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AUTONOMOUS LAWN MOWER ROBOTIC CONTROLLER DESIGN AND IMPLEMENTATION

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***Abstract:**The goal this work is to create and test a behavior-based lawn mower robot controller that is capable of autonomously cutting grass on playgrounds and lawns. The "sense-act" strategy is used by the controller to operate autonomously in a dynamic, unstructured, and unfamiliar environment. The Motor Schema architecture is used to implement the controller, which uses the cooperative coordination method and continuous response encoding for behaviour coordination. A collection of behaviours that are running simultaneously carry out the mowing procedure. Obstacles are found and avoided using sonar ranging. Shaft and visual odometry are combined with the Global Positioning System (GPS) for local positioning, while GPS is used for global positioning.. Optocouple sensors and a camera are used to identify a grassy area.*

***Index Terms**:Arduino UNO,L239D Motor Driver Shield, UV Sensor, Grass cutter.*

I.INTRODUCTION

To be able to complete the necessarytask in an outdoor environment, which is frequently unpredictable and dynamic, robot controllers use a behavior-based approach. The traditional strategy for mobile robots, or the hierarchal strategy, depends on ambiguous symbolic information on the global model. According to this approach, the world shouldn't be chaotic and dynamic, which is only likely in enclosed, secure environments with unchanging objects. The controller developed using this technology sequentially processes the environmental data to identify the appropriate actions. In addition, generating the environment map requires a lot of processing power and long-term memory (LTM).By employing the sense-act paradigm in parallel, a behavior-based controller eliminates all of these flaws,while dispensing with any reliance on outside information.

Robotic lawn mowers are still in their infancy, therefore it will take a lot of research to find out how to mow lawns on their own. The authors of proposed a thoughts for mowing chores were not included in the mobile robot design. Further not considered are local positioning, static and dynamic obstacle detection, and obstacle avoidance. Disregarding autonomy while using remote monitoring and human control also demonstrates a lack of intelligence. The authors of suggested an ideal route for a mobile robot to follow, but they did not grant the robot autonomy to navigate through a field of grass. Robots must first traverse boundaries in order to carry out navigational tasks. Moreover, an obstacle avoidance algorithm would only be effective against static obstacles—not against moving ones. The fundamental idea inA mobile robot concept was discussed without any simulation or implementation data. A hierarchal mower architecture was used in needing boundary information for fields with a lot of memory and no concurrency. The localization of the robot is difficult without both global and local location.

II. DESIGN METHODOLOGY

The five concurrently operating behaviours that make up the intended controller. These behaviours will react properly to environmental inputs by changing the robot's motor activities. The robot immediately begins to rove around the workstation, as is typical of a robot. Until it detects an obstruction or locates the target, the robot keeps travelling in the same direction. The robot employs behaviour to avoid obstacles after using sonar ranger to identify their presence. It keeps looking for the target, which is a grassy pitch, and as it locates it, it begins to go in that direction. By employing the Blob Finder algorithm and a camera, the goal is found by looking for a green colour field. When it achieves the objective,Together with other suitable behaviours, it begins executing the mow behaviour. The developed controller uses optocouple sensors with global coordinates to monitor for changes in grass height in order to distinguish between mown and unmown grass. Moreover, the robot employs shaft and ocular odometry for local location and GPS for global positioning. With this positional data, the grass pitch is traversed.

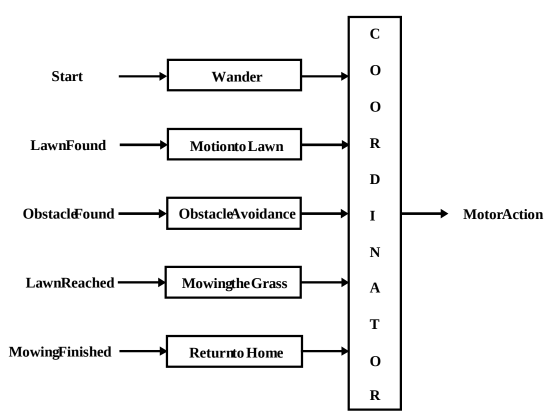
III. Controller Design

A lawn mower controller is created using Motor Schema Architecture. A situated-activity-based method is used to develop and characterise the behaviours of robots. By analysing the environment in which the robot must operate, this technique enables the definition of a complete set of robot behaviours. For the robot to independently finish the mowing task, it must be able to search the work field for grass without running into anything. It must then move towards the grass when it is located. As the robot in an outside setting has no knowledge of the dynamic, unstructured environment, it should be able to respond instantly. The robot should return to its starting place once the mission has been finished. That is extremely clear by simply examining the problem, since it is simple to define robot behaviour. The stimulus-response diagram of a robot controlling a lawnmower is shown in Fig. 1. Mowing must be done automatically and requires five fundamental behaviours.

The coordination block takes the output from each behaviour and generates the proper overall motor response for the robot at any given moment for a specific value of external stimuli. The simplest definition of stimulus-to-response (s) mapping links each behavior's response to an environmental stimulus onto the motor response.

Where is the behaviour,it causes the motor response r to begin when stimulus s is received. More specifically, a reaction must be elicited when the stimulus' value rises above a predetermined threshold. r = 0 if (s,) for all, otherwise r = f(s). ሺ´ ሺ.

Where is the behaviour that causes a motor response to be initiated after receiving a stimulus (s)? More specifically, a reaction must be elicited when the stimulus' value rises above a predetermined threshold. : If (s,) for all then r = 0, otherwise r = f(s)



F =

G/sonar[s] 2 in other places

To create motor actions, the robot continuously functionally encodes stimuli. This enables the robot to interact with the world in an endless number of ways. Every moment of the day, a robot uses cues to determine its motor actions.Several robot behaviours coexist with obstacle avoidance behaviour, and some of them do so in parallel. Similar to how mowing and moving towards home will go hand in hand with avoiding obstacles.

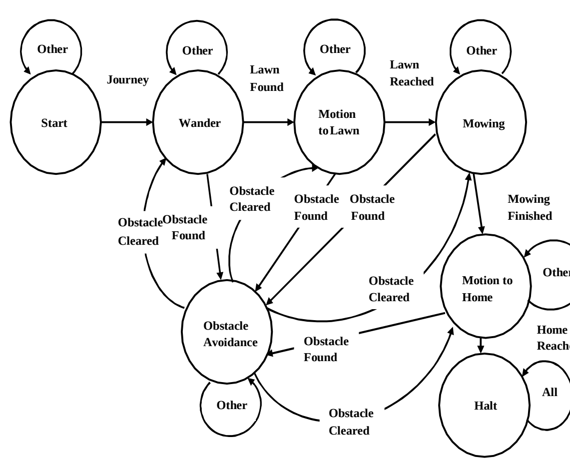
The cooperative technique, which consists solely of adding the behavioural responses that each behaviour produces vector-wise,is used by the proposed controller to coordinate behaviour. The confluence of environmental stimuli and behavioural reaction in a cooperative coordinator produces intelligence's cunning.

IV.Experimental Design and Assessment

The created lawn mower robot controller is imitated by the Player/Stage mobile robot simulator. Pioneer 3DX mobile robot platform model is utilised for simulation in Stage, and it is outfitted with all necessary equipment, including sonar sensor arrays, cameras, GPS, etc. To test the control algorithms, each behaviour is written and simulated in a simulation environment.walking aimlessly, which just activates the robot motors. Robot keeps acting in this way until it comes across a barrier or a green area. The wandering simulation results.The behaviour is displayed in Fig. 3.Robots employ the Artificial Potential (AP) theory for translating sensory data into motion towards goal behaviours for obstacle avoidance and information from sonar about behavioural responses.

A robot initially starts acting in a primitive way, i.e.devices with sensors. This method creates a field that represents the based on an arbitrary potential function, in the navigational space. According to AP field theory, impediments have a repellent potential field, whereas goals have an attracting potential field. Goals and impediments each have their own potential fields built. Then, a global field is built by super-positioning these two fields .

Artificial potential is calculated from the readings for each sonar sensor's distance (Fig. 4). the outcomes of a behaviour simulation for avoiding straight obstructions if there is a wider potential field where the rear sensors are the same thing occurs. Fig. 4 displays the simulation findings for this behaviour.



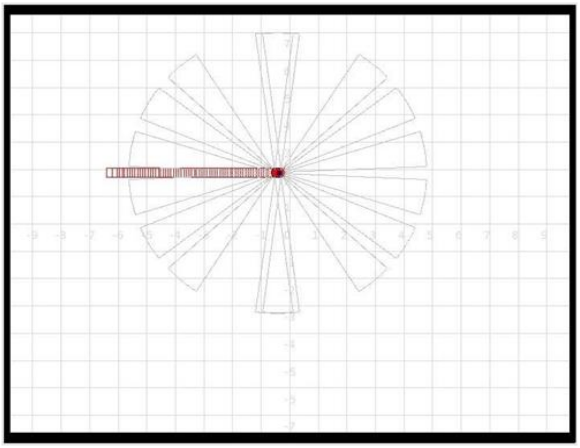


Fig. 4 displays the simulation findings for this behaviour

The robot utilises a camera to gather stimuli from the environment as it moves over a grassy area to mimic lawn behavior; otherwise, it would continue to wander and avoid obstacles if it came across them. The robot uses a blob-finding algorithm to sense the green colour of the ground. As soon as it senses this colour, The slope and distance between the robot's current location and the grass are first calculated by this algorithm. The attractive potential field (APF) is computed instantly using these distance measurements. The RPF function and the procedure used to determine APF are pretty similar,The gain in APF is worth far more than the gain in RPF.

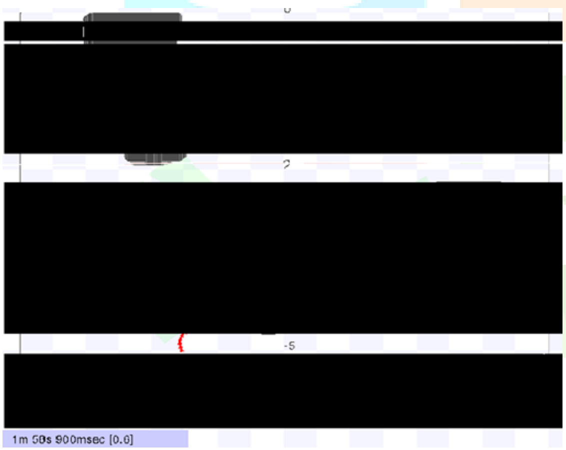


Fig. 3: Wandering behaviour simulation

The fundamental formula underlying the growing with d's objective distance, the force-distance connection grows quadratically., and that distance .Results of simulations of the behaviour of avoiding obstacles with the gradient using the aforementioned repulsive potential field (RPF) function, a field is calculated for each sensor.

The robot is then guided through the workspace using these field values so as to avoid running into any impediments. The algorithm determines whether the forward or back sensors are producing a higher repulsive field by comparing the total of the RPF readings from the four front sensors—2, 3, 4, and 5—and the three back sensors—10, 11, 12, and 13—together.There might be some obstructions close to the robot if the four front RPF values are added together and are higher than the four rear RPF values. The robot must then determine whether to turn clockwise or anticlockwise in order to get around the obstacle after determining that there is one in front of or behind it. The robot then compares the values of the sonar sensors on either side to determine which side is affected by a stronger repulsive potential field: if the right side has a larger value, turn left, and vice versa. The robot does not operate if both sides' RPF values are the same. move, turn, or transpose. In order to guide the robot towards the lawn without running into obstacles, APF and RPF values are combined to create a global field; in RPF, the robot seeks to avoid obstacles, whereas in APF, it tries to turn in the direction of a goal. The robot's steering angle is calculated using the turning angle data that result from its mobility towards a goal and its behaviour in avoiding obstacles.

The robot uses a Blobfinder proxy that can edit the photographs it takes to simulate itself in the player or stage. The robot can identify green using the blobfinder proxy, as well as the edge of a grassy field or lawn. Fig. 5 displays the simulation findings for this behaviour.The robot starts the mowing behaviour after it has reached the intended destination, which is the grass pitch. Three micro-behaviors are involved in this behaviour: preparing the tool for cutting grass, traversing a field, and distinguishing between mown and unmown grass. GPS, shaft odometry, and optocouples are all included into the robot to prevent repetitively moving across mowed regions.

Fig. 5: Motion to lawn behaviour simulation findings.

The size and perimeter of a grass field are determined using a blob finder and GPS fusion. Additionally, it offers field area data that can be used to determine the coordinate values for each of the field's four corners. Following corner detection, the robot determines the equation along the line that connects the two corner coordinates and travels to the other end along that line. Here is the slope intercept version of the line equation.:

$$y = mx + c$$

The robot uses the motion to home behaviour to return to its home location after finishing the mowing activity. This behaviour makes use of the home location's registered coordinate data and the last position of the robot. Robot determines the slope of the line between these points using these points. The robot proceeds to the second corner, steers at a 90-degree angle, and then once more determines the line equation connecting the second and third corners. The robot will keep doing this until it has circled the entire field. The robot then reduces the coordinate values for corners by a certain amount of x and y, based on the precise measurement of the cutting blade, and then follows the previously mentioned process. Figure 6 illustrates the idea behind this technique, and Figure 7 shows the simulation results for this behaviour.

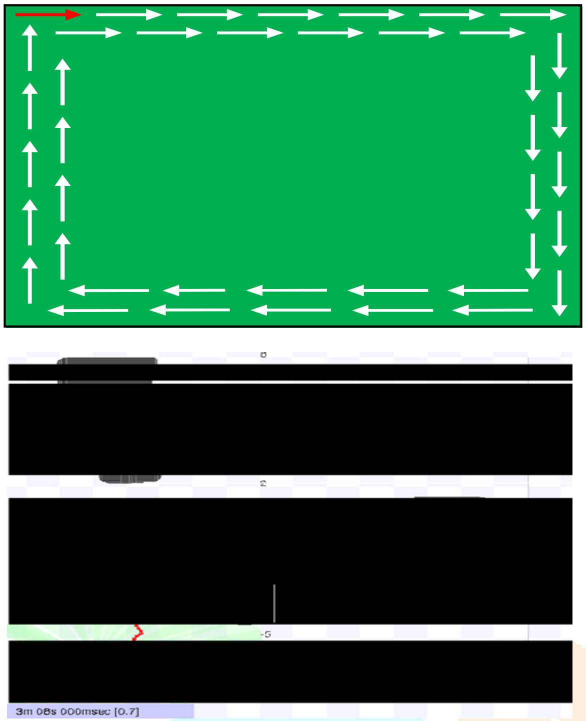


Fig.6 Grass field traversing strategy

When avoiding obstacles, the robot begins to follow By contrasting it with the fresh slope computed at each instantaneous value of the robot's location, we can determine that slope. By using this method, the robot is guaranteed to reach its goal, which may not be possible if it acts like a lawnmower. Fig. 7 displays the simulation findings for this behaviour.

Fig.7 Motion-home behaviour simulation results

V. CONCLUSION AND FUTURE SCOPE

The created controller is operational and provides comprehensive data as well as a work schedule for the real robot's hardware implementation. With a few adjustments, the robot controller's efficiency can be enhanced. With modest modifications, a camera can be utilised for both visual odometry and obstacle detection, which helps to overcome the challenges presented by moving obstacles and the mistake in local coordinates brought on by wheel slip. For motion to grass behaviour as well as for determining the borders of the lawn, better and more intelligent strategies can be used. Most importantly, there is still much space for the mowing duty to be improved with various grass patterning. Several mowing patterns can be created by enhancing grass field crossing techniques with machine vision techniques.

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