DATA SENSORS

The Path to Precision Agriculture

Edmund W. Schuster
Laboratory for Manufacturing and Productivity – Data Center Program
Massachusetts Institute of Technology

On April 24, I attended a meeting in Washington D.C. titled **"Engineering Solutions for Specialty Crop Challenges."** The meeting had over 100 attendees, mostly from industry. As part of the agenda for the first day, I gave an overview of my work in modeling agricultural risk. Besides industry-oriented presentations, there were two full days of discussions organized by specialty crop category (day 1) and engineering topic (day 2).

Day 1 - Industry breakout sessions:

Wine and Grape

Tree Fruits and Nuts

Citrus and Subtropicals

Ornamentals

Berries and Brambles

Day 2 - Engineering Topics

Sensors and Sensor Networks

Precision Agriculture

Education and Workforce

Information Technology and Decision Aids

Automation/Robotics/Mechanization

Socio-Economic and Enterprise

During conference, several important topics dominated discussion. The following describes macro themes that form a context for examining the research needs of the specialty crop agricultural industry.

A common issue expressed by nearly all meeting attendees relates to the shortage of labor and the prospects for automation using robotics. Another focus involved the application of "systems" ideas as a way of developing effective technological solutions.

Beyond specific industry issues such as the availability of labor, attendees noted that the forces of globalization are forming a new competitive environment for many high margin specialty crops. This creates a need for better methods of determining production costs (and projected profit) along with an improved understanding of supply chain dynamics and global economic systems. Many growers stated that increasing the yield of specialty crops was the best way to meet competitive challenges from overseas.

With the prospect of gradual global warming, the possibility exists that a shift in optimal growing areas will take place across the United States. Slight changes in average temperature (and climate) might also cause new patterns of plant disease and pest concentration.

While potential climate shift is a long-term factor, there exist short-term trends that will have an immediate impact on United States agriculture. Urbanization has caused a significant loss of productive land and has increased the competition for water. Demographic shifts and the general increase in American population will have uneven impacts across the country. For Example, Southern states like Florida are experiencing rapid population grown as baby-boomers retire. Given continued economic expansion, the construction of dwellings, roads, shopping centers, and businesses will consume ever-increasing amounts of land.

Based on the April 24-25 discussions, it appears that research needs for the specialty crop industry comprise three main areas; mechanical/electrical, quantitative technologies including modeling and data analysis for decision making, and supply chain related issues. Cutting across all three of these areas, sensors offer a particularly interesting application of computer technology.

An important area for future research, agricultural sensors exhibit several differences as compared to traditional industrial sensors that measure temperature, light, humidity and vibration. Though the use of sensors in agriculture is at an early stage, there seems to be several type basic types; 1) fixed sensors that are placed in a distributed manner, covering many acres of orchards, vineyards, vegetable fields, or orange groves, 2) sensors attached to agricultural machinery to measure yield per area or the density of foliage. In all cases, cost will be an overriding factor in deployment.

There are many ideas for developing agricultural sensors. Some include:

- A sensor placed on a tree or grape vine to measure internal water uptake for irrigation planning purposes.

- Development of a new family of sensors designed to analyze the internal quality of fruit. This might include measuring the maturity in the field (sugar and starch content and the rate of growth).

- From a food safety perspective, sensors are needed to measure pathogens and other chemical contaminates.

- In terms of the efficiency of agricultural production, sensors could measure the concentration of pests and perhaps various plant diseases that appear in the field. This would provide better information on when and where to apply chemicals.

- Nanotechnology offers some opportunities for creation of agricultural sensors.

- Forecasting crop size and timing presents an interesting opportunity for sensors relating to the measurement of maturity rate and weight. This might include detection of certain chemicals such as phenols that have significant pharmacological properties.

In all applications of agricultural sensors, there is concern about making the data interoperable and applying various means such as mathematical models to analyze the data. The M Language, under development at the MIT Data Center Program, might offer a solution to this problem. By using existing standards such as XML, the M Language can integrate data through a unique treatment of semantics. In addition, M also provides a framework for making mathematical models interoperable with data.

Historical productivity improvements in agriculture have mostly originated from greater mechanization, hybrid varieties with higher yields, and various agricultural chemicals that enhance nutrients in the soil and control the spread of pests and plant diseases. In the future, the use of sensors might represent the next frontier in agricultural productivity. Broadly speaking, researchers call this discipline *precision agriculture*. More data about field conditions is critical to targeting the application of agricultural chemicals and optimizing the use of water. Given a world of finite resources and growing population, chemical application and water availability are significant issues. Data, gathered through a new generation of agricultural sensors, holds the promise of improved analysis that will lead to the best way of applying these inputs.