Precission Agriculture

January 14, 2015

1 Introduction

1.1 Concept

Precision agriculture recognizes the inherent spatial and temporal variability associated with soil and crop factors, and uses this information to prescribe the most appropriate management strategy on a site specific basis.

Precision agriculture is seen to be the correct way ahead for crop producers in the next millennium because crop production is more precise, because inputs are optimized leading to reduced costs and environmental impact, and because the concept provides the audit trail that consumers and legislation increasingly require.

Precision agriculture is based in the combined use of a set of technologies:

- Variable Rate Technology
- Remote sensing
- Positioning system

1.2 Stages

There four general stages of PA practice (remote sensing could be involved in the first three stages):

- data collection
- field variability mapping

- decision making
- finally management practice

1.3 Limitations

The limitations identified for applications of remote sensing systems in farm management include:

- the lack of high spatial resolution data
- the collection and delivery of images in a timely manner
- image interpretation and data extraction issues
- the integration of these data with agronomic data into expert systems.

2 Variable Rate Technology

Variable Rate Technology, probably the best developed part of the PA system, applies production inputs at rates appropriate to soil and crop conditions within fields. Variable rate systems have been demonstrated for several materials, including:

- herbicide (Mortensen et al., 1995)
- fertilizer (Fergusen et al., 1995; Schueller, 1992)
- insecticide (Fleischer et al., 1996)
- seeds

Hanson et al. (1995) described a herbicide application system mounted on a tractor with a GPS guidance system which was linked to a digital weed map, allowing only weed-infested areas of the field to be sprayed.

Brown and Steckler (1995) described a system combined image-derived weed maps with a GIS-based decision model to determine optimum herbicide mix and application rates for no-till corn and resulted in reductions of herbicide use by more than 40%.

Long et al. (1998) have shown that nitrogen fertilizer can be targeted according to a previous season grain quality (protein content) map to improve the efficiency of uptake and reduce spatial variation in quality in the current season.

3 Remote Sensing

Environmental remote sensing essentially makes use of radiant energy, captured by radiometric and sensing devices mounted on platforms ranging from field vehicle to satellite, to extract information on ground features along large swath areas within a short period of time. The basic underlying premise of remote sensing applications in PA is that differences in crop and soil factors can be detected through variations within the spectral responses.

In the case of crops, multispectral reflectances and temperatures of crop canopies relate to two basic physiological processes: photosynthesis and evapotranspiration. In both processes, LAI, the ratio of leaf surface area to ground area, is the fundamental canopy parameter. Therefore, LAI is a basic parameter that can link multi-spectral remote sensing to crop growth and condition for biological measurements.

Remotely sensed images obained with aircraft and satellite-based sensors have the potential to provide the input maps required by variable rate technologies, for the whole field (not just sample sites) and within the time and space requirements of PA applications. The operational success of VRT requires accurate maps of:

- weeds
- crop nutrient deficiencies
- insect infestations
- other crop and soil conditions

4 Positioning Systems

The satellite constellation is complete and receivers typically receive signals from 8 to 12 satellites above the horizon. Most receivers used in precision agriculture are 12 channel and use *phase smoothed pseudo-range positioning* with claimed sub-metre accuracies. A typical example is the Trimble Ag132 receiver with integral differential receiver.

Positioning resolution is seriously limited by the deliberate downgrading, known as *selective availability* (SA), of satellite signals by the US Department of Defense (Langley, 1997a). Although diferential mode compensates for much of the downgrading, there will be significant gains when SA is turned off.

Kinematic GPS, where position is determined by measuring the phase shift in the satellite carrier signal between transmission and reception, gives the potential for centimetre accuracy. Phase shift smoothing is, however, being used in current pseudorange receivers to improve position resolution. By using a double-diferencing technique (Spilker and Parkinson, 1996; Langley, 1998), real-time kinematic (RTK) GPS is possible to provide high resolution dynamic positioning.

Concurrent advances in GPS technology have provided the moderately priced, accurate positioning system necessary for field implementation of VRT.

5 Remote Sensing Platforms

5.1 Airborne

Examples

- A high-resolution airborne remote sensing system has been developed by SpecTerra Services of Perth, Western Australia. Their data, known as Digital Multi-Spectral Imagery (DMSI) can be applied for mapping and monitoring crop and soil variability

5.2 Satellite

Limitations

- timeliness of images because of cloud cover
- poor revisiting times
- cost
- poor spatial resolution
- lack of processing to produce imPositioning Systemsage data of use to the crop manager

Examples

- The LACIE and AgRISTARS programs not only produced ro-bust methods for regional crop identification and condi-tion assessment, but also defined the physics of relations between spectral measurements and biophysical proper-ties of crop canopies and soils.
- X-Star project, led by Matra Marconi Space, plans to launch a high-spatial resolution satellite with a 10 spectral band scanner in 2004.
- IKONOS, a high-spatial resolution satellite with frequent revisit time satellite, was launched in September 1999.

- ESR2, a satellite with a synthetic aperture radar (SAR), which have the advantage of penetrating clouds.
- medium resolution satellite imagery (e.g.,LandsatTM, ASTER, SPOT5), are only useful for large scale studies
- higher resolution satellite imagery (e.g.,WorldView-2 and GeoEye-1) cannot provide high frequency data for emergent situation (e.g., nutrient stress monitoring, disease)with a limited 1–2 day revisit period
- RADARSAT-1, SPOT, and CASI

Instruments

- high resolution (1 – 2 m) images from AeroCam (AeroCam 2003), a multispectral airborne camera that was developed and is operated by UMAC
- medium resolution (20 – 250 m) multispectral images from Landsat Multispectral Scanner (MSS)
- Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+)
- Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)
- Moderate Resolution Imaging Spectroradiometer (MODIS)
- surface relief from the Shuttle Radar Topography Mission (SRTM)

5.3 UAV

Advantages

- utra high spatial resolution
- relatively low operational costs
- near real time image acquisition

6 Decision Support Systems

Future work should be focused on assimilating remotely sensed information into existing decision support systems (DSS), and conducting economic and technical analysis of remote sensing applications with season-long pilot projects.

6.1 Standarized file and data formats

- ISO 11787: referred to as ADIS (agricultural data interchange standard)
- ISO 11783: data bus standardization for tractors and attached implements, based on the Controller Area Network (CAN) protocol

6.2 Geographic Information System (GIS)

Comercial

- LORIS from Kemira
- AMAIS from Farmade
- Agromap from Claas
- Digital Northern Great Plains (DNGP), a web-based remote sensing system available at http://dnpg.umac.org
- Zone Mapping Application for Precision-farming, a decision support tool based on DNGP available at http://zonemap.umac.org,
- Geospatial Data Abstraction Library (GDAL) for raster data
- OpenGIS Simple Features Reference Implementation (OGR) library for vector data
- MapServer to combine various raster and vector layers into a final image
- PROJ.4 Cartographic Projections Library for coordinate conversion between different projections and datum.

Opensource

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7 Marketing

- to promoting their use among the end user community, we followed the innovation adoption/diffusion model of Rogers (Rogers 2003).
- to identify and engage early adopters, we followed a learning community approach (Seelan et al. 2003), where producers were treated as full partners and not as clients of researchers.