-CPS uses farmer's knowledge for Semi-Supervised Non-CNN Annotation to detect weeds.



Thematic overview of proposed WeedOut.

Why This Matters



Overview of proposed WeedOut.

Novel Contributions

- ✓ No prior data or training is required by WeedOut.
- ✓ Solution is not tightly coupled with visual features of crops.
- ✓ Provides insights on weeds present and weed pressure.
- ✓ Simple and computationally less intensive solution.

Related Works

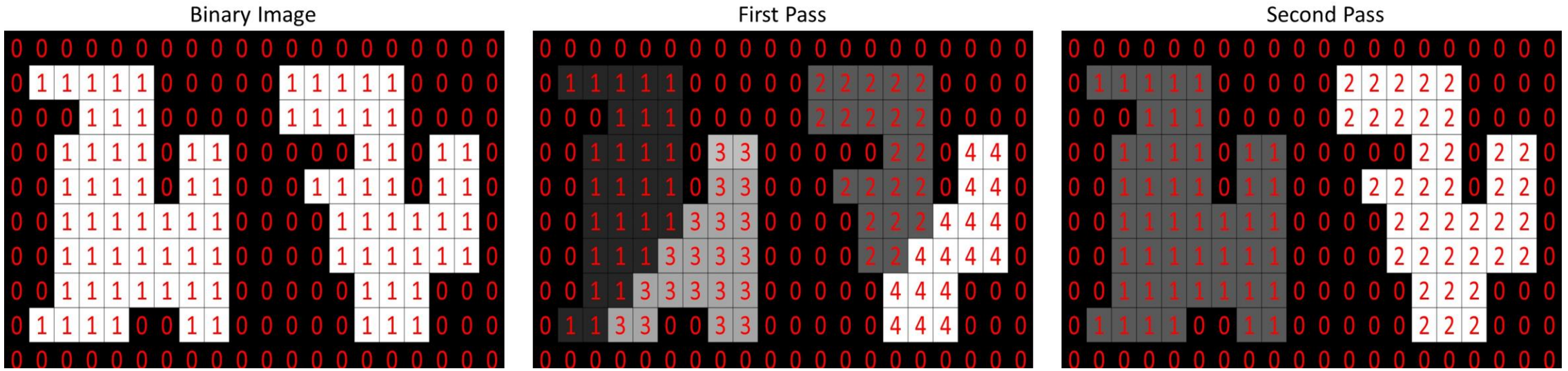
Work	Year	Assumptions made	Features considered	Remark
Louargant et al.	2019	Cultivation of crops is performed in rows.	Spatial and spectral properties of crop.	Specific to crops which vary in vegetation indices.
Ota et al.	2022	Cultivation of crops is performed in rows.	Spatial and geometric features of crop.	Needs a greater number of weeds for better classification.
Bah et al.	2017	Cultivation of crops is performed in rows.	Position of crop in farmland and orientation of super pixels.	Specific for crops that are cultivated in rows.
Rani et al.	2017	The average area of a primary crop is greater than that of a weed.	Area occupied by individual crop.	Weeds larger in size may be classified as primary crops.
Irías Tejeda et al.	2019	The average area of a primary crop is greater than that of a weed.	Area occupied by individual crop.	Weeds larger in size may be classified as primary crops.

Related Works

Work	Year	Assumptions made	Features considered	Remark
Aravind et al.	2015	The average area of a primary crop is lesser than that of a weed.	Area occupied by individual crop.	Weeds smaller in size may be classified as primary crops.
Siddiqi et al.	2009	The average area of a primary crop is lesser than that of a weed.	Area occupied by individual crop.	Weeds smaller in size may be classified as primary crops.
Maria Persson et al.	2008	NA	Shape of the crop.	Needs to be trained with shapes of primary crop at various orientations.
WeedOut	2023	**NA**	**Shape of the crop.**	**No training needed, works for all types of crops and all patterns of cultivation.**

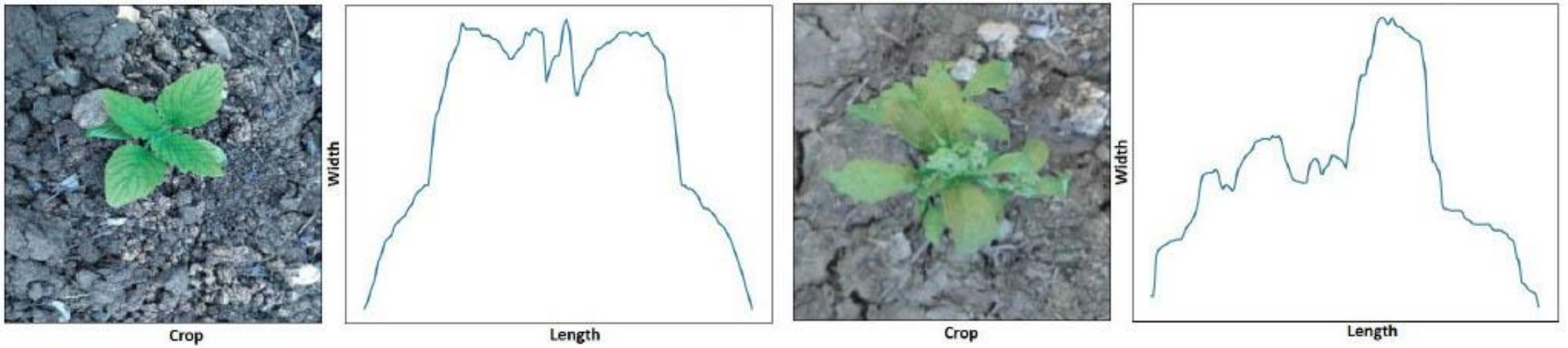
Working of WeedOut

- Object detection by 2 Pass Connected Component algorithm.



Working of WeedOut

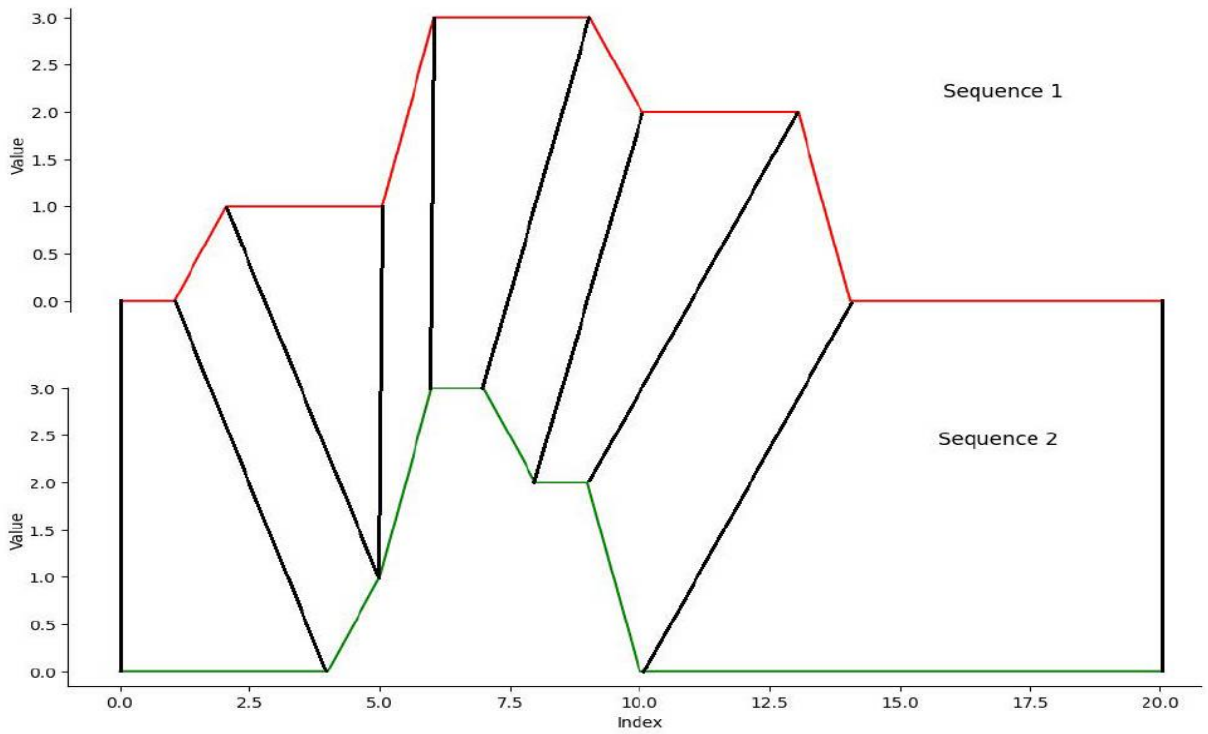
- Profile plot its defined as a plot describing variation in width of a plant with length.



Profile plots of two different crops.

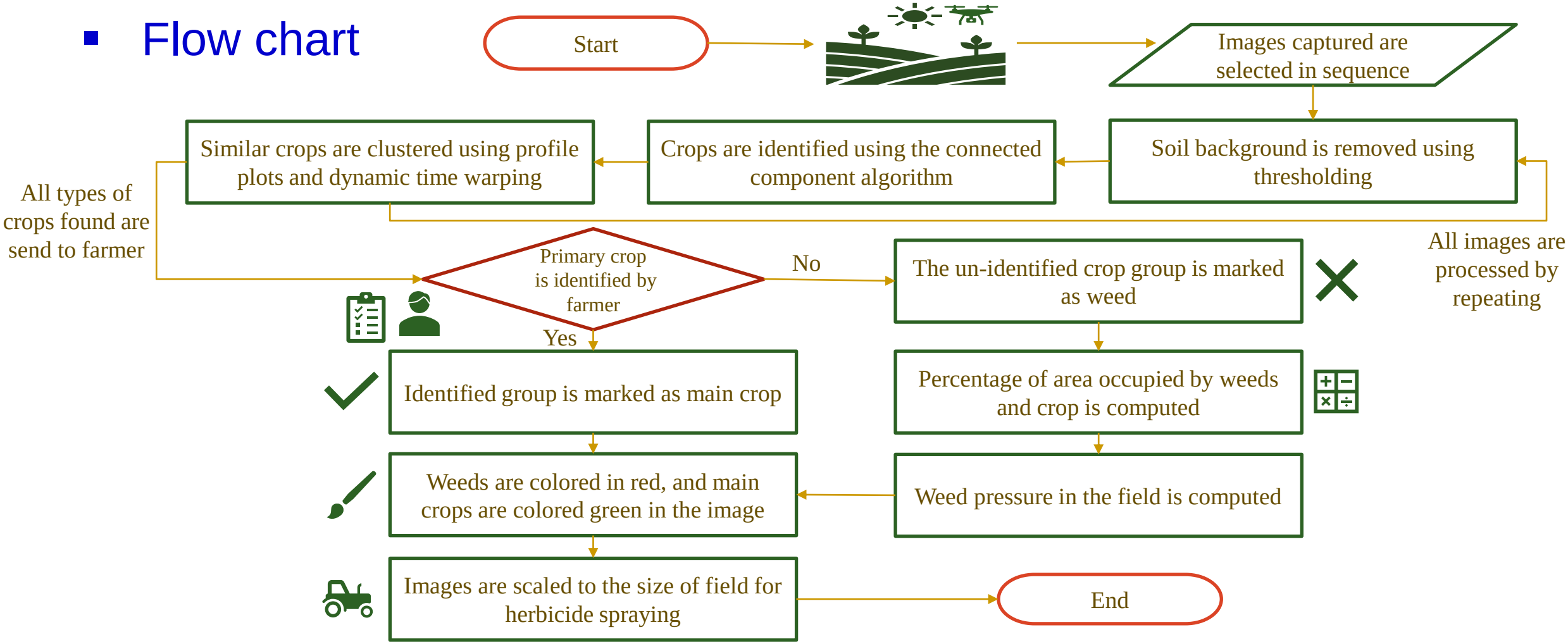
Working of WeedOut

- Dynamic Time Warping of two signals is finding best alignment between them by stretching and compressing one of them along time axis while distance between corresponding points is being minimized



Working of WeedOut

- Flow chart

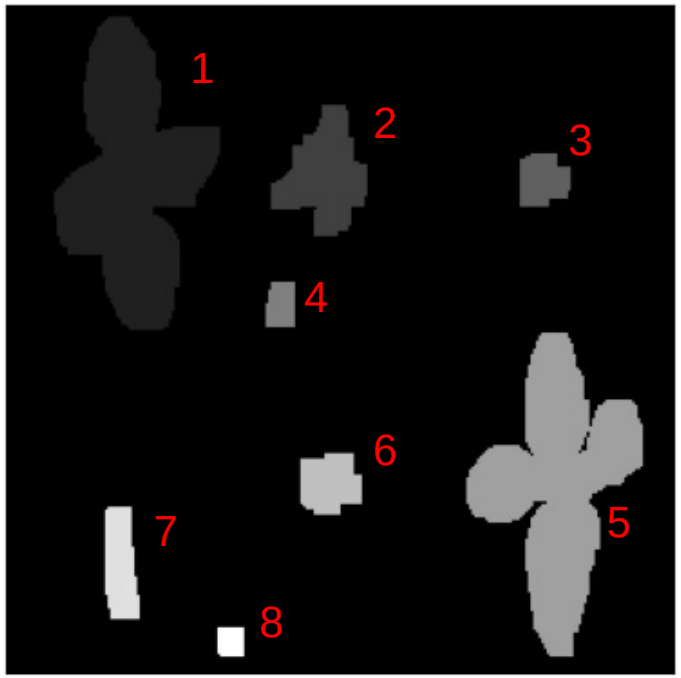


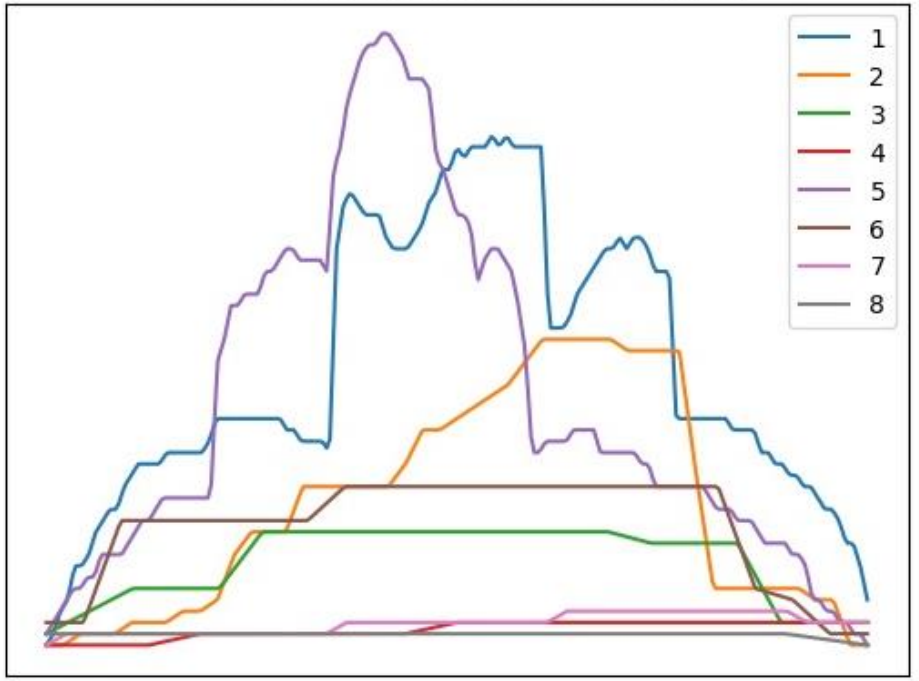
Implementation and Results

- Proposed solution was implemented with python and a Computer Vision library OpenCV on a data set from kaggle.
- To create an image of a farmland multiple images were combined and results of one of such image are discussed below.

Implementation and Results

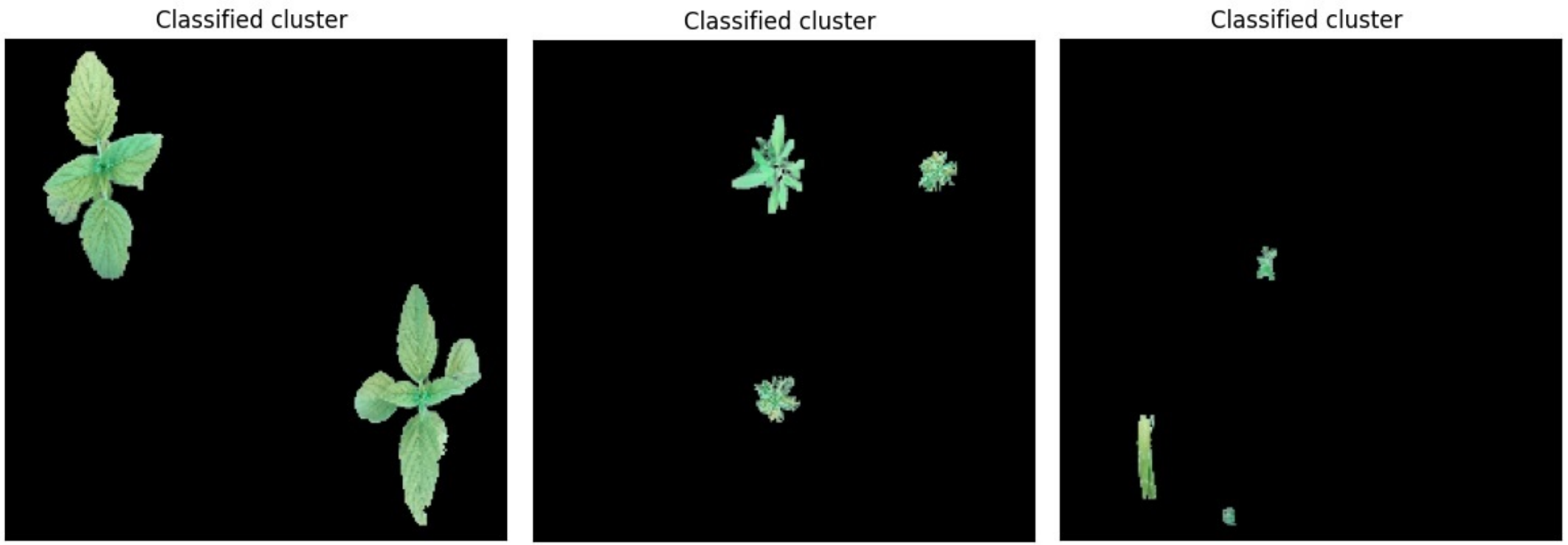
- Profile plots of every crop identified are plotted.





Implementation and Results

- Crops with similar profile plots are clustered together by DTW.



Implementation and Results

- Sample from each cluster is presented to farmer.
- In this experiment farmer selected cluster 1 as his primary crop.

```
Cluster  1
Percent of Area occupied :  0.7494587679590632
```

Sample from classified cluster

```
Cluster  2
Percent of Area occupied :  0.17742570360165322
```

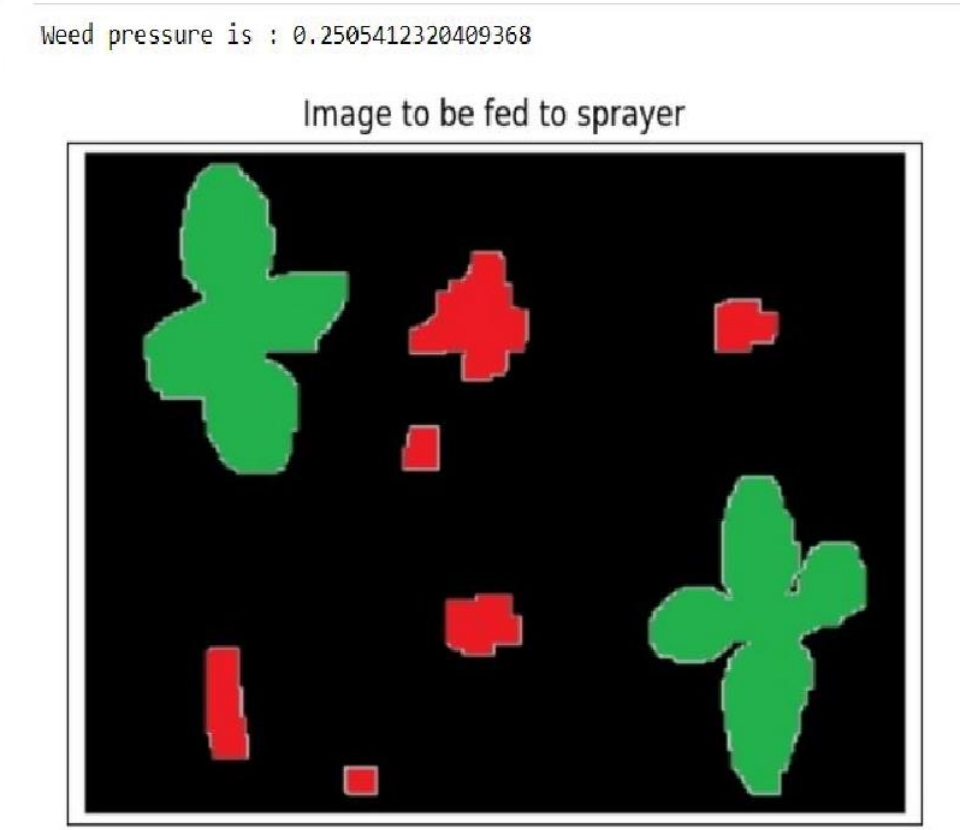
Sample from classified cluster

```
Cluster  3
Percent of Area occupied :  0.07311552843928361
```

Sample from classified cluster

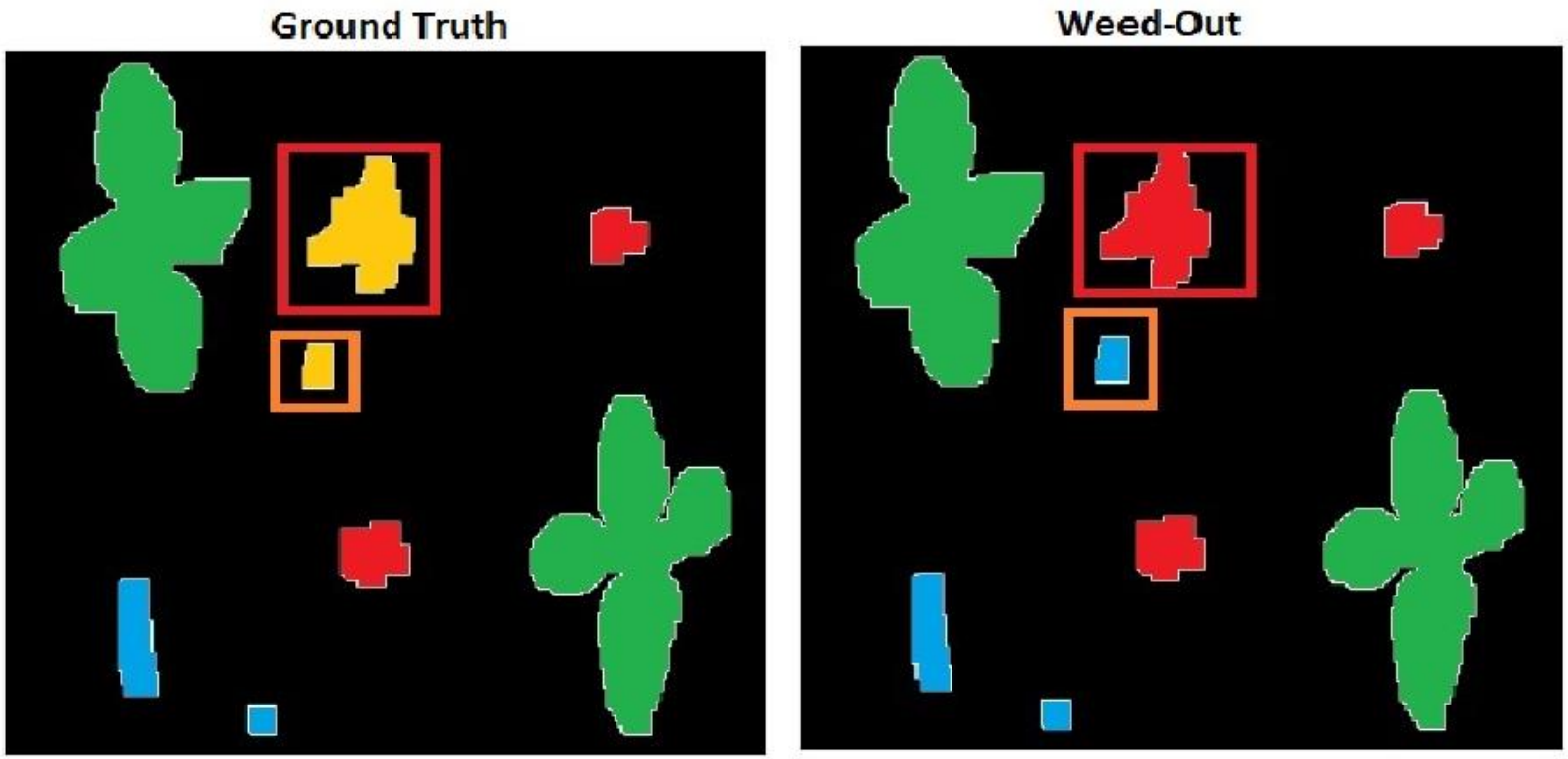
Implementation and Results

- Primary crop is colored in green, weeds are colored in red.
- Results are presented to user with weed pressure and fed to sprayer.



Implementation and Results

- Comparison between ground truth and results of proposed method.



Implementation and Results

- The same algorithm is fed with 20 of such images to simulate a small sized farmland and calculate its performance metrics.
- The proposed clustering method showed an accuracy of 93% while F1 score for primary crops and weeds were 0.80, 0.95 respectively.

	Actual Classes				
Predicted Classes	1	2	3	4	5
1	18	0	0	0	6
2	0	20	0	1	3
3	0	2	18	1	3
4	2	1	3	16	2
5	1	3	3	2	15

Confusion Matrix for all classes identified

	Actual Classes	
Predicted Classes	Primary crop	Weed
Primary crop	18	6
Weed	3	93

Confusion matrix for primary crop and weed

Conclusion and Future Work

- Current article proposed a novel methodology for an A-CPS delegated with weed management utilizing shape of crops and domain knowledge of farmer to detect weeds.
- The presented method demonstrated efficiency in identifying weeds particularly.
- WeedOut fails to differentiate overlapping crops and different crops with similar shapes.
- Methods to distinguish crops even in cases of overlap with help of edge detection and considering some additional geometrical features that help in more accurate identification can be explored as future works for the proposed solution.

Thank You !!