Robo Kisan- A Helping Hand to the Farmer

Anshuka Srivastava

Abstract—Industrial revolution no doubt is adding a lot to the human life but at the same time it is polluting the atmosphere as well. Agricultural industries are no exception. In order to crack the demand and supply gap, it became essential to minimize the losses on the farm and increase the yield; various control strategies, which include chemical applications, have been developed and are in practice. But the use of these chemicals & pesticides are endangering the environment by polluting the atmosphere. Now this pollution has started giving health hazards which has to be taken urgent care.

Hence there is increasing pressure to reduce the use of pesticides in modern crop production to decrease the environmental impact of current practice and to lower the production costs. It is therefore imperative that chemical sprays are only applied when and where needed. Since diseases in field are frequently patchy, chemicals may be avoided from being applied unnecessarily to disease-free areas. Main object of present research is automation of the early detection of grape plant disease and assist the farmer by giving the information regarding targeted application of the required medicine to protect and care their infected plants from diseases. At present the prevalent practice of detection is by human eyes which have its limitations because there are many microscopic disease symptoms beyond visual observations. Due to limited visual nature of the plant monitoring task, computer vision techniques seem to be well adapted. An automated machine/ robot can send the information by voice/computer message or automatically apply the required chemicals at target point. In view of the above the present research was conducted and a robotic farm assistant carrying a SENSOR capable of detecting downy mildew disease and recommending proper chemical dose has been developed.
This robot has been developed in two folds: 1. an automatic navigator the "Robo Kisan" equipped with sensors for automatic mobility in the grape field and 2. a sensor for detecting the downy mildew disease.

***Keywords*— disease detection, downy mildew, farm helper, navigator, robot.**

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. DM causes a huge loss to the vine industries in many countries. 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]. The module reads the color data comprised of three-color components, namely red, green and blue along with the structure of the leaf. Skeleton of a leaf reveals information of particular crop hence a software was developed to characterize grape leaf. The problem led to the development of a sensor that would check the feasibility of the system based on image processing. Hence a mathematical model had been developed for representing the variation of color data for DM disease and the healthy leaves with the illumination. A model can reproduce a distribution along with its interpolations. Therefore, it is convenient to use a model for repetitive data. This paper presents a robust system that is useful for natural environmental condition at any illumination under 4000 Lx. In order to make the sensor fully automatic it was needed to develop an automatic navigator capable of carrying the sensor and moving around the crop field for data collection for the sensor. A navigator could be similar to an autonomous guided vehicle (AGV) with special features/capabilities.

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]. This paper describes a design of a robotic assistant for the farmers that is developed by the author. Present navigator is designed to make it carry sensors and other handy tools as per requirement. This navigator can moves straight on the sides of the rows of tomato, egg plant or grapevine to harvest the desired fruits. This type of navigator is also useful in the field crop 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. This navigator has to move in crop field so proper planning for it's wheels have been done by considering the worst condition of soil-moisture that may be possible on field [17]. 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 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. Author present a robot mounted with a sensor (Robo Kisan) which 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

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robot collects the disease data from the field & transmits it to the controller 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 DM 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 robot was made 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. All the microcontrollers used in this work were programmed using the RW-Programmer Interface developed by the authors [18].

II. DESIGN DESCRIPTION

The purpose for the development of present navigator is to navigate the pre-defined grape 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. *Control circuit and power panel*

Mechanical System design:

The mechanical system consisted of 1.25 mm mild steel angle frame of size 40 X 46 sq mm, height from ground 175 mm, aluminums base to carry the entire load which ultimately transferred to the four tires, high density poly ethylene(HDPE) used for body of the navigator. Total height of the robot was 475 mm. Teflon tires, 2.5 X 30 mm, were used for drive and tugged rubber tires, 2.5 X 30 mm, for steering purpose. This was done to obtain best motion at various steps in motion on field which depend on the rolling resistance, thrust and drawbar pull developed by the wheel; this is described in figure 1.

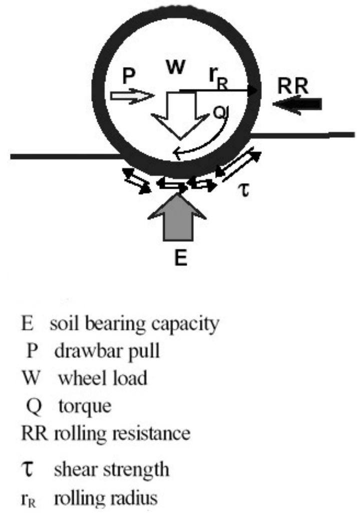

Figure 1: Factors affecting mobility.

The driving mechanism was synchronized chain and aluminium shafts. A simple kinematic chain formed perfect steering mechanism controlled by geared motor. HDPE gave high strength and at the same time it supported easy adjustments for tool holder and tool adjusting/positioning mechanism which was mounted on front top of the body. The tool holding mechanism was built by Teflon sheets and pipes. The 3-D view of the developed conceptual robot is given in figure 2.

Figure 2: 3-D view of the developed conceptual robot.

Control Circuit and Power Panel:

Microcontrollers for data acquisition system, motion controllers, sensors, path planning and obstacle avoidance system has been modeled and programmed. Sensors are mounted on the front surface of the robot and with some contact switches, Dual front whisker sensors, optical wheel encoder for distance measurement, diffused scan sensor for obstacle avoidance and motion in grape field, on-board controller, Controllable red and green LED's, Sound output transducer. Two user defined push button switches, 3 User-defined motor control ports, Serial communications port, Expansion connector, Sockets to accept a controller chips, Dimensions: 15" x 10"x 5" runs on 8 AA-cell batteries for approximately 5 hours The motion of the robotic navigator is automated using the on chip computer and the control circuit used is given in figure 3. Twelve lithium-ion cells, 4 volt, 4 ampere, used for battery pack to empower the driving and steering motors.

III. DOWNY MILDEW DISEASE DETECTION SENSOR

DM Disease could be detected by applying thresholds (T) for red(R), green (G) and blue(B). Binarization of the grapevine image, using the thresholds (T) for DM disease, results in the image that contains information about the presence of the DM disease. If a pixel color value falls within the T, as defined by equation 1, it could be possible diseased area. Cp being the pixel color.

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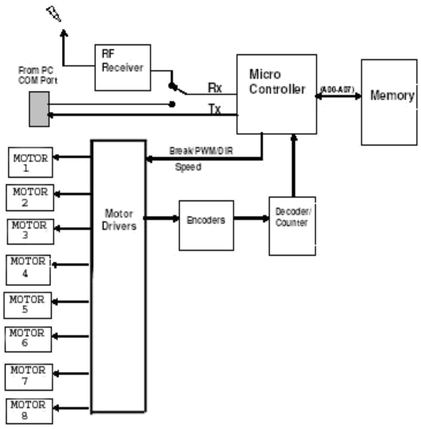

Figure 3: The control circuit of the base navigator.

$$T : C_p \in [C_{p(min)},\ C_{p(max)}] \qquad (1)$$

Where, p stands for the three colors namely red, green, and blue. *If equation 1 satisfied only then a recheck for the presence of the disease was performed.* For this, disease model was used and if the model was found to be satisfied for a pixel it was declared as DM diseased spot.

DM Disease Modeling

The thresholds obtained in a cuboid form from the histograms included some color values which did not define the disease called the noise. Hence, the histograms of the disease was studied and the curve fitting the data for various combinations for varying illuminations were studied and modeled for the confirmation of the DM disease. The models are described in table 1, 2.

Table 1: Color model for DM disease

Color	Model	Smoothing Parameters	RMSE
Red	Spline	P = 0.9957	0.7758
Green	Spline	P = 0.9962	0.6467
Blue	Spline	P = 0.9957	0.8865

Table 2: Color model for DM disease variation with illumination

Color	Model	Parameters	RMSE
Red	Cubic Polynomial Polynomial	p1= 1.568e-008 p2= -0.0001237 p3= 0.3056 p4= -66.81	4.2616
Green	Cubic Polynomial	p1= 1.134e-008 p2= -9.125e-005 p3= 0.2386 p4 = -48.87	3.728
Blue	Cubic Polynomial	p1= 1.123e-008 p2= -8.509e-005 p3= 0.2124 p4 = -46.31	2.381

Architecture Of Proposed Sensor

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.
This system is capable of detecting one singularity (specified disease) using the light and color information. The results can be described by the following example:
Grape field images including both sides of the healthy and diseased leaves had been collected under different lighting conditions from the Grape field at Horticultural Research Institute, Ibaraki Agricultural Center, Japan, during August-September, 2003. Images were also collected in natural lighting conditions from Kasama Grape field, Ibaraki, Japan, where they were grown in natural condition, during June, 2003. The very first experiment was to check the image processing method for the disease detection in the field. For this, data collected from the healthy and diseased parts of grape were compared and presented by the authors [2].

Experiments

In order to detect the disease directly from the image, without any image extraction, all aged leaves were included in the experiments. Thresholds were performed on enhanced image to detect the disease on the image. Figure 4 shows images (collected by an automatic digital camera and processed by the modules) [2].

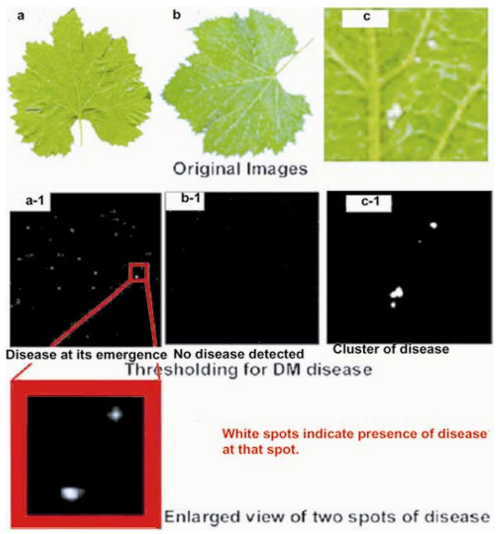

Figure 4: A set of three Original images including their processed images.

Figure 4 includes three different images from the grape field, a diseased leaf image with the disease at its first (emergence on the surface) state [a], a healthy leaf image [b], image of a part of a leaf with disease growing only at two points [c], their respective images, after processing, with disease detected as white spots on the final images [a-1], [b-1] and [c-1]. [Figure 4] describes clearly the DM disease, detected, at its very early stages. In processed image the diseased part, turned white and the rest turned to black. The first image [a] in the set contains disease at the time of its emergence to the surface, according to the human visual observation of the leaf 19 visible spots showed presence of disease on it. Out of 19, 12 spots were clearly visible on the processed images due to their relatively bigger sizes and each of the 19 spots were recognized and recorded as in binary data. The middle image [b-1] of the set is an image of a healthy leaf. The module showed no disease detected in this image. The image [c-1] showed the disease had started at two points and grew up there.

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IV. RESULTS and DISCUSSION

Experiments showed that

The navigator can travel in the grape field automatically and can make desired moves by itself.

It can successfully collect the field data and process it on the onboard super computer. The special feature of this sensor is that it does not require any comparison with the other model via location of the pixel unless presence of the DM disease is indicated by thresholding. This avoids extraction and reallocation of the part of image on each image. Hence, it saved unnecessary processing time for each image. Experiment confirmed that the proposed system detects the disease at the point of its emergence on the surface of the plant. Total number of spots of the disease present on the image and the numbers obtained by the sensor were examined for accuracy of the sensor. On comparison, sensor based results and human vision results were found to be the same by number of spots of disease. Results were satisfactory as it could detect all the DM disease spots in the image. Output image contains the information about the amount and the place of disease spread in an image (number and size of spots). The information regarding percentage crop area in an image affected by the disease saved in binary file, this means the estimation of the intensity of the disease is also possible and, the data could be useful for further research. The results prove that the approach is suitable for DM disease detection. Root mean square errors (RMSE) in models were found to be 0.6467. The errors are only applicable if there is any disease. On healthy leaves sensor works well hence no falls detection. On the basis of the experiments it could be concluded that the present sensor is time optimal and perfect for DM disease detection under normal environmental conditions. The unmanned robot Robo Kisan was capable of successfully scanning the grape field at BHU field and in HRI field in India. Hence the robot “Robo Kisan” is suitable for the grape field for automatic detection of the downy mildew disease, moving in the real field hence acceptable to act as an assistant to the farmer.

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, can carry tools and can be a helping hand to the farmer on field.

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