Development of a Robotic Navigator to Assist the Farmer in Field

Anshuka Srivastava and Swapnil Kumar Sharma

Abstract—This paper reports on development of a robotic navigator, "Robo Kisan", developed to assist the farmer in the crop field and show the complete function of the sensor for crop disease detection. This robotic navigator equipped with sensors for automatic mobility in the crop field is developed in two folds: Hardware design and Software design. A short description of the sensor for crop disease detection along with the navigator hardware and software are described in detail. The goal of the present design of the navigator is to make it carry sensors and other tools as per requirement to help the farmer in detecting the disease and other repetitive jobs.

Key words— agriculture, disease detection, microcontroller, navigator, robot, software platform

I. INTRODUCTION

Disease detection in a crop plays an important role in crop field management. Present convention for diseases control is to apply the necessary chemicals before the occurrence of the disease. Still on search if any sign of disease is found again chemicals are applied for the control. Hence, many prediction models have been developed. Reports show that a great damage to crop and food loss is due to infection by diseases [1]. Present convention is time taking, costly and unnecessary application of chemicals is hazardous. It is desirable to detect the disease at its early stage to control. Hence, a sensor was developed to perform the job of field observations of Downy Mildew (DM) disease in Grapevines. Authors had selected image processing as a tool for making the sensor. A module, comprised of four small modules was made and had been presented by the authors [2]. A navigator could be similar to an autonomous guided vehicle (AGV) with special features/capabilities.

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An autonomous guided vehicle (AGV) is a typical transport component utilized within a warehousing complex. AGV is the first high technology system in material handling [3]. This kind of vehicle offers a high degree of flexibility in transporting material and interacting with plant equipment and personnel [4]. According to researches in the field of material handling [5], [6], [7], [8], [9], [10] and [11], AGVs are crucial components to facilitate and optimize such a transport system. There are a number of flexibilities for an AGV system in material handling, such as diversity of vehicle types, route simplification between processes within complicated networks and the ability to program and retrofit with new tooling to deal with diverse industrial needs [12]. However, many existing automated warehouses that deploy AGVs use a centralized or hierarchical control paradigm that is integrated with the rest of the material handling systems, [13] [14], [15] and [16]. With the intervention of a central controller, AGVs require various kinds of guidance for navigation, communication media for transmission of information among AGVs and well-organized jobs definition generated during the system planning stage. With these approaches to material handling, these AGVs cannot be regarded as fully autonomous. To achieve fully automated warehousing, a control framework for dispatching material handling tasks, specifying individual AGV behaviors, controlling information exchange between AGVs and accomplishing delivery tasks automatically is necessary.

This paper describes a control framework that is developed by the authors. The goal of the present design of the navigator is to make it carry sensors and other tools as per requirement. The navigator moves straight in the given field like grape field having no set rows as well as can move on the sides of the rows of tomato, egg plant etc. to harvest the desired fruits. This type of navigator is also useful in the field crops where harvesting is done at a number of time intervals and it is different from that of whole crop harvesting. Hence, repeated motion of the navigator is planned. The navigator can also help the farmer by providing the necessary information regarding crop and the field condition as well. The navigator aims for the step movements in the field. At first step it moves at a speed of 20 mm/second and then it must stop for a while so that the plucking tool and the other sensors can do their respective jobs of sensing, collecting data and plucking of the

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ripened fruits. The navigator can also be useful in detecting diseases in the crop and cutting flowers with stems such as rose flowers, orchid flowers etc as well.

For the first time in the world the present robot mounted with a sensor (Robo Kisan) has been developed to detect the Downy Mildew Disease of grape. It will give its information at the farmer's door on a speaker or computer. This robot collects the disease data from the field & transmits it through the radio waves to a super computer where data processing is done to find out whether the grape vine has been infected with the Downy Mildew Disease or not. This robot is capable to detect the infection of Downy Mildew Disease even at the earliest stage of infection. If there is no infection of the disease no information is sent to the farmer. It is worth mentioning that the disease is very disastrous & the moment infection takes place it spreads very swiftly and if proper care is not taken in time the whole crop is destroyed. Moreover, manual observations from time to time are made in the field to detect the disease. This is very much time and labor consuming and involves more cost as well as pollutes the environment. The manual observation is tedious and laborious. Their efforts, however, could now be replaced by the present Robo Kisan. Grape fruits are used for raw consumption as well as in wine industries. Therefore, to meet the need grape cultivation is done on a very large scale. The difficulty in finding out the disease is that it is visible only when it has developed well in the plant and by that time it becomes very difficult to save the diseased plants due to its rapid spread. This way a great loss occurs to the grapes vine resulting in huge reduction in the fruit yield. This loss finally speaks on the wine industry and fruit market. It is very difficult to observe each and every leaf of the vine in the orchard. Further it is worth pointing out that it comes into visual observation when it has spread in big quantity. It is necessary to destroy the disease the moment it infects so that the whole plant may be saved. When infection takes place, first of all it appears on the leaf in a very small size like a dot. This is not possible to be observed by the necked eyes. When the disease has spread in the larger area only then it is visible by the eyes. Therefore, it becomes very necessary to detect it at the time of its emergence on the surface. Keeping this in view the present research was conducted and a sensor was developed capable of detecting the disease on its very onset. For this a robotic navigator is designed on which the sensor is mounted and it is sent in the field to collect the data. It performs the observation in few hours that a manual observer will take a number of days. Apart from this the disease gets no time to spread and pesticides are spread in the infected region controlling the disease and saving the whole vine. This saves money, time and labor. The developed DM disease detection method was tested under the laboratory conditions and thereafter tested under the natural conditions. The navigator is capable of carrying various necessary tools and moves all around the field without the help of the farmer.

II. DESIGN of ROBO KISAN

The purpose for the development of present navigator is to navigate the pre-defined crop field. The basic requirements for this navigator are ability to move in a straight line motion, make U turn, speed controls at different situations, to carry necessary tools.

The aim is to realize an economical mechanical design which when aided with controls and actuator can perform the field investigation automatically. Hence the design of the navigator is completed in two parts namely

1. Mechanical system design
2. Electrical and Electronic system design (design of software for personalized microcontrollers)

A. Mechanical System design:

Criteria:

1. Decision of the size of the frame (35X40 mm)
2. Decision of the type of loads to be carried (16 kg)
3. Decision of the type of material to be used for the design of the frame work (Mild Steel)
4. Decision of the type of driving mechanism (consists of three dc stepper motors)
5. Decision of the type of steering mechanism (simple differential method)
6. Decision of the type of the design of the tool holder and tool adjusting/ positioning mechanism (Using IR sensor)
7. Decision of the type of material to be used for the design of the tool holding mechanism (Aluminium alloy)
8. Decision of the type of material to be used for the design of the driving mechanism (Aluminium alloy)
9. Decision of the type of material to be used for the design of the steering mechanism (Aluminium alloy)
10. Decision of the type of material to be used for covering the electronic parts (HDPE).

MECHANICAL STRUCTURE

The mechanical structure of the navigator the "Robo Kisan" is comprised of the frame, two similar rear driving wheels and two front wheels. The tough rubber wheels are used. Front wheels are steered by single steeper motor, the rear wheels are driving wheels which are powered by two dc motor of 12 volt and 10 amp of current rating. It is an on board computer controlled mobile robot designed for crop field. The chassis has been made of MS flat and MS angle. The complete 3-D view of the developed conceptual robot is given in figure 1.

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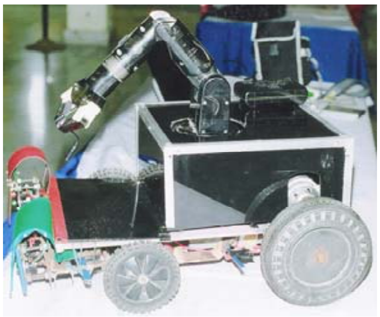

Figure 1: 3-D view of the developed conceptual robot

B. Electrical and Electronic system design

We have considered following factors

1. soil factors affecting the driving of the vehicle (soil reactions for different soil)
2. torque requirement for driving mechanism (soil factors and total load on navigator)
3. torque requirement for steering mechanism(soil factors and turning angle)
4. power requirement for driving mechanism (for 6 hrs)
5. power requirement for steering mechanism (lithium battery pack)
6. motors for steering and driving mechanism(dc stepper motors)
7. motor for the tool positioning mechanism(dc motors)
8. decision of the sensors(Infra red based sensors along with ccd cameras)

CONTROL CIRCUIT AND POWER PANEL

By programming a super computer comprised of the on-board microcontrollers, motion controllers, sensors, path planning and object avoidance system has been modeled. Sensors are mounted on the front surface of the robot and with some contact switches, some other features are mentioned such as rugged aluminum frame Dual front whisker sensors; optical wheel encoder for distance measurement, on-board controller controls all the motors, Controllable LED's, Sound output transducer. Sockets to accept a controller chips, Dimensions: 15" x 10"x 5" Runs on 8 lithium ion batteries for 6 hours or more. The motion of the robotic navigator is automated using the on chip computer and the control circuit used is given in figure 2.

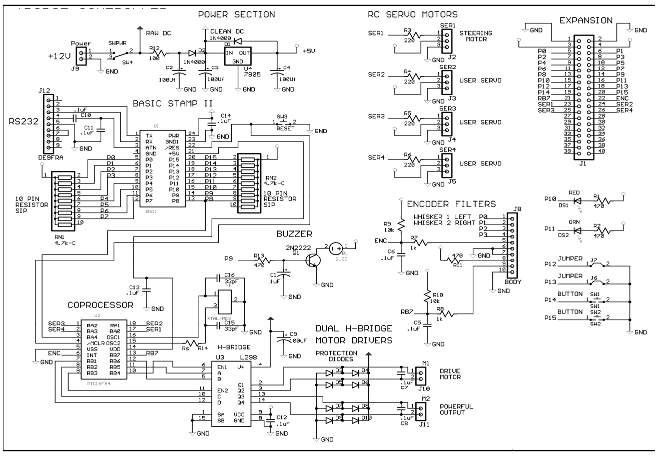

Figure 2: The control circuit of the Robo Kisan

The proposed sensor consists of four modules:

Module 1: Image formation (image grasping or collection of illumination by the camera sensor, image creation and camera out put as voltage signal),
Module 2: image pretreatment
Module 3: Linking the visual data to illumination and
Module 4: recognition of Downey Mildew (DM) disease using mathematical model (see figure 3).

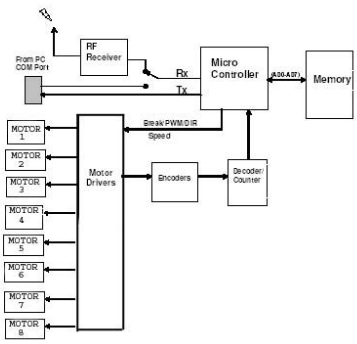

Figure 3: The architecture of disease detection sensor

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III. SOFTWARE DESIGN AND ICROCONTROLLER DESIGNS

Software has been developed under visual basic 6 for writing and personalizing our microcontrollers (see figure 4).

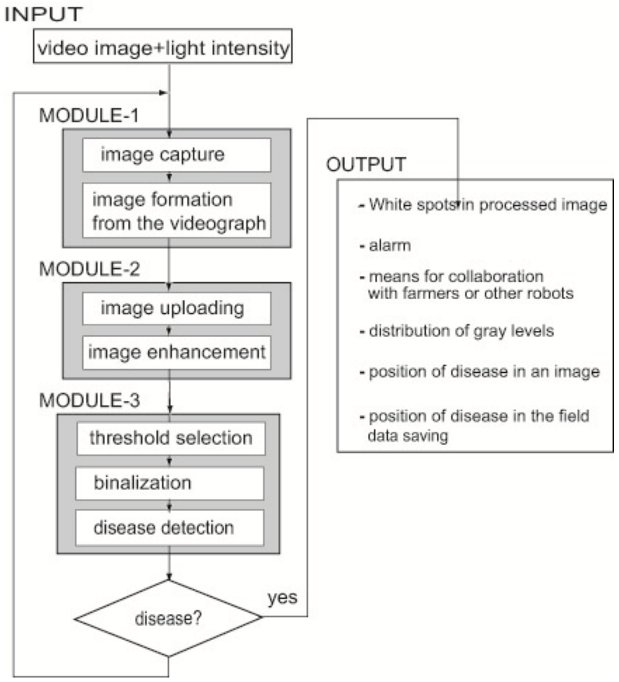

Figure 4: The architecture of microcontroller programmer software.

IV. RESULTS AND DISCUSSION

Experiments with the Robo Kisan showed that

1. The navigator can travel in the crop field automatically and can make desired moves by itself.
2. It can successfully carry tools.
3. It can collect data for processing and give the report.
4. The software developed can program the microcontroller successfully.

V. CONCLUSION

A robot has been developed along with a specified sensor and checked for its performance. Experiments showed satisfactory results. It was concluded that the present robot is time optimal and perfect for DM disease detection under normal environmental conditions and move in crop field with ease. It can carry tool to the field with the purpose of assisting the farmer.

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