Research in Modern Biological And Agricultural Technologies

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Current Research Projects

- Wireless sensor network (WSN) applications
  - Precision agriculture
  - Environmental monitoring
  - Study on critical issues on WSN applications
Research on WSN

First generation of WSN (2007-2008)
- Soil Moisture monitoring
- Tmote system

Second generation of WSN (2008-2010)
- Soil property monitoring (Soil MC, EC, Temp)
- Crossbow system

Wireless camera sensor network (2008-2013)
- Pecan weevil population monitoring
- Janic system

Radio propagation model for WSN used in crop field (2009-2013)
- Second generation WSN
- Wheat field
- Corn Field

Cattle monitoring (2005-2013)
- Grazing activity
Soil Moisture Monitoring System

**Structure:**
Star-topology with 10 Sensor Nodes, one Central Node and one Base Node.
Second Generation

The WSN Conceptual Model

- Sensor Station (cluster member)
- Field
- Central Node (cluster head)
- In-field WSN layer
- Cellular and Internet layer
- Web Server (Data Storage)
- Gate Way
- Cellular Modem
- Cellular Tower
- Network User
- PC
- Internet
Second Generation

Sensor Node Components

- Solar Panel
- Rechargeable Battery
- IRIS wireless Board
- Signal Conditioning Board
- Pin Extension Board

Multiplexer

ECH2O Soil Moisture Sensors EC-5

Field Installation
INSECT MONITORING

- Central Station
- Cellular Modem
- Battery Pack
- Microcontroller
- Wireless Module
- Antenna
- Image Sensor
- Light Source
- Weevil Trap
- Sensor Node
- Research Center
- Grower’s Home
- Cellular Tower
Radio Signal Path Loss Model

In the field, wheat canopy is the major reflection surface and obstacle along the transmission path, attenuation introduces by plant height.

Sketch map of plant influences on radio wave propagation inside wheat field, $h_t$ and $h_r$ are transmitter and receiver height, $h_p$ is plant height and $d$ is the separation distance.
Radio Signal Path Loss Model

Wheat Field at different growth stages

Stage 1: 0 \text{ m} \leq H < 0.05 \text{ m}, \text{specular reflection, Fresnel zone clear;}
Stage 2: 0.05 \text{ m} \leq H < 0.4 \text{ m}, \text{diffusion reflection, Fresnel zone clear;}
Stage 3: 0.4 \text{ m} \leq H < 1 \text{ m}, \text{diffusion reflection, obstacles within Fresnel zone.}

Where $H$ is the plant canopy height in $m$. 

Wheat Field at different growth stages
Radio Signal Path Loss Modeling

Wheat fields: based on two years tests

Model without plant height blocking, $R^2 = 0.822$

$$PL(d) = 15.092 + 24.863 \log_{10}(d) - 5.631 \log_{10}(h_t) - 3.449 \log_{10}(h_b) + 5.397G_b$$

Model inside plant height 1, $R^2 = 0.810$

$$PL(d) = 18.897 + 22.216 \log_{10}(d) - 7.171 \log_{10}(h_b) + 5.071G_b$$

Model inside plant height 2, $R^2 = 0.843$

$$PL(d) = 12.147 + 26.239 \log_{10}(d) - 7.529 \log_{10}(h_t) + 4.808G_b$$

Model inside plant height 3, $R^2 = 0.899$

$$PL(d) = -80.369 + 31.674 \log_{10}(f) + 26.363 \log_{10}(d) - 2.484 \log_{10}(h_b) - 8.438 \log_{10}(h_t)$$
Radio Signal Path Loss Modeling

- Antenna height
  - Height level 1 2m
  - Height level 2 allows 60% Fresnel zone clear
  - Height level 3 the height of corn plants

Corn fields
Radio Signal Path Loss Modeling

Corn fields:

• Investigate radio signal path loss characteristics at different corn growth stages
• Parameters: corn height, density, transmission direction, antenna height, plant growth stages

<table>
<thead>
<tr>
<th>VT</th>
<th>R5</th>
</tr>
</thead>
<tbody>
<tr>
<td>h1</td>
<td>d1 d2 d3</td>
</tr>
<tr>
<td>h2</td>
<td>d1 d2 d3</td>
</tr>
</tbody>
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Radio Signal Path Loss Modeling
Radio Signal Path Loss Modeling

Corn Fields

- Path loss models
  - VT: corn grows to the maximum height
  - h2: ignore diffraction

Transmission angle at 45°:

K(d) = 19.02 – 10*6.9*log10(d)

Transmission along a column:

K(d) = 11.77 – 10*6.1*log10(d)

Transmission along a row:

K(d) = -11.99 – 10*4.3*log10(d)