Intelligent See and Spray: Less chemical - Greater Yields

NRI: INT: COLLAB: An autonomous insect Sense, Identify, and Manage PLatform (SIMPL) to advance crop protection strategies

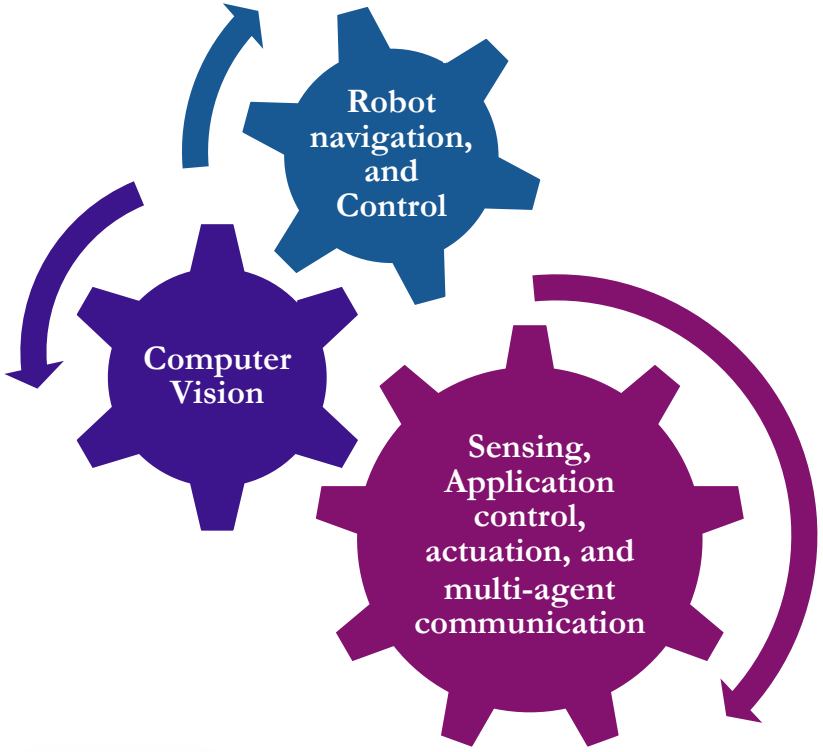
Award #2019-67021-28995 || Ajay Sharda, Daniel Flippo and Brain McCornack – Kansas State University, and Cuncong Zhong – University of Kansas

Challenge

- U.S. farmers spend $15.2 billion worth of pesticides
- Blanket application due lack of pest incidence knowledge

Solution

- Sense, identify and targeted pest control under the canopy
- Computer vision, autonomous ag system and multi-agent communication



Scientific Impact

- Scalable and modular sensing, control and communication sub-systems for ag and beyond

Broader Impact

- Functional smart system for adoption
- Environmentally sustainable
- Scale independent Ag robotic
- Significant reduction (potentially 40%-60%) in chemical usage

Building Image Library

- 4 Sample dates (Sedgwick County, KS)
- 4 camera positions (1 top and 3 canopy view)
- GoPro Hero Session 5 sensor, 0.5 sec timer
- ~110K raw images in JPEG format (RGB)
- Images labeled
  - Sugarcane aphids at varied densities
  - Indirect evidence (sooty mold and honeydew)
- PhD Student (Ivan Grijalva)

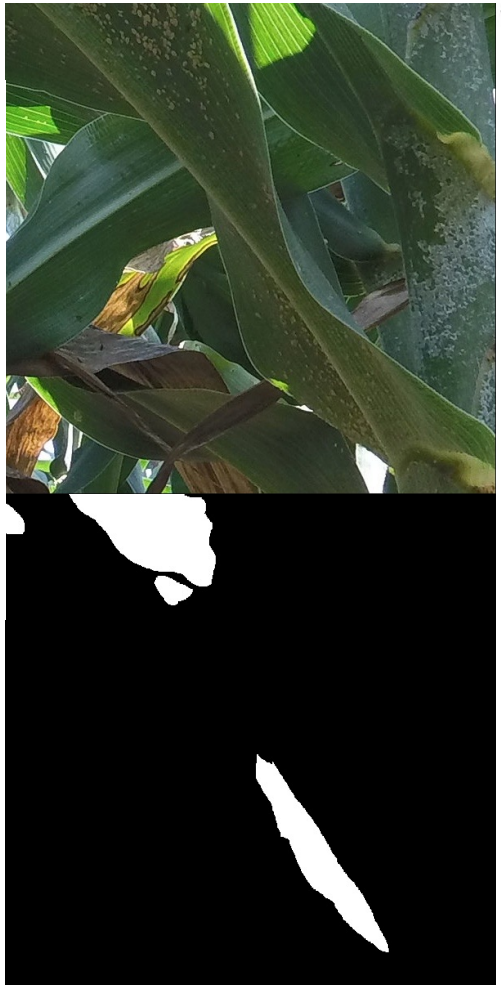
Dataset

DetSegImages

SegmentationClass

DetAnnotations

```
<annotation>
  <folder>Aphid_2021</folder>
  <filename>222246.JPG</filename>
  <orig_image>MG0060278</orig_image>
  <size>
    <width>600</width>
    <height>600</height>
    <depth>3</depth>
  </size>
  <object>
    <name>aphid_cluster</name>
    <percent>0.022186</percent>
    <bndbox>
      <xmin>111</xmin>
      <ymin>231</ymin>
      <xmax>287</xmax>
      <ymax>471</ymax>
    </bndbox>
  </object>
</annotation>
```



```
<annotation>
  <folder>Aphid_2021</folder>
  <filename>153460.JPG</filename>
  <orig_image>TG0010505</orig_image>
  <size>
    <width>600</width>
    <height>600</height>
    <depth>3</depth>
  </size>
  <object>
    <name>aphid_cluster</name>
    <percent>0.035025</percent>
    <bndbox>
      <xmin>78</xmin>
      <ymin>0</ymin>
      <xmax>256</xmax>
      <ymax>112</ymax>
    </bndbox>
  </object>
  <object>
    <name>aphid_cluster</name>
    <percent>0.001875</percent>
    <bndbox>
      <xmin>0</xmin>
      <ymin>11</ymin>
      <xmax>23</xmax>
      <ymax>48</ymax>
    </bndbox>
  </object>
  <object>
    <name>aphid_cluster</name>
    <percent>0.002842</percent>
    <bndbox>
      <xmin>182</xmin>
      <ymin>100</ymin>
      <xmax>228</xmax>
      <ymax>135</ymax>
    </bndbox>
  </object>
  <object>
    <name>aphid_cluster</name>
    <percent>0.025794</percent>
    <bndbox>
      <xmin>306</xmin>
      <ymin>318</ymin>
      <xmax>467</xmax>
      <ymax>559</ymax>
    </bndbox>
  </object>
</annotation>
```

Sugarcane Aphids: Detection Results

AP	VFNet [1]	GFLV2 [2]	PAA [3]	ATSS [4]
Setting 1	46.7	45.9	45.4	46.3
Setting 2	60.3	60.3	60.3	60.6
Setting 3	62.5	62.1	62.5	63.0
Setting 4	57.6	57.2	57.4	58.0

Average precision of aphid detection of 4 state-of-the-art learning models

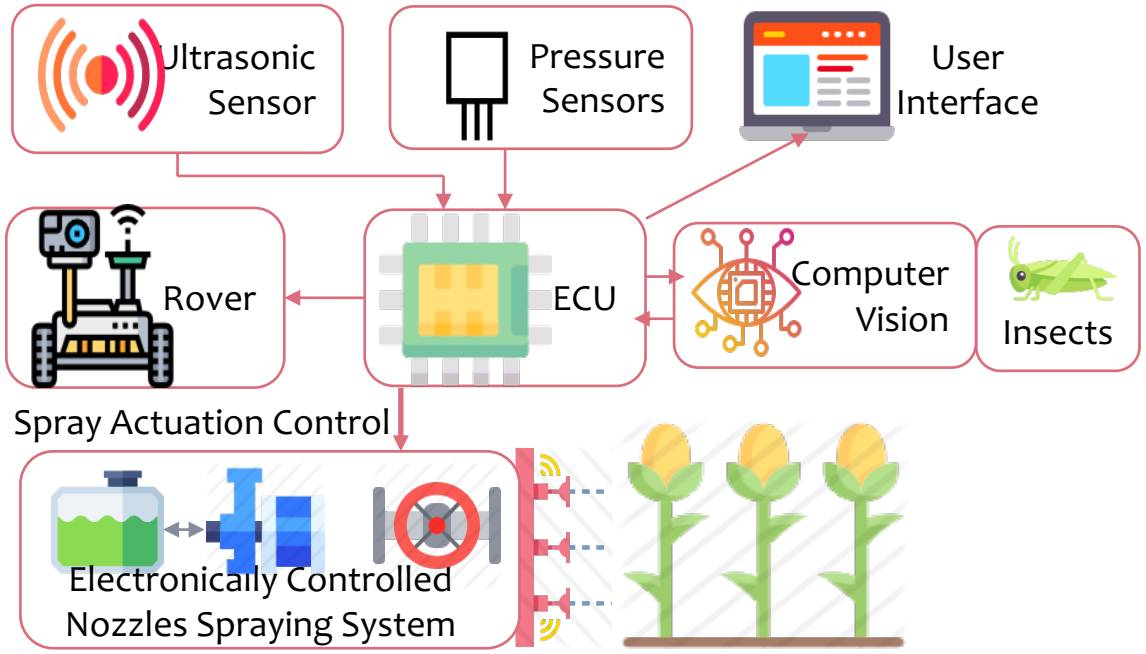
[1] Zhang, Haoyang, et al. "Varifocalnet: An iou-aware dense object detector." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2021.

[2] Li, Xiang, et al. "Generalized focal loss v2: Learning reliable localization quality estimation for dense object detection." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2021.

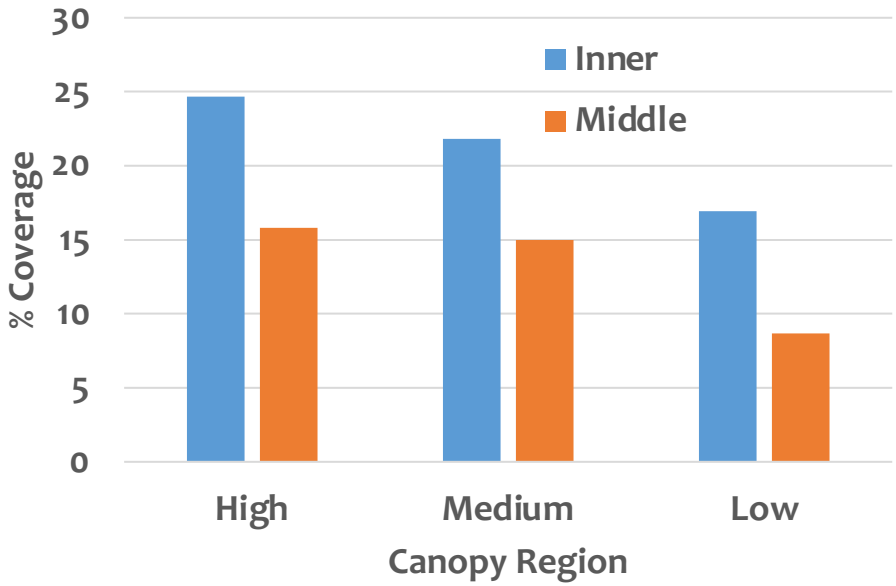
[3] Kim, Kang, and Hee Seok Lee. "Probabilistic anchor assignment with iou prediction for object detection." *European Conference on Computer Vision*. Springer, Cham, 2020.

[4] Zhang, Shifeng, et al. "Bridging the gap between anchor-based and anchor-free detection via adaptive training sample selection." *Proceedings of the IEEE/CVF conference on computer vision and pattern recognition*. 2020.

Autonomous Liquid Application Coverage: Field Validation



Autonomous Liquid Application Coverage: Field Validation



Future Work

- Integration of Aphid detection with computer vision
- Integrating computer vision system with liquid application
- Lab and field scale validation for system performance
- Develop basic economics and potential of chemical savings