POTATO YIELD MAPPING METHODS

by
Ron Campbell and Ray R. Hollist
HarvestMaster, Inc.

Introduction/Product History

HarvestMaster, Inc. is a Logan, Utah based agricultural electronics company dedicated to providing Information Machines for Agriculture. Over the past few years, we have focused primarily on field data collection systems for Ag researchers doing variety testing and plant breeding.

During the fall of 1993 we were solicited by a potato farmer in South East Idaho to provide data logging capabilities for their yield mapping program. We provided the data loggers, and Washington State University provided a research physicist to instrument the harvester, program the data logger and acquire the data. To our knowledge this was the first continuous flow yield maps done for potatoes.

About the same time, Dr. Steve Rawlins of USDA-IAREC in Prosser, WA invited us to cooperate with him in the mapping of corn, wheat and potatoes at their research site in Patterson, WA. In 1994, potato yield was again mapped at the USDA site as well as a portion of a center pivot in the Columbia River Basin of Washington. After the 1994 season, some product improvements and revisions were made, and a beta test release was scheduled for the fall of 1995. Seven units were sold to companies, universities and growers in Washington, Idaho, Minnesota and North Dakota. Potato yield was mapped on between 500 and 1000 acres of potatoes and sugarbeets. This included five complete center pivots in Washington.

Objectives

At the beginning of this project, we identified three key reasons for developing this technology. They are:

> 1) It makes a lot of sense to move Ag research to the actual farm where those results are expected to be valid. That is, we ought to be doing our research on the same soils, with the same tillage practices, and in the same climate as where we intend to use these results

---

This Presentation is part of the Proceedings of the 1996 Washington State Potato Conference & Trade Show.

2) There appear to be many gains possible in terms of site specific management practices on the farm. Site specific yield information is one of the critical pieces of information required before implementing site specific farming.

3) There has been a lot of work done mapping yields in grain crops such as corn, wheat and soybeans, but none to our knowledge, on the yield mapping of bulk crops such as potatoes and sugarbeets. Our overall objective was to determine if such a system were feasible.

Next, we determined the key objectives that needed to be met in the field for producers to adopt this technology. These are:

1) Develop a simple conveyor weighing method.
2) Integrate the weighing sensors with a suitable data acquisition system.
3) Incorporate an accurate harvester position sensor with the yield sensor.
4) Develop a method to transform raw yield measurements into maps.
5) Design the system to be both durable and easy to operate.

System Design

The overall operation of the system consists of four modules working in unison. These are; weight measurement, position measurement, signal control and conditioning, and serial communications and data storage.

Weight Measurement

The weight measurement system consists of a pair of load cells and a conveyor speed sensor. The load cells are designed to replace a set of idler wheels across from each other on the final delivery conveyor of the harvester. Load cell placement is the most critical aspect of a successful installation. Improper placement can lead to inaccurate weight readings, and worse, loss of data and diminished return on investment. The load cells should be placed on a flat section of conveyor that will not be affected by the raising and lowering of the boom. The roller on the load cell should be no higher or lower than the upstream and downstream idler rollers.

The conveyor speed sensor should be mounted so that it is facing the shaft of the conveyor drive system. A magnet is attached to the shaft, and the speed sensor is placed so there is approximately 1/4" between the tip of the sensor and the magnet. Weight per unit length of the conveyor multiplied by conveyor travel per second gives weight of product per second, a mass flow measurement.

Position Measurement System

For position measurement we used the Global Positioning System (GPS), operated by the Department of Defense. The GPS is a constellation of 24 satellites in continuous orbit around the earth. Orbiting satellites are continuously sending out a signal. Receivers here on earth pick up the signal and determine where the receiver is approximately located.

For agricultural purposes, we must use Differential GPS in order to have high enough accuracy's for yield mapping and other site specific applications. Accuracies without DGPS will range between 30 and 300 feet.

DGPS requires a base station to be positioned over a known location on the earth. The base station receives the GPS signal, calculates the difference between where the GPS says it is and where the base station knows it is located. The base then sends out a correction factor to the roving receiver. Simultaneously, the receiver on your harvester is picking up the raw GPS signal and also the correction factor from the base. With this information, the roving unit calculates where it is at that moment in time. This process can be repeated every second. Typical DGPS accuracy's range from less than 20 inches to 15 feet depending on the quality of GPS equipment you are using.

For our tests this year, we used GPS equipment from Ashtech and Trimble Navigation. Both systems performed very well in the field. The Ashtech system was rated as sub-meter and performed typically in the 70-80 cm range. The Trimble receiver was rated at 2-5 meters and performed well within its specifications. For the 1996 season we will be supporting our system to work in conjunction with Ashtech, Trimble, NovAtel and Rockwell GPS receivers.

Along with the harvester GPS receiver, it is necessary to have a Differential Correction Signal from somewhere. There are three options typically available.

1) The user could invest in their own base station. The advantage is to have control and access to the signal at all times. The disadvantage is the cost to purchase and then maintain a base station.

2) There are several differential corrections services available for an annual fee. These include AM, FM and satellite broadcast corrections. You can typically purchase the accuracy of signal you want. Higher accuracies do cost a little more.

3) Lastly, many areas of the US are covered by the Coast Guard Beacon System. This includes major inland waterways, the Great Lakes and coastal areas. The signal is free, but you still have to purchase a receiver. Individual producers will have to weigh the options and decide which system best suits their needs.

Signal Conditioning and Control Unit (SCCU)

The SCCU functions to convert raw weight and conveyor speed into reliable information and to receive position information. When the harvester starts to operate, the load cells output a raw signal as does the speed sensor. The conditioning portion of the SCCU makes this information useable to the computer.

We are receiving a GPS position at a given interval that is set by the user. Typical intervals are 1, 3, or 5 seconds. Weight is continually being accumulated. At a given time interval a GPS position is requested. Calculations are made based on distance traveled and swath width to determine area harvested between GPS positions.

Weight divided by area give us yield in sacks/acre. The yield at that GPS position is sent to the task computer, and stored in a file via a serial communications link.

Serial Communications and Data Storage

In order for the Yield Monitor to give us any valuable information, we must have a means of communicating with it, and it must have a means of sending us the information it is measuring. This process is controlled through a serial communications link.

A Task Computer is located in the cab of the tractor and a cable is attached between the SCCU and the Task Computer. The computer serves two functions. First, it tells the SCCU what information to collect at what time intervals as well as to calibrate and troubleshoot the system. Second, the Task Computer collects and stores the data received from the yield monitor. Data is stored in an ASCII file for easy transfer to software mapping packages.

Data Collection Issues

Through the 1995 harvest season, it became evident that growers didn't want to be transferring data back to the office computer every day. In fact, most growers wanted to store an entire seasons data on the Task Computer and then retrieve the data at the end of the year. There are some options available to accomplish this. An ASCII file is easily read by most computers, but does not efficiently use data storage space. One option is to store data in a binary file, effectively doubling the storage space. HarvestMaster would supply software to convert the file back to ASCII when it is transferred to the office computer. A second option is to use larger memory cards. Cards are available up to 20 Megs now. The only limitation is cost. A third option is data telemetry. This means that as data is collected on the harvester it is sent via a radio link back to the office PC. Once the data is safe on the office computer, then data on the task computer could be deleted or overwritten. This would decrease the need for large data storage on the task computer. All of these options can be made available.

Yield Map Generation

Now we have acquired the data, what do we do with it. Our primary reason for collecting the data was to map crop variability. Many software packages are available that will generate yield maps. After we evaluated several packages, we decided to offer ArcView by ESRI (Environmental Systems Research Institute) to our customers.

System performance

Weight Measurement Accuracy

Accuracy specifications on the system are not officially released yet, however, preliminary indications are that 2% is certainly achievable and possibly even 1%. We did see some deviations as high as 10%. Adjustments in load cell placement and some software modifications should put all measurements in the 2% range.

North Dakota State University did the most extensive accuracy verifications, and their research indicates accuracy's in the 2-3% range were accomplished on a sugar beet harvester.

Position Measurement Accuracy

With the equipment we were using, we attained sub-meter to 3 meter accuracies. Position accuracy is dependent primarily on the amount of money you spend. Higher accuracies equal higher cost. Some GPS receiver manufacturers are stating accuracies between 8" and 15".

1995 Harvest Season Accomplishments

We felt a number of our objectives were accomplished this year. The system did prove itself in the field. There were no hardware failures on the weight measurement equipment. We did have a minor problem with a GPS receiver, but steps have been taken to correct the problem. System components were integrated into one enclosure. We were able to use a single task computer to record both yield and position data. Larger acreage's were mapped, with even more acres expected for 1996. Perhaps the most important accomplishments was learning what our customers expected from the system.

Enhancements Expected for 1996

Some changes will be made for the 1996 North American harvest season. These are;

1) Further reduce package size.
2) Improve the quality of electrical connectors.
3) Add status indicators.
4) Set correction for antenna offset. Since the antenna can't always be in the center of the harvester, over the digging blade, there needs to be a correction applied)
5) Correct the RF interference problem. CB radios did cause some interference of weight measurements. Cables will be shielded.
6) We will offer a variety of task computers for use with the yield monitor:

   a) HarvestMaster Pro 2000 Hand-Held Field Computer

   b) HarvestMaster RDT (Rugged Data Terminal)

   c) Ashtech Ag Navigator

   d) Rockwell Vision System

Conclusions

Much was accomplished during the 1995 harvest season. While our objectives were met, continued refinement and improvement are needed. We had anticipated a product release for the 1996 harvest season, but have decided to do an additional year of product assurance before final release. We will make 30-40 units available for purchase this year.

We will continue to work closely with growers who make an investment in our product. Any product improvements made after the 1996 season will be upgraded on systems in the field at no additional cost. Warranty will also be extended an additional year. For any additional questions, contact HarvestMaster at your convenience.

HarvestMaster, Inc.
Information Machines for Agriculture
1740 N. Research Parkway
Logan, UT 84341-1941
Phone: (801) 753-1881
Fax:(801) 753-1896