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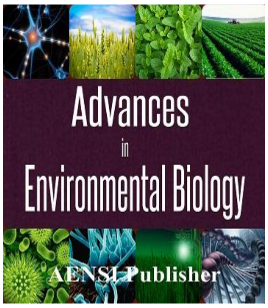

Using GPS in the Path finding System of a Tractor and the Consideration of its Influence on the Tractor's Function in the Farm

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ABSTRACT

One of the most modern methods for the path finding of a tractor in the farm is utilizing GPS. In this research first of all the path finding system of the tractor by means of GPS was being made and then the influence of this system on the increase of emptiness or vacuity and the overlapping of the tractor was being scrutinized in the form of a test project of split-split plot under the framework of totally haphazard blocks was being considered three times. This research was being carried out in 2013 in a farm located in Shoushtar by means of three factors of kinds of tractors in two levels(Ferguson tractor and the Romanian tractor), the speed in three levels(6km/h, 7km/h, 8km/h) and the kind of marker in two levels(Normal marker and digital marker[the system which is being designed in this project]).The results of doing the test illustrated that the effect of the kind of the marker on the amount of deviation from the path in a tractor on the probability by a level of %1 is meaningful and the digital marker which works by means of GPS has a less amount of deviation than the usual marker. On the other hand, the interaction of the kind of marker and the moving of a tractor on the amount of a tractor's deviation from the path was meaningful with the probability by a level of 1% and the normal marker in the speeds of 6km/h and 8km/h illustrated a more amount of deviation from the path. The influence of the kind of marker on the number of deviation from the path in a tractor on the probability by a level of %1 was meaningful and the normal marker illustrated fewer numbers of deviations from the path than the digital marker.

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INTRODUCTION

It is a long time that the farmers and the drivers of agricultural machinery have used several methods to drive this machinery in the farms while doing the strip tillage and other kinds of operations that finally the machine takes the minimum amount of emptiness and overlap. One of the state-of-the-art methods in this field is using the GPS system (global positioning system) to direct the driver while moving in the farm. The GPS-equipped systems or machines lead to a lesser amount of tiredness for the operator than the mechanical-based directing systems and gives rise to the least amount of ocular tensions. Since by installing the light strip indicator on the monitor exactly in front of the operator there is no need to turn back and look back and looking around continuously [4]. In the semi-dry areas with low humidity and high temperature and vast farms other directing systems such as foamy markers are too much influenced by the temperature in a way that most of the foams will be vaporized before the operator turns round and goes through the next path. On the other hand, when the GPS systems get frozen due to the low temperature of the foam, operate well [5].

In the present research first of all the path finding system in the tractor by means of GPS was being made and after that the influence of such a system was being scrutinized on the loss of emptiness and the overlapping of the tractor and the possibility of a faster movement in the tractor which directly influences the yield of the farm.

Exact direction or navigation of the agriculture machines in the farm can be difficult, boring and sometimes dangerous. The automatic position-regulating systems by means of GPS can adjust the position of the machine in the farm and they are able to direct the agriculture machinery to the proper location in a way that overlapping

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or emptiness perishes that as a result of it the yield of the machine increases. Besides, these processors are indefatigable in comparison with humans [10].

Lowenberg et al. (1999) by performing some studies about GPS-oriented systems came to this conclusion that these systems make it possible to perform agricultural operations when there isn't enough visual acuity in the farm and during the night, in the foggy weather and when there is a time limitation to perform agricultural operations such as farming and in the areas which at night due to the lesser breezing the time is ripe for poison spraying, these systems are the top choices and have the minimum amount of impressionability from the environmental air.

The ability to develop the information exactly in a momentary manner for the automatic control of the machine in the farm is necessary. O'connor *et al.* in a research which was being carried out in Stanford University in California were able to measure the location of the agriculture machinery by developing the DGPS (digital global positioning system) technology with an error of few centimeters.

Stoll *et al*., by carrying out a research on the GPS-oriented navigation system came to this conclusion that by increasing the speed from 1 meter to 2 meters per second, the amount of deviation from the path increases from 25 millimeters to 6 millimeters.

Also Sullivan *et al*, in a research on the GPS-directing system concluded that to send data with an acceptable speed from GPS to the system, the external frequency of GPS should be at least 5 Htz.

Another usage of GPS is to use agricultural products in a changing way and compatible with the situational requirements. Conventional agricultural management systems are generally based on the monotonous usage of agricultural products over the farm. In these systems by spreading a monotonous amount of fertilizer throughout the farm which often requires different amounts of fertilizer only a negligible part of the requirements of the farm will be met and other areas receive the fertilizer more than or less than the requirement. In a research carried out by Ghazvini *et al*, in Borkhar, Esfahan, the locational changes in the fertility factors of the soil (i.e. nitrogen, potassium, and phosphorus) and the function of the wheat grain by means of variogram (the statistical function specific to the analysis of the locational structure) and by means of GPS and GIS were being investigated and digital maps were being produced. By means of these maps it became obvious that in the widespread nitrogen, phosphorus and potassium fertilizer spreading method to produce the maximum amount of function only %13, %25, and %11 of the area of the field receive a proper amount of fertilizer respectively and the rest of the field receives an amount of fertilizer which is more than or less than the required amount. While in the VRA method (variable-rate application), the whole area of the field receives a proper amount of fertilizer and we can economize in our urea fertilizer consumption by at least 56 Kgs in a hectare.

MATERIALS AND METHODS

The present research was being carried out in a farm located in Shush tar, Iran in 2014. The area under study was located at 48 and 34 degrees north latitude and the 36° and 40 minutes north longitude. The area's altitude is 700 meters and has a subtropical weather. At the beginning of carrying out the test, the path finding system of the tractor was being designed. Then this system was being used as a marker to direct the tractor under the framework of a test project for the poison spreading operation in the field. The test project was being carried out through a split-split plot (by means of a bendy which is being broken two times) in the form of totally haphazard blocks three times. This project had three factors which the factor A represents the kind of tractor at two levels (a1=Ferguson tractor, a2=Romanian tractor), factor B represents the speed at three levels (b1=6km/hr, b2=7km/hr, and b3=8km/hr) and the C factor represents the kind of marker at two levels (C1=Normal marker, C2=the directory system which is the system being designed in this project). The test was being carried out in areas by 30 meters in length and 18 meters in width and to carrying out the test in a monotonous way, all the repetitions about the C1 marker and C2 marker were being carried out incessantly and continuously without dismounting or mounting the system. In order to minimize the error of the operator in all the repetitions, just one tractor driver was being employed who had an equal amount of experience in driving both kinds of tractors. Although the speed of proceeding of the tractor is being illustrated by GPS as well, but because of the probability of error in this test the time-based method of measuring of speed is being used for moving with the speeds of 4 km/hr, 6km/hr, and 8km/hr.

Designing the path-finding system for the tractor:

To design this system, GPS (global positioning system) was being used to measure the coordinates of the area of the farmland. Then this data was being sent through GPS for decoding to the mediator software (this software is called SDK which exists in the market). After being decoded, this data was being sent to the main software which has Delphi language. After that, the data which is obtained from GPS is being refined to omit the surplus parameters such as height and other unworkable parameters in this project. In the next step, the refined data will be changed into the coordinates of Y and X and four areas which are determined as the borderline areas of the farm will be saved. To determine the approximate coordinates of the farm, the area of the farm which is under harvest should be illustrated completely on the screen. For this purpose, the soft wares reduce the coordinates of the farm as much as possible to be illustrable on the monitor.

Since this software is designed for movement in the straight and parallel lines, so in this level the sides of the farm are being rotated by means of a function including a rotating matrix until we can move alongside the largest side of the farm. In this level the first path should be traversed by the driver until it can be registered as the first path and till the next lines of movement will be drawn by a definite distance which is the width of the machine (the width is being given to the machine after determining the borderline of the farm) and the driver by observing the path and the directory arrows on the monitor will be guided through the path. The order of performing these things by means of the software is being illustrated in the diagram No.1 and the path and the directory arrows on the monitor screen are being illustrate in the diagram No.2.

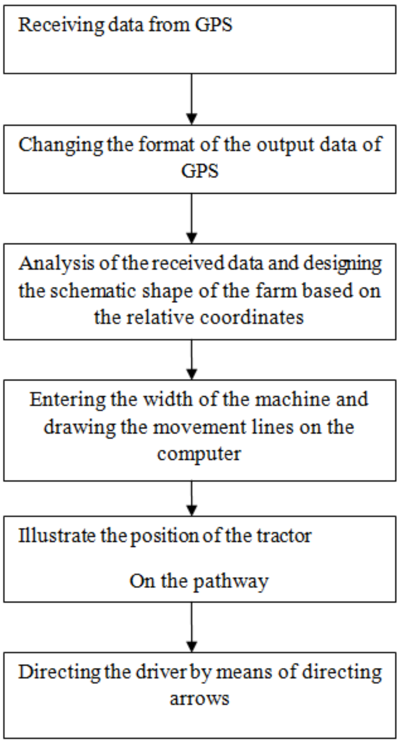

Diagram 1: Hierarchy of the tractor path finding software.

By determining the borderline areas of the farm and register the coordinates of these points by means of GPS which is being carried out in this research, the chosen points are being connected to each other by means of the software and gives a sketch of the farm. Since the measurement exactness depends on various factors such as GPS, the geographical situation of the area, topography, the number of covering satellites, etc; so, to reach certainty about the amount of exactness of the machine, DNR software which was being submitted by the designer of the machine is being used. In this method, the coordinates of the place are taken from a point and with a definite time interval simultaneously and the submitted coordinates will be registered by means of GPS and then this will be registered after every 50 seconds on the exact place for half an hour. After this phase, the registered points will be determined in a shape and their amount of precision will be achieved.
The machines which are being used in this project are as follows:

GPS machine: In this project a GPS machine of eTrex Vista version made by Garmin factory is being used which enjoys some facilities such as digital compass, barometric altimeter, a system to show the sunset and the sunrise, the map of Iran and the whole universe and the capability of measuring the area of a disorganized polygon that these capabilities are being used to submit the area of the farm and the coordinates of the points while moving through the path.

Mesi Ferguson tractor: In this project a 258 Mesi Ferguson tractor of the year2003 were being used to carry out the tests that its steering system was being rechecked to achieve certainty about the precision of the navigability of its steering system by the agency of the company.

Advances in Environmental Biology, 8(21) October 2014, Pages: 1314-1320

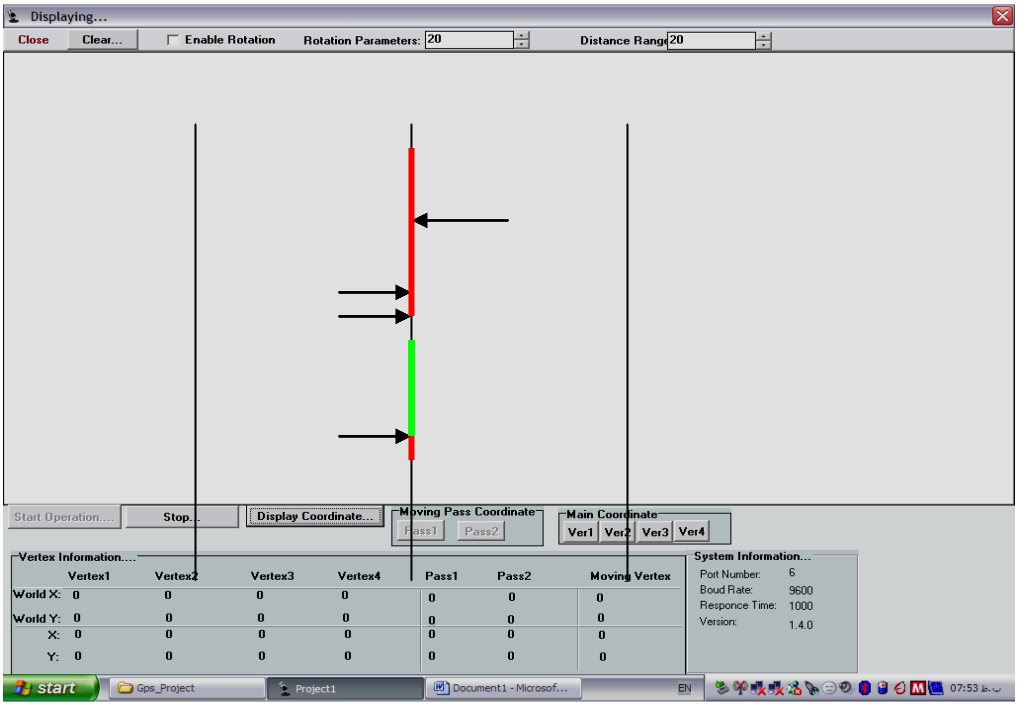

Diagram 2: Pathway and the directing arrows on the screen.

Universal Tractor:

A Universal U650 tractor of the year 1984 was being used in this project which in spite of its old age is technically well. But in order to achieve a better result it was being checked and reviewed and it was went under maintenance revamping specifically in the steering area.

Gun poison spreading machine:

In this test a gun poison spreading machine for the farms which is mountable at the back of the tractor with 400 litres volume with a width of 8 meters was being used.

Statistical calculations and data analysis by means of MSTATC and drawing the shapes by means of excel software 2003 was being carried out. The measured factors during carrying out this test are as follows:

Determining the precision of GPS:

Since the mentioned research project is based on GPS, and it has precision, measuring the precision of the GPS used in this project is necessary. Determining the precision is being done and submitted by means of the DNRGARMIN software which is presented by the producer of the machine . The mentioned software measures the precision of GPS based on CEP(circular error probable) method that is the probability of the circularity error. In this method, after creating a connection between the portable computer and the GPS machine, the coordinates of a point are being measured 100 times and with the same time intervals by moving the GPS and the results will be presented by the software.

The amount and number of deviations:

While doing the experiment, the pathway of the poison spreading machine was being determined by means of a colorful liquid which was being poured down from the lower point of the nozzle at the left side of the gun under the influence of the gravity near the surface of the earth. This pathway while the driver was being led through the arrows on the monitor screen was accounted for as the path passed while using the digital marker. When the driver usually and without using the directing system spreaded the poison, the colorful liquid illustrated the past way in a normal marker position. It is worth mentioning that the rest of the poison spreading nozzles are being clogged and the poison spreading pump was being deactivated as well. The determined trajectory by means of the colorful liquid was being compared with an assumed straight line which should be passed and in each pathway during 60 minutes from each part by two times of traffic in each part the amount of deviations from the pathway in which the amount of deviation in them is more than 20 centimeters was also being counted and it was being registered as the number of deviations.

RESULTS AND DISCUSSIONS

Accuracy of GPS:

The results of measuring the accuracy of GPS are presented in table1. Based on these results, more than half of the points are located on a circle centered by the reference point and by a diameter of 0.53meter and %90 of the registered points are on a circle by a diameter of 3.5 meters, %95 of the points are on a circle by a diameter of 9.2 meters and %98 of the points are on a circle by a diameter of 13.6 meters. Since this system is being used for the poison spreading operation, the exactness of 3.5 meters which contains %90 of the points is acceptable; while in a similar project being carried out in Japan, which is being done by means of a speedometer device, light fiber, and GPS, a tractor which is being attached by a ploughshare was being directed through a parallal pathway with an exactness of 12 centimeters.

Table 1: The results of exactness measuring based on the circular error probability method.

Radius(m)	Percentage of the registered Points on the circle
0.73	60
4.5	80
8.2	85
11.6	88

The amount of Deviations: The influence of the brand of the tractor, its velocity and its interaction with the amount of deviation from the pathway isn't meaningful and it can be concluded that the path finding system of the tractor for the both kinds of the mentioned tractors and the three mentioned speeds has an almost similar amount of deviation. The effect of the kind of marker (the C factor) on the amount of deviation from the pathway on the probability by a level of %1 is meaningful and the amount of deviation due to the usage of the digital marker as it has been illustrated in figure No.3 is less than %1.

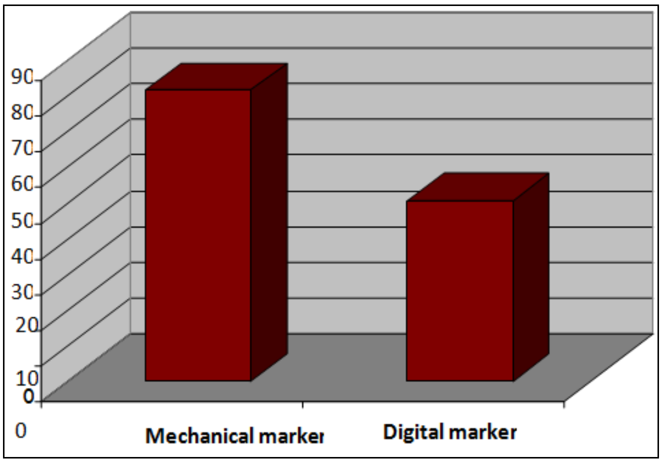

Diagram 3: The influence of the kind of marker on the amount of deviation from the pathway.

By doing the average comparison through Duncan multiple range test, according to diagramNo.4, in the two speeds of 6km/hr and 8km/hr, the amount of deviation while using the mechanical marker illustrated a meaningful difference in comparison with other cases on the probability by a %1 level and while increasing the speed (more than 4km/hr) using the digital marker is a better choice.

The number of deviations:

The results which are obtained from the analysis of the variance of the date relevant to the deviation from the pathway illustrated that the kind of tractor, the proceeding speed, and the influence of their interaction on the factor of number of deviations do not have a meaningful influence. The influence of the two kinds of mechanical and digital markers on the number of deviations from the pathway on a level by 0.01 is meaningful and the average of the number of deviations is lower for the mechanical marker. Since the amount of deviation with a normal marker is more than that of the digital marker, so the sensitivity in the movement of the digital marker is more which its reason can be the accuracy and the more affectability of the digital marker from natural factors such as roughness of the land and with a little experience from the driver in working with this kind of tractor (diagram5).

The interaction of the proceeding speed and the kind of marker on the average number of deviations is meaningless. Of course, according to diagram No.6, the digital marker by a 6km/hr speed in comparison with

Advances in Environmental Biology, 8(21) October 2014, Pages: 1314-1320

the two other speeds has the minimum number of deviations; while in the normal marker by increasing the proceeding speed, its number of deviations increases as well.

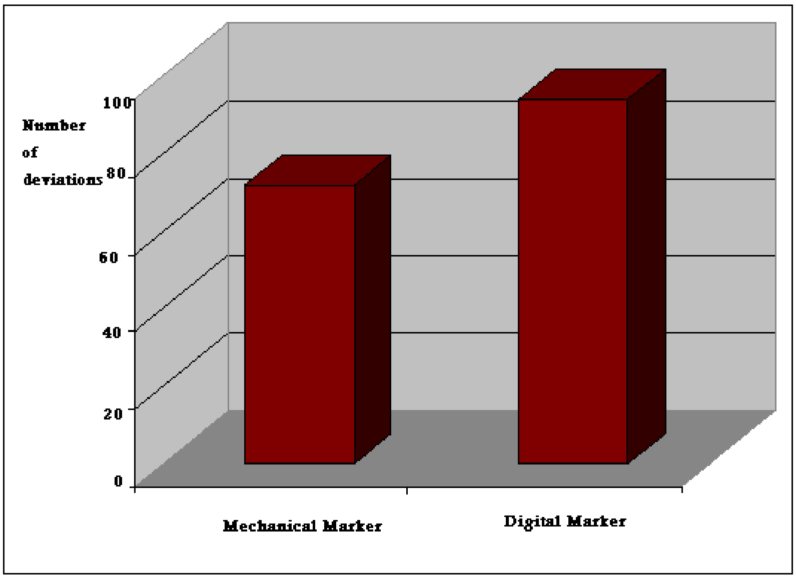

Diagram 4: The influence of the kind of marker and the amount of speed on the amount of variation from path.

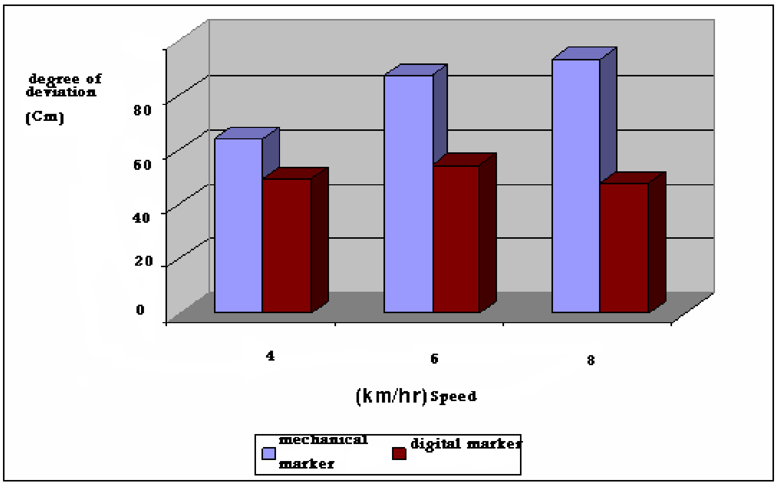

Diagram 5: The influence of the kind of marker on the number of deviations.

According to the calculations being done about the achieved map out of the test, in each hectare, the mechanical marker in comparison with the digital marker has 72 square meters of overlap and 42 added square meters of emptiness or vacancy. If we consider this amount of overlapping while spreading poison and tilling throughout the entire area of the farm under cultivation, in the year 2005, by calculating and considering the 694000 hectares of the land that are under the cultivation of wheat, we will undergo an approximate cost of 400000 Rials per each hectare of the farm, 80000 Rials per each hectare which is under the cultivation operation. The cost of 2080000000 Rials and 416400000 Rials for poison spreading and the extra tillage of the farm. In addition to the extra costs due to overlapping and the harms or losses which are inflicted in the farmer due to widowness of the farm under the tillage while doing the agriculture operation, we should consider the extra traffic in the farm and the congestion due to that. According to the low cost of using this system (about 8 million Rials), using the digital markers in the farms with a tillage of over 500 hectares is a proper choice. Besides, in these kinds of farms operations such as spreading diverse kinds of fertilizers by means of a fertilizer spreading machine is practically followed by various problems in terms of the way of navigation on the pathways which these problems will be resolved to a great extent by using these kinds of systems.

Advances in Environmental Biology, 8(21) October 2014, Pages: 1314-1320

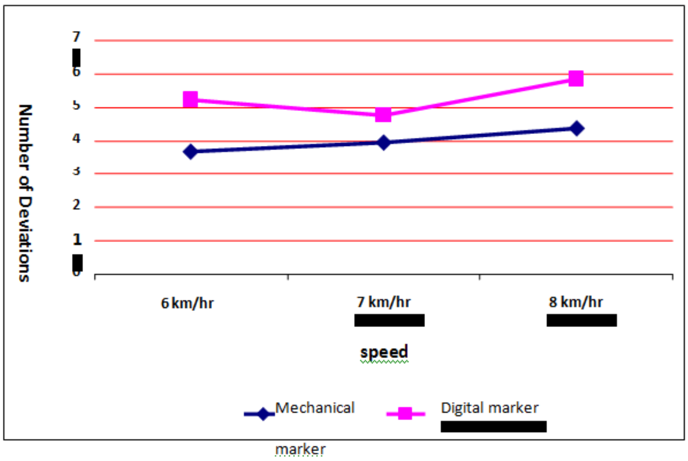

Diagram 6: The interaction of the kind of marker and the amount of speed on the number of deviations from the pathway.

Conclusion:

The measured accuracy of the GPS machine (i.e. standing on%90 of the measured areas in a circle by a radius of 3.5 meter, is acceptable for performing the poison spreading operation.

The effect of the kind of marker on the amount of deviation from the pathway for the tractor on a probability level of %1 is meaningful and the digital marker which works by means of GPS has a less amount of deviation. On the other hand, the interaction of the kind of marker and the speed of the tractor on the amount of deviation from the pathway in a tractor had a meaningful influence on a probability level of %1 as well in which the mechanical marker in the speed of 6km/hr and 8km/hr illustrated a more amount of deviation from the pathway.

The influence of the kind of marker on the number of deviations from the pathway for a tractor is meaningful on the probability level of %1 and the normal marker has a fewer number of deviations. Its reason can be the added accuracy and the impressionability of the digital marker from natural factors such as unevenness of the farm or the lack of enough experience on the side of the driver working with this kind of tractor.

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