

AST 426 :Data Analytics and Machine Learning in Agriculture III

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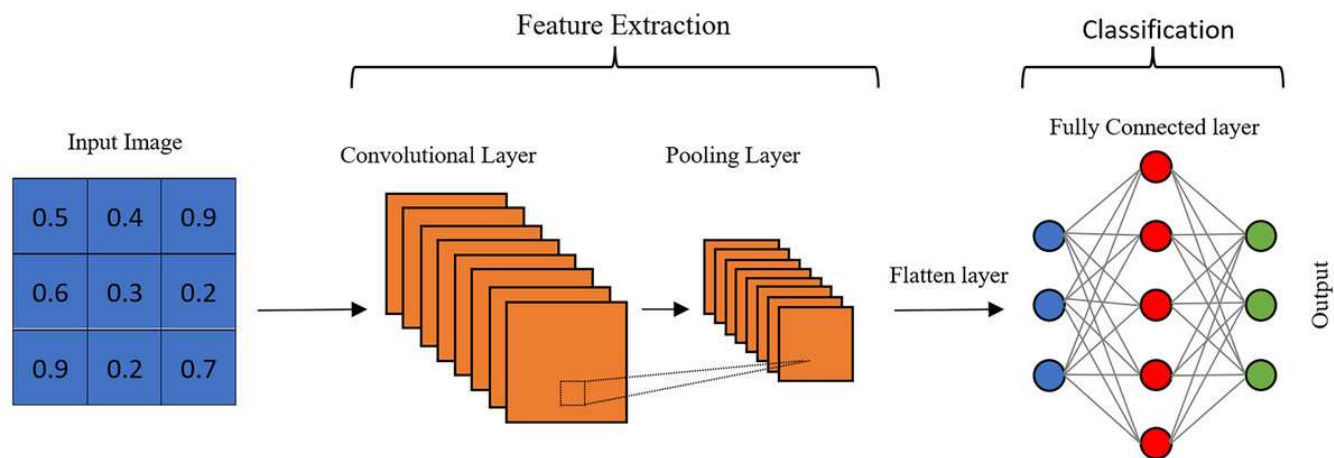
**SOUTH DAKOTA
STATE UNIVERSITY**
*College of Agriculture, Food
and Environmental Sciences*

AST 426 :Technology Applications for Precision Agriculture

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Convolutional Neural Network (Recap)



[CNN Explainer \(poloclub.github.io\)](https://poloclub.github.io/CNN-Explainer/)



Convolutional Neural Network (Recap)

[Convolutional Neural Networks \(CNNs\) explained \(youtube.com\)](#)

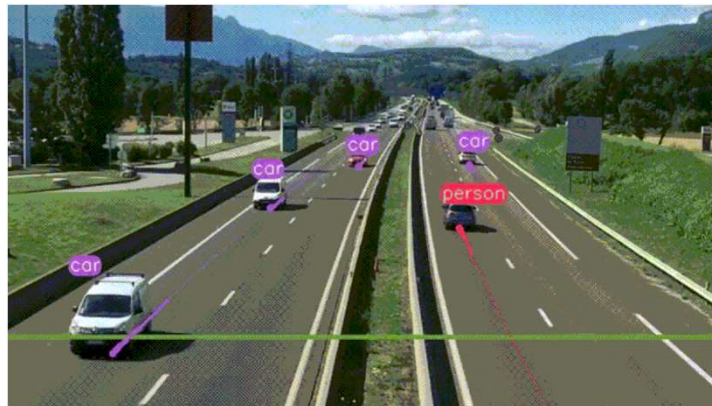
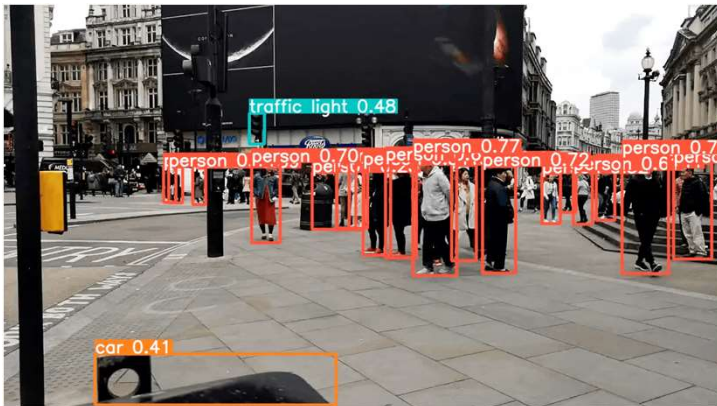
[Convolutional Neural Networks Explained \(CNN Visualized\) \(youtube.com\)](#)



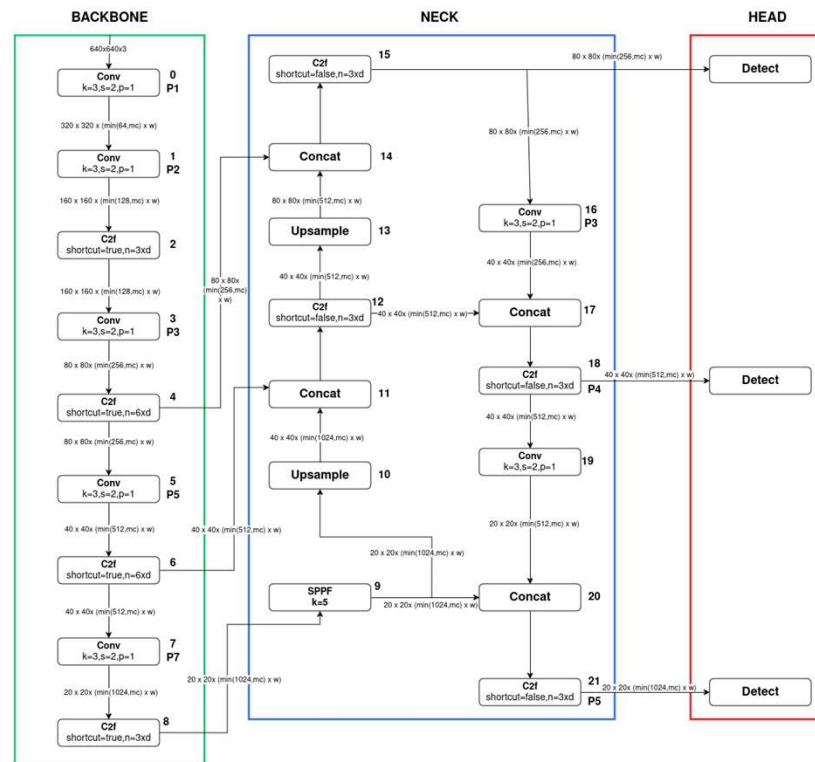
YOLOv8

You Only Look Once version 8 (YOLOv8)

- YOLOv8 is **CNN-based deep learning model** for **object detection** that predicts bounding boxes and classifies objects in real-time.
- It **can be used to identify weeds in a crop field**, automatically locating their position and type for **precision spraying**.



YOLOv8 Network Architecture



CNN Performance Metrics

1. Precision

- Precision measures how many of the crops predicted as diseased were diseased.
- High precision means if your model says a crop is diseased, it's very likely true, which reduces false alarms.

$$Precision = \frac{TP}{TP + FP}$$



CNN Performance Metrics

2. Recall

- Recall measures how many of the actual diseased crops were correctly identified by the model.
- High recall ensures you capture most of the diseased crops, preventing missed cases that could spread.

$$Recall = \frac{TP}{TP + FN}$$



CNN Performance Metrics

3. F1-score

- F1-score is the harmonic mean of precision and recall, balancing both.
- It helps find a middle ground between catching all diseased crops (recall) and ensuring accuracy in those predictions (precision).

$$F1 = \frac{2 \times \text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$



CNN Performance Metrics

4. Accuracy

- Accuracy measures the proportion of correct predictions out of all predictions made.
- If you are classifying healthy vs. diseased crops, accuracy tells you how many crops were correctly identified, both healthy and diseased.

$$Accuracy = \frac{TP + TN}{TP + FP + TN + FN}$$



CNN Performance Metrics

5. Mean Average Precision (mAP)

- mAP evaluates object detection models (like YOLOv8) and considers both precision and recall over different confidence thresholds.
- For detecting weeds, mAP measures how well the model identifies weeds, considering accuracy across different conditions (small weeds, large weeds).

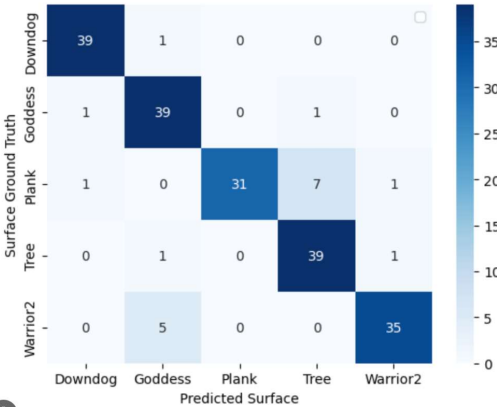
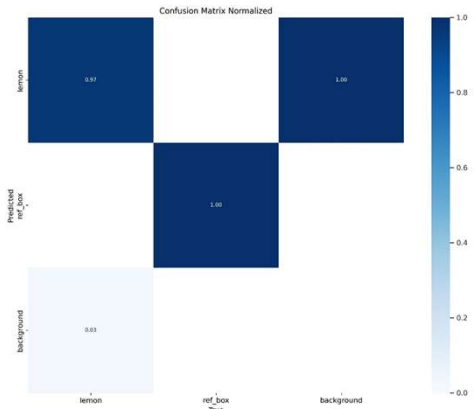
$$mAP = \frac{1}{k} \sum_i^k AP_i$$



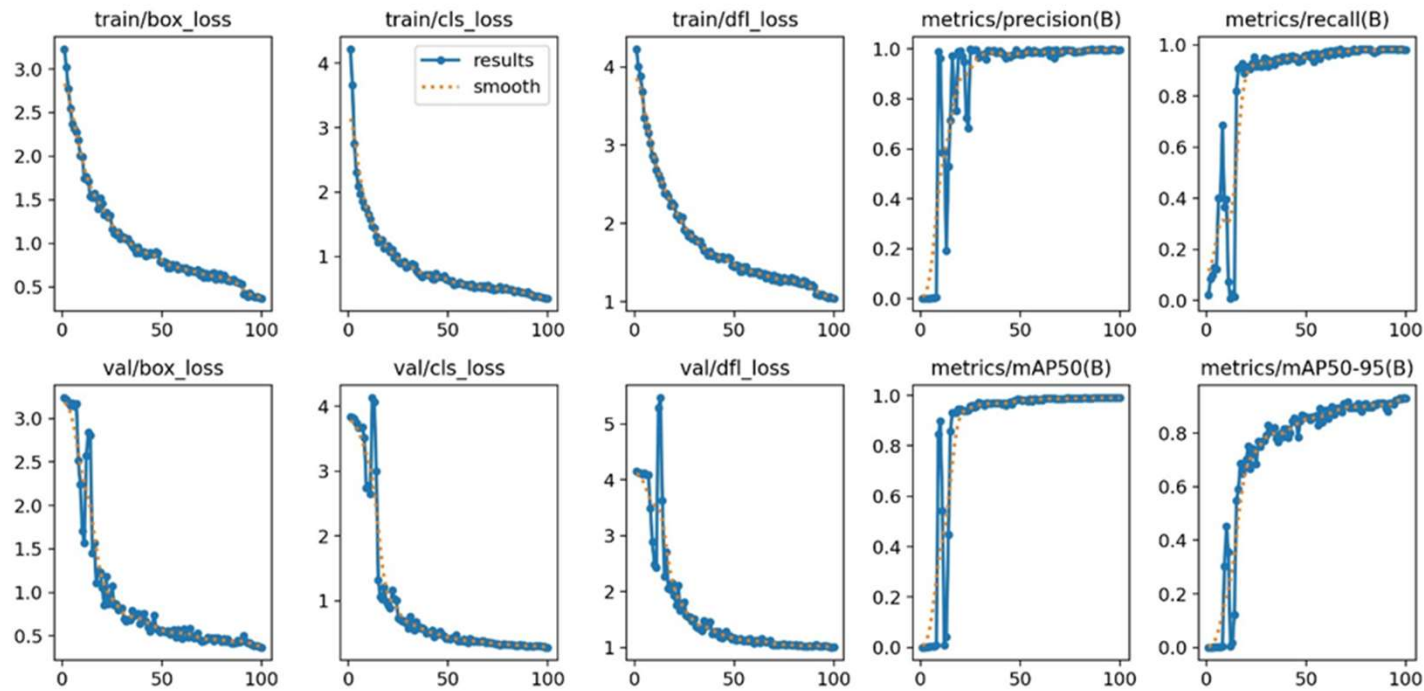
CNN Performance Metrics

Confusion Matrix

- A confusion matrix is a table used to evaluate the performance of a classification model by showing the actual vs. predicted classifications.
- It helps you understand how well your model is performing, especially for multi-class problems.



YOLOv8 Training Graphs



Quiz

1. Which metric would you focus on to minimize the number of weeds that are mistakenly not detected by the YOLOv8 model?

A) Precision

B) Recall

C) Accuracy

D) F1-Score



Quiz

2. If you want a single score that balances both precision and recall, which metric should you consider?

A) Accuracy

B) mAP

C) Recall

D) F1-Score



Quiz

3. Which metric would be most suitable to assess the YOLOv8 model's capability to correctly detect weeds in a densely populated field, without missing too many weeds?

A) Precision

B) Recall

C) Accuracy

D) mAP



Discussion

4. Imagine you are deploying a **see-and-spray** system for weed detection using YOLOv8 on a large-scale **corn field**. The model achieves **high precision but relatively low recall**. **What would be the potential consequences of this performance in the field, and how might it affect the overall efficiency of weed control and crop health?** Discuss what trade-offs you might need to consider if you were tasked with improving the model's recall and suggest strategies or additional technologies that could be integrated to enhance weed detection accuracy and overall system effectiveness.



Discussion Answers

If the see-and-spray system achieves high precision but relatively low recall, it indicates that the **model is highly accurate in detecting actual weeds but misses many weeds present in the field**. In practical terms, this means **the system will spray accurately when it detects a weed, but it will also miss a significant number of weeds**. This can lead to several consequences:

- i. Missed weeds continue to compete with crops for resources (water, nutrients, sunlight), reducing crop yield and quality.
- ii. Surviving weeds could reproduce, causing a larger weed infestation over time and making subsequent weed management more challenging
- iii. Farmers might have to resort to additional manual inspections or apply a broadcast spray to cover areas missed by the system, increasing costs and reducing efficiency.



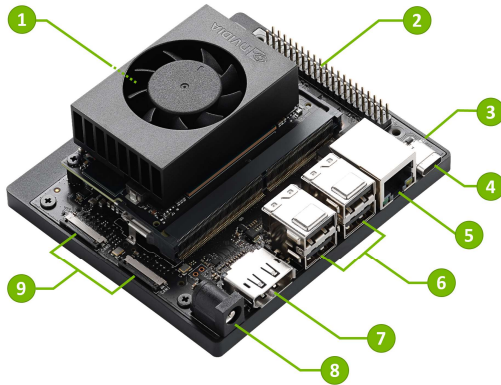
Discussion Answers

Trade-offs in Improving Recall

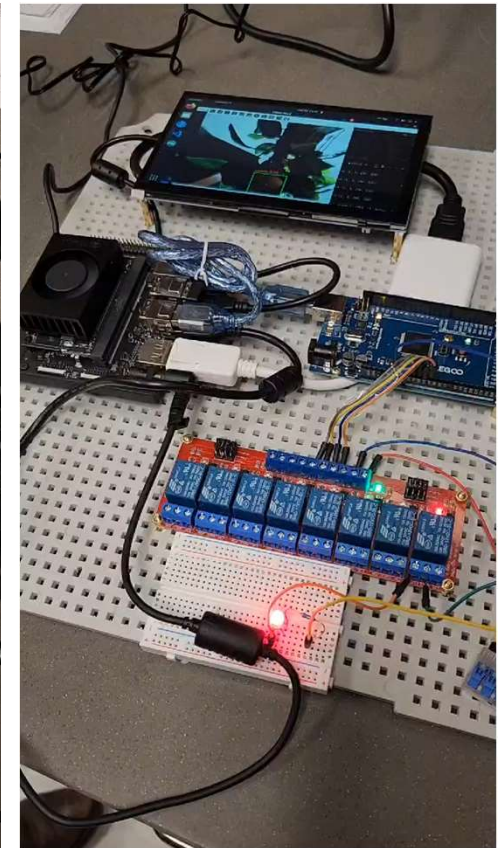
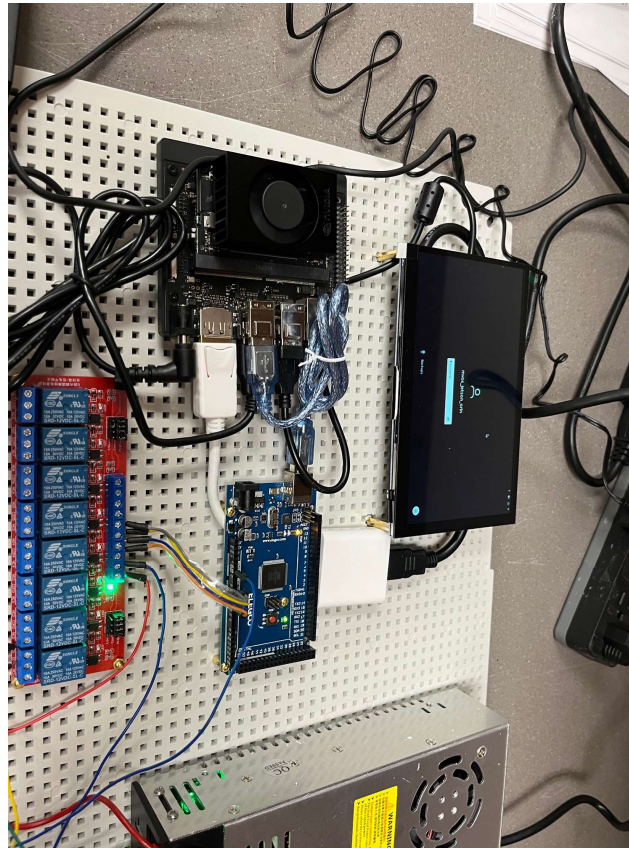
- Improving recall might require **lowering the detection threshold of the YOLOv8** model, which would **lead to detecting more potential weeds**. However, this could also decrease precision, **causing the system to mistakenly identify crops or bare soil as weeds**, leading to **unnecessary or harmful spraying**.
- The balance between precision and recall depends on the context. For example, missing weeds in certain crops might be less damaging than mistakenly spraying a crop, especially for delicate or high-value crops.



See and Spray System Hardware Components



- | | |
|--------------------------------------|--------------------------------------|
| 1 microSD card slot for main storage | 6 USB 3.1 Type A ports (x4) |
| 2 40-pin expansion header | 7 DisplayPort connector |
| 3 Power indicator LED | 8 DC Barrel jack for 19V power input |
| 4 USB-C port for data only | 9 MIPI CSI camera connectors |
| 5 Gigabit Ethernet port | |



<https://developer.nvidia.com/embedded/learn/get-started-jetson-orin-nano-devkit>



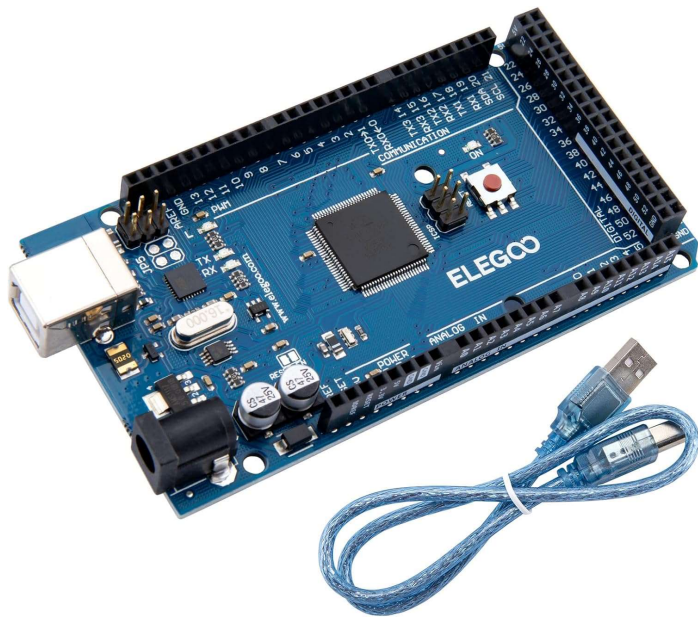
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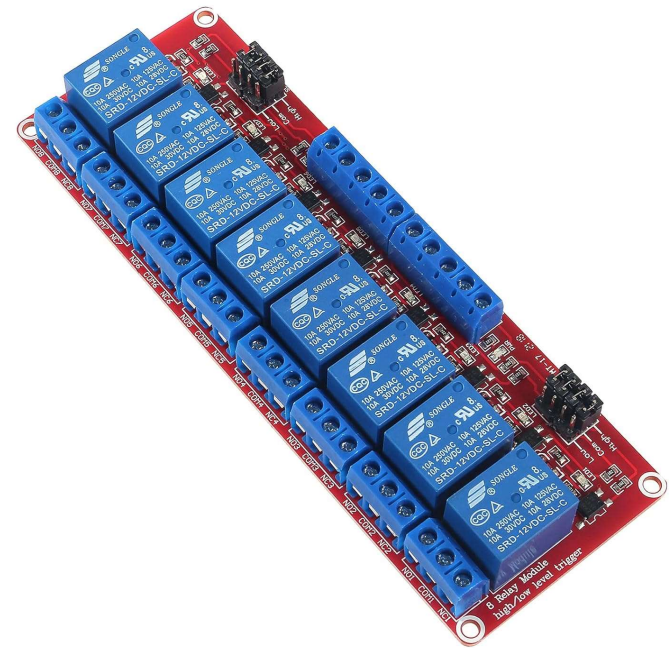
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See and Spray System Hardware Components



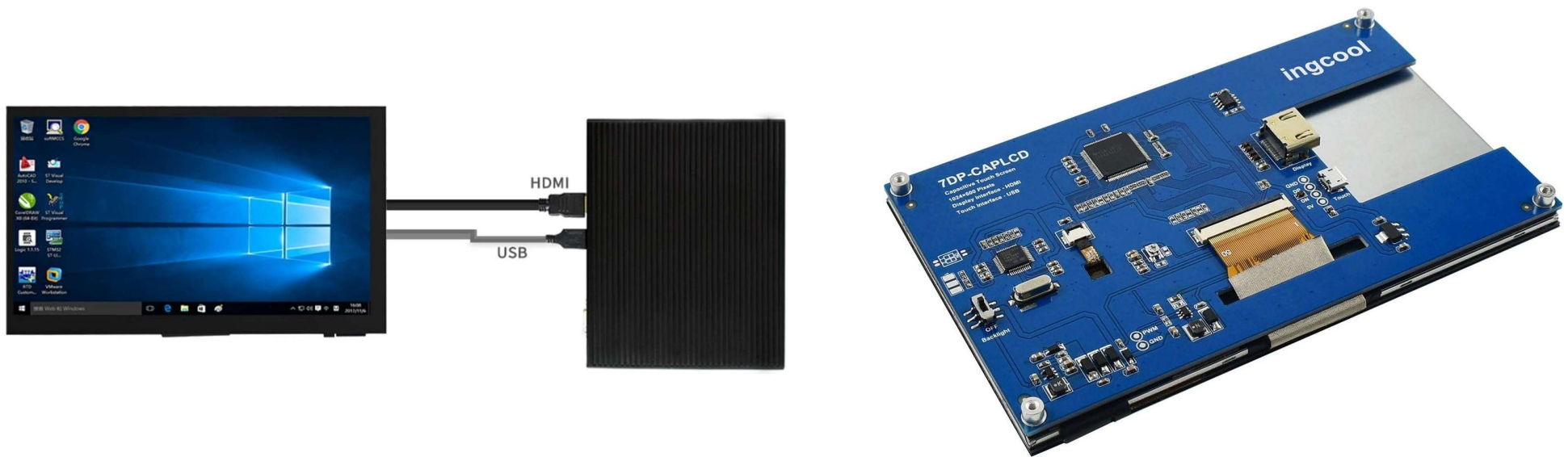
Arduino ELEGOO MEGA R3 Board ATmega 2560



DC 12V Relay Module 8 Channel Relay Board



See and Spray System Hardware Components



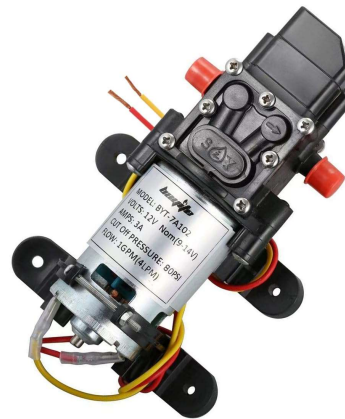
7-inch HDMI LCD 1024x600 Resolution Capacitive Touch Screen IPS Display Module



See and Spray System Hardware Components



Arducam 4K 8MP IMX219 Autofocus
USB Camera Module



12V DC Fresh Water
Pressure Diaphragm Pump



Brass Electric Solenoid Valve,
1/2" 12V Air Valve Normally
Closed for Water Air Gas Fuel
Oil



Next Lecture

- Guest lecture by Dr. Diganta (Dig) Adhikari, Syngenta Inc.

