

DEVELOPMENT OF AUTOMATED TRACTOR IN JAPAN¹

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ABSTRACT - The computer controlled operator-less automated tractor is developed. The tractor is controlled three layered control system constructed by the one 32 bit computer, one 16 bit computer and four 8 bit microcontrollers. The first layer of the controller performs the control of the primitives of the tractor, the second layer harmonizes these primitives, and the last layer makes the decision of the activity of the tractor. The most remarkable function of the system is its location detecting system. That is performance by the spectrum spread radio wave which is used in the communication between Voyager (artificial space ship to outer space from solar system) and earth. The performance of the automated tractor is competitive to the tractor of manual operation equipped with pto driven cultivator. The optimization of the parameters of the pathway of tractor, the selection of gear, pressure and an opening of fuel pump are next target of the research work.

Purpose

There is an inevitable trend of population movement into big city from rural area. So there happens the shortage of the man power in agricultural production in Japan and U.S.A. as well. Particularly in Japan, it is said that we will not able to see any young people in rural villages in 21st century. The shortage of the worker is a big problem of Japanese agricultural production in next century. This is one of the big motive of the development of automation system in the agricultural production.

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The another reason is the positive aspect of this social phenomena. That is the motive of cost reduction. If the population of farmers goes down, the average acreage of farmstead goes up. But the average area of the farm is so small and scattered that Japanese farmer can not afford to use the big farm machineries. So they have to use several small tractors. But each tractor needs operator. In the result, it is necessary to use automated farm tractors.

One more reason of the development of the tractor is good for not only Japan but also for whole world. That is relating the soil compaction problem which is overwhelming in U.S.A., Germany, Brazil as well. Usually the compaction of the top soil is relating the pressure of the footprint of the tractor. The area of footprint of the tractor is proportional to the largeness of the tractor. So there is no difference of soil compaction of the top soil between using big tractor and small one. But the compaction of the sub-soil layer is proportional to the weight of the farm machinery. So using small tractor is the advantage to avoid exceed soil compaction. Using small tractor means using many operator. So here again it is necessary to develop the automated farm tractor.

Configuration

The first layer of the control system consists of 5 actuators, a throttle valve controller, left and right brake cylinders, a clutch motor, a three-point hitch link cylinder, a Power Take Off (PTO) clutch solenoid. There are 5 sensors for each of these actuators. These primitives of controller of the tractor are controlled by 4 microcontroller name uPD7810 by NEC. The microcontroller is one of the microprocessor family which is the descendant of Intel's 8051 microcontroller. This central processing unit is equipped with 16 bit accumulator registers, serial communication port, three 8 bit parallel input/output ports, 8 bit AD converter with 8 channel multiplexer, and counter timer. They are packaged in a small surface mounted device. Each microcontroller is designed to control the 2 actuators, and one of the microcontroller is used for the binding of three other microcontrollers. The communication of the microcontrollers are performed through the RS232C ports, and the system is also connected to the microprocessor of Intel's 16 bit 80286.

This microprocessor is used for the communication between the host supervising computer and tractor mounted control system. It creates the

command sequence code for the microcontrollers to avoid the contradiction of the control system. For example, when throttle is opened to accelerate the tractor, clutch is turned on and brake is turned off. Or if the tractor in the turning motion, the PTO clutch is turned off. This microprocessor, as well, interpret a macro command which is sent from supervising computer into separated simple command to the first layer microcontrollers.

The host computer is supervising the total system. It measures the location of the tractor, and according to the initially predetermined information of the pathway and the location of the tractor, it creates some macro commands and send them to the onboard microprocessor. To the host computer 4 pole short range radar system is connected.

If the number of farm machinery increases, the system will be reconfigured to fit for the operation mode of multiple machinery.

Location detection

The location detection of the farm machinery is the most important in the development of automated tractor. This is performed by the short range active radar.

The radar system is using the spread spectrum signal for the shifted phase detection that is the result of the difference of the distance from the tractor and the 4 pole radar transducers. The calculation of the range and direction is performed by the simple triangular measuring method. The equation of the location of the target is as follows:

$$\sqrt{(x - k)^2 + y^2} - \sqrt{(x - \ell)^2 + y^2} = D_{k\ell}$$

where k, ℓ is the number of each radar transducer.

The spread spectrum signal has great advantages of high signal to noise ratio, secret data communication, and range detection capability. There are several method of modulation in the spread spectrum modulation such as frequency hopping and direct spreading. In the country that the usage of spread spectrum communication is permitted like U.S.A., and kind of method will be possible to be used. But the country not allowed to use this method such as Japan, only direct method will be able to be adopted.

Control commands

The control commands transmitted from the supervising computer is as follows.

number of the tractor	1 byte
number of components of commands	1 byte
number of data	1 byte
command components	n byte
data	n byte
sum check code	1 byte

The communication between the supervising computer and each tractor is supported by error correction method. The number of the tractor is used to specify the commands and the data is for the specific tractor. Almost all commands are simple macro command, but more primitive commands are also available for direct control of the tractors. The data mainly consist of the location data of the tractor. Using these commands and data, each tractor or some other farm machinery will cooperate to perform the farm works with high precision and efficiency.

Conclusion

The system is being tuned for the adequate response to the communication and commands. It will be developed that the heuristic optimization of the pathway of the tractors using some fruitful algorithms in the study of the artificial life. The system is ready to be easily extended to these newest technology, so it will be sophisticated in the production in the farm as well as in the production of industry.

The work with heavy load have been already transported into machine work by the development of the farm machinery such as tractor and combine harvester. But the work of tiredness and boring is still covered over the field works. Young people don't want to work in the village. This phenomena cannot be easily admitted, but the phenomena of decreasing population in the rural area is spreading worldwide. If we can lead the life, that is, work with robotic tractor just considering the condition of plant growth and its market with the help of computer based decision supporting system, and is to go to the city for fresh information at any time, isn't it a better quality of life? The agriculture in 21 century must be a little bit different from that of this century.