APPLICATION OF GPS FOR PRECISION MECHANIZED IRRIGATION

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Summary

The development of control technology in precision mechanized irrigation has led to the application of GPS technology. We will illustrate the current status of GPS products from OEMs to third-party vendors and how their products apply to the mechanized irrigation industry. Information on product categories, products available, market acceptance, and costs compared to other options will be presented. Conclusively, we will focus on general information on the use of GPS, issues surrounding the use of GPS for precision irrigation, current applications, and future needs.

Introduction

GPS (Global Positioning System) was created and realized by the American Department of Defense (DOD), and was originally based on and operated with 24 satellites (21 required satellites and 3 replacement satellites). Today, approximately 30 active satellites orbit the earth from a distance of 20,200 km. From either the earth's atmosphere or low orbit, GPS satellites transmit signals which find the exact location of a GPS receiver; the receiver must be on the surface of the earth to acquire the GPS coordinates. GPS is currently being used in aviation, nautical navigation, and determining position on land. Furthermore, it is used in land surveying and other applications where the determination of an exact position is required. GPS is a free service that can be used by any person in possession of a GPS receiver; the only requirement is an unobstructed view of the satellites (ie: view of the sky) (kowoma.de, 2009).

Agricultural applications use GPS technology for equipment guidance; the equipment uses lightbar-guided and automated steering systems that help maintain precise swath-to-swath widths. Guidance systems are packaged with a display module that issues audible tones or lights as directional indicators for the operator's use. The operator monitors the lightbar to maintain the desired distance from one swath to the next. Automated steering systems integrate GPS guidance capabilities with the vehicle steering system.

GPS is also used with yield monitoring systems; the sensor is typically located at the top of the clean grain elevator. As the grain is transported into the grain tank, it strikes the GPS sensor and the amount of force applied to the sensor represents the recorded yield. The data is displayed on a monitor located in the combine cab and stored on a computer card that is transferred to an office computer for analysis (Nowatzki et al., 2001).

Another use for GPS in agricultural applications is field mapping in which it is used to locate and map specific field regions, such as areas that include high weed, disease, and pest infestations. Objects such as rocks and poorly drained regions can be recorded as landmarks for future reference. GPS is used to locate and map soil sampling locations, allowing growers to develop contour maps that show fertility variations throughout fields.

GPS has also been commonly used in agriculture for precision crop input applications. The technology is used to vary crop inputs throughout a field based on GIS maps or real-time sensing of crop conditions. Variable rate technology requires a GPS receiver, a computer controller, and a regulated drive mechanism mounted on the applicator. Crop input equipment, such as planters or chemical applicators, can be equipped to vary one or several products simultaneously (Kowatski et al., 2004). As GPS technology has been used in agriculture for several years, it is only logical that it should also be applied to mechanized irrigation.

With center pivots, control technology has been used for more than thirty years to stop the machine, reverse it automatically, and turn endguns on and off. These controls were originally based on electro mechanical switches stationed at either the last regular drive unit or at the pivot point. The function of these switches depended on their physical placement; it was often difficult to estimate how the pivot would behave, particularly when turning endguns on and off. Depending on certain circumstances, the endguns could turn on or off fifty feet or more from where the operator intended.

In the early 1990s, new position methods were developed by the center pivot manufacturers to provide position information to computerized control panels. These included, but were not limited to, resolvers and encoders. The position information was displayed on the panel, enabling the operator to determine settings that controlled endguns and stopping of the pivot. The computerized control panel then made the positioning decisions instead of trying to rely on mechanical switches. With the advent of computerized control panels, the door opened for multiple changes around the field, such as the control of six pie-shaped sectors or more, multiple settings on a single endgun, and control of a second endgun. These innovations moved mechanized irrigation into the realm of precision irrigation. If setup properly, these control panels were reasonably close to duplicating what the operator wanted; but, like the aforementioned mechanical switches, they were still using a positioning estimate at the pivot point, a large drawback. At this time, a decent solution for linear machine positioning did not exist.

In the past, the most successful guidance solution for center pivot corner arms depended on following a signal from a buried wire. Successful guidance for linears had three choices – following a furrow near the cart, following an above-ground cable (also near the cart), or following a signal from a buried wire (similar to the center pivot with a corner arm), which was usually placed near the middle of the linear machine. It was found that each of these guidance solutions have limitations due to the high risk of damage from farm operations and/or lightning.

Discussion

Mechanized irrigation manufacturers have been working on GPS applications since early 2000 (Segal & Chapman, 2000); the first commercial packages utilizing GPS for precision irrigation control arrived on the market a few years later (Reinke, personal communication, 2005). The early GPS applications were first focused on center pivots and secondly on linear machines in order to eliminate the need for cables and/or any other type of land-based guidance, such as furrow.

Work rapidly expanded to use GPS in providing position information to a center pivot as an alternative to electro mechanical devices reporting position at the pivot point. The GPS receiver is placed on the last regular drive unit and is controlled either by sending information to the computerized control panel or by sending the information directly to another control device. Market suppliers quickly entered the field, such Farmscan, which soon began to utilize GPS information to control banks of sprinklers based on a pre-determined prescription map (Farmscan, 2009).

Current applications of GPS with mechanized irrigation include reporting position for center pivots and linear machines, and guidance of linears and center pivots with corner arms.

Center pivots that utilize GPS technology on the last regular drive unit can replace previously used mechanical switches, resolvers, and encoders, which estimate position information from the pivot point. As the GPS receiver is stationed at the last regular drive unit, the technology provides more accurate information on the position rather than estimating the position of the last regular drive unit from the pivot point. Estimating from the pivot point has the potential for errors, unless the pivot alignment is maintained in an extremely straight position. The more spans on the center pivot, the more the risk for error due to nonalignment. Depending on the center pivot manufacturer, the grower may configure and adjust endguns or pivot stops using the GPS information found either at the computerized control panel or at the end of the center pivot with a PDA or laptop through Bluetooth technology. Third-party suppliers of GPS-based units operate independently from the control panel, providing information via the internet (Kim et al., 2006). Depending on the supplier, the GPS data can be used by the control device to program the on and off cycles for one or two endguns, stop, reverse, and change the speed of the center pivot, or, depending on the sprinkler hardware, turn on or off banks of sprinklers.

GPS technology is also being used for linear applications to control endguns and the machine's operation, which includes stopping, reversing, and changing speed. When utilized with linears, the GPS data is processed in a specially designed control panel, such as the Valley AutoPilot Linear.

On both the center pivot and linear GPS position, accuracies of +/- 3 meters is typically recorded with single-band GPS receivers and WAAS (Wide Area Augmentation System) correction signal.

Guidance for linear machines and center pivots with a corner arm is different from positioning in that the desired accuracy must be much higher in order to maintain correct tracking of the linear or corner (Barker, 2005). Generally, the accuracy is typically +/- 3 cm. To achieve this accuracy, the addition of a reference base station is required.

The marketplace has rapidly embraced the use of GPS technology in agricultural equipment, such as tractors, combines, and sprayers. GPS has literally become a part of the farming life. The acceptance of GPS for mechanized irrigation has begun to develop and flourish, and farmers expect GPS technology to be utilized with irrigation. Growers who currently use GPS for positioning linear machines and center pivots are pleased with the performance and the ease of operation. For instance, one farmer recently stated that his operators used to complain when the air conditioning went out of the tractor cabs, but now the first thing they complain about is when the GPS is malfunctioning (R. Pollard, personal communication, 2009).

Still today, some equipment manufacturers offer control panels without GPS to provide a traditional technology choice to their customers. The cost of GPS for center pivot or linear positioning varies with the type of package that best suits the customer's needs. Costs can be three to six times the price of an encoder or resolver type position sensor; however, the improved accuracies shown and recorded outweigh the high price tag.

GPS guidance for linear machines has good reception and acceptance by growers, the only drawback being the perceived cost. Customers using linear GPS guidance have experienced much improved performance and accuracies; this is because a linear machine always tries to maintain itself perpendicular to whatever guidance is being used, and the machine will continually steer itself to accomplish this. Each of the traditional types of linear guidance – furrow, above-ground cable, and below-ground cable – is difficult to install and/or maintain perfectly straight. As more steering is needed to keep alignment straight using traditional guidance solutions, there is more potential for non-uniform watering and delays moving down the field. Customers who have switched to GPS guidance have observed significantly less steering and more consistently completed field passes, which inevitably lead to better watering patterns and more dependable operation of the linear. The cost of GPS guidance varies greatly when compared to below-ground cable guidance, as in some cases, due to installation costs, the GPS guidance may actually be less expensive. Another major benefit of GPS guidance is it cannot be damaged due to lightning; in some areas of the United States, below-ground guidance cannot be used at all due to constant occurrences of sky to ground lightning.

Conclusion

Farmers expect GPS to become available for all of their equipment, including center pivot and linear irrigation machines. GPS has become a commonality for determining the current position of the last regular drive unit of a center pivot or a linear cart. OEM and third-party companies currently provide GPS options that determine position information. Using GPS to guide a center pivot corner arm and linear machines has been slower to gain acceptance due to the initial investment and limited data on reductions in operating costs and/or other associated benefits. Reliability and durability have proven to be very good and few issues surround the use of GPS for precision irrigation in the United States. Internationally, positioning offers some challenges due to the lack of a correction signal, such as the WAAS in the United States. Some areas do have DGPS (Differential Global Positioning System) correction, which improves the performance of single channel receivers. If correction is not available and improved position accuracy is desired, the only option is to use a dual channel receiver, which often costs five to eight times the cost of a single channel receiver.

Potential future changes in GPS technology include offering choices for tracking accuracy. It may also become possible to considerably reduce the initial investment if an operator will accept more variability in their wheel tracks.

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