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Design and Manufacturing of Agriculture Weeding Robot

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Abstract: A recent trend in the agricultural area is the development of mobile robots and autonomous vehicles for precision agriculture. In farming one of the fundamental issues facing a farmer is the cost of running the farm. If the equipment the farmer is using can be made more efficient & reliable, the cost of farming will be reduced. One way of making agricultural equipment more efficient is to develop autonomous functions for the equipment. The aim of this paper is to develop an autonomous agricultural vehicle. The environmental impact of agricultural production is very much in focus, while the competition demands high efficiency.

Presently weeding is done manually without the use of pesticides. With the development of an autonomous agricultural vehicle with sensors for weed detection, it will be possible to avoid the use of pesticides. The vehicle uses high precision Global Positioning System, encoders, compass, and tilt sensors, to position itself and follow waypoints.

Keywords: Agricultural robot, wireless sensor network, GPS, Precision agriculture.

I. INTRODUCTION

Agriculture comes from two Latin words Ager which means a field and Culturia which means cultivation, the tillage of the soil. A lot of the world's workers (42%) are involved in agriculture in some way.[5] India being an agricultural country needs some innovations in the field of agriculture this can be achieved through modern technologies which assist computing, communication and control within devices [1]. Today the environmental impact of agricultural production is very much in focus and the demands to the industry is increasing. The production of agricultural products is growing and the competition is getting bigger, therefore the farmer has to be very efficient to be able to compete.

At the same time the demands, for less use of pesticides and fertilizers, from the consumer and the legislation are increasing. Therefore the farmers have to use high technology in the fields for weeding, spraying, etc., earlier weeding were done manually but today it is neither profitable or possible to get a sufficient number of labor for this job. In this paper, an autonomous agricultural vehicle, for test and development of sensors, tools and information technology in the field, is going to be developed.

The goal of decreasing herbicide usage has so far focused on reducing the herbicide dosage or replace chemical weed control by hoeing and harrowing. Environmental impact of agricultural production is very much in focus, while the competition demands high efficiency. The conventional weed control strategy is to apply the same dose rate of herbicide or the same intensity of physical treatments to the whole field.

To obtain efficient and accurate weed control systems they must be developed to target specific parts of the field.

A field in which the crop is established in rows can be divided into three weeding target areas:

The area between the rows (inter-row area)

The area between the crop seedlings within the rows (intra- row area),

The area close to and around the crop seedlings (close-to-crop area).[4]

A. Weed control

Farmers control weeds to increase plant growth, to improve crop yield and quality, and to reduce habitat for insect and disease vectors. They may also control weeds to prevent a buildup of weed seeds in the soil, to keep their farms safe from wildfires and other hazards, and to reduce grain dockage and livestock losses resulting from poisonous plant infestations. In addition, farmers are obligated under the provincial Weed Control Act to control noxious weeds. Province-wide noxious designations apply to 21 plant species in B.C. Another 28 plant species are designated noxious within specific regions. Legislated noxious weeds must be controlled to prevent the injurious distribution of seeds.

1) *Weed Control Goals :*On-farm weed control programs are designed to accomplish the suppression of weed growth, the prevention or suppression of weed seed production, the reduction of weed seed reserves in the soil, the prevention or reduction of weed spread, and noxious weed eradication. Practices that help prevent weeds from becoming a problem include sowing

high-quality seed which is low in weed seed conteSnt, cleaning farm machinery, cleaning animals before moving them, using only well-rotted manure for soil amendment purposes, and using total farm weed control practices. Such practices include cleaning fence lines, irrigation ditches, farm roads, stockyards and any other on-farm sources of weed seeds.

See also Farm Practice: Farmstead Maintenance

2) *Integrated Weed Management ;* Integrated Weed Management is a balanced approach which includes:

a) Managing the resource to prevent weeds

b) having knowledge of being able to properly identify weeds

c) making inventories, and mapping and monitoring weed populations and damage

d) making control decisions based on knowledge of potential damage, cost of control and environmental impact of the control decision

e) using control strategies that may include a combination of methods to reduce weed populations to acceptable levels while evaluating the effectiveness and effects of management decisions

3) *Weed Control Methods*

a) *Biological :*Biological weed control involves the use of natural agents such as insects, nematodes, fungi, or viruses. Agents used for this purpose undergo rigorous testing to ensure specificity. Agriculture and Agri-Food Canada and the United States Department of Agriculture. As a further precaution, agents are not introduced without the approval of the BC Plant Protection Advisory Council

b) *Chemical :*Farmers use herbicides to kill or suppress undesirable vegetation. All herbicides used must be federally registered. Farmers must follow label directions and obey all pesticide laws.

B. Cultural

Cultural practices can be used to suppress weeds and to provide a competitive advantage to the crop being grown. Seedbed preparation techniques, seeding rates, variety selection, drainage, fertilization, the use of cover crops, and crop rotation are among the cultural practices used.

C. Physical

Burning: Fire can be used to destroy weed seeds and mature weeds. Flaming machines may be used to kill weed top growth between crop rows. Cultivation: Tillage kills weeds by burying the entire weed, depleting weed food reserves, exposing underground propagules to frost or desiccation, and encouraging the rotting of underground propagules. Cultivation can be done any time during the growing season such as prior to seeding, while the crop is growing, and after harvest. See also Farm Practices: Farmstead Maintenance

D. Mobile Equipment

1) *Grazing:* Horses, sheep, goats, hogs and cattle can be used to control weeds.

2) *Hand Weeding:* Hand weeding can be used for small plots or areas.

3) *Mowing:* Tractor-operated mowing equipment, gas-powered handheld mowers, weed eaters, and the like are used to prevent weed seed production and to deplete underground food reserves. Mulching: Mulches such as clean straw, hay, manure, tar paper, sawdust and dark-coloured plastics can be used to control weeds.[3]

E. Problem faced by weeding robot

Development and construction of an autonomous robot for weed control in row crops e.g. sugar beets or maize. The robot can be divided into four main modules:

A vehicle as a platform for carrying e.g. weeding tools for in row weeding. The vehicle could be equipped with the control modules described below.

A control unit, with input from Vision, GPS, and other necessary sensors, are providing the vehicle and the tools with the necessary control signals.

A GPS module that provides the vehicle with its global position in real time.

A vision system detecting the position of the crop relative to the vehicle position.

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The main goal of this paper is the development of the vehicle and the control unit, with possibility of using different sensor technologies. We want to test the vehicle and control unit and show that the robot is capable of following a path under field conditions.[14]

F. Machanical System

The aims of this paper is to develop a modular robotic platform able to move around in typical Indian agricultural environments with the main purpose of in-field data acquisition and new technologies research for sensing in agricultural area. Its main features are the robustness, mobility, high operating capacity, and autonomy consistent with agricultural needs. The robotic platform will feature a multifunctional structure to allow the coupling of different data acquisition modules to study spatial variability through embedded sensors and portable equipment. The proposed platform is composed of two main subsystems: the robotic platform subsystem and the modules subsystems. This paper focuses on the robotic platform subsystem.[7]

1) *Robotic platform*

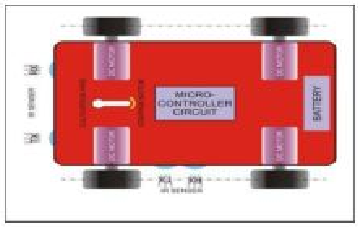

Figure 1: Designing of vehicle

For developing the structure of robotic agriculture machine, simple technique is used. As shown on figure 1, it shows the designing of vehicle.

It has four wheels which are individually driven and steered. These wheels drive respectively with two dc motor, provides direct drive without gearing. Also there are two sliding bearings, respectively connect to the front wheel and body, so that the front wheel can rotate between $+45^0$ or -45^0 around bearing. All dc motors are energized by dc supply through microcontroller circuit. Color sensor sets at the front edge of vehicle for sensing color of the weed in the way of vehicle, provides instruction to microcontroller for controlling motion of weed cutting tool through a servo motor. The weed control tool is fitted at back side of assembly, shown in figure 1. It is used to cut the weed present between two columns of the crop controlled by servo motor. At weed cutting section, a servo motor and an infrared sensor is used to put the weed control tool in ground and check whether the tool is placed in ground or not by infrared sensor. If any error is detected in this process like weed cutting tool is not dropped in land, battery backup problem etc., then it stars buzzer and shows the fault on display board. One small tank is mounted at front side to store herbicides to kill weed. Horizontal pipe is mounted at front and small nozzles are connected in front of robot and with the help of small pump herbicide is provided to nozzle for spaying. Due to spraying weed would be kill.

2) *Electronic Layout:* The electronic layout of Weed Robot is shown in Figure 2.

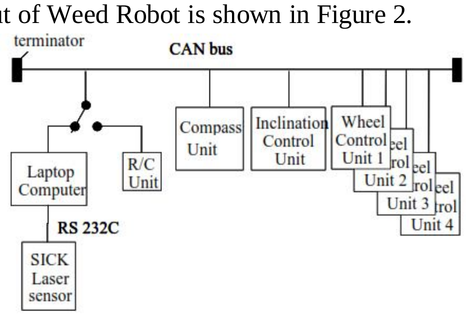

Figure 2. Electronic control systems

Each wheel was controlled by a Wheel Control Unit, which contained a BasicAtom microcontroller (ATOM PRO24-M, Basic Micro, Farmington Hills, MI) under control of a dedicated MBasic program. A major advantage of the BasicAtom microcontroller is the hardware PWM generators, which allow for reliable motor control. The function of the Wheel Control Unit was to generate the appropriate PWM signal for the motors when a steering/driving input is received from the main controller unit. In crop guidance mode, this steering input was transmitted by a laptop computer that interfaces with a SICK (LM291, SICK® AG, Duesseldorf, Germany) laser range finder. In Remote Control mode, these signals were generated by another Basic Atom microcontroller unit that interfaced with the Remote Control Receiver. An electronic compass (126703CL, Jameco Electronics, Belmont CA, www.jameco.com) was used for end-of-row turning. The laptop computer was used to interface with the SICK laser range finder as well as the Electronic Compass and to compute the appropriate steering and speed control message for the Wheel Control Units. The communication between the laptop computer and the SICK Laser Range finder was implemented using RS232C, and the communication with the electronic compass was implemented using a Serial Peripheral Interface (SPI) bus. All other communications were implemented using a Controller Area Network (CAN) bus (Etschberger, 2001). The programming language used for the guidance tasks was 'C'

F. Guidance

The crop guidance functionality of the robot was based on a SICK laser range finder unit. This unit projects a 180-degree horizontal laser sheet and calculates the distance to any object in the field of view with an angular resolution of 0.5 degrees. Table 1 shows the specifications of this sensor.

Type	Scanning angle	Resolution/Accuracy	Range (10%reflectivity	Data Interface	Transfer rate	Power consumption	Weight
LMS291	180^0	10mm/±35mm	30 m	RS232 RS422	9.6/19.2/38.4/500 kb	20w	4.5 Kg

Table 1. Specification of SICK laser scanner

A simplified model of corn stalks was to regard them as perfectly cylindrical shapes, placed in rows at constant distances as shown in Figure 3. The laser scanner measures the shortest distance in 0.5-degree increments. To control the robot, information is needed regarding the left and right side nearest row. Data filtering was performed using the following steps:

1) Collect distances and associated angles from SICK laser scanner.
2) Convert cylindrical coordinates to Cartesian coordinates within 2 m radius.
3) Discard lateral coordinates outside 15<|x|<80 (this window was chosen arbitrarily)
4) Discard longitudinal coordinates larger than threshold D. This value is adaptive; D is 150cm during between-row guidance and 80cm during headland turns.

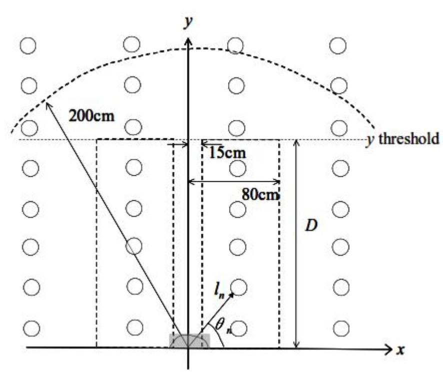

Figure 3. Simplified model of corn stalks in the field

G. Between-the-row guidance

The between-row guidance control was based on the difference between the current heading and an aiming point, which was calculated using the filtered data from the SICK laser scanner. The aiming point was simply the mean value of the Cartesian coordinates of the corn stalks. A low pass filtering action was applied over time to compensate for the movement of corn stalks under high wind conditions.

H. End-of-row turning control

The turning at the end of the row was performed using a series of steps as follows:

1) Detect the end of row by observing loss of data from SICK range finder.

2) Continue moving forward using current heading for 10 seconds (chosen based on maximum travel speed).
3) Perform zero radius turn through 180º using electronic compass.
4) Fine tune robot orientation with latest row using SICK range finder. Proper alignment was assumed when the average of the corn stalk coordinates (aiming point) is in the center of the detected coordinates.
5) Move transversely (using crab steering) and stop when the robot is in line with the adjacent row using SICK laser sensor. As in step 4, proper alignment was assumed when the average of the corn stalk coordinates (aim point) is in the center of the detected coordinates.
6) Enter adjacent row.

Figure 4 shows the end-of-row turning method.

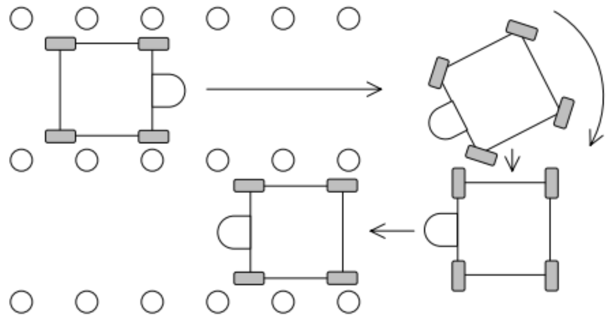

Figure 4. End-of-row turning sequence

I. *Electronic layout*

The electronics were built around a single 40-pin BasicAtom module and no network was required. The advantage of the around a single 40-pin BasicAtom module and no network was required. The advantage of the BasicAtom unit is its built-in hardware Pulse Width Modulation unit, which is very well suited to BasicAtom unit is its built-in hardware Pulse Width Modulation unit, which is very well suited to drive DC motors. To interface the microcontroller with the motors, motor controller boards were drive DC motors. To interface the microcontroller with the motors, motor controller boards were used (OSMC Power Unit,www.robot-power.comused (OSMC Power Unit, www.robot-power.com) To interface with the 8 infrared sensors and 2 ultrasonic sensors, a dedicated board was developed which multiplexed the sensors to the microcontroller unit. The ultrasonic sensors (134105CL, Jameco Electronics, Belmont CA, www.jameco.com) used analog output voltages, and were connected to Analog/Digital converter ports on the BasicAtom. The electronic compass (126703CL, Jameco Electronics, Belmont CA, www.jameco.com) had a Serial Peripheral Interface (SPI) and output pulses that were counted using a pulse counting command in MBasic. A 20*4 serial LCD unit (LK204-25, Jameco Electronics, Belmont CA, www.jameco.com) was added to display the output of the sensors in real time. Figure 7 shows a diagram of Weed Robot electronic units.

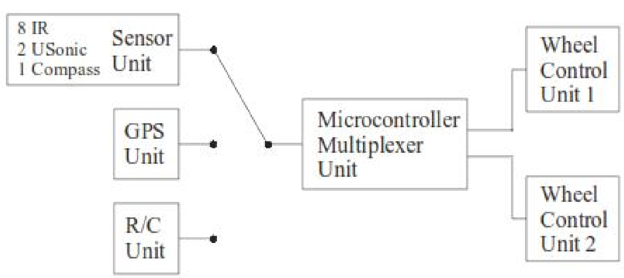

Figure 5. Diagram of Weed Robot electronic units with
1) Remote Control, 2) GPS and 3) Crop guidance modes

For the programming BasicAtom'sMBasic language was used. This language is a modern Basic variety that supports compilation and allows for simple uploading of the compiled code into the microcontroller using a fast serial connection.

II. WEED MAPPING

Weed mapping is process of recording the position and preferably the density (biomass) of different weed species using aspects of machine vision. One method is to just record the increased leaf area found in weedy areas as weeds are patchy and the crops are planted in rows (Pedersen 2001). Another more accurate method is to use active shape recognition, originally developed to recognise human faces, to classify weed species by the shape of their outline (Søgaard and Heisel 2002). Current research has shown that up to 19 species can be recognised in this way. Colour segmentation has also shown to be useful in weed recognition (Tang et al. 2000). The final result is a weed map that can be further interpreted into a treatment map.

III. CROP GUIDANCE

For crop guidance, Weed Robot uses an array of sensors for in row guidance and end-of-row turning (Figure 8). The crop guidance of the robot was performed by simply attempting to keep an equal distance from the corn stalks on the left and right. As a distance indicator, the average value of the infrared and ultrasonic sensors was used and outliers were removed using a median filter approach.

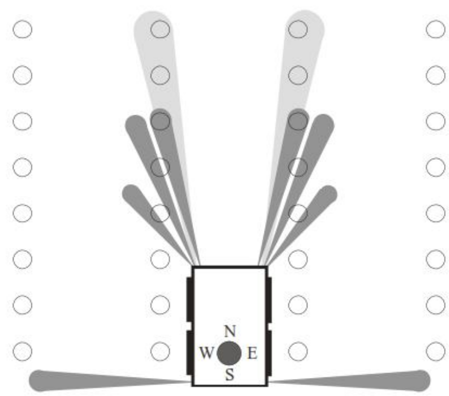

Figure 6. Sensor arrangenment with 2 ultrasonic sensors and 8 infrared Between-the-row guidance sensors (6 long distance, 2 short distance)

When the average left sensor output was higher (closer to stalks) than the average right sensor outputs, the right motors were decelerated which steers the robot to the right and vice versa. The amount of deceleration was proportional to the difference between the average left and right sensor outputs, a classical proportional/integrating action control approach. Constants for the proportional and integrating action were obtained by experimentation and observing the amount of sway in the crop rows.

A. End-of-row turning control

The end-of-row turning was accomplished using the following steps (Figure 9):

1) Detect the end of row by observing loss of data from infrared sensors.
2) Continue moving forward using current heading for 5 seconds (chosen based on maximum travel speed).
3) Perform zero radius turn through 90 degrees using electronic compass.
4) Move perpendicular to the crop rows until the rear sensors 'see' the previous crop row.
5) Reverse the robot through 10 cm (time based, about 1 sec in 75 cm rows)
6) Turn again in the same direction through 90 degrees using electronic compass.
7) Move forward into the new row.

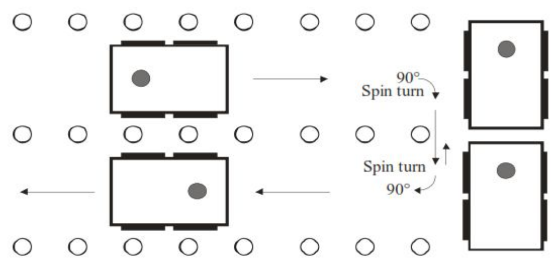

Figure 7. End-of-row turning sequence

IV. THE FLOW CHART OF THE PROGRAM

The procedures of suggested method are the following:

A. Starting the wireless camera with its tuner (connected to the computer through USP connection).

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B. Capturing the image of the environment by the wireless camera using the multiviewer program.

C. MATLAB program initialization.

1) reading the captured image.

2) removing the noise in the image by special filters.

3) processing the image from step (b) and applying special program to discriminate between the weed and the plant then, discovering/defining the coordination of each one and saving it in specific matrix.

D. Starting the Mobotism program.

1) receiving the weed and plant coordination from the MATLAB program.

2) building the environment including the weed and plant location.

3) applying special program to give all the possible and optimum paths.

4) choosing one of these optimum paths and sending the coordination to the C++.net.

E. Initialization of the c++.net program.

1) receiving the coordinates of the path from the Mobotism program.

2) sending the coordinates to the mobile robot.

3) stopping a mobile robot at a certain distance from the weed to give the gripper or the pump motor the facilities for elimination or spray.

F. Starting the MATLAB program again to the wireless kit receiver fixed on the mobile robot to catch the weed.

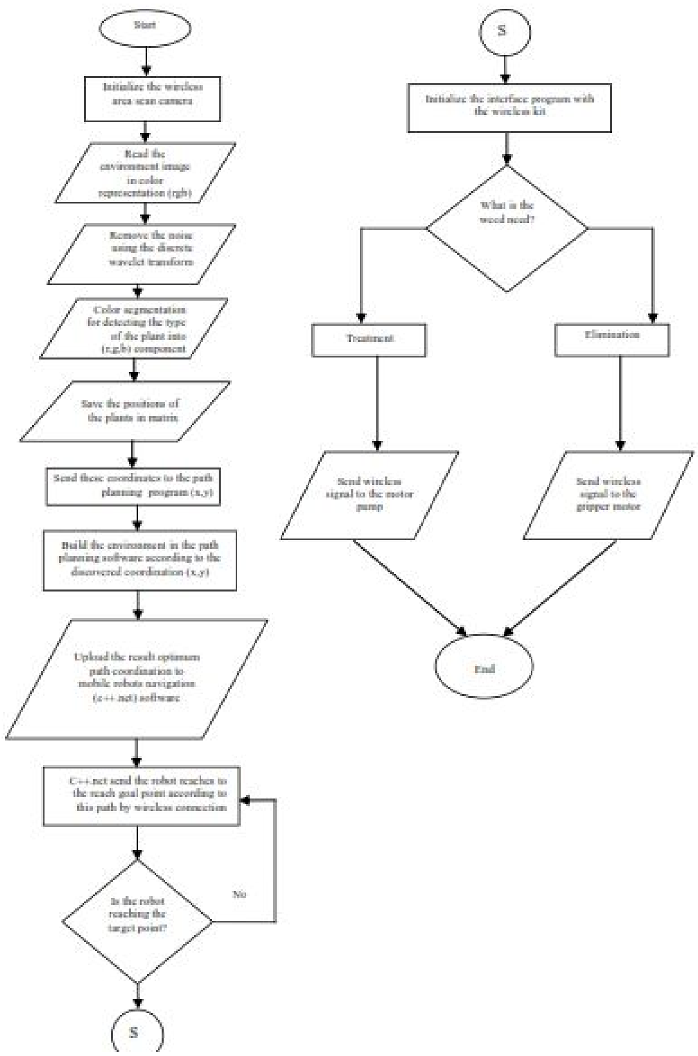

Fig. 8:- The flow chart

V. CONCLUSION

In this paper, we proposed real development of weeding robot. The assembly is developed for weed control system in ploughed land automatically i.e. no man power required. This paper consist of two different mechanisms. First mechanism contains making an assembly of vehicle and its motion, where second mechanism is cutting the weed in between two crop lines. Turning at the end of the row will be performed using the spin Turn and crab moion. The end-of-row turning method used a compass for 90-degree turn and SICK laser will use to precisely align the robot to enter adjacent row.the SICK laser application required tilt control which added an additional tilt sensor and linear actuator. The work independent on available or on the ready software. The new program in MATLAB, C++.net will built and give us experimental results.

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