Row Detection and Automated Steering with Ag Leader

Math-285, Kevin McConnell & Noah King

Ag Leader: Context

Mission Statement, Background Information

What Is Ag Leader?

Founded in 1992 in Ames, Iowa

Now largest private precision farming company, worldwide market with offices in several countries.

Made the first commercially successful on-the-go yield monitor

Helps farmers *"plan, plant, apply and harvest more efficiently and accurately"*

Ag Leader's Mission

“provide a workplace that inspires motivated individuals to create innovative products”

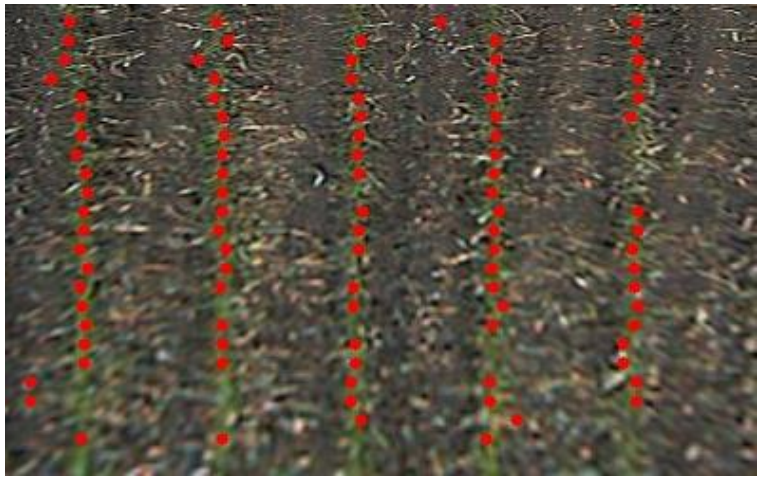
Project Outline

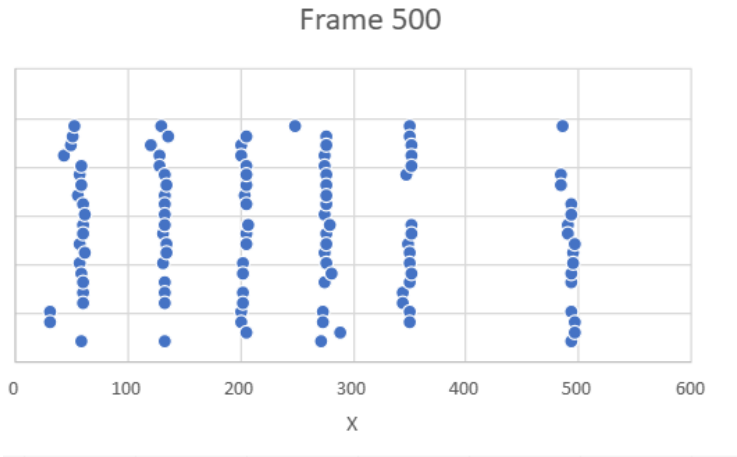
Main Ideas, Goals, & Plan

Our Data

- Based on a camera on a farming vehicle
- Given .csv files
- Crop points represented via (x,y) values
- Roughly 2000 row frames per set

- Mentors:
  - Josue Calderon & Apurba Das; Controls System Engineers





What Is Our Project?

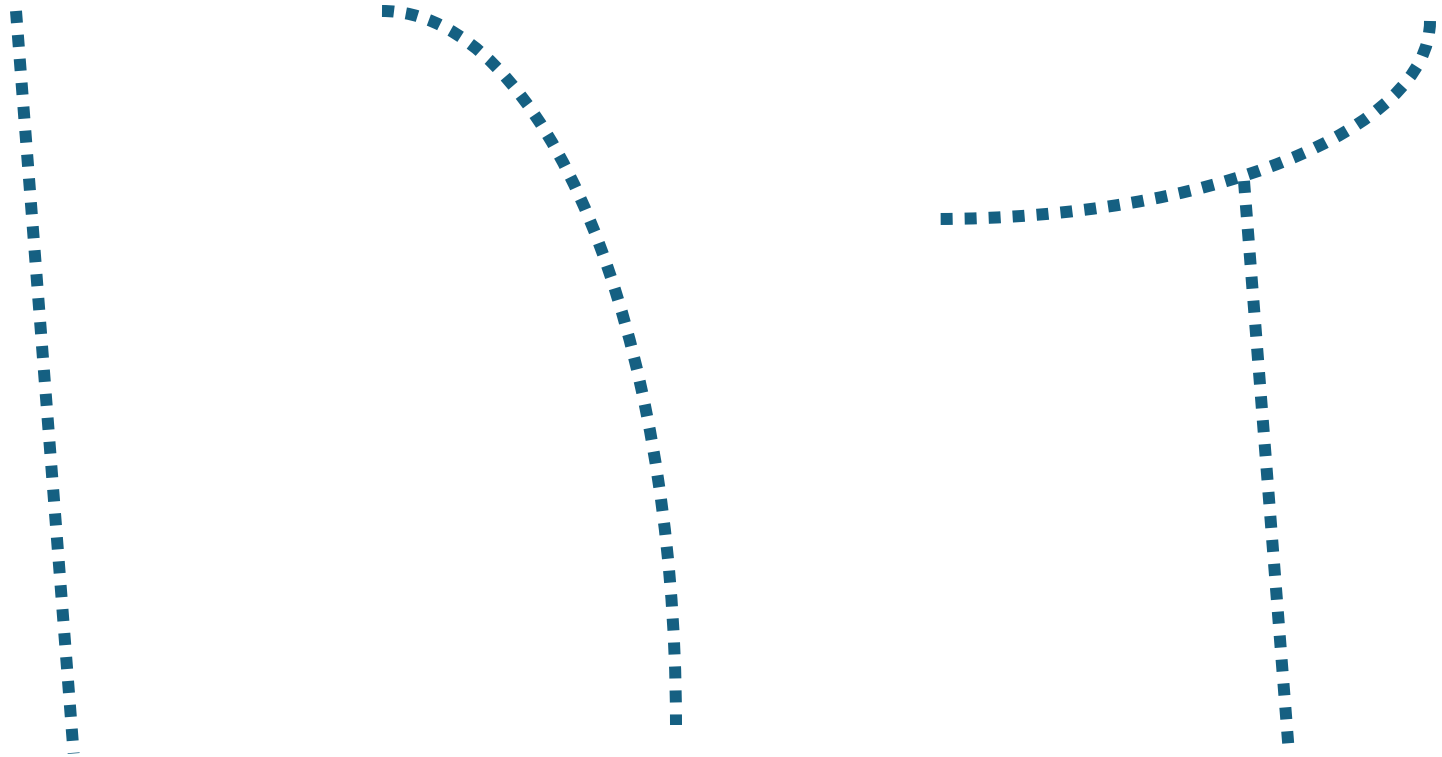
- Dynamically track and correctly join a series of points in space (points already provided)

- **Project involves:**
  - Identifying points representing rows accurately
  - Varying numbers of rows
  - Varying number of points per row
  - Dealing with straight and curved rows

Row Types

Project Involves:

- Straight rows
- Curved rows
- Headlands

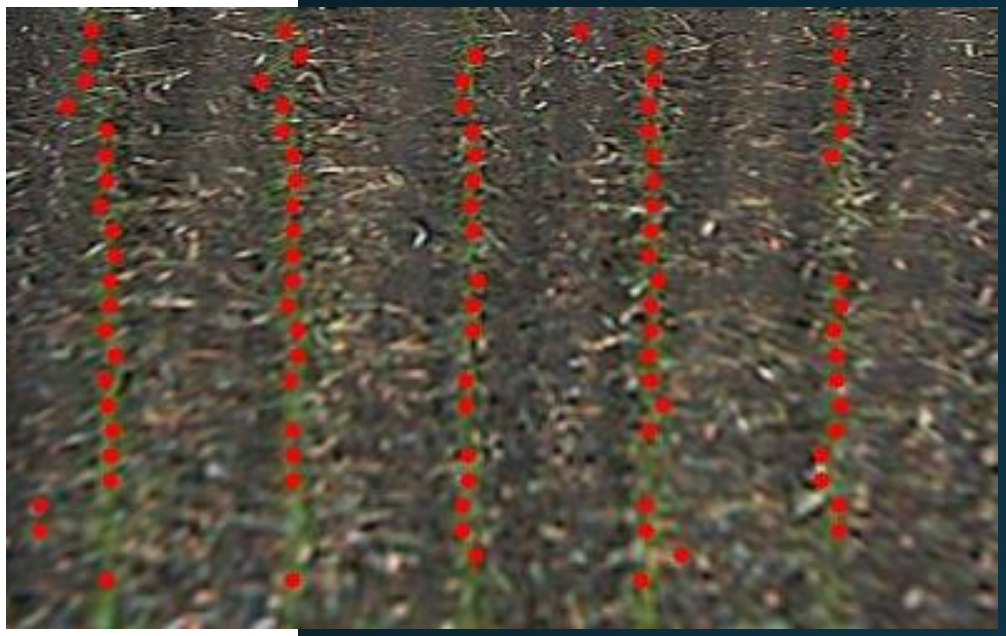


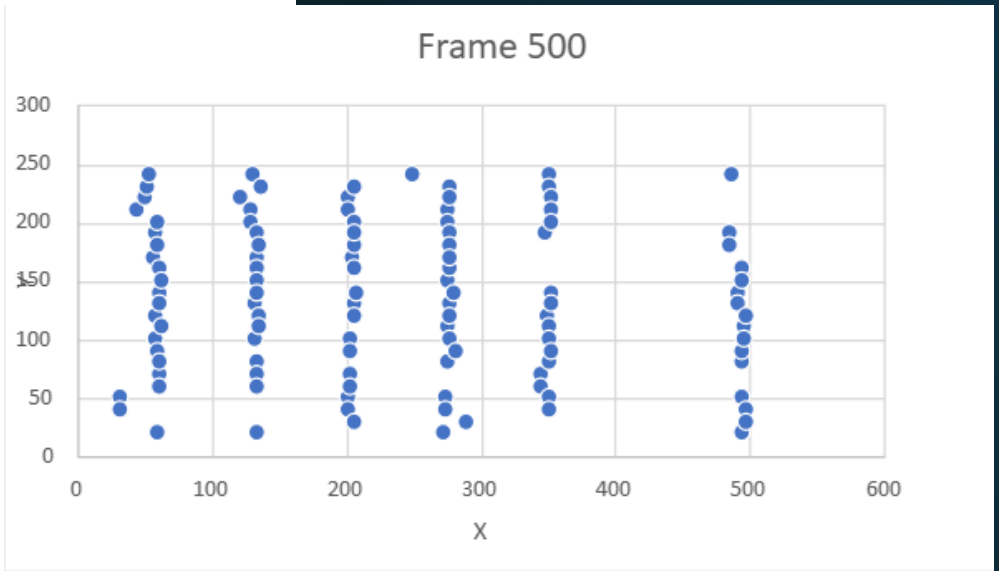
Our Goals

Classify	Classify points into separate rows to determine the number of rows in a frame
Explain	Computationally explain why each point belongs in a row
Steer	Steer a vehicle based on these rows

Imperfections in Rows:

- Weeds
- Fallen plants
- Offset plants
- Missing Rows





Big Ideas

How do we mathematically determine where the rows are?

How do we throw out bad data points?

How do we mesh the rows into one input to steer the vehicle?

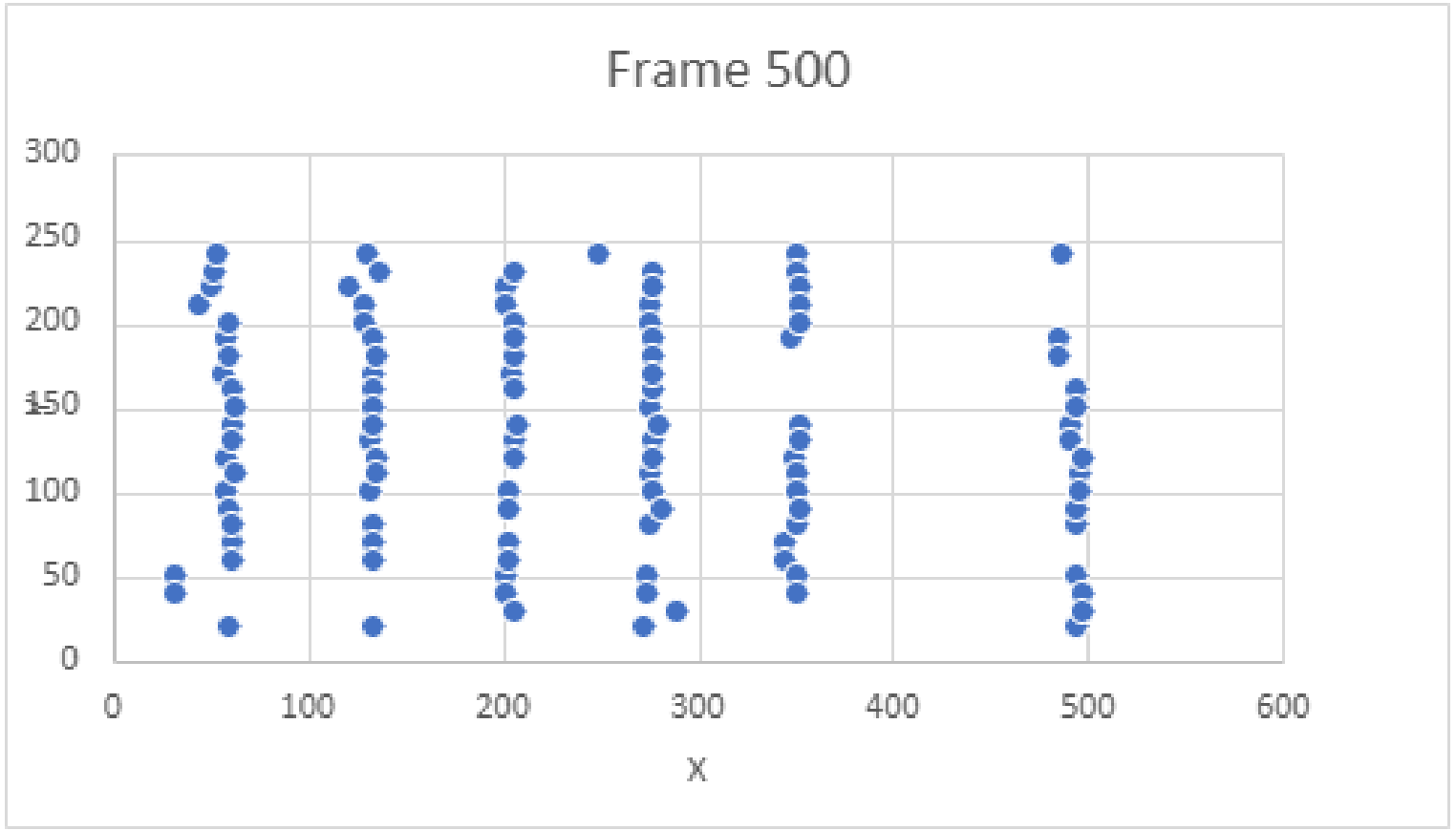
Methodology

Tests, Experimentation

Our Workflow

1. **Straight Data**
   - Excel Single Frame Experimentation
   - Python Full Implementation
2. **Curved Data**
   - Python Single File Experimentation
   - Python Full Implementation

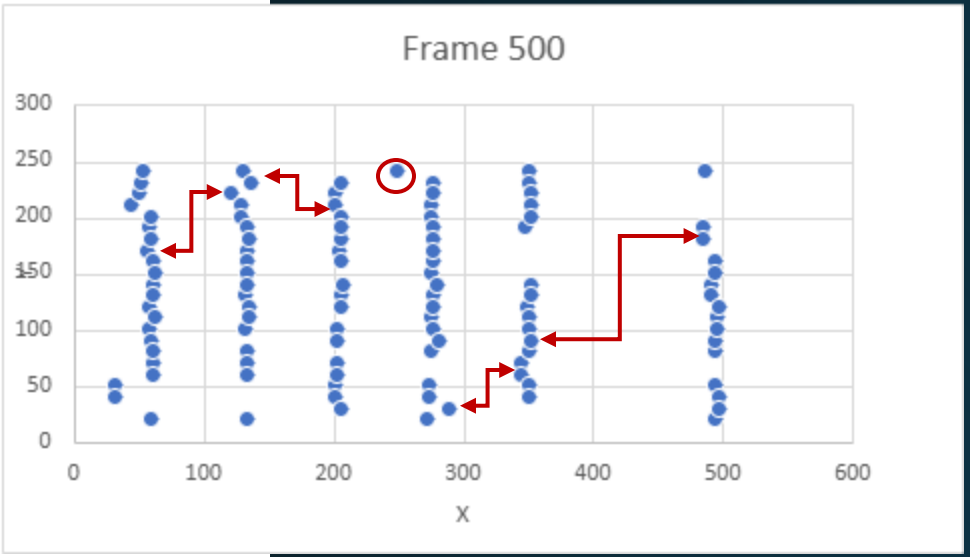
Section 1: Straight Rows

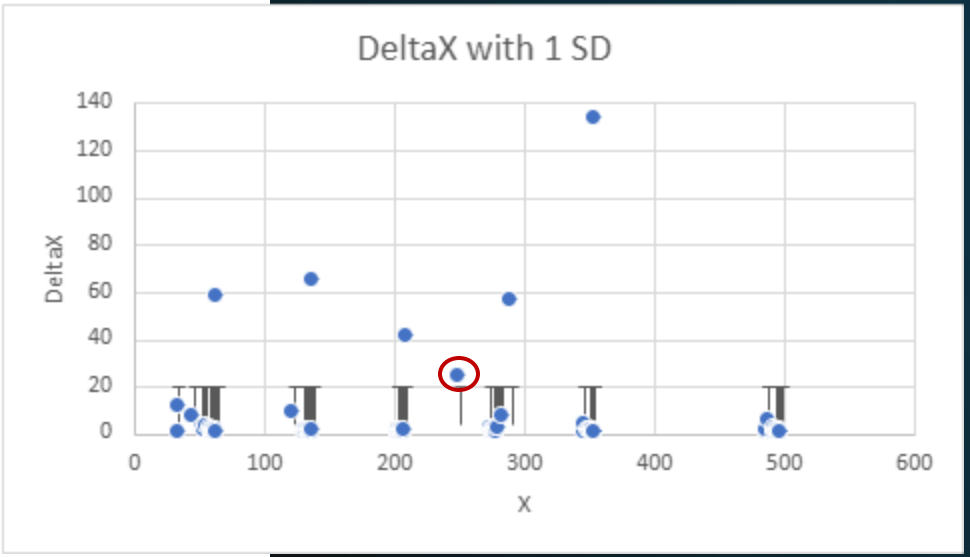


Sectioning Rows

1. Find DeltaX values
2. Detect large jumps in DeltaX values
    1. EX: {1,0,2,1,0,2,**53**,2,0,1}
3. Set a standard deviation from the DeltaX trendline
4. Each large jump outside the SD is the starting point of a new row

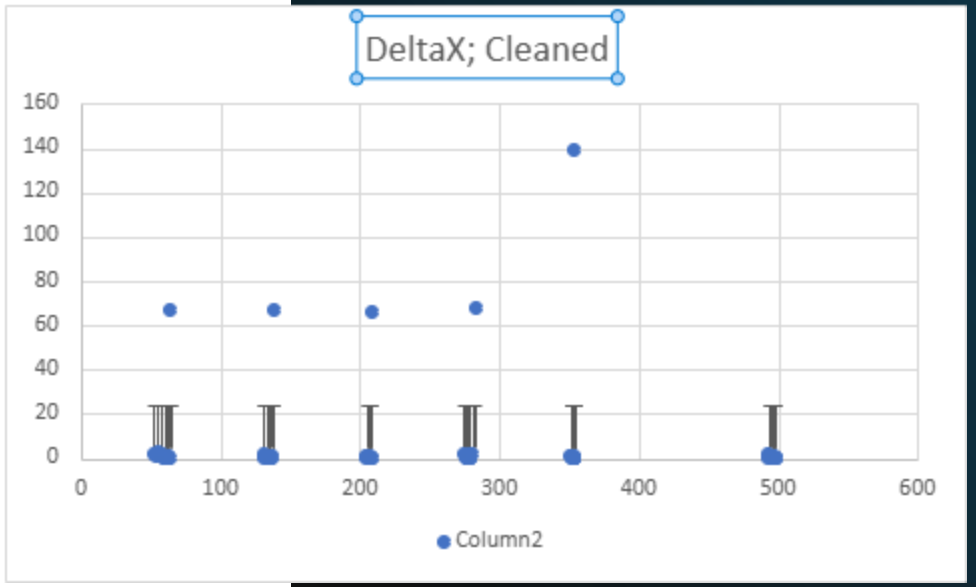
- Issues: More row jumps than there are rows





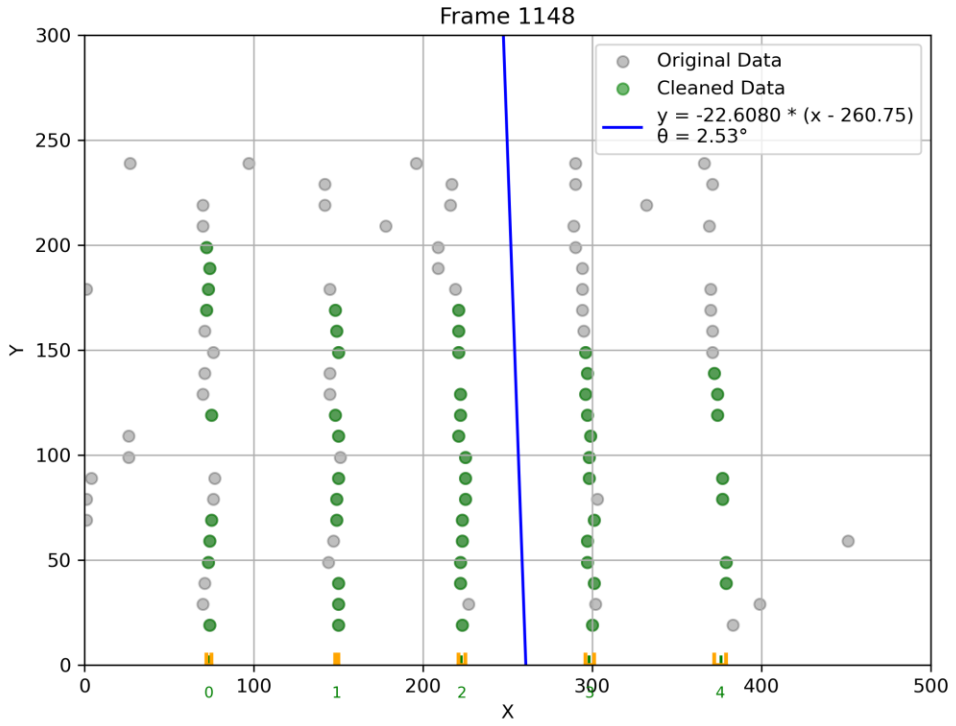
Cleaning Rows

1. Apply “Chemotherapy” method
    1. Removing bad points, but also good points
    2. Works because there are way more good points than bad
2. Apply a 1 SD to the DeltaX graph
3. Anything outside 1 SD is deleted
4. Run DeltaX graph again
5. Anything outside of 1 SD is our row jumps

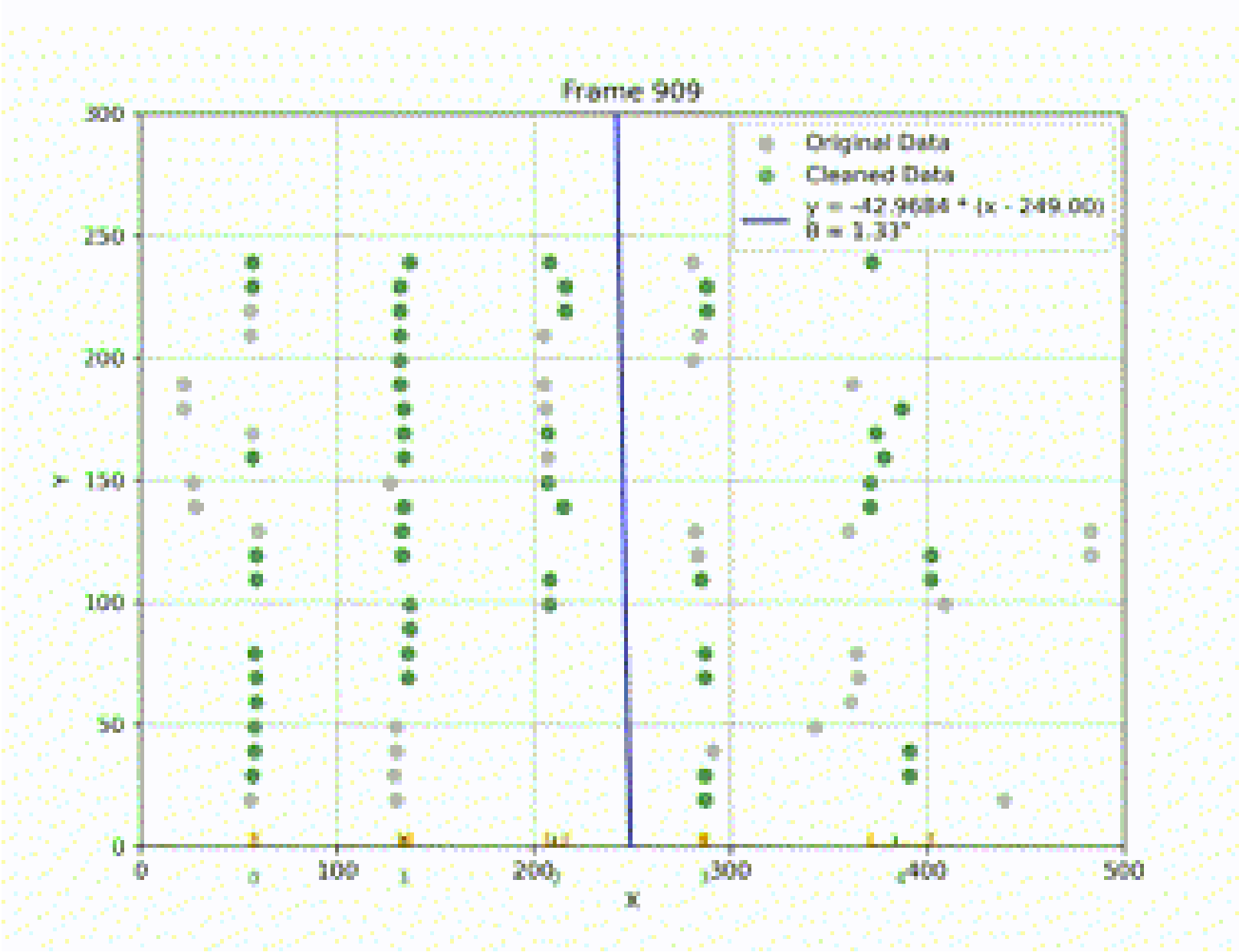


Steering The Vehicle

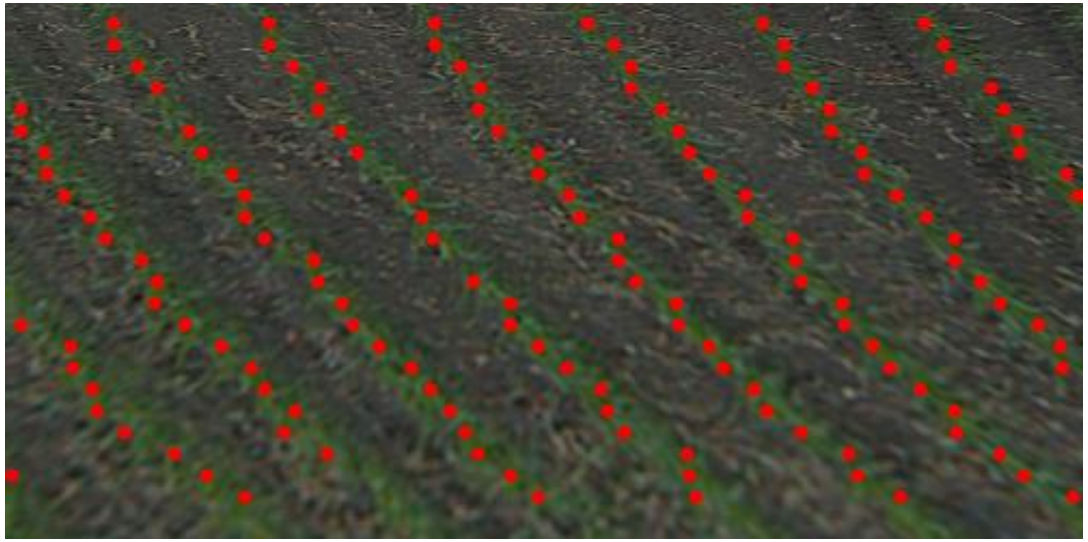
1. Trendline cannot overlay a row (destroys crops)
    1. If there are 6 rows, trendline will be between 3 & 4
    2. If there are 5 rows, trendline will be between 2 & 3
- Find trendline for each individual row
- Take the average of each row's slope (sloping)
- Find a midpoint between each pair of rows, plot the line on the one closest to x=250

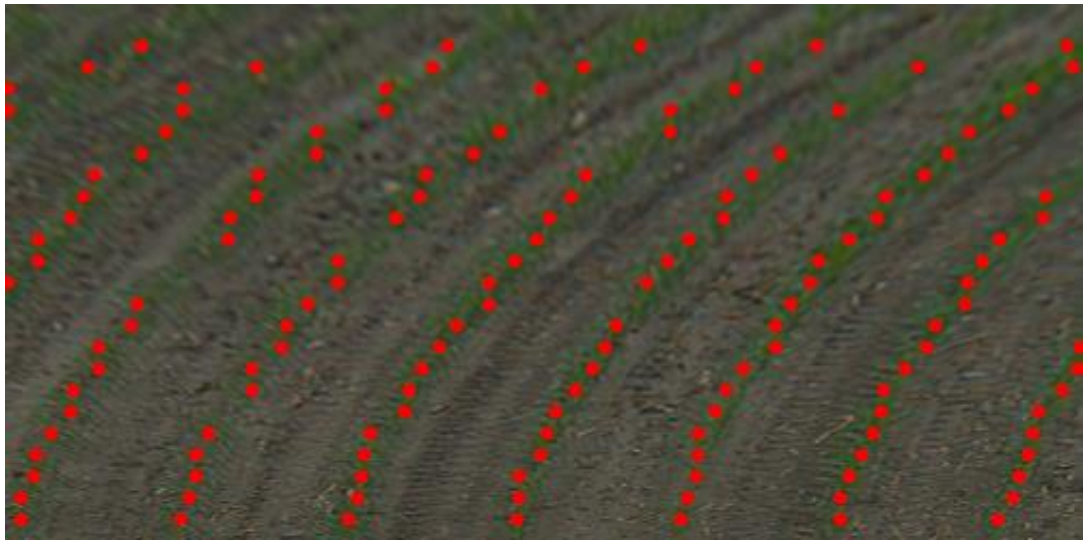


Final Product (Programmed)



Section 2:
Curved Rows





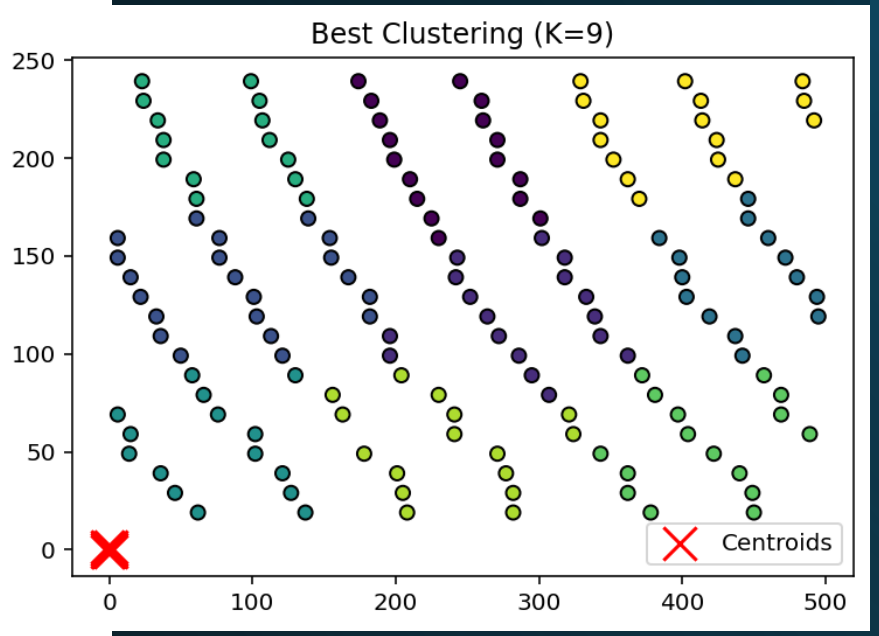
Sectioning Rows

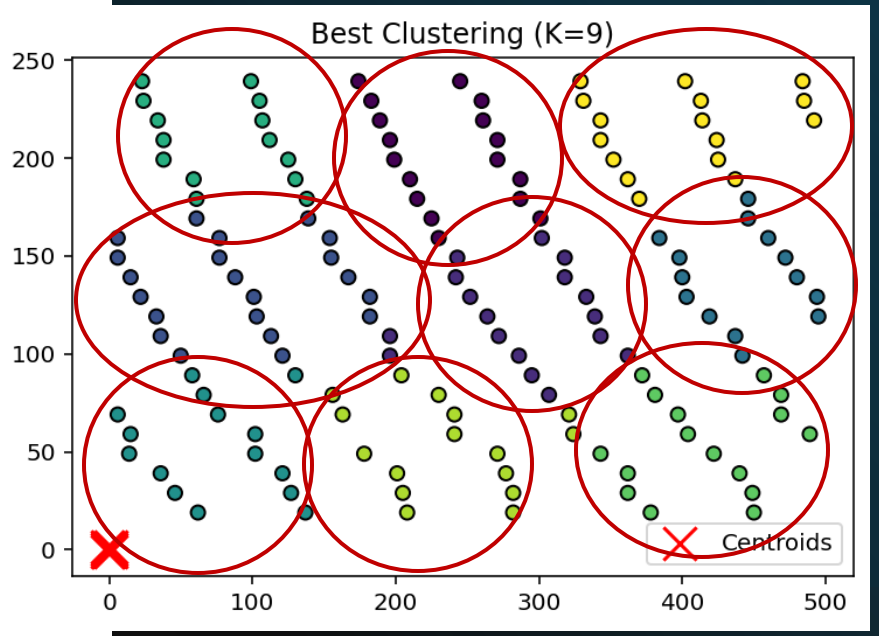
*DeltaX/Chemotherapy no longer works

1. K-means
   - Groups based on a centroid
2. DBSCAN
   - Groups based on density (more later)

Issues:

- hard coded row numbers (K-means)
- Radial grouping on linear data (K-means)
- Lack of data makes DB scan unable to pick up zero density regions(DB scan)

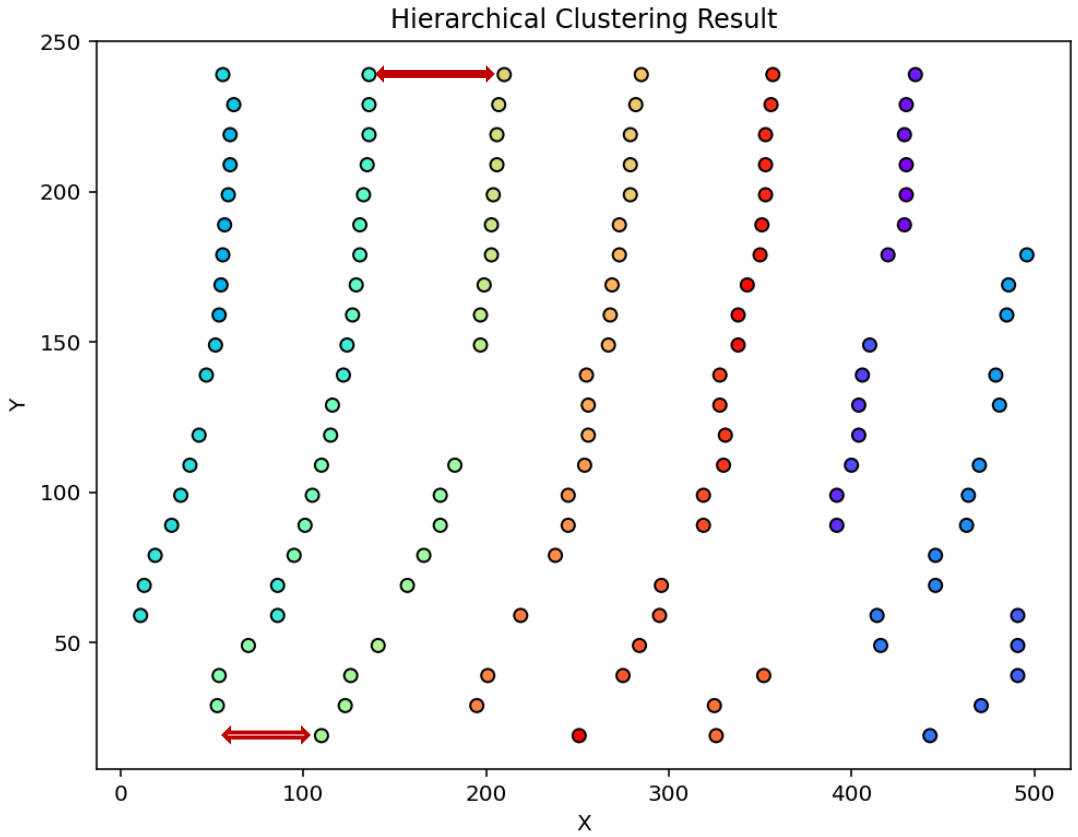




Sectioning Rows Cont.

3. Hierarchical Clustering
   - Row number is not hard-coded

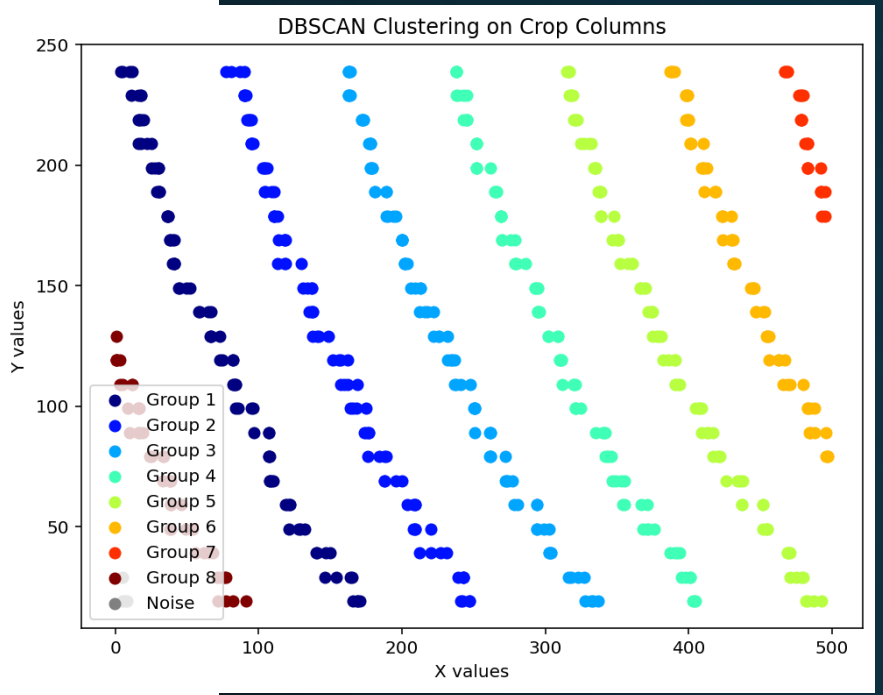
Issues: not efficient when width between rows fluctuates



Sectioning Rows Cont.

4. Overlapping frames
   - Increases density for DBSCAN
   - Take previous 3 frames and combine data

Results: Extra data works well with battling width between rows

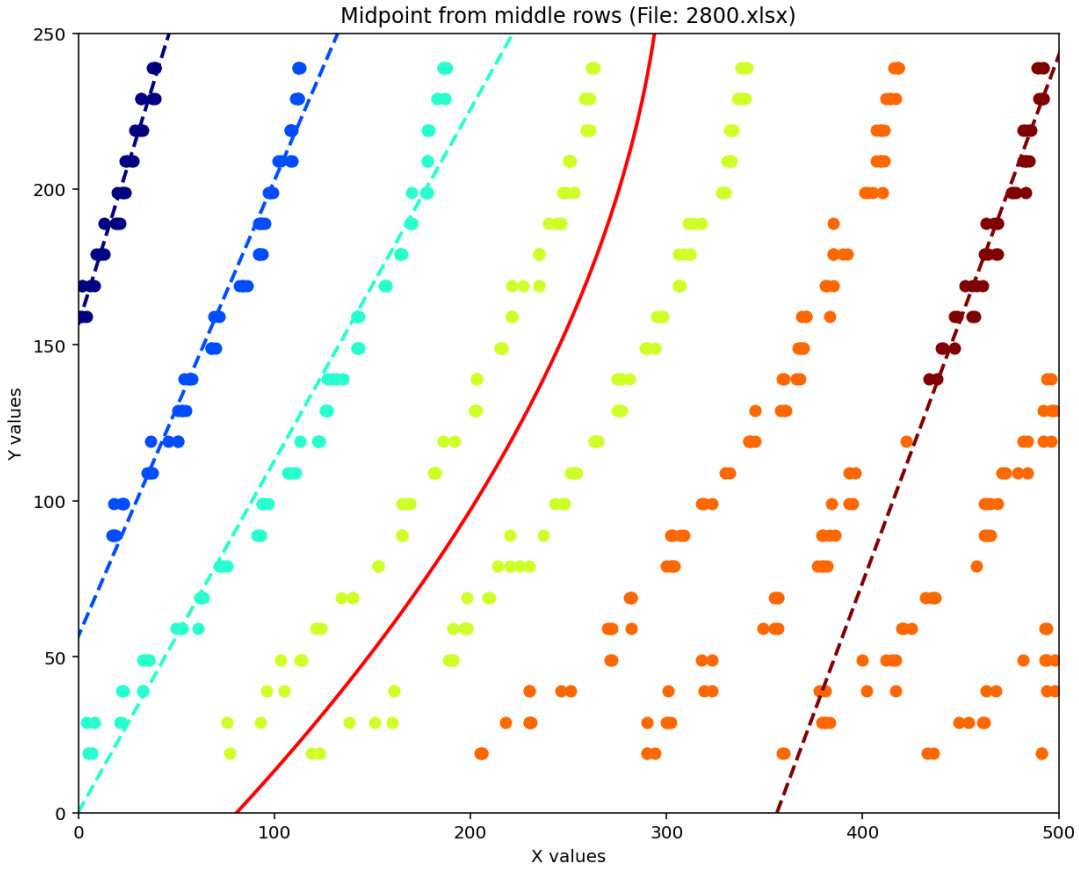


Steering the vehicle

1. DB scan isn't perfect, program still needs to work.

2. Apply a convexity test to fits. Removes any fits created by bad clusters.

3. Find remaining good fits



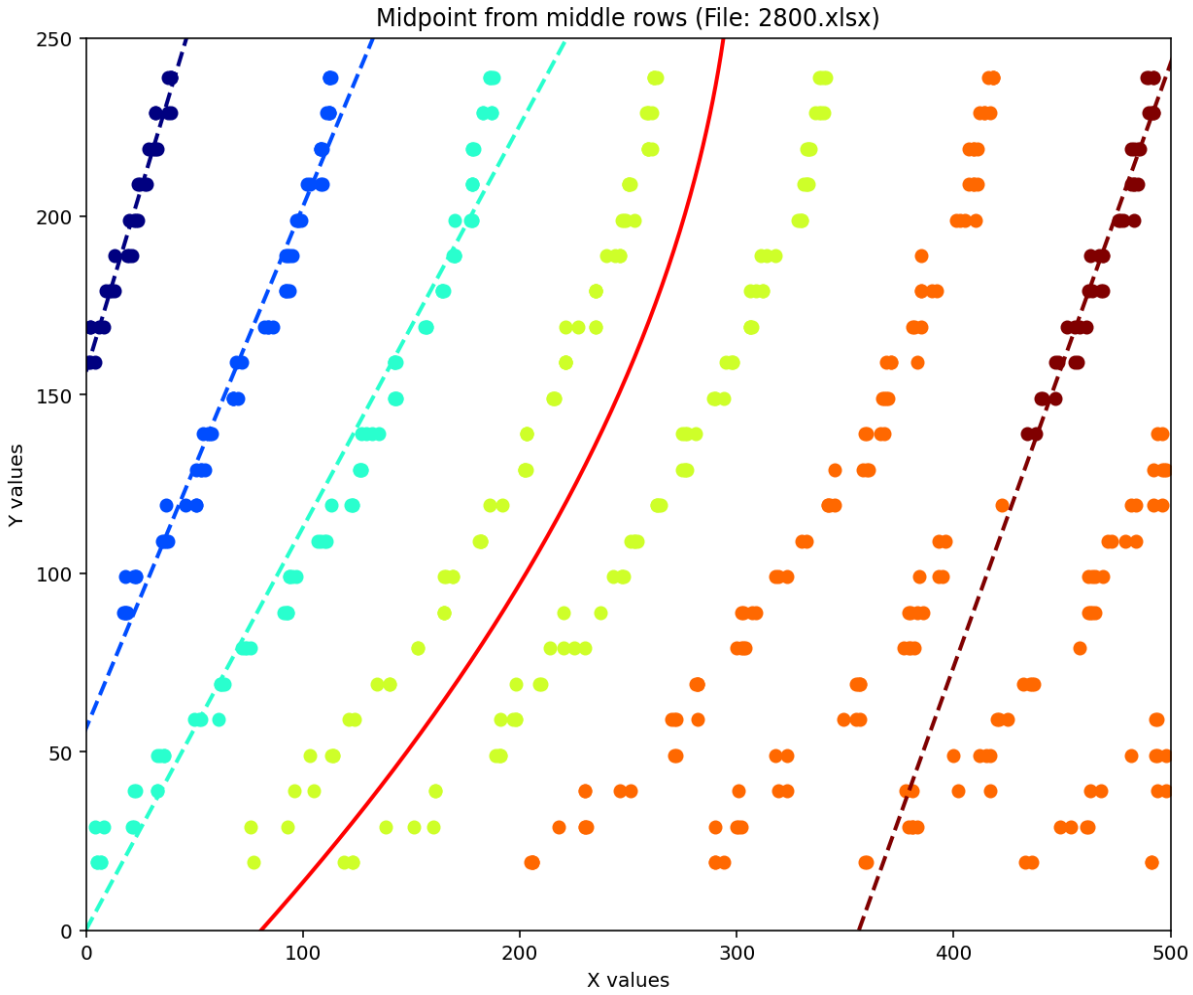
Original fit applied between Blue and teal clusters; Shifted over to a better position and then extrapolated

Steering the vehicle

1. Y values are standardized and evenly spaced due to the way the points are taken from image recognition.

2. Utilizing this and overlay, each Y has several X, can average them to find a midpoint between at that same Y value.

3. Find all midpoints, then take a fit of them to get full line.



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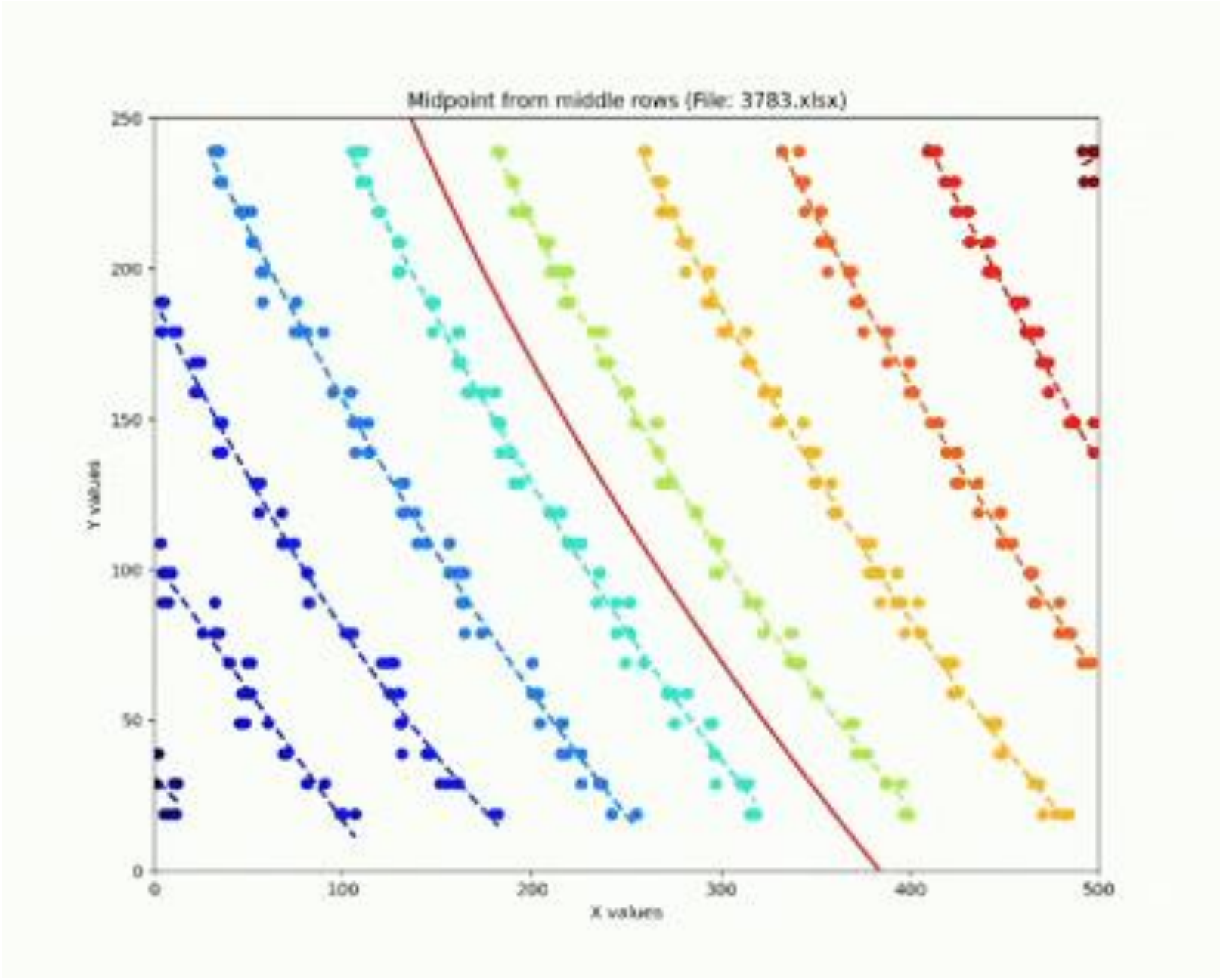
Final Product (Programmed)



Results

Findings, Analysis

Findings

Straight rows are grouped via DeltaX values

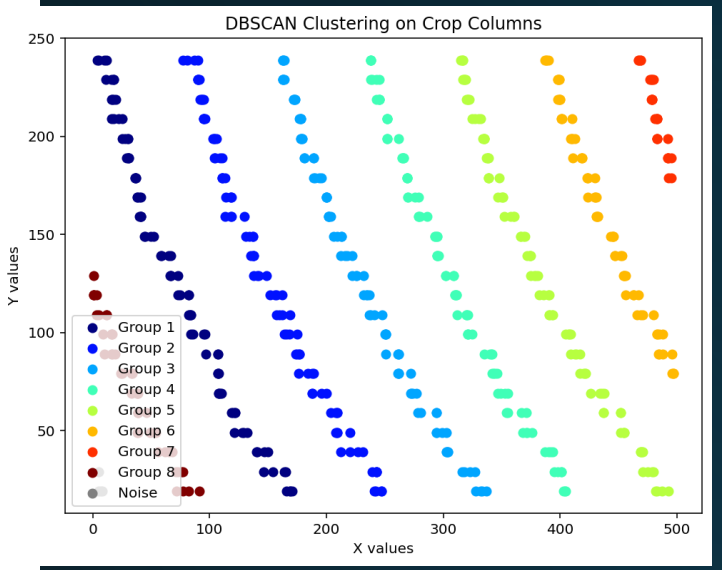
Curved rows use overlaying frames and a DBSCAN

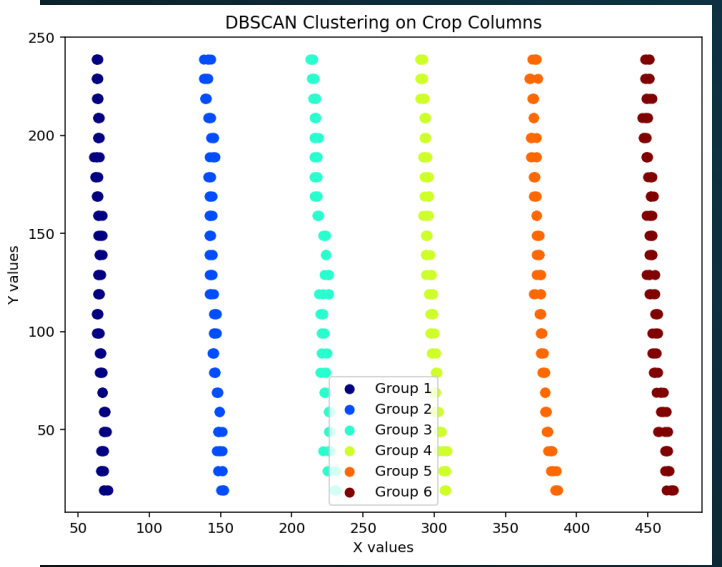
Solution to combine these programs TBC

Closing Remarks

Straights & Curves are separate programs

Headlands are untouched (expected)





Questions?

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