PRECISION OF AGRICULTURAL MACHINERY GUIDANCE AND AVOIDANCE OF ACCIDENTS BY USING MODERN TECHNOLOGIES

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Abstract. *The main concept of precision agriculture is optimization, which means the precise use of resources, be it fertilizers, pesticides or irrigation water, which has positive effects on the environment. As a result, product quality is improved, and energy consumption decreases significantly. More and more, agricultural technology companies include GPS satellite navigation systems in their product catalogue. From the simplest, with the manual direction to the best, with automated section and assisted steering. So GPS systems are being searched by Romanian farmers. Satellite guidance systems can be mounted on any farm equipment on the holding, regardless of the brand, provided they have power steering. With regard to the precision of GPS systems, there are several models on the market, from the simplest, with a manual direction, which provides a 30 cm accuracy between two passes to the most advanced, with automatic assisted steering, which has an accuracy of 2 centimeters between passes. Thanks to the technology that has advanced a lot in the past, as an example, the GNSS receiver Topcon AGI-3 can receive signals from all existing satellite constellations, GPS, GLONASS, Galileo, EGNOS, using 72 universal patented by Topcon. Galileo, EGNOS and Copernicus satellite communications offer high positioning precision, with a very important role in many domains. Thus, an addition to this project, automated guidance technologies for agricultural machinery, would be to detect and avoid obstacles that may appear on the ground. Also, animals that have a localization chip can be identified within a 20 meter radius of the machine, with rover software, as well as individuals with a mobile phone, or any device that receives a signal from satellite systems.*

Keywords*: GPS systems, agriculture precision, GLONASS, power steering, Trimble Rover.*

INTRODUCTION

Thanks to state-of-the-art satellite navigation services (Galileo and EGNOS) and Earth observation (Copernicus), citizens across Europe will live safer, more efficient and greener.

Galileo is a satellite navigation system or Global Navigation Satellite System (GNSS), currently under development, intended primarily for civilian use. The Galileo system is interconnected with Global Positioning System/Navigational Satellite Timing and Ranging and Global Navigation Satellite System (GPS/NAVSTAR and GLONASS) to provide high positioning accuracy. The reference and coordinate system used will be ETRS89 (European Terrestrial Reference System) type.

Still at the project stage, Galileo is the future European civil aviation radio navigation system. Currently, an intermediate European system, EGNOS, covering most of Europe and North Africa, operates. The Galileo navigation system will ultimately lead to the independence of European countries from the US Global Positioning System (GPS).

EGNOS (European Geostationary Navigation Overlay Service) is a complementary SBAS-based improvement system that improves the accuracy of signals used for satellite navigation in the European Union. EGNOS is the precursor of the GALILEO system and aims to improve and complement the GPS satellite navigation systems, GLONASS and GALILEO.

EGNOS coverage covers most European countries and neighboring countries with the European Union. Expansion capacity also extends to other regions, such as North Africa,

through an extension called the ISA (Inter-regional Satellite-based augmentation system in the African-Indian Ocean region) (Moscovici 2015) .

Receiving EGNOS signals is possible with a GPS/SBAS compatible receiver in the EGNOS coverage area. Most receivers currently marketed in Europe meet this requirement and are already available on the market from a variety of manufacturers.

An EGNOS receiver is like a GPS receiver, has the same size, uses the same antenna type but has special software that allows the receiver to lock on the code used by EGNOS satellites and to calculate EGNOS corrections for GPS signals(Ritt 2002).

Another satellite navigation system is Copernicus, which is considered to be the world's best satellite Earth observation program. It allows us to monitor the planet we live in, its atmosphere, the seas and the oceans as well as the continents. With its seven satellites currently in orbit, Copernicus will soon become the largest data provider in the world after Google. Copernicus also gives us access to the most accurate climate and environmental data - free, open, and available data. Satellites help us with precision farming or monitor climate change and urban pollution.

The satellite navigation system (NAVSTAR GPS) became operational on 17.07.1995 but was developed in 1970 by the United States Ministry of Defense. As of 1st May 2000, the GPS system became free to public users and reached a precision of +/- 5 meters.

MATERIAL AND METHODS

GPS technology used in agriculture helps maximize productivity, better control of input costs (herbicides, plant protection products, chemical fertilizers, seeds, fuel) and profit optimization. With GPS systems, there is no need for milestones to mark the field. The chemical application operations are done precisely, thus eliminating overlapping errors. Thus, the management of the sections of the herbicide ram allows the nozzles to be stopped if they pass over portions that have already been sprayed.

This translates into fuel economy and inputs because the rows are parallel, regardless of their shape (straight, curved, round).

One important thing is that, by using precision systems, productivity is improved even under difficult working conditions such as fog, night. Another advantage gained through GPS systems is the high level of operator comfort. Agricultural applications that can be made vary depending on the type of GPS system used. In the case of automatic guidance systems, the farmer has to make field mapping operations for better calibration of the device and for making a plan of the land to be worked. The measurement of agricultural areas can be done with GPS systems for agriculture able to quickly and efficiently collect the points describing the perimeter of a plot. Surface measurement can be done automatically or by manually collecting the points that represent the corners of the parcels (HERBEI 2014).

A very important feature that can be implemented through this project is also the permanent monitoring of the field where the machines operate, in order to prevent further accidents that may occur. Thus, animals with a localization chip can be identified within a 20 meter radius of the machine, with rover software, as well as individuals with a mobile phone, or a device that receives a signal from satellite systems.

Also as a complement to the original idea to avoid work accidents that do not fit in the above situations, it could be mounted on agricultural equipment that detects absolutely any obstacle by using a proximity sensor radar that scans the ground in front of the machine within a radius of 20 meters, as well as an infrared camera for night vision and unfavorable climatic conditions. All these sensors must be connected via Bluetooth or Wi-Fi so that the self-driving system can acting on the machine brake (Picture 1).

Figure 1. Internet connecting farmers with agricultural machinery

Manual guidance is done with GPS systems for agriculture starting from a reference line (straight or curved) and defining the machine's working width. Based on these parameters, the GPS system is capable of generating virtual lines to be followed by the driver, maintaining the machine on a precise and repeatable trajectory, even in difficult weather conditions (night, dust, slope or heterogeneous soils).

Auto-guiding lets you take control of your vehicle and maximize your GPS. There are three accuracy classes: Egnos (free signal, 0-20 centimeters precision), Omnistar correction (5-10 cm precision signal) or RTK (base station, 2-3 centimeters precision).

The precision within the 1 centimeter radius was reached due to a differential correction signal (DGPS) and is used in agriculture for self-hydration, seeding, fertilization and herbicide placement and soil analysis.

Two years after the official launch of the GPS system for civilians, global agriculture has successfully installed the first prototype of a self-guided GPS system on three tractors in Eastern Europe, and has thus taken the first step in its professional reputation as a market leader for the adjustment and consultation in the Global Positioning System.

Figure 2. GPS guideline for agricultural machinery

For companies that act in the field of agriculture, these systems allow location in real time or according to a history of agricultural machines and employees using them, from any computer or phone connected to the internet, for better management of agricultural machinery and for the efficiency of agricultural works. One of the main problems that arise in the

agriculture industry is that often the agricultural area has no clear physical boundaries. For this reason, it is complicated for machines to fit exactly in a certain area. Therefore, a GPS monitoring system is absolutely necessary (Picture 2).

GPS systems for agriculture can be divided into several major categories, depending on the operations they can do:

- for measuring agricultural areas;
- for manual guidance;
- for self-guiding and the management of sections of the herbicide ramp;
- for fleet tracking and fuel consumption.

RESULTS AND DISCUSSIONS

Also starting with the simplest LED-based system and ending with the most advanced Topcon Precision Agricultural Systems (TPAS) systems, TOPCON systems are designed to increase productivity and reduce costs. Topcon's solutions combine ease of operation with high performance in operation as well as full operator control over workflow. The systems are designed to be easily moved from one machine to another for different types of agricultural machinery and equipment.

Topcon systems allow for future upgrades and allow for hardware configuration according to the user's present and future wishes. Topcon Satellite Technology allows you to view all existing and future satellite constellations as well as improve positioning accuracy by increasing the reception rate from 10 Hz per second (for example 10 measurements per second) to 20 Hz as well as positioning stability.

All these provide 24 hours a day work and 7 days a week for uninterrupted work.

Topcon systems allow you to choose the precision of working according to the desired operations, such as WASS / EGNOS corrections with a precision of +/- 20 centimeters, accuracy of +/- 5 centimeters using the OmniSTAR correction system to the highest level precision - max. 2 centimeters for RTK corrections received from its own facilities, TPI local networks, and the Rompos national system (Picture 3).

Figure 3. GPS rover from TOPCON

Automatic, reliable, stable, high-precision guidance system with easy-to-use software, easy viewing of parameters and papers-is all you need to work with great precision, quickly and easily.

The Topcon System 150 is distinguished by its highly accurate and reliable antenna, Topcon AGI-3, with an integrated GNSS receiver (Picture 4). Thanks to Topcon's "Paradigm

G3" technology, the Topcon AGI-3 GNSS receiver can receive signals from all existing satellite constellations, GPS, GLONASS, Galileo, EGNOS, using 72 universal channels operating on topcon patented technologies. The AGI-3 receiver can receive corrections via UHF, GSM or GPRS radio modem from both its own and NTRIP via GSM-GPRS (Herbei 2010).

Figure 4. GPS antenna on the tractor trailer

The Topcon System 150 can be configured on different precision levels, ie Autonomous submetric accuracy, WASS/EGNOSS with +/- 20 centimeters precision, +/- 5 centimeters + OmniSTAR paid system and RTK using core corrections own network of permanent stations with a maximum accuracy of 2 centimeters.

The Topcon 150 system is designed to work on surfaces of any shape, on any relief and allows the choice of working mode (right line, curve, adaptive or circular curve). While working on the display, the current line number, machine speed and surface are displayed. All stored information can be downloaded / uploaded via the USB port in PDF format and the contour in SHAPE format (NOVAC 2011).

Another automatic guidance system used in agriculture is AFS, which has surprised by its performance since its inception.

For an integrated precision and maximum productivity, the Advanced Farming System (AFS) developed by Case IH has been designed. It has been at the forefront of precision farming activities for more than 10 years, allowing farmers to control the entire crop production cycle. The Case IH AFS system includes all the tools you need for the machine's repeatable positioning error not to exceed 2.5 centimeters.

Thus, the likelihood of overlapping situations will be extremely low, which will reduce the operating costs of the machine and maximize the productive potential of all types of crops.

Farm machines have an advanced control system, whether it's an interactive configuration or a special function, you just have to watch the AFS Pro monitor. This way, you will be able to monitor the productivity, fuel consumption and machine utilization, track the images captured by outdoor cameras, record all crop data, and manage the equipment connected to the machine using ISOBUS technology. The software that manages the operation

of the AFS Pro Monitor is interactive and fully customizable, ensuring fast connectivity with other AFS farm equipment (Picture 5).

Figure 5. Synchronous direction with GPS rover of two agricultural machines

The guiding system uses "light-bar" (AccuGuide) kits with simple plug-and-play installation. A complete range of RTK radio receivers is used, from which you can choose the precision of the machine. Thus, the positioning error of the machine can reach up to a minimum of 2.5 centimeters XFill technology ensures machine operation for up to 20 minutes after the RTK system has been shut down.

There are many variables that influence agricultural production - so it is important to understand what is happening and why. Now, we can better manage agricultural activities by making the decisions that are required by current realities. With the Case IH AFS Farm Management Pack, it permits to view step by step the work done, the degree of machine utilization, the fuel consumption recorded for the execution of each work and, most importantly, the productivity of the threshed crop.

The Case IH AFS Connect telematic system will allow to monitor and manage the operation of your machine even if the person is at the farm office. Case IH AFS Connect uses precision signals based on GPS technology as well as wireless data networks. Analyzing the data you receive through this system can help you improve fleet logistics, reduce fuel consumption, and maximize the performance of your machines.

Broadly speaking, a simple GPS system includes a receiver and monitor that display useful information such as speed, course, direction of travel, distance traveled, distance to destination, work area, row number. The GPS receiver mounted above the cabin gathers information from the satellites surrounding the ground and calculates the exact location of the machine and displays it on the display.

To calculate a 2D (latitude and longitude) position, a GPS receiver must simultaneously receive signals from at least three satellites. If the receiver collects information from multiple satellites, the position calculation is more accurate. GPS systems receive at the same time signals from three satellites, and signal accuracy is pretty good.

To increase accuracy, a contract with a signal provider such as Omnistar, which also provides services to Romania, and a subscription is paid for the period in which it is desired to obtain greater accuracy can be made. The Omnistar subscription is for each GPS system. A more complex system, called RTK, which offers a precision of 2-3 centimeters and has a 30 km radius of coverage, includes the placement of an additional farm station to fix the captured

GPS signal. With the best possible precision we can identify the future obstacles that can be encountered on the tern, so the machine is stopped in time.

The practical study was carried out in Remetea Mare commune, Timis County, and consisted in using Topcon and AFS systems on a surface of 30 hectares that was shown (Picture 6). The first stage consisted in connecting to the Galileo, EGNOS,GLONASS satellite systems.

Figure 6. Case Machinery with auto GPS in Timis county

The precision of 1 centimeter was reached due to a differential correction signal (DGPS), as can be seen in the figure, being used for self-guiding. In the figure we can see the map, the error and the different characteristics of the agricultural machinery. On the surface on which the work was executed, no hindrance was encountered, in order to be identified and avoided (Picture 7).

Figure 7. GPS rover monitor showing a precise map

CONCLUSIONS

A very important feature is the prevention and avoidance of further accidents that can occur by installing on the agricultural machinery devices that detect absolutely any obstacle using a proximity sensor radar that scans the ground in front of the machine within a radius of 20 meters and a room with infrared for night vision and unfavorable climatic conditions, thus

the autonomous steering system acting on the brake. By developing a software that uses data from the GNNS technology of positioning the machine and identifying animals that have chips or human factors that have a phone with the activated location will be beneficial for both farmers and animal protection.

In conclusion, through this project, we presented the GPS precision of mounting on agricultural machinery and ways to prevent accidents that may occur during the use process. GPS technology used in agriculture helps maximize productivity, better control over costs and save time. The GPS receiver mounted above the cabin collects information from the satellite systems that surround the Earth, calculates the exact location of a device and displays it on the screen so the operator can manage the jobs accurately.

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