DIRECTORATE OF ADVANCED STUDIES
EVENT CATALOGUE
2021

27TH SEMINAR OF DAS EVENTS CALENDAR – 2021

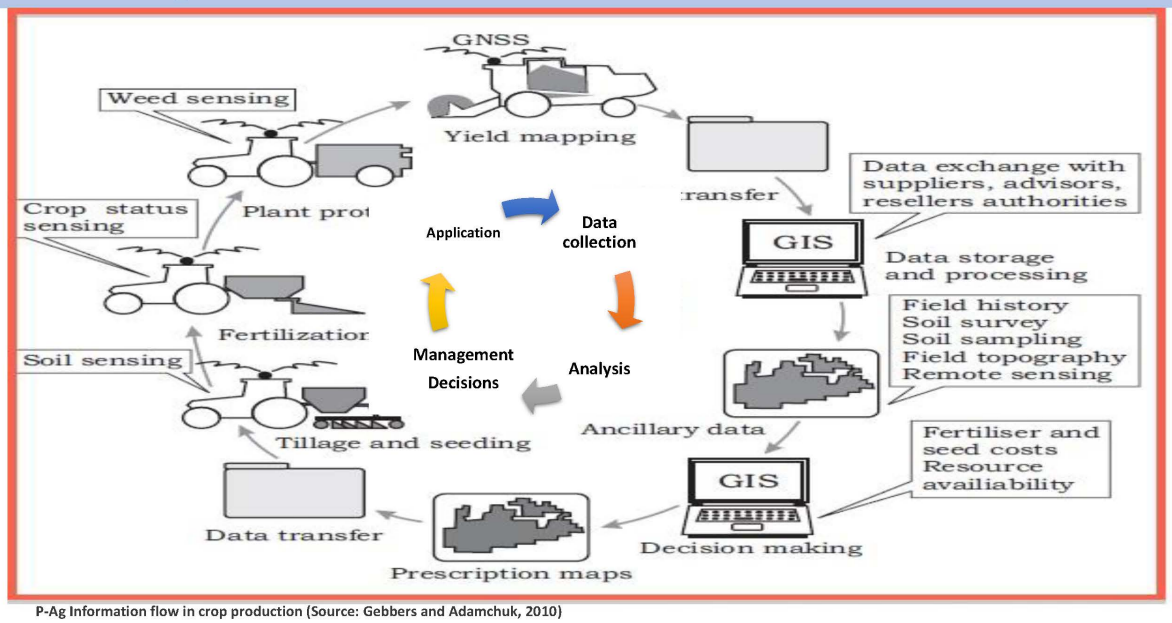
VARIABLE RATE SPRAYING SYSTEM FOR SITE SPECIFIC AGRO CHEMICAL APPLICATION

ACTIVITIES

Precision Agriculture-Objectives

Reduce the amount of inputs required to grow crops and increase harvestable crop yield = LOWER COSTS
Increase the efficiency of agrochemical applications = LOWER ENVIRONMENTAL IMPACT
Automate and log farm operations = DATA ANALYSIS, EFFICIENCY & CONVENIENCE
Minimize labor engagement in farm operations = AUTO PILOT, GPS guided, WiFi connected

Precision Agriculture



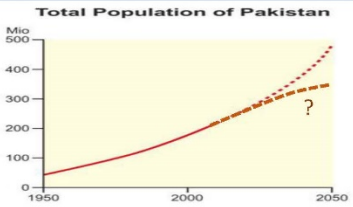
P-Ag Information flow in crop production (Source: Gebbers and Adamchuk, 2010)

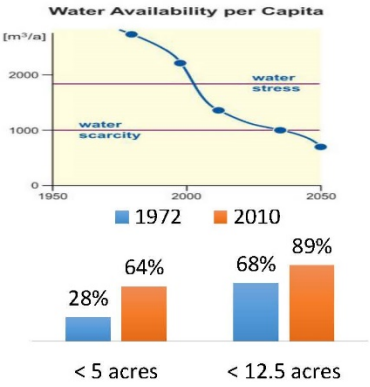
Need of Precision-Agriculture in Pakistan

- Agricultural Area : 26%
- Contribution in GDP: 21%
- Employment provision: 45%

Population growth
Global warming
Water scarcity
Loss of fertilizer and nutrients
Environmental degradation
Food prices

Rural population
Availability of Farm Machinery
Land and soil quality
Seed germination
Profitability
Land and water productivity

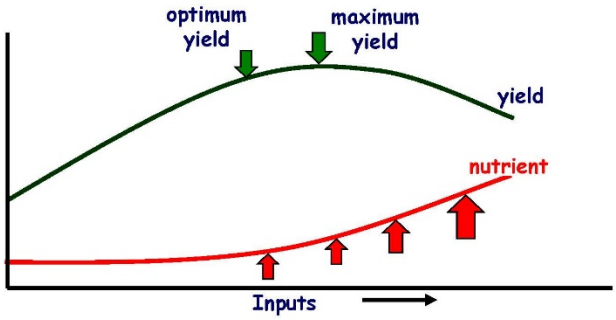




Source: (Winiger, 2010, J.Briscoe, U.Qamar, 2006)

How this can be achieved

Reduce the amount of inputs required to grow crops & increase harvestable crop yield = LOWER COSTS

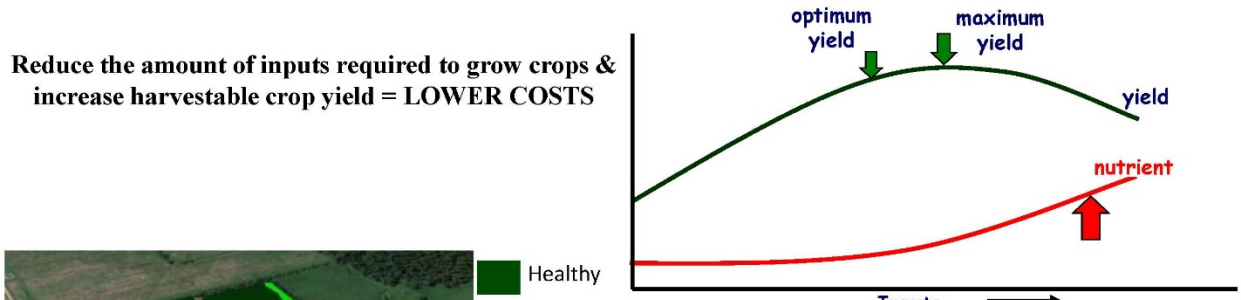


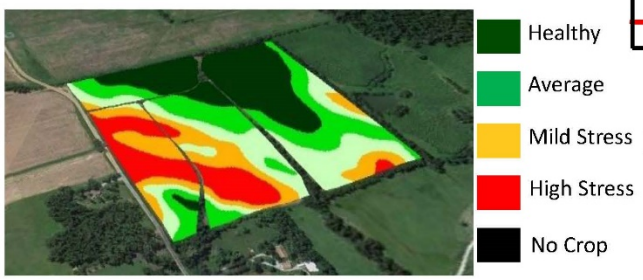
Agricultural Inputs

- Seed & Seeding
- Water
- Fertilizer /nutrients
- Weedicides
- Agri. Machinery

How this achieved

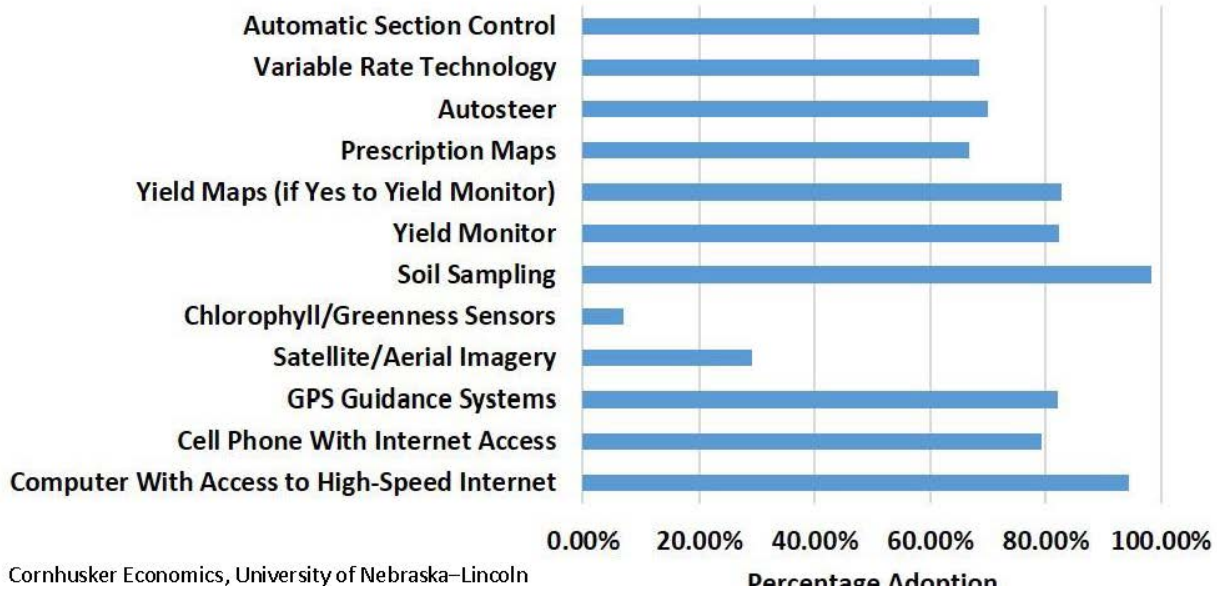
Reduce the amount of inputs required to grow crops & increase harvestable crop yield = LOWER COSTS





Increase the efficiency of agrochemical applications
=
LOWER ENVIRONMENTAL IMPACT

Global Adoptability



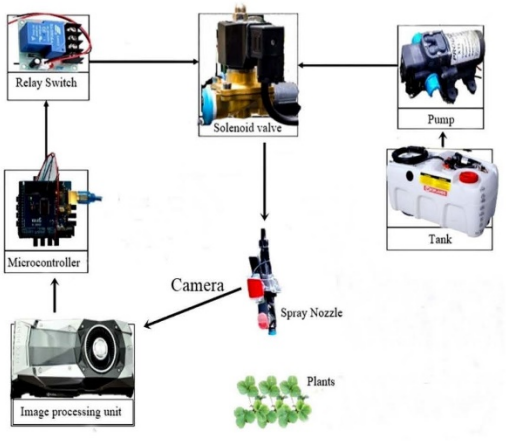
Cornhusker Economics, University of Nebraska–Lincoln

Variable Rate Spraying System VRSS

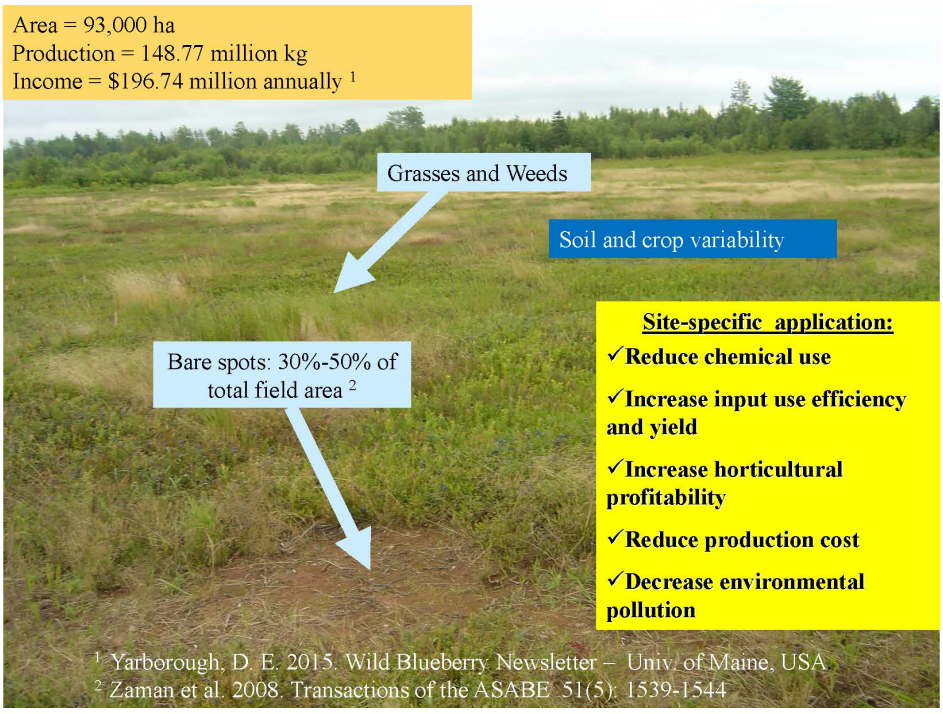
Variable rate spraying system is basically an Artificial Intelligence based site specific crop management technology which allows the product to apply at changing rate.

Variable rate spraying allows the growers to apply adjusted volume rate of pesticides to the target only.

Using VRSS, up to 40-50% of chemical is saved as compared to conventional sprayer, which results reducing input cost and minimal hazards to the environment .



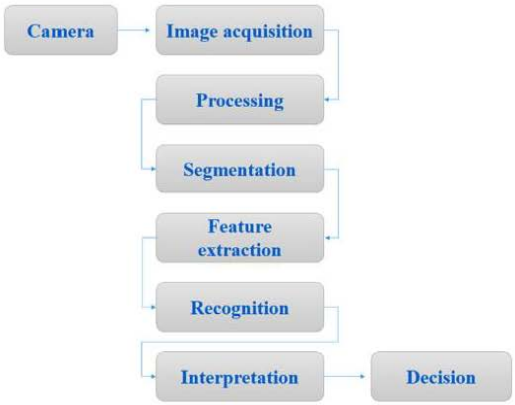
Deep learning based Variable Rate Spraying System



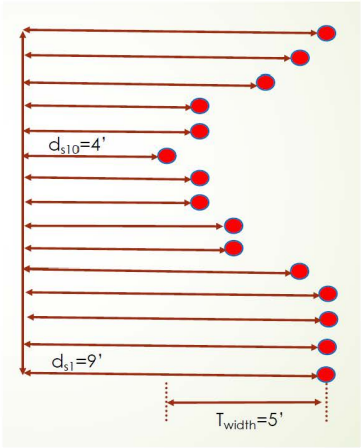
Types of Variable Rate Sprayers

1. Machine vision based:

Machine vision is an efficient method to provide recognition of vegetation position, size, shape, color, and texture information. Machine vision is a computer's ability to see an artificial vision system uses one or more video cameras to acquire images.



Sensor based VRSS



- Ultrasonic Sensor
- LIDAR

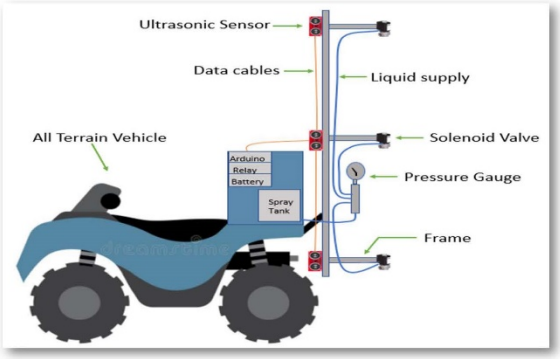
(Light Detection and Ranging)

- RADAR

(Radio Detection and Ranging)

Methodology (Sensor Based for Orchards)

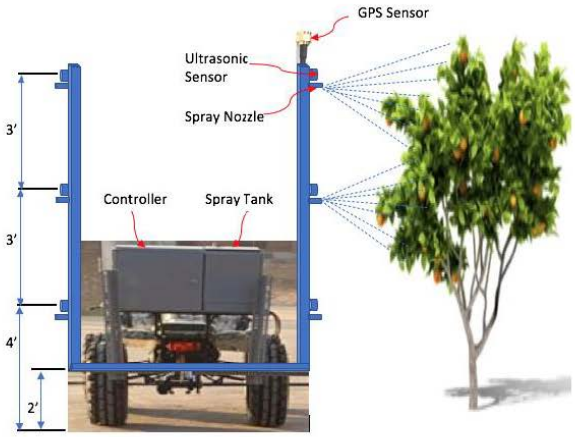
- Step 1: Field visits will be carried out to obtain data regarding various physical parameters of the plant
- Step 2: VRSS will be developed using computer/micro-controller, equipped with solenoid valve-controlled sprayer, flow valve, pressure gauge, and shutoff valve.
- Step 3: Testing on orchard for its performance evaluation under different field conditions.



Materials for orchard variable rate sprayer system

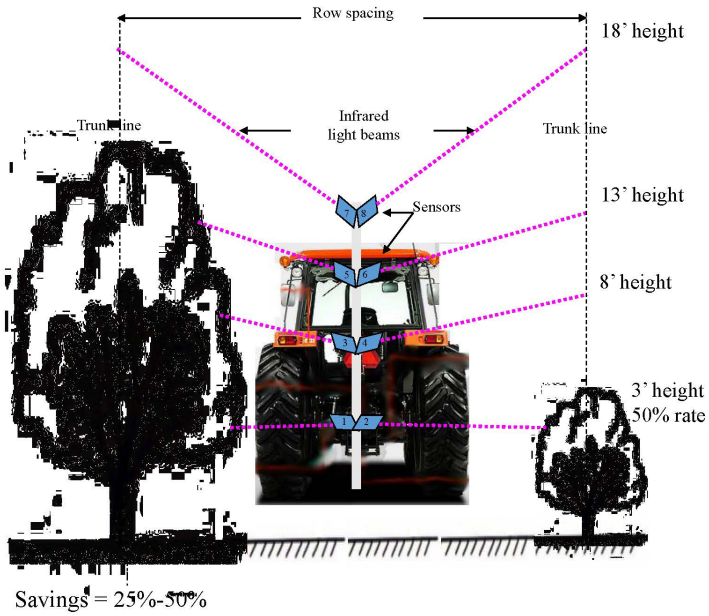
Sr.	Equipment	Description
1	Ultrasonic sensors	Measure the distance to the target
2	Arduino board	Arduino boards to read inputs
3	Speedo Meter	Bicycle operated wired speedometer
4	Solenoid valves	3/4 inches input and output
5	Battery 1	For pump and other electrical works
6	Battery 2	For Solenoid valves
7	Pressure Gauge	For pressure monitoring
8	Bypass valve	To control overflow
9	Pressure control valve	For adjustment with nozzles
10	Nozzles	For spraying
11	Filter	For clearing agrochemical
12	Pump	12 V pump with 15 lpm discharge
13	Shut off valve	On/Off purpose to take pauses
14	Flow meter	Flow calculations and display
15	Supply tank	15 L

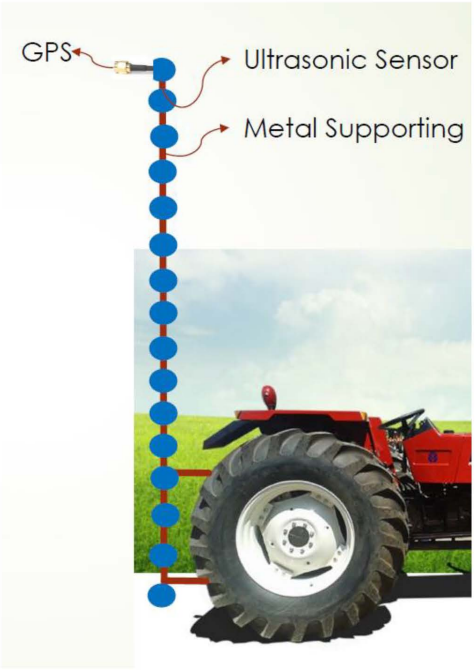
Variable Rate Spraying System Sensor based



Variable Rate Spraying System Sensor based

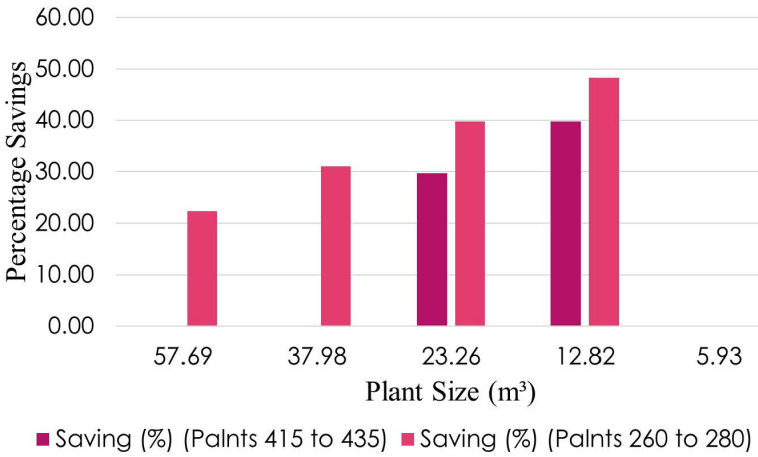
Another Prototype





Variable Rate Spraying in Orchards
(Real time based)

Saving of VRSS over Conventional Sprayer



Nauman et al., 2019

Salient Features

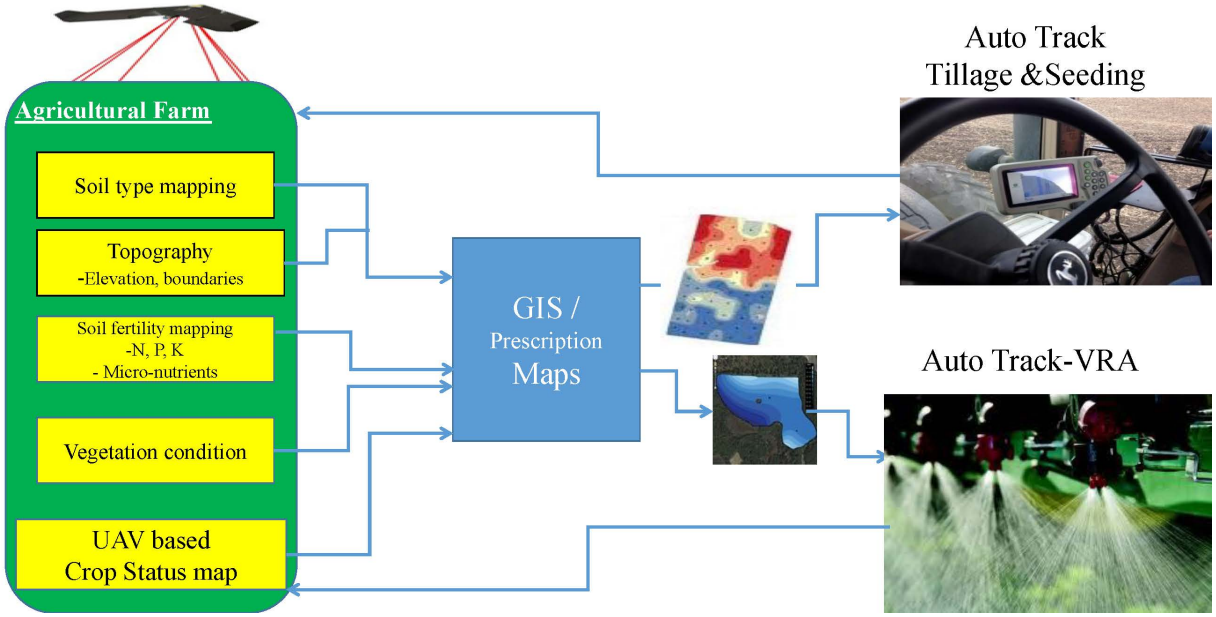
- Automatically detects tree canopy height and width variability
- Adjustable sprayer height, width, nozzle flow rate and spraying angle to ensure equity in application for young to old orchards
- Applicable in wide range of tree canopy volumes orchards i.e. 12 m^3 to 60 m^3
- Gives best results at forward speed of 4 to 5 km/hr, with average field capacity of 1 ha/hr
- Saves spray application cost up to 40% depending upon canopy volume and height

UAV-Variable Rate Spraying System

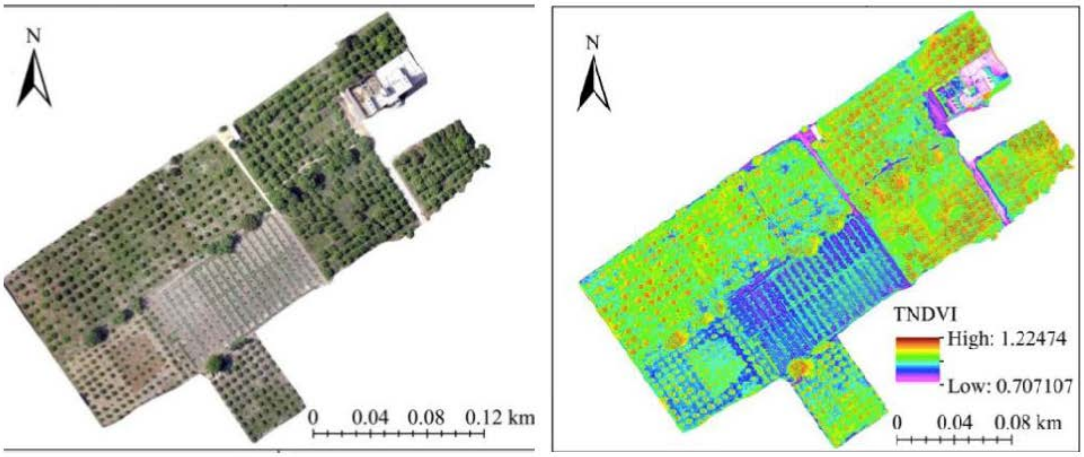
- This is a sensor based Unmanned Aerial Agro-chemical Spraying System (UAAS)
- Indigenized and deployed to spray agro-chemicals for insects, pest control in crops and orchards.
- Spraying Height: 2 – 4 m
- Speed: 2 – 5 m/s
- Coverage: 3.5 – 7 acres/hr
- Ensures no excessive, overlap or Gaps in Spray Patterns.
- 60% Increased Efficiency due to High Coverage

- Agrochemical applications
  - Manual (2000 – 4000 Rs/ha)
  - Tractor mounted (2500 Rs/ha)
  - Aerial
- Non uniform coverage, efficiency, health hazards
- UAVs are Used Globally for management of crops and orchards
  - 20% - 30% proved savings in agro-chemicals
  - Needs improvement in
    - vegetation detection
    - penetrability into the crop canopy
    - droplet coverage ratio
    - heterogeneous droplet distribution

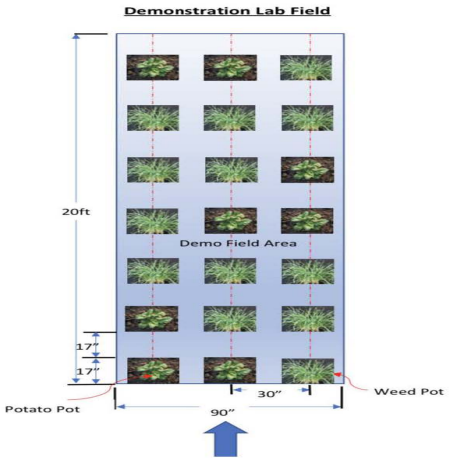
UAV Monitoring and VRSS



Orchard monitoring



VRSS using AI and Deep Learning



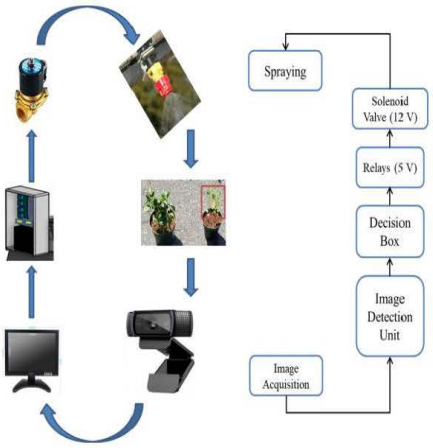
Methodology (Row Crop)

Step 1: Assembling of all equipment according to the proposed design to develop Variable Rate Spraying System.

Step 2: Develop image library from the field of selected crop, based on different features like weather and plant condition.

Step 3: Processing of captured images using Ubuntu software by labeling and making boundary boxes.

Step 4: A detection algorithm (Yolov3) will be used for target recognition while VRS is operating on crop.



Nazar et al., 2020

Design Parameters

• Mounting Vehicle	ATV Economical
• Plant Height	Up to 18", Adjustable
• Detection Mechanism	Machine vision
• Volume of Spray	Up to 8 L/m per nozzle
• Number of Nozzles	3
• Distance of Nozzles	1.5 Foot
• Tank Size	10 liter
• Vehicle Speed	5-10 km
• Visual Interface	Touch screen
• Microcontroller	Real Time
• Data Logging	High speed with wifi
• Play back simulation	On PC/ Laptop

Data Acquisition

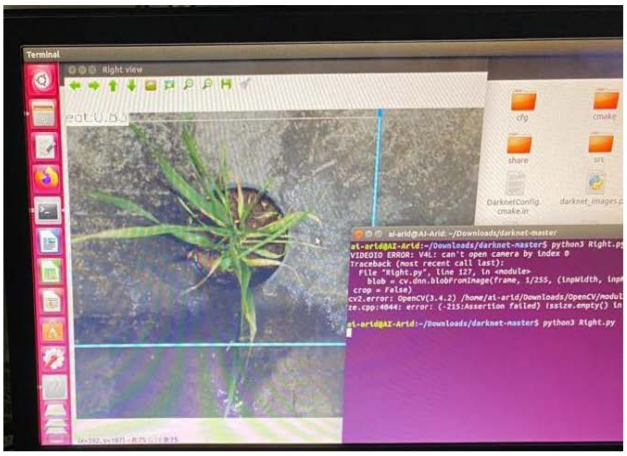
International data source

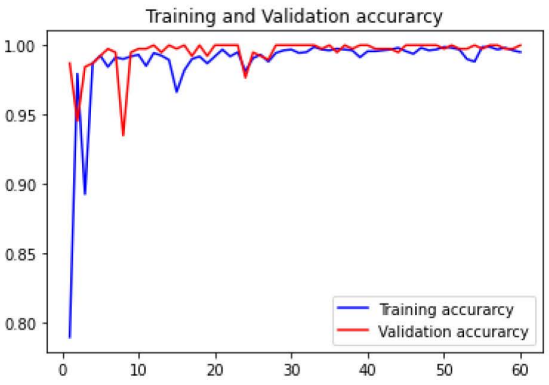
Local data source(Research Farm)

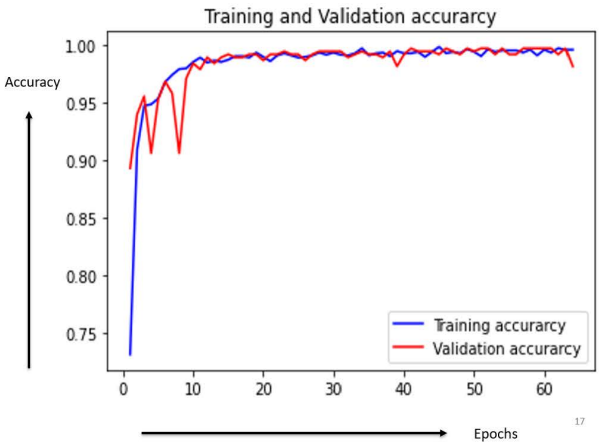
Image preprocessing Tool

Algorithms

- Mobile Net v2
- YOLO V3





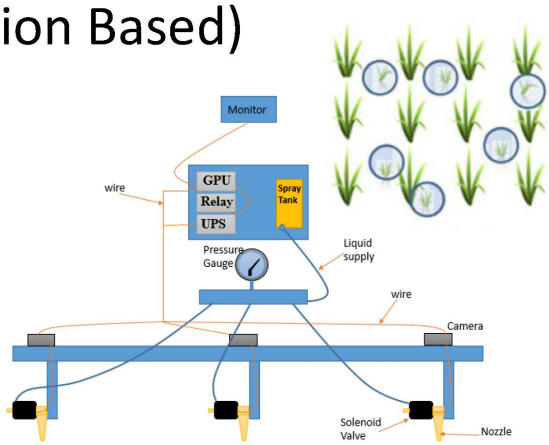


17

```
[INFO] Calculating model accuracy
6/6 [==============================] - 1s 80ms/step - loss: 11.8040 - acc: 0.9774
Test Accuracy: 97.74011373519897
```

```
[INFO] Calculating model accuracy
13/13 [==============================] - 1s 32ms/step - loss: 3.3868 - acc: 0.9925
Test Accuracy: 99.25000071525574
```

Variable Rate Spraying for Row Crops (Machine Vision Based)



Schematic Diagram of VRT Sprayer

Variable Rate Spraying for Row Crops (**Machine vision based**)

- Spraying amount is adjusted by the control unit in real time according to geometrical structure of the plant.
- Reduction of pesticides losses
- Real time
- Cost Saving
- High compatibility
- Reduce Environmental Impacts

Data Acquisition from International Data Source

Maize dataset was acquired from Kaggle which is international dataset repository.

The dataset contains:

Blight disease = 1445

Common rust = 1306

Gray leaf spot = 1376

Healthy = 1162

Data Acquisition from Koont Research Farm

The dataset was acquired from Koont Research Farm PMAS AAUR on different dates. Three diseases and two pest patterns' were found on maize crop which was planted in Koont farm. The diseases are categorized as Blight, Sugarcane Mosaic Virus and leaf Spot. The pest patterns are categorized as Leaf Miner attack and Armyworm attack. Size of the dataset is 27.1 GB. The number of samples that was collected are as follows:

Blight = 3420

Sugarcane Mosaic Virus = 552

Leaf Spot = 871

Pest pattern = 4019

Armyworm Attack

Blight Disease

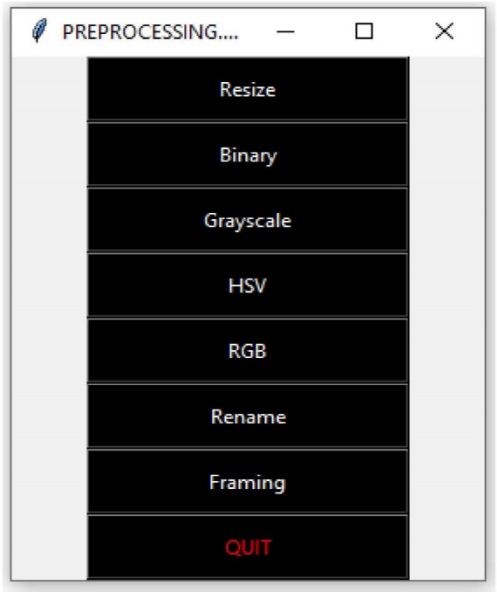
Leaf Miner Attack

Armyworm Attack

Leaf Spot Disease

Sugarcane Mosaic Virus

Image preprocessing Tool



Parameters

Parameters used in vgg16 algorithm are as follows:

- Batch size = 32
- Optimizer = Adam
- Epochs = 60
- Dense = 1
- Loss = Binary cross entropy
- Evaluation metrics = Accuracy, Loss
- Activation Function = Sigmoid
- Train_size = 80%
- Test_size = 20%

International dataset

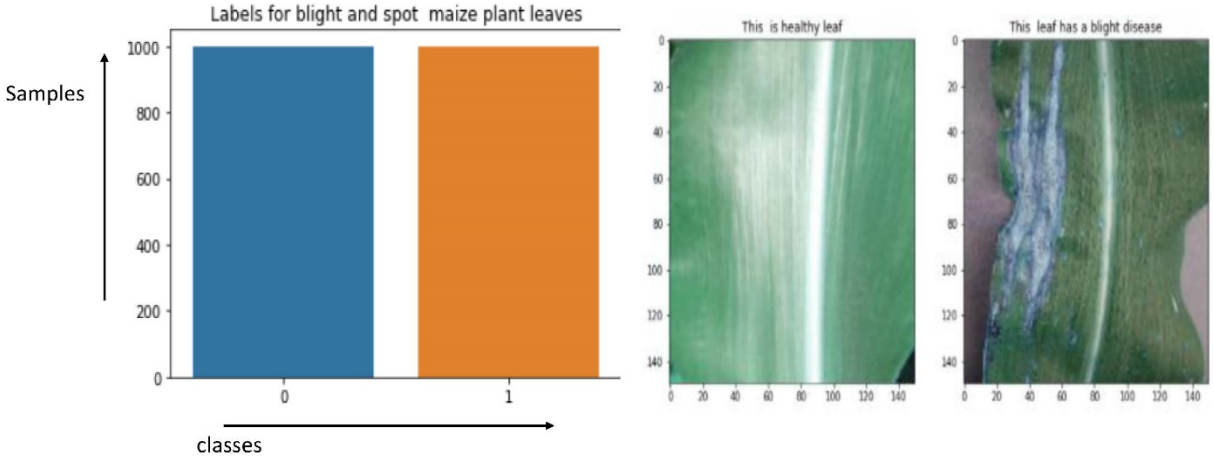
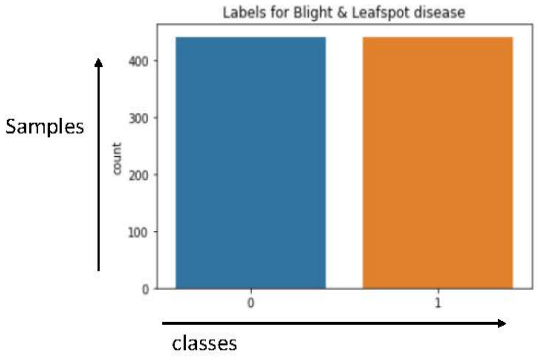
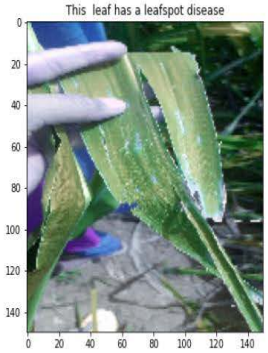
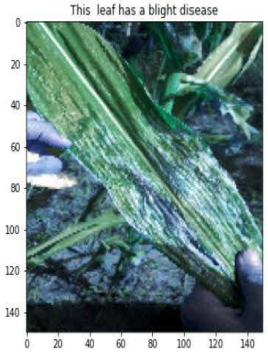


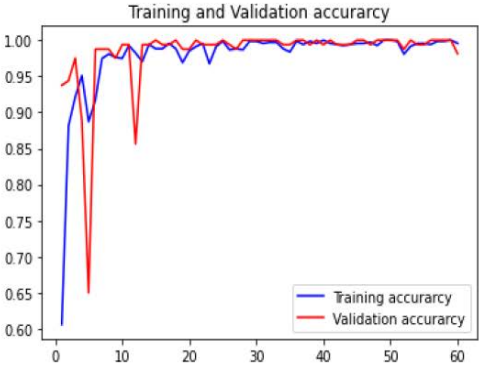
Image classification using VGG16 algorithm on custom dataset

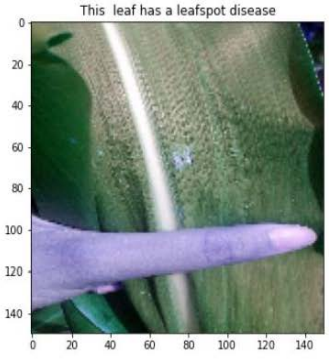


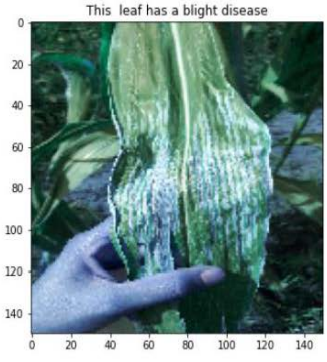




ANN Algorithm





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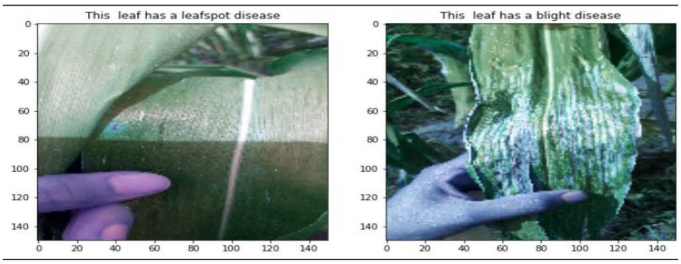
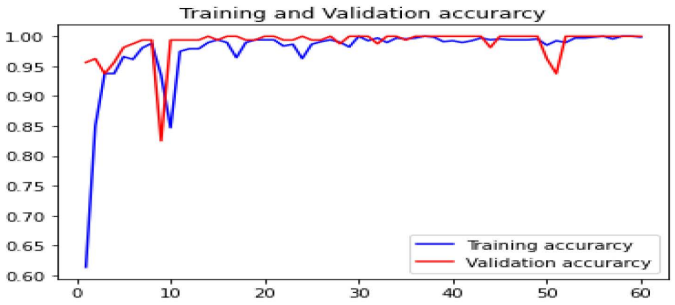
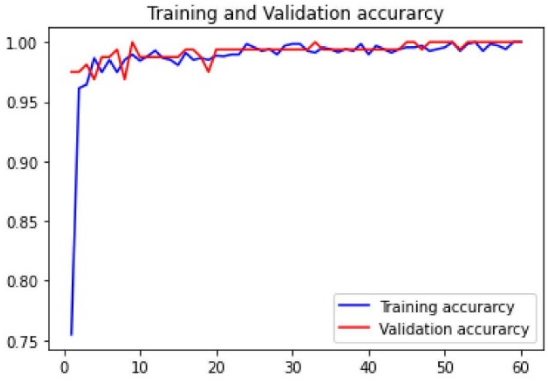
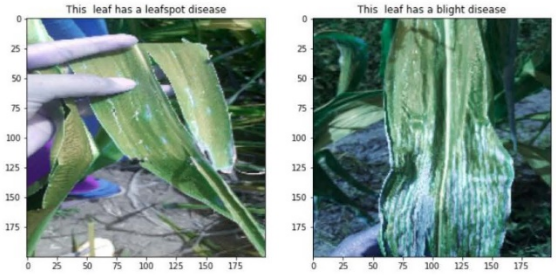
[INFO] Calculating model accuracy
6/6 [==============================] - 0s 49ms/step - loss: 7.0405 - acc: 0.9774
Test Accuracy: 97.74011373519897
```

```
[INFO] Calculating model accuracy
6/6 [==============================] - 2s 349ms/step - loss: 72.1878 - acc: 0.9605
Test Accuracy: 96.04519605636597
```









YOLOv4 mAP

Total 56 images are used for training which consists of blight disease and armyworm pest pattern. The algorithm gives 50% accuracy on testing data.

```
 calculation mAP (mean average precision)...
 Detection layer: 139 - type = 28
 Detection layer: 150 - type = 28
 Detection layer: 161 - type = 28
48
 detections_count = 1273536, unique_truth_count = 46
class_id = 0, name = disease, ap = 0.00%         (TP = 0, FP = 2937)
class_id = 1, name = pattern, ap = 0.00%         (TP = 0, FP = 1109)

 for conf_thresh = 0.25, precision = 0.00, recall = 0.00, F1-score = -nan
 for conf_thresh = 0.25, TP = 0, FP = 4046, FN = 46, average IoU = 0.00 %

 IoU threshold = 50 %, used Area-Under-Curve for each unique Recall
 mean average precision (mAP@0.50) = 0.000020, or 0.00 %
Total Detection Time: 3983 Seconds
```