Precision Agriculture Robot for Seeding Function

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Abstract-

In recent years, robotics in agriculture sector with its implementation based on precision agriculture concept is the newly emerging technology. The main reason behind automation of farming processes are saving the time and energy required for performing repetitive farming tasks and increasing the productivity of yield by treating every crop individually using precision farming concept. Designing of such robots is modeled based on particular approach and certain considerations of agriculture environment in which it is going to work. These considerations and different approaches are discussed in this paper. Also, prototype of an autonomous Agriculture Robot is presented which is specifically designed for seed sowing task only. It is a four wheeled vehicle which is controlled by LPC2148 microcontroller. Its working is based on the precision agriculture which enables efficient seed sowing at optimal depth and at optimal distances between crops and their rows, specific for each crop type.

Keywords- Agribot, Precision Agriculture (PA), Precision Farming, LPC2148

I. INTRODUCTION

In India generally the traditional seed sowing methods includes the use of animal drawn funnel and pipes driller or drilling using tractor. Earlier method requires labour and a very time and energy consuming. Whereas in tractor based drilling operators of such power units are exposed to high level of noise and vibration, which are detrimental to health and work performance. The emphasis in the development of autonomous Field Robots is currently on speed, energy efficiency, sensors for guidance, guidance accuracy and enabling technologies such as wireless communication and GPS.

Many agriculture operations are automated nowadays and many automatic machineries and robots available commercially. Some of the major operations in farming which are under research and automation are seeding, weeding and spraying processes. When it comes to designing a robot for automating these operations one has to decompose its idea into two considerations which are agriculture environment in which robot/system is going to work and precision requirement in the task over traditional methods. Based on this for seeding process, considerations which are taken into account in terms of environment are: robot must be able to move in straight way properly on bumpy roads of farm field, soil moisture content may affect the soil digging function, sensors to be selected for the system must be chosen by considering farming environmental effects on their working. Apart from these three other requirements are in terms of accuracy required in the task and these are: digging depth, particular optimal distances between rows and plants for certain type of crop, rows to be sown at a time and accurate navigation in the field. Whereas the other processes like weeding, spraying and harvesting, for which functioning depends on seeding stage by knowing the exact location of crop and then making those operations on it accordingly. So the major stage of all subsequent operations is maintaining a precision in seed sowing process. When considering the physical aspects of the vehicle or robotic system, farmer's present condition in particular area plays a major role in designing these aspects. Considering facts of farming industry of India, system to be developed must have advantage over traditional methods and tractors in terms of cost, speed, accuracy in operation for which it is designed, fuel consumption and physical energy required by human for it. By targeting these issues and considerations properly the end product will be real help for farmers.

A general-purpose autonomous robotic control system designed for agriculture field applications has four core abilities: guidance, detection, action and mapping [2] which are considered in the designing according to application requirement. These abilities are interlinked and sequence of operations to be executed by interlinking these four abilities is given by system of system architecture in paper [8]. This architecture has the two data sets Precision Farming Data Set (PFDS) and Precision Agriculture Data Set (PADS) as links between systems. PADS is continually updated by sensing the required information of crop and soil, based on this PADS sensed data and navigation data of land in PFDS follow-up operations can be done for e.g. fertilizer spraying. All subsequent machinery-based operations on the crop will be then based on the seeding placement accuracy. Here, proposed system for seeding is mainly based on two stages guidance and action. Agronomical needs for the crop growth are indicated by precision agriculture term, so agronomical needs in the prototype developed are spatial distances to be maintained between two rows and two crops.

II. METHODOLOGY

Many of the system designed for agriculture operations of seeding, weeding and fertilizer spraying are based on the camera and machine vision. The navigation of the vehicle is based on GPS, Wi-Fi and remote controlled system. Use of these systems can achieve the level of accuracy but the final cost of the product is very high. The system proposed in this paper is cost effective and does not require the costly equipments for its navigation; it is designed to be automatic and light weight. These advantages make it real aid to farmers.

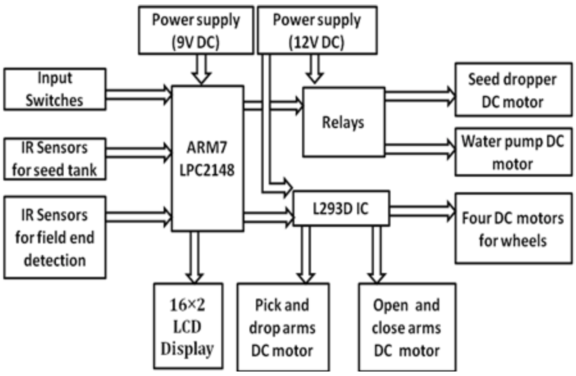

Figure 1.Block Diagram

Figure 1 shows complete block diagram of Agriculture robot developed for seeding operation. Inputs given to system are switches to select crop type, IR sensors to check conditions for seed tank and field detection. Output is obtained through mechanical parts to perform seeding operation and movement of these parts controlled using DC motors. Power supply given to ARM7 board is through 9V battery and to motors using 12V battery source.

A. *Working*

Automation in seeding operation provides the accuracy in these spatial distance requirement of crops than traditional methods. Spatial requirement for each crop must be satisfied to have equal access of air, light, ground moisture, etc. Seed sowing in proposed system is as follows: digging the soil at a crop specific depth, dropping of seeds in the hole, covering it by soil and then pouring water on it. Distances between crop rows and crops is given in table. Completion of row is detected by IR sensors by detecting the compound wall surrounded by field. After detection of first row the robot will turns to its left by 90° and will cover distance between two crop rows and again turns to its left by 90° to continue sowing for second row. Similarly, the end is detected after second row and the root will now turns to its right by 90° cover row distance and again turns to right by 90° to cover third row. So, by alternately turning to its left and right with specific crop row distance, Agribot will execute the sowing of each crop row.

B. *Experimental setup*

The ARM7 Development Board with NXP's LPC2148 microcontroller is the main block. Input of crop type is given manually by selecting one of the four input switches. 16×2 LCD display is used to output the names of chosen crop or to display any error if occurs. Seed tank and water tank are connected for storage of seeds and water respectively. A DC motor is connected for rotating wheel mechanism to drop the seeds. Submersible entirely waterproof DC water pump is used for pouring the water. IR sensors are connected near seed tank to check if it is empty before starting the sowing operation. Other pair of IR sensors is connected in the front side of vehicle to detect field end.

The proposed system is the open loop control system, i.e. no feedback is given from the output side. Input to this system is crop type and desired output is the execution of sowing task. This execution in the project is achieved through mechanical parts. Two v-shaped arms for Agribot are used, closing of which will dig the soil and opening of it will release the soil to cover the pit. Two DC motors are required for movement of these arms, one for up and down motion and other for opening and closing. Four DC motors are used for driving the four wheels of vehicle. DC motors of arms and wheels are connected to L293D IC to enable them rotating in both clockwise and anticlockwise direction. Relays are connected to DC motors of water pump and seed dropping.

III. RESULTS AND DISCUSSION

Main objective of automating the seeding operation is to make it more efficient and accurate in its working over traditional seed sowing methods. There are three major distances in seed sowing operation and these are digging or sowing depth for seeds, distances between two crops and two rows. This can be interpreted as row and column distance. Experiments are done on the wet soil and distances covered by the robot are compared with predefined optimal distances. A practical value of two rows and two crops distances differs from 4cm to 8cm and 2cm to 3cm respectively from theoretical values. Results of distances covered by Agribot are arranged in tabular form in the table below. Agribot is also able to detect the field end by detecting the compound of the field. Accuracy obtained is satisfactory and can be improved by utilizing more mechatronic design methodology, modern controllers and advanced information systems.

Table1. Crop Distances (Theoretical and Practical values)

Crop Type	Distance between two crops(y cm)		Distance between two crop rows (x cm)	
	Theoretical	**Practical**	**Theoretical**	**Theoretical**
Cotton	15cm	12cm	60cm	53cm
Maize	12cm	9.5cm	45cm	38cm
Soybean	7cm	6cm	50cm	42cm
Wheat	5cm	5cm	25cm	21cm

IV. CONCLUSION

An autonomous robot is developed to perform the complex farming task of seeding. Agribot in this project is designed to perform sowing only for four crops: cotton, maize, soybean, wheat. Row and column distances required for these four crop types are modeled in the system. With slight variations of few centimeters in the distances defined robot successfully covers distances between crops and their rows. Navigation technique using IR sensors in Agribot is easier and less bulky over other existing agriculture robotic systems. Ease of handling and precision working makes this agriculture robot real aid for farmers. Less complexity in the mechanical design and simpler navigation technique makes the system of lower cost and less bulky compared to conventional tractors. Also the coverage area by the robot is restricted because of its dependence on DC battery. Other crop types can be included by modeling their required optimal distances. In future, the system can be modified for other farming tasks too such as weeding and spraying processes with some mechanical designing modifications and by using advanced controllers and sensors. More advanced and fast system can be developed with more focus on implementation of right mechanical parts and their designing.

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