GNSS for Precision Agriculture

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GNSS for Precision Agriculture:
Plan of the Presentation

1. What’s Precision Agriculture?
2. Benefits of Precision Agriculture
3. Soil Sampling and Its Types
4. GNSS Uses in Precision Agriculture

The METIS project is managed by the European GNSS Supervisory Authority through Euro-MED GNSS I project
What’s Precision Agriculture?

- Also called “Site-Specific Farming”
- It’s an agricultural concept based on applying the right inputs at the right place at the right time.
- It’s relying on the existence of in-field variability.
- Used to manage areas within fields, rather than using the same management on whole the field (Variable-Rate Application).
- Application of a single rate of inputs may result in over-application in part of the field and under-application in another.
Benefits of Precision Agriculture

- Better estimation of the real needs of the crop.
- More accurately predict crop yields.
- Increase of the output and/or reduction of the input.
- Better planning and time management agricultural activities.
- Apply insecticides the places where insect problems exist only.
- Helps farmer set an history of his farm practices and results,
- Helps the farmer in his decision making and traceability requirements.
Soil Sampling

- Includes taking small amounts of soil from representative areas of a field and chemically processing it.
- Needed to determine what rates should be used and where the material is to be applied (variable-rate application).
- Provides a basis for recommendations on improving soil production capability.

Types of Sampling:
- **Grid Sampling**: the field is divided into a grid using suitable cell size,
- **Zone Sampling**: the fields are broken into smaller areas based on some feature (e.g. color, soil texture, landscape position, or remotely sensed data on moisture content or electrical conductivity).
Grid Soil Sampling

- Create a map showing the field boundary (Layer)
  - Using the GNSS to mark the corners of the field
  - Using aerial imagery or satellite imagery loaded into a GIS program
- In the GIS program, grid the field using suitable cell size.
- Navigate to grid point using the GNSS navigation compass
  - Take samples,
  - Mark sample location with GNSS
- Send sample to lab for analysis
- Load maps into a GIS package
- Attach lab results to sample points on the map
- Generating a site-specific map of the properties and
- Finally, using this map to control a variable-rate applicator.
Semi-Automatic Soil Sampler
GNSS Uses in Precision Agriculture

1) Point Guidance
2) Parcel Area Measurement
3) Topographic Mapping
4) Center-Pivot Irrigation
   ▪ Placing Center-Pivots Using GNSS
   ▪ Alignment Control of Center Pivot
5) Variable-Rate Applicators (Top Dressers and Crop Dusters)
6) Yield Mapping
7) Tractor GNSS-Assisted Steering
8) Tracking Livestock
9) Agricultural Remote Sensing
(1) Point Guidance

- The target point is selected on map screen.
- The target position is highlighted.
- A cursor location indicates present position.
- The GNSS navigation compass provides guidance to target.
(2) Parcel Area Measurement

- Walk the field boundary with GNSS unit;

- Denote Perimeter and Area estimate;

- Allowed tolerance = Perimeter \times 1.25 \text{ m.} \quad \text{(JRC Technical Guidance Document)}

- Error = \frac{\text{True Area} - \text{Measured Area}}{\text{Perimeter}} \quad [<1.25 \text{ meter}]

- With EGNOS, performance significantly improved! Meaning significantly better area estimate.
(3) Topographic Mapping

- Starts with the collection spatial data with elevation/height data from an RTK GNSS system (within 2cm horizontal accuracy).
- Once the data is collected, a software analyses the data to produce contour, elevation, slope and aspect maps.
(3) Topographic Mapping

- The topographic data is collected by driving a tractor over the field while performing a farming operation at regular swath intervals, with the GNSS unit logging data points every 5-10m.
- The narrower the swath width the better, as more data is collected to produce more detailed topographic maps of the landscape.
(3) Topographic Mapping

Topographic Farm Maps Benefits:
Useful for designing farm layouts:
• Maximize farm operational efficiency,
• Control erosion, and
• Minimize water logging.
Derived Maps from Topographic Mapping

**Slope Map:**

Blue represents areas of very low slope (< 0.5%); which maybe prone to water logging.

Red represents areas of higher (steeper) slope, which have higher susceptibility to erosion.

Contour lines laid over satellite imagery.

This shows slopes and surface water flows; an extremely useful planning and layout design tool.
(4) Center-Pivot Irrigation

- Also Called “Circle Irrigation”

- It is a form of overhead (sprinkler) irrigation in which equipment rotates around a fixed point (pivot) to irrigate a circular area centered on this pivot.

- consists of several segments of pipe joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length.

- It is fed with water from the pivot point at the center of the arc.

- Used where terrain is flat.

- The crops are planted in a circle to conform to the center pivot.
Placing Center-Pivots Using GNSS

1. Measuring the field boundary with a GNSS unit.

2. Transferring the field boundary information from the GNSS unit to a computer.

3. Using GIS software in the computer to locate the pivot point.

4. Going back out to the field with the GNSS to mark the location of the pivot point.
Placing Center-Pivots Using GNSS

Contours and Sites for Center-Pivot Irrigation Systems
Alignment Control of Center Pivot

Components:
• 3 GNSS Controls:
  – 1st at the center pivot structure which functions as a stationary reference.
  – 2nd at the center length of the water pipe.
  – 3rd at the last or outermost drive unit.
• Drive motor on the center drive unit
• A computer-operated control

The 3 GNSS controls and Drive motor are operatively connected to the computer-operated control

The computer operated control:
- Computes straight line between the center pivot structure and outermost drive unit.
- Operates the drive motor on the center drive unit so that the center drive unit will be positioned within some tolerance of this straight line.
(5) Variable-Rate Applicators

- Allow farmers to treat only affected areas of a field.
- GNSS is needed because variable-rate equipment needs to know where to change the rate of an input.
- Calculates the desired amount of chemical to apply at each moment in time.
- A GNSS system must be used to continuously correlate the location in the field with a coordinate on the map and the desired application rate for that coordinate.
- Most variable-rate controllers actually attempt to synchronize the application rate with the position in the field by "looking ahead" on the map for the next change in rate. This takes into account the time required to change the rate coming out of the applicator and the ground speed of the tractor.
Agricultural Aircraft

- It is an aircraft that has been built or converted for agricultural use.
- They have spraying systems built into their wings, and pumps are usually driven by wind turbines.
- They are referred to as:
  - Top Dressers: when used for aerial application of fertilizer (aerial topdressing);
  - Crop Dusters: when used for aerial application of pesticides (crop dusting)
Agricultural Aircraft: Crop Dusters

• Insects don’t attack a field with a uniform distribution. Instead, outbreaks of insect activity are concentrated in certain areas.
• Workers strolling the crops can use a GNSS to record the locations of insect problems.
• Crop-duster pilots use these data to selectively target the problem areas instead of treating an entire field.
• Saves time, fuel, insecticide and crop exposure to chemicals.

Variable-Rate Application of Pesticides
(6) Yield Mapping

- Traditionally, farmers had one average number in terms of crop yield for a field.
- Average crop yield masks the variability in yield that exists across a field.
- A yield map assesses the field production and how it varies spatially over a field.
- Allows a producer to research the question of why certain areas produced the way they did.
- Used for decision-making in regard to the next planting.
(6) Yield Mapping

• The yield map provide 2 important pieces of information:

  – Yield Variability:
    • illustrated on a map by a set of colors, each color representing a yield range.
    • The map legend will tell you how to read yield variation.
    • Map showing mostly one color means Lack of yield variability.

  – Yield Production:
    • Indicated by the relative magnitude of low and high yielding areas.
    • Which color prevails the map indicates whether there is a high or low yield in a field.
    • Areas of low production may indicate problems in soil nutrient levels, water stress or pest pressure.
Yield Monitoring System Components

Most yield monitoring system has the following components:

- Mass Flow Sensor
- Grain Moisture Sensor
- Computer with Mapping Programs and Display
- GNSS Receiver with Its Antenna
Yield Monitoring System Components

• Mounted at the top of the clean grain elevator in the path of the grain.
• The volume of the grain moving through the clean grain elevator is measured by the amount of displacement of the impact plate that occurs when grain hits the impact plate.
• The displacement of the impact plate is in-directly related to the amount of grain flowing through the clean grain elevator.
Yield Monitoring System Components

Grain Moisture Sensor:
- Located near the Mass Flow Sensor
- Measures the dielectric properties of the grain as the grain flows.
- The higher the dielectric constant of grain, the higher the moisture content.
- Important for various reasons including:
  - Calculating the corrected grain yield,
  - Time of harvest,
  - Estimating costs of grain drying,
  - Storage and handling issues to minimize losses.
Yield Monitoring Concept of Work

Every Second

- GNSS Receiver
- Grain Flow Sensor
- Grain Moisture Sensor

as the combine harvests

• Using GNSS unit readings; ground speed and covered distance can be calculated
• The area harvested = Distance covered × the swath width
• corrects the grain yield for the measured moisture content
• Mapping program prepares a yield map using all stored data across the field
(7) Tractor GNSS-Assisted Steering

- Farmers record their routes while they plow their fields with a recording GNSS system.
- The tractor can then be programmed to follow the same route - for cultivating, fertilizing, pest control and harvesting.

The Wired Tractor

Hands-Free GNSS Assisted Steering
(7) Tractor GNSS-Assisted Steering
GNSS Visual Guidance System

You can see your path before you drive it!
(8) Tracking Livestock

- The location of valuable animals on a large farm can be monitored by GNSS transmitters attached to the animals collar.
- GNSS collars are available with other Accessories like activity-, temperature- or mortality sensor.
- When the animals are sent to market, GNSS transmitters can also be used to track their location.
Remote Sensing = monitor their fields’ condition without physically touching them using remotely sensed images taken from a point of view high above the field (e.g. satellites or aircraft).
(9) Agricultural Remote Sensing

• Agricultural remote sensing is not new and dates back to the 1950s.

• Observing the colors of leaves or the overall appearances of plants can determine the plant's condition.

• Most remote sensors use the same visible wavelengths of light seen by the human eye (Passive) and also detect energy from wavelengths that are undetectable to the human eye (Active).

![Electromagnetic Spectrum Diagram]
(9) Agricultural Remote Sensing

Spectral Signatures of Crops and Soil

Spectral Signatures of Healthy and Stressed Sugar Beets
Remote Sensing Work Concept

Remote Sensor

Ground Station

The Passive Remote Sensing Process
Agricultural Remote Sensing Uses

- Basemaps in variable-rate applications of fertilizers and pesticides.
- To identify nutrient deficiencies, diseases, water deficiency or surplus, weed infestations, insect damage, hail damage, wind damage, herbicide damage, and plant populations.
- Problems within a field may be identified remotely before they can be visually identified.
THANK YOU!

http://www.aui.ma/GNSS/metis/