Guidance Technology

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Many years ago when I first suggested that it was possible for a tractor to drive by itself , I was met with such comments as: "that's just a gimmick", "Why would you want to do that? Farmers like to drive their tractors.", or "It is just not possible." With this paper I will try to advance convincing reasons to dispel the myth that guidance technology is just a gimmick; but rather a very valuable technology for farming.

Figure 1 Outback Guidance System

What is Guidance Technology?

Most people would understand guidance as some sort of light bar that an operator uses to steer a farm vehicle on a parallel pass. The operator steers. An example is the Outback Guidance System as shown in Fig. 1. If the system has the ability to steer the tractor in an auto-pilot mode, then we would call it auto-steering. Figure 2 shows an electric friction drive that can move the steering wheel. In this paper, guidance technology will be defined to be all of these, guidance, auto-steering, and anything else that controls and steers a vehicle to a predetermined path. For this we will need a positioning system that can tell us where the vehicle is at all times. Typically GPS is used for this. This technology will not only have the ability to steer the tractor, but also to control such things as speed, and the on/off control of the applicator. So, I am taking the liberty of extending the scope of the definition of guidance.

Figure 2 Auto-steering: friction drive

Do We Need Guidance Technology?

At first glance, one might think that guidance is just another novelty, and at best a device that could reduce some of the stress of the operator. But indeed this investment, has a return in real dollars. An economic analysis was done [3] and it clearly demonstrate the returns. In this paper I am going to try to convince you that not only is this technology a good investment, it is also the first step to a new way of farming that is more profitable, friendlier to the environment and more attractive to the consumer. We need this technology – we need it now.

How Bad Is the Overlap?

Figure 3 An example of lateral overlap

In doing parallel passes, farmers know that missing is not allowed. But we are not perfect drivers so we overlap to compensate for our imperfection as is shown in Fig. 3. Twenty years ago we did studies[3] to measure the amount of overlap and it was concluded that overlap was about nine percent of the implement's width. With a perfect auto-steering system, we could save nine percent of our time and inputs. If our inputs were $100,000, then we could save $9,000. If the auto-steering system cost $9,000, then it would pay for itself in one year. But one could argue that the current auto-steering systems are not perfect and that a one or two percent overlap still occurs. But even then, it is still a pretty good investment. And the story is just starting – it gets even better.

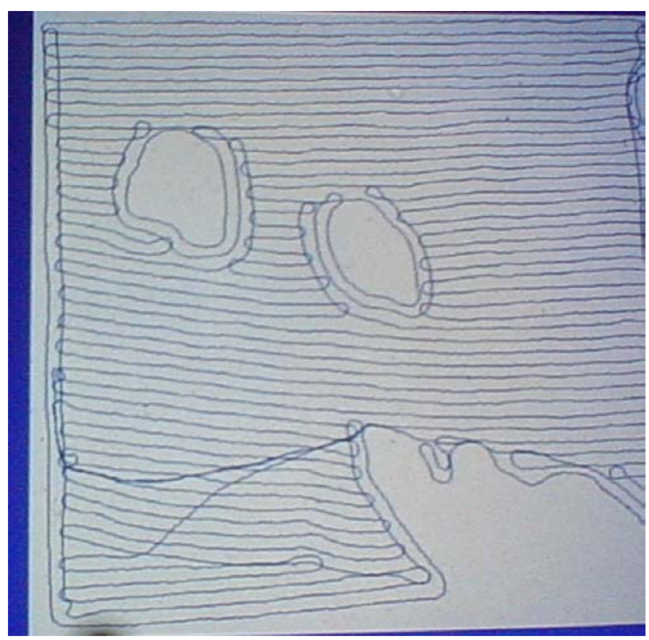

Figure 4 Manually driven field took 42.11 km

More recently we did studies to determine the overall working efficiency in doing a field. [1,2] In one example the distance for manual driving was 42.11 km, Fig. 4; but if this field were driven in an optimal manner, as in Figure 5, it could all be covered with a distance of only 34.33 km. We repeated this experiment many times, with different drivers, in different fields, with the same result, we are driving an extra 20 to 25% to work our fields manually. If we could only drive the field in an optimal manner, with no overlap and in an optimum pattern – just think of how much fuel, time and inputs we could save -- maybe 20 to 25%.

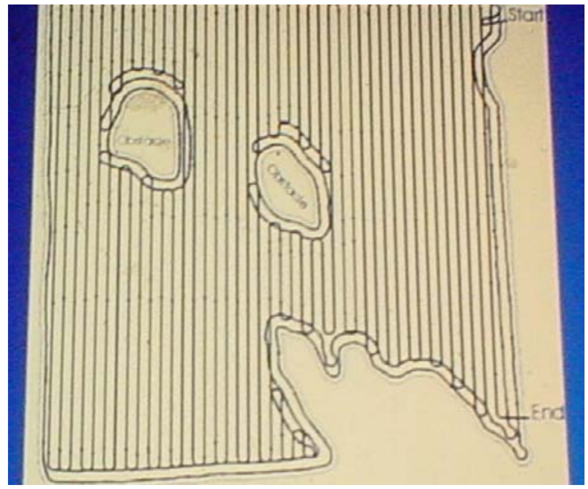

Figure 5 Optimum Course 34.33 km

Small is Beautiful

In analyzing these optimum field patterns, it became very clear that big fields with no obstacles provided the highest degree of efficiency. Farmers know this intuitively and are busy making bigger fields and removing any and all obstacles in them. They are pushing down bushes and shelter belts, draining sloughs, removing stone piles and generally getting rid of anything that gets in the way of the large equipment. The question arises: 'Could we achieve higher efficiencies, without making the fields bigger and without removing all the obstacles'? The answer is – YES, by using smaller equipment. How is it possible that smaller equipment can actually be more efficient? Well, think of it this way; the efficiency comes about from a ratio of how much time is spent in the turns as opposed to time actually doing something. Relatively speaking a small piece of equipment spends much less time in the turns at the headlands. Less time, relatively speaking, is spent in the headlands turning. Of course a smaller piece of equipment will take longer; but that argument can be countered by having a number of smaller units working simultaneously. This then raises the question of having more operators; but what if we didn't need operators? What if the smaller units were driverless? We would then have the best of all worlds. We could keep the sloughs, and shelterbelts and still maintain a high degree of efficiency.

Predetermined Paths

A driverless tractor must know exactly the path it will follow to work a field. It needs a predetermined path. This path can be generated by having an outline of the field perhaps obtained by having someone drive exactly on the outside of the field and around the obstacles, all the while recording a series of positions. An example of this is shown in Figure 6. With this position data that outlines the field, and by knowing the implement's width

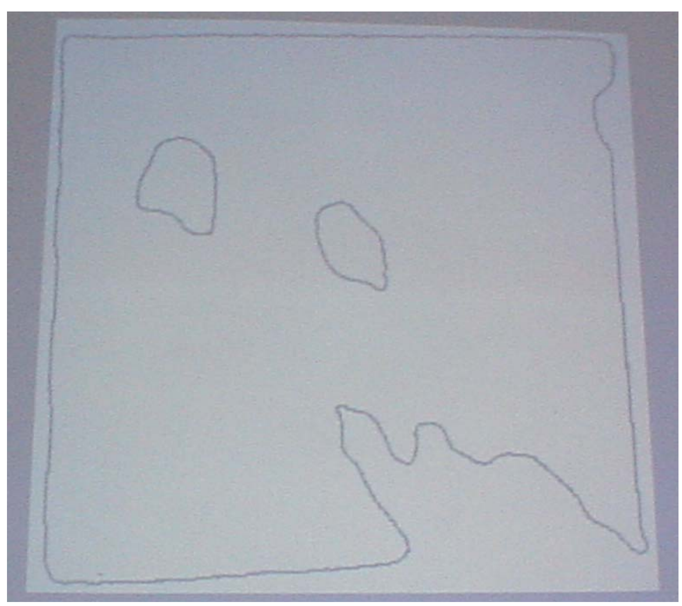

Fig. 6 Field & Obstacle Perimeters defined by driving

and the desired direction of travel, it is a fairly simple process to fill in the field with a path to which one wants the vehicle to follow. This predetermined path can be downloaded into the driverless tractor and when it is placed in the field it will faithfully follow this path.

But what if it rains and a slough becomes bigger than in the generated field pattern? The right thing to do would be to regenerate a new path with newly acquired outlines of the sloughs. The new outlines would only take minutes to drive around with a quad and a few more minutes to generate a new path with a computer. But let's say we sent the driverless tractor out with a path that did encounter water. This would certainly be a problem for a conventional operation, one in which we were working the ground; but if the operation did not involve draft, it is quite possible that the unit could tolerate and drive right through a certain amount of water. If the field has been zero-tilled, there will be reasonable footing, and if the unit is not pulling an implement, and is light weight, it could drive right through the water.

There is another problem with driverless tractors and that is liability. What if the unit hits something like a cow or a truck or a person? There would be no driver to blame. Who would be liable? First of all this unit will be much smaller than the tractors we have now, and it will probably be travelling much slower, so even if it did hit something, it would only be capable of limited damage. Secondly, it would have a number of layers of safety stop-sensors. These may include – a motion and infrared sensor to detect humans and animals in front of it. A bumper extending in front could be used as a 'last-resort' kill switch. More complex vision recognition could also be used, but it is probably not necessary.

There are two obstacles impeding the adoption of small driverless tractors, other than the traditional reasons of not wanting change. The first is the liability as was previously discussed, and the second is having a cost effective, accurate, and reliable positioning system. Everyone seems to be pinning their hopes on GPS, but I don't think GPS will be the positioning solution for farming in the future.

GPS

Is GPS cost-effective, accurate, and reliable? The answer is yes and no. Yes, GPS receivers are coming down in cost and one can buy a handheld for less than two hundred dollars – but the accuracy isn't there. More expensive DGPS systems have sub meter accuracy but they may cost several thousand dollars and there may be additional costs for a differential correction subscription. For the really accurate RTK systems, one would be paying tens of thousands of dollars. Also the differential receiver must be close to the mobile receiver. If the differential correction signal OR the satellites are blocked, an acquisition time of tens of minutes is needed. One needs RTK for really precise farming, yet these systems are not cost-effective, and worse yet they are not reliable. They simply do not work in fields with trees or other obstacles.

There are a number of interesting things that can be done with real precision. Seeding between stubble rows would be possible. Fertilizer placed in ridge tills could be aligned exactly with the seed placement for optimum use of the fertilizer. With in crop operations it would be possible to keep narrow tires between the crop rows.

Conclusions

Currently we are using Guidance Technology to drive on parallel lines with GPS. In the future this technology will be used to work the entire field automatically by following predetermined paths. Greater efficiencies will be achieved by using small unmanned vehicles. We need better positioning systems and we need to address the liability issues with driverless tractors. If these road blocks are overcome, and if we develop and adopt this technology, it will benefit the farmer, the environment and the consumer.

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