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Agrobot: Agriculture Assistance Robot using Rocker Bogie Mechanism and Image Processing

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Abstract*: In this paper we have proposed to build an all-terrain mobile robot for environmental observation, surveillance and assistance in an agricultural field. The robot's working is based on rocker bogie mechanism, it is also equipped with a gimbal for establishing a camera. The rocker bogie mechanism is achieved with th help of 6 different wheels controlled by arduino and l298n. The gimbal's orientation is controlled by servo motors which use PWMs for functioning.With the continued demand for food and an ever-growing population, the agriculture industry continues to search for new ways to improve productivity and sustainability. There is a need for efficient and precise techniques of farming, enabling farmers to put minimal inputs for high production. Image processing techniques can be used to enhance agricultural practices by improving the accuracy and consistency of processes while reducing farmers' manual monitoring.

I. INTRODUCTION

Robotics is a field that is rapidly developing and constantly being probed into for applications that demand a large workforce. Mobile robots are widely used as automated guided vehicles or self-guided vehicles for different environments, either for indoor or outdoor applications. For agricultural applications, elementary motion control and navigation are the key functions required for safe, reliable and accurate operation of a mobile agent.

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In such applications, a system to remotely and manually control the motion of the robot is developed, using options such as Bluetooth communication, WiFi communication and GSM. Robots are now being employed in hospitals, disaster management, surveillance or agriculture. Our all-terrain remote-controlled robot solves a few problems that farmers face in their fields, such as, manual inspection of crops in large plantations such as coffee and banana which is difficult, expensive and requires a large workforce,detection of insignificant visual symptoms such as small spots that are likely to be neglected in manual inspection and contraction of diseases during the manual inspection.There are chances of agriculturalists contracting diseases due to pests that infest the plant, eventually increasing the risks in crop maintenance and the spread of diseases.

II. MECHANICAL STRUCTURE AND DESIGN

The chassis' design is based on Rocker-Bogie mechanism. This mechanism is developed keeping in mind mobility andmanoeuvrability over any and all types of surfaces.

While building a robot, the suspension system is usually not required, but depending on the circumstances, there will be instances when the suspension cannot be avoided. The bogie The dimension of the chassis is calculated on the basis of the maximum height of obstacle we want the robot to overcome. The famous Mars rover, Curiosity is equipped with wheels in a rocker-bogie suspension. The primary mechanical feature of the robot is its true-blue all-wheel-drive capability, which is achieved by 6 motors powering the six wheels of the robot. in the rocker-bogie design refers to the system of linkages that have a drive wheel at each end. There are no springs or axles at any of the wheels, which allows the robot to climb over multiple obstacles, such as rocks, while at the same time ensuring that all the six wheels of the systems are in contact with the ground, thus, ensuring proper traction as well as manoeuvrability.To achieve this properly the dimensions of linkages should be proper. Assuming the obstacle to be a stair with a height and length of 150mm and 370 mm respectively, we design the structure to climb stairs with higher stability. It is required that only one pair of the wheel should be in a rising position at a time. To find the dimension of bogie linkages, the first pair of wheels should be placed at the horizontal position means at the end of the rising as shown in Fig.1.

and the second pair should be placed just before the start of rising.

There should be some distance between the vertical edge of stair and second pair of the wheel to striking of wheels.

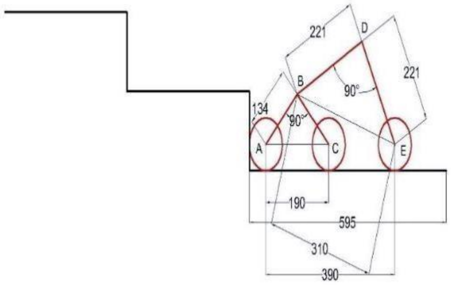

Fig. 1-Dimensions of the Rocker Bogie Structure

Now, to obtain the distance between the first and second wheel through CAD software (190 mm). Using Pythagoras in ΔABC in Fig.2 and assuming lengths AB and BC is x, $AC^2=AB^2+BC^2; 190^2=x^2+x^2; 190^2=2x^2; x=134mm$, hence, AB = BC =134 mm.

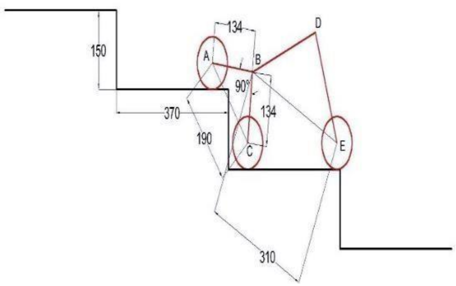

Fig. 2-Dimensions of ΔABC in the Structure

Third wheel pair should nearly complete its rising before starting of rising of the first pair of the wheel. By placing the wheel in such manner we obtained the dimension of link BC (311mm).

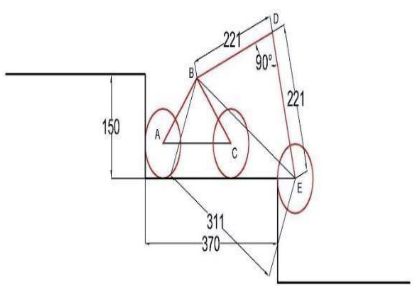

Fig. 3-Dimensions of ΔBDE in the Structure

Using Pythagoras in ΔBDE in Fig. 3 and assuming lengths BD and DE is $y. BE^2=BD^2+DE^2; 311^2=y^2+y^2; 311^2=2y^2; y=221mm$, hence, $BD=DE=221mm$. By considering all these lengths and angles we have drawn the whole mechanism. We take acrylic width is 40 mm suitable for drilling 15 mm diameterholes.

III. HARDWARE ARCHITECTURE

The robot is a passive springless and symmetric mechanism. Each side of the robot has a rocker and a bogie: the rocker is connected to the rear wheel, and the middle wheel and the front wheel are connected by the bogie. The two sides of rocker-bogie are connected by the differential bar attached to the main body, which ensures that the six wheels are in contact with the ground all the time providing a stable platform for the scientific instruments and sensors. The structure joining all the six wheels consists of the other components such as the Bluetooth module, the Arduino, board and the L298N which finally connect the mobile to the serial monitor.These components are attached in such a way that the robot functions hands-free and runs through a radio controller. Its suspension system is good at dealing with obstacles and excellent traversability. However, the rocker-bogie based robots must move at a very low average speed to ensure the stability of travelling. In some situations, mobile robots mostly face slightly uneven terrain with rarely significant obstacles on it.

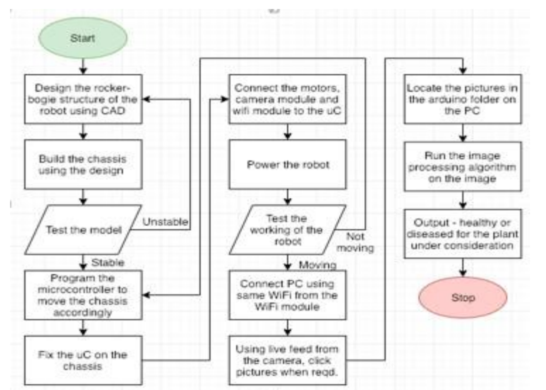

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Fig. 4-Flowchart describing the steps in building the robot

Nevertheless, when it needs to deal with obstacles, it can switch to its original configuration without losing its native robust capability.The Bluetooth modules are used to connect the mobile and the Arduino. The mobile sends the commands via this module which operates the robot's wheels in attaining forward, backward and side motions. Six DC motors are connected to L298N driver module in such a way that a group of three DC motors are connected together to either side of the driver module. The two sets of wheels receive signals independently and different combinations of such signals control the direction of motion of the robot.The L298N is the motor driver which consists of 4 inputs in an H-bridge for 4 motors. The image acquisition is done using an OV7670 camera which is a low cost Arduino camera module, adopted as a surveillance camera with a digital image processing chip-OV0706, specially designed for image acquisition and processing application also to connect with Arduino controller which is able to read image and data via UART serial port, and then perform some image processing. This camera is attached to a gimbal stabilizer.Once the robot enters the field, the camera captures the images of the diseased plants and transfers them to the farmer's laptop from where he can take the required action. In addition to that, the gimbal helps in capturing the image at the appropriate angles.

The gimbal is a 2 axis pan-tilt mechanism made by using two servos oriented perpendicular to each other.

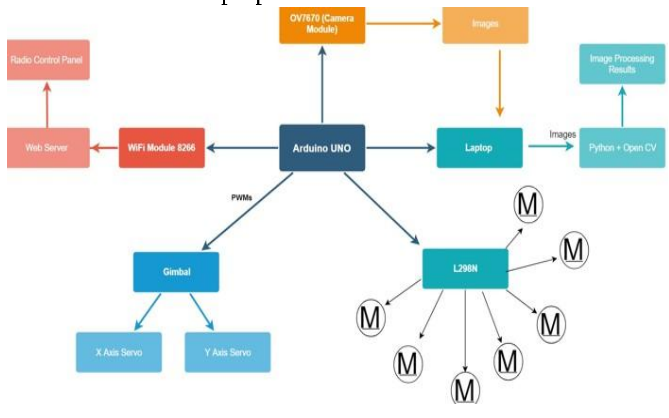

Fig. 5-System Architecture Block Diagram

IV. SOFTWARE ARCHITECTURE

The 6 DC motors (BLDC- Brushless DC motors of 12V) control the manoeuvrability of the robot which is run manually by the user. The left, right, back and forward commands are given by the controller. This robot is built to tackle all terrains for agricultural surveillance such that it can detect diseases in plants in areas inaccessible to farmers. These motors are coded using Arduino UNO.

The Bluetooth module, HC-05 is powered by giving a3.3 voltage using a voltage divider on a 5 voltage. To check if all the motors are accurately working, each of them is checked with the help of a multimeter. Once the connection with the Bluetooth module is established, commands are sent from the mobile to the serial monitor. The RC Bluetooth controller in the mobile controls the functioning of the robot. Its wheels are designed in such a way that they can overcome or tackle any type of terrain be it rocky or step. Traversability reflects the mobile robot's ability to adapt to significant rough terrains. They will be challenged with different obstacles commonly appearing in farms and agricultural fields. Therefore, the ability of the mobile robot to overcome vertical obstacles depicts its traversability.

The L298N motor controller follows the H-bridge configuration, which is handy when controlling the direction of rotation of a DC motor. A simplified H-bridge is shown below.

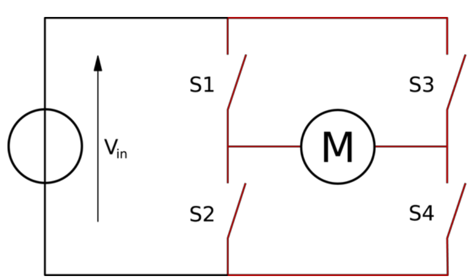

Fig. 6-Simplified H Bridge Structure

It has 4 inputs corresponding to the 4 switches where the motors are connected. The Arduino Uno is used for coding this motor driver by giving signals for the wheels to go in the required direction. The all-terrain robot thus functions by giving input commands by the farmer to strategically tackle the field and take surveillance of the farm.For acquiring the image of the diseased plant in a large field, an image processing camera such as an OV7670 is used for visual capturing on the Arduino. It is a small size, the low voltage that is powered by a +3.3 power supply camera.To attain the image, the java code (JDK required) is executed through a command line. The script will search for images received from Arduino and them saves them. This camera features 300 kilo pixel lens specially designed for processing application. Is based on transistor logic communication interface and hence very convenient to connect to the Arduino which is able to read image and data via UART serial port and then perform image processing. Thus the image can be attained on the laptop screen where the data is being saved. This is where the farmer will take the necessary actions required to curb the illness of the plant.The robot is equipped with a gimbal stabilizer setup which utilises the OV7670 for capturing images. It works as a mechanical arm as well for positioning the image processor camera near the diseased plant.OpenCV (Open Source Computer Vision Library) is used by with Python for image processing, This program uses the image processing algorithm on the image. The output on the screen finally displays the spots and bruises of the plant thereby helping the farmer accomplish the purpose of decreasing the number of ill plants in his agricultural stretch.

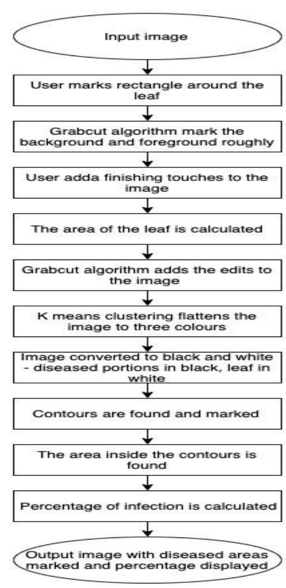

Fig. 7-Image Processing Algorithm

V. IMAGE ANALYSIS

Fig. 7 shows the proposed algorithm for processing images to detect the percentage of infection in plants. The algorithm marks the diseased areas using image processing techniques alone and uses the ratio of the diseases regions to the total area of the leaf to calculate the extent of infection.

The process is roughly carried out in four steps which are explained in the following sections

A. Background removal

Images acquired from a field often tend to include other leaves, the ground or the entire plant. For maximum efficiency, the algorithm focuses on one leaf at a time and processes it to detect the diseased areas on it. An important requirement in this step is the removal of unwanted background to bring the leaf under consideration, into the foreground.The GrabCut function provided by OpenCV offers promising outcomes in this aspect. The user first defines a rectangle, outside which, everything is considered a definite background. The function segments the image inside the rectangle and intelligently blacks out regions around the leaf rendering an image of the leaf on a black background.The process of blacking out the background, however, depends on the image and the algorithm itself. It so happens that the function sometimes misclassifies foreground as background and vice versa. In this case, the user can select areas to be included as foreground explicitly, using mouse control. Similarly, regions from the foreground can also be pushed into the background.After a predefined number of iterations, the GrabCut algorithm gives the expected result - only the image of the leaf on a black background.

B. Segmentation of the image using K means clustering

The K means algorithm is an unsupervised learning technique used for classification of data points depending upon their features. The steps in this process are very simple - a few points are selected as centroids, then the distance of the data points to each centroid is calculated. Each data point is then grouped under its nearest centroid. This iteration continues until an end condition is reached.On images, K means clustering yields an interesting result - a flattened image. Flattening of images can be extremely useful in reducing the colours in an image, giving very few pixel values to deal with while processing the image. It also reduces the size of the image.In our algorithm, with K=3, clustering flattens the image to just three colours - a black background which was obtained in the previous step, a green colour to depict the leaf and a shade of brown representing the diseased spots on the leaf.

C. Binarization of the image

The clustered image can now easily be converted to a binary image. The image is first converted to grayscale. If the grayscale equivalent of brown in the clustered image is set as the threshold, the binarization converts all pixels below the threshold (the green portions of the leaf) to white and the diseased regions (brown or black) to black. The background continues to remain black for the rest of the process.

D. Finding contours

Contours are curves joining all the boundary points where a sudden change in colour occurs. In the binary image from the previous step, the two colours in the image are black and white.With a high contrast between the diseased and the healthy regions on the leaf, finding contours becomes very easy. OpenCV provides a function to find a list of all the points comprising a contour in the image. We can then draw curves along these points, using inbuilt functions in OpenCV, to mark the diseased areas on the leaf.

Fig. 8-Original Image

Fig. 9-User Interface for background removal

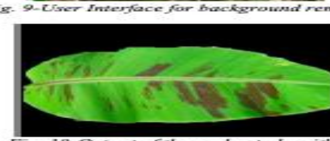

Fig. 10-Output of the grabcut algorithm

Fig. 11-Binarized Image

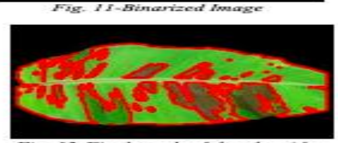

Fig. 12-Final result of the algorithm

E. Final results

The algorithm outputs the original image with the diseased portions (contours detected in section 1.4) in red. The area of the leaf is calculated by counting the number of pixels in the image after applying background removal and the diseased area is calculated by counting the pixels inside the contours marked by the algorithm in the last step.

The ratio of the diseased area to the total area of the leaf gives a deeper insight into how diseased the plant is and what measures can be taken to curb it.

VI. CONCLUSION

The proposed robot with all terrain traversing capabilities is designed in such a way that it could reach and acquire the image of every leaf possible. The image which is acquired by an OV7670 camera module is sent wirelessly to the computer where an image processing algorithm determines infection level and the areas affected. The camera is installed on a 2 axis gimbal which works with the help of servo motors. The gmbal increases the range of image acquisition. Th image processing algorithm works on OpenCV. This helps in detecting diseases in its initial stage which in return increase productivity and avoids crop failure.

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