Maximizing field efficiency of farm machinery using GPS data

By Reza Ehsani

Today's competitive agricultural market requires optimum management of resources and minimization of operating costs to maximize profits. One of the major expenditures of any agricultural production system is machinery costs. Increasing the efficiency of agricultural machinery could result in major cost reduction. Most often, field managers do not know how efficiently their field machinery is operating and/or where is the source of inefficiency. The purpose of this article is to illustrate how GPS data can provide very useful information about the efficiency of agricultural equipment.

Operational analysis is an approach to increase machine capacity and increase efficiency. Driver performance and field conditions affect total operation costs, such as fuel, lubricants and repairs, especially in larger machinery which have higher hourly operational costs. Another important issue in any farm operation is farm machinery timeliness. Management strategies to improve planning and scheduling such as motion-and-time study will reduce peak machinery demand and maintain a stable machine force on the farm, leading to increased yield and profitability.

There are three major factors that affect how a machine is utilized in the field: operator, machine, and field characteristics. Field characteristics include field size, shape, topography, layout, row length, row-end turning space and field conditions which affect how fast one can drive in the field. In the past, measuring factors such as field efficiency was very difficult, time consuming and required someone with a stopwatch on site during operation. Now, Global Positioning System (GPS) can help us measure this information much faster and simpler.

GPS receivers send out strings of data that contain information about the latitude, longitude, elevation, speed, time and date. The raw GPS data will require processing before they can be used for any application. Most GPS receivers do not store all the data that they generate; however, there are a few GPS receivers commercially available that can collect and store all of those data. These GPS receivers are mainly developed for GPS tracking. GPS tracking systems are increasingly used for different applications such as asset management and law enforcement. There are several GPS tracking products available that can record and store the data.

Trackstick (http://www.trackstick.com/) is one of the companies that provides a GPS receiver with internal memory to store the data. The software included with the GPS can export the data into Google Earth (www.google-earth.com) format which can be opened inside the Google Earth program where the driven path will be overlaid on top of aerial images, providing a great visualization of driven path. Figure 1 shows an example of the data stored by these GPS receivers. This system records GPS data every five to 10 seconds. The "Status" column shows the speed of the vehicle. Also, if the vehicle stops at one location for more than a certain amount of time, the receiver records that information as well. In Figure 1, the record Number 60 shows that the vehicle was stopped for two minutes in that particular location. The program also allows one to see the exact location by clicking in the last column where it says Google map. Figure 2 shows the path of a field machine in a citrus grove.

Rec#	Date	Latitude	Longitude	Altitude	Status	Course	GPS Fix	Signal	Map Link
49	05/18/2009 11:46 AM	28.106367	-81.714033	171.6 ft.	5 mph	N	Y	10	Google Maps
50	05/18/2009 11:46 AM	28.106162	-81.714097	172.2 ft.	7 mph	S	Y	9	Google Maps
51	05/18/2009 11:46 AM	28.105958	-81.714095	171.9 ft.	7 mph	S	Y	9	Google Maps
52	05/18/2009 11:46 AM	28.105732	-81.714095	169.9 ft.	8 mph	S	Y	9	Google Maps
53	05/18/2009 11:47 AM	28.105485	-81.714095	166.3 ft.	9 mph	S	Y	9	Google Maps
54	05/18/2009 11:47 AM	28.105265	-81.714095	162.7 ft.	6 mph	S	Y	9	Google Maps
55	05/18/2009 11:47 AM	28.105248	-81.714158	160.8 ft.	5 mph	N	Y	8	Google Maps
56	05/18/2009 11:47 AM	28.105438	-81.714167	160.4 ft.	8 mph	N	Y	10	Google Maps
57	05/18/2009 11:47 AM	28.105665	-81.714163	160.1 ft.	8 mph	N	Y	9	Google Maps
58	05/18/2009 11:47 AM	28.105897	-81.714155	161.4 ft.	8 mph	N	Y	9	Google Maps
59	05/18/2009 11:47 AM	28.106132	-81.714152	162.4 ft.	8 mph	N	Y	9	Google Maps
60	05/18/2009 11:47 AM	28.106360	-81.714147	164.7 ft.	Stopped 2 min	N	Y	9	Google Maps
61	05/18/2009 11:49 AM	28.106120	-81.714207	151.6 ft.	7 mph	S	Y	7	Google Maps
62	05/18/2009 11:49 AM	28.105935	-81.714218	152.6 ft.	7 mph	S	Y	9	Google Maps
63	05/18/2009 11:49 AM	28.105743	-81.714222	154.9 ft.	7 mph	S	Y	9	Google Maps
64	05/18/2009 11:49 AM	28.105535	-81.714222	155.2 ft.	7 mph	S	Y	9	Google Maps
65	05/18/2009 11:50 AM	28.105327	-81.714228	156.8 ft.	7 mph	S	Y	9	Google Maps
66	05/18/2009 11:50 AM	28.105227	-81.714250	159.8 ft.	2 mph	SW	Y	9	Google Maps
67	05/18/2009 11:50 AM	28.105222	-81.714258	163.7 ft.	1 mph	SW	Y	9	Google Maps
68	05/18/2009 11:51 AM	28.105385	-81.714355	160.4 ft.	6 mph	N	Y	9	Google Maps
69	05/18/2009 11:51 AM	28.105568	-81.714362	157.8 ft.	7 mph	N	Y	10	Google Maps
70	05/18/2009 11:51 AM	28.105785	-81.714347	160.8 ft.	8 mph	N	Y	9	Google Maps
71	05/18/2009 11:51 AM	28.106005	-81.714348	164.7 ft.	8 mph	N	Y	10	Google Maps

Fig. 1. *An example of the data that can be recorded by GPS*

Fig. 2. *Driving path of a tractor to and from a grove*

The exact location where the machine was driven in the field at a certain date and time is shown. Just the visualization of this data can be very beneficial. For example, in Figure 2, it is clear that the driver skipped driving a row and this might be very important for some applications such as spraying or fertilizer application.

The collected data also can be exported into a spreadsheet program where additional analysis can be undertaken. For example, analyzing the time that a machine was idle during a field operation is possible. This could be machine down time or stopping for other reasons; however, this is the time that the machine was not accomplishing useful work. Adding up the total amount of machine downtime during a season can help the manager decide if it is time to purchase a new machine (or not) if the unproductive time was due to equipment issues. The GPS data can show if the machine was operated at the optimum speed. The performance of two operators can also be compared from this data. Collected data can help the field manager to improve management decisions and the whole system could cost less than $200 per unit.

A problem with utilizing commercially available receivers is that they are not designed for agricultural applications; therefore, there are some shortcomings with these tracking systems. The first issue is the minimum logging intervals; for agricultural applications, we need to log at least one data per second or better. The current systems are logging data every five to 10 seconds, which make the turning points very unrealistic (Fig. 2). Also, the GPS receivers are not very accurate and there might be a 3- to 6-foot error in the actual GPS position data.

Acquiring more in-depth information from GPS data requires developing software that can better analyze the data to calculate the field efficiency information more accurately. For example, an accurate measure of field efficiency requires measuring the time that was spent at a turning point. Computer programs are being developed at the Citrus Research and Education Center (CREC) to process and analyze raw GPS data and collected accurate machine performance information to increase efficiency.

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