Georeferencing by post-processing sensor outputs
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I. Introduction
  A. Field-based high throughput phenotyping (FBHTP) generates massive raw phenotypic data
    1. Raw data with GPS outputs (UTC time, elevation, longitude, and latitude)
  B. Primary job before data analysis: geo-processing
    1. Assign absolute coordinates to sensor based on vehicle geometry
      a) i.e. how to do it on KSU PheMu with two RTK GPS receivers

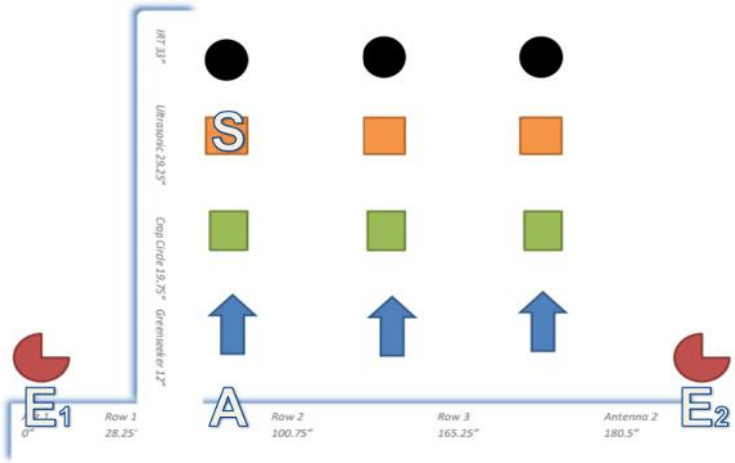

Figure 1 Instrumentation layout of KSU PheMu

$$A\left\langle x_{E_1}+\frac{E_1A}{E_1E_2}\left(x_{E_2}-x_{E_1}\right), y_{E_1}+\frac{E_1A}{E_1E_2}\left(y_{E_2}-y_{E_1}\right)\right\rangle$$

$$S\left\langle x_A+\frac{SA}{E_1E_2}\left(y_{E_2}-y_{E_1}\right), y_A+\frac{SA}{E_1E_2}\left(x_{E_2}-x_{E_1}\right)\right\rangle$$

    2. Georeferencing: position sensor outputs within each field plot
  C. Pre-processing: GIS-based geo-referencing approach
    1. Generate the field map in GIS by surveying the field
      a) Accurate positioning
      b) Supporting multiple plot shapes
      c) GIS technology needed

II. Method A: generating a field map from geographic information of field plots
  A. Geographic information:
    1. Field boundary: four corners (NW, NE, SW, SE)
    2. Plot length (L) and width (W)
    3. Distance between two plot centers (D)
    4. Column and range quantities

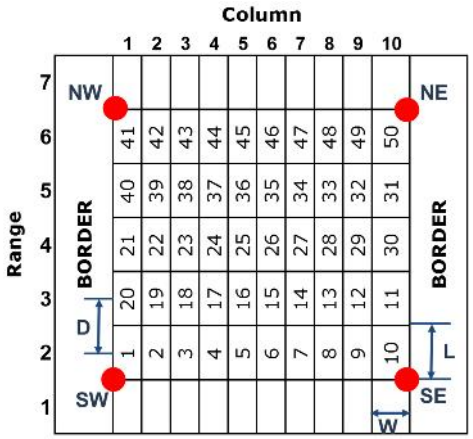

Figure 2 Field layout

B. Algorithm
   1. Set the field boundary
   2. Search the starting point and the ending point of each column
   3. Segment each column into plots according to the range quantity
   4. Find the center of each plot
   5. Trim each plot based on pre-defined plot length and width

C. Example: generating the field map of Ashland-BYD, KS

III. Method B: generating a field map from data pattern information

A. Due to limitation of Method A: i.e. irregular field layout

B. Data pattern:
   1. Feature of sensor outputs related to the plots geographic distribution
      a) High/low GreenSeeker (NDVI) outputs – wheat/soil
      b) High/low UltraSonic (distance) outputs – soil/wheat

C. Algorithm
   1. Set the field boundary
   2. Categorize sensor outputs into two clusters (i.e., high and low)
   3. Filter the low NDVI cluster or the high ultrasonic outputs cluster
   4. Generate field plots by merging geographically adjacent sensor outputs

D. Example: generating the field map of Ashland-PhenotypingPlot, KS

IV. Discussion

A. Method A
   1. Generate a field map from an accurate planted field
   2. Limited by the field plots geographic distribution

B. Method B
   1. Generate a field map from two data patterns
   2. Not limited by field plots geographic distribution, but limited by data patterns
      a) Plot missing example
      b) Unclear data patterns example

C. Both methods
   1. Limited by sensor outputs (so called post-processing)

2. Limited by irregular plot shapes (i.e., center pivot arc-shaped plots or contoured plots)