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Unmanned Ground Vehicle Navigation Using Distance Measurement

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ABSTRACT: Unmanned ground vehicles or driverless vehicles are the vehicles which do not require human assistance for navigation. A lot of research is been carried out for finding efficient mechanism so that the vehicle can go places without an onboard driver. The presented paper describes one such method. In the method proposed in this paper, the vehicle navigates around by calculating the distance between the obstacle and itself. Unmanned ground vehicles can be used in many such applications where the presence of human is hazardous. These applications could be in war field, mines, surveillance etc. These vehicles could also be used by handicapped people where there will be no need for them to drive the vehicle themselves. Thus, unmanned ground vehicles are beneficial for both military and civilian applications.

KEYWORDS: Unmanned Ground Vehicle, Doppler Effect, Steering Wheel Mechanism.

I.INTRODUCTION

Unmanned vehicle is the vehicle which operates without an onboard human presence. Three types of unmanned vehicles are there. These are unmanned ground vehicle, unmanned aerial vehicle and unmanned underwater vehicles. These vehicles can be operated either by remote known as remote controlled or remote guided vehicles or these can be autonomous vehicles which can navigate on their own.

Unmanned ground vehicles are those which operate while in contact with the ground and without the presence of human onboard. These vehicles would consist of several sensors on it to sense its surrounding environment. Based on this sensed data either it would make decision on its own or it would send this data to human operator for making appropriate decision. In the first case the vehicle would be called an autonomous ground vehicle and in second case it would be called as teleoperated ground vehicle.

Unmanned vehicles are useful in many applications where the presence of human operator is inconvenient or dangerous. These applications could be in surveillance, target engagements, explosive disposals, runways and airport security, mine detection, security operations in hazardous environment. These vehicles would be efficient and safe for civilian and military purposes.

Unmanned vehicles can be used in industries because of which human labor is reduced and it can also help to avoid loss of human life. These vehicles are available in different shapes and sizes which depends on the application in which they are used. A lot of research work is going on unmanned ground vehicle in civilian and military applications.

II.LITERATURE SURVEY

One of the operating principle of unmanned ground vehicle as mentioned in [1] is by using image sequences of actual traffic scene. In order to obtain perfect geometric consistency of vehicle and road environment GPS data were used to give vehicle position and scale transformation. However this approach could not be promising as traffic conditions change rapidly and any miss communication from GPS could lead to accident.

Another approach could be by detecting obstacle from 3D LIDAR data collected from hybrid cross-country environment. This mechanism was presented in [2] in which a new graphical approach based on Markov Random field

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was presented. The projection of every laser scan in x-y plane is segmented by applying maximum blurred line. This method is acquired for preprocessing. After this step the same properties of line are combined based on K- means clustering algorithm. By using comer detection method, line segment nodes are positioned precisely. In next step undirected graph for Markov Random field is build by taking advantage of line segment nodes. By analyzing line segment features and by solving graph cut an energy function is calculated. This energy function helps to classify between ground and obstacle.

Unmanned ground vehicles could be navigated by using intelligent control methods. [3] proposed an neural network for tracking the path of an unmanned vehicle. The input provided to the neural network are velocity, friction coefficient, hope radius, output is velocity difference. For steering control prevention control method is adapted. Different velocity, turning radius and ground surfaces can be adapted by this neural network method. A multi-step neural network was proposed for controlling steering of wheeled mobile robots having complex mathematical model. Neural networks have reduced learning capacity for learning maximum overshoot, overshoot time, steady steering angle and speed. In order to control steering of wheeled mobile robots an GA fuzzy neural network is used. Firstly, a neural network model of mobile robot is developed. The best control parameters are found by using fuzzy neural network and GA method. GA fuzzy neural networks are used for combined speed and direction control of wheeled mobile robots. To achieve this first a controller based on fuzzy neural network is built, then to find best control parameters optimum GA algorithm is used.

As proposed in [4] a steering system could be developed for unmanned ground vehicles by using PID controller. Using this steering system vehicle heading could be determined throughout the specified path. Firstly, a model for controlling the motion of vehicle was developed based on the constraints imposed by the wheels of the vehicle. Then, vehicle servos is achieved by a mathematical model. Finally for steering the vehicle, a PID controller was designed. Optimal genetic algorithm was used for tuning the controller. The Achermann mechanism was applied in which non slipping and pure rolling constraints of wheels are assumed. In order to test the PID controller, four-wheel vehicle navigating through the use of GPS receiver is used.

As indicated in [2], where a traffic scene was obtained from 3D LIDAR, one can also obtain 3D traffic scene constructed from a new framework proposed in literature [5]. In this 'floor-wall' geometry and traffic scene is constructed in two steps. In the first stage, Markov random field (MRF) and support vector machine (SVM) using super-pixels are applied to obtain road plane specifications. In second stage, for constructing background scenes road boundaries control nodes are specified. For supplementing foreground traffic elements, it is assumed that they are perpendicular to the road planes. Virtual vehicle position helps to generate new viewpoint images in model space. Traffic incidents can be simulated by organizing supplemented foreground traffic elements and background scenes based on the scene models.

Literature [6] describes an overview on current research activities focusing on autonomous vehicles developed since DARPA challenges. This paper tells that three elements stand common to all autonomous ground vehicles. These elements are sensors which monitor environmental movement along with vehicle movement and for vehicle control actuators and onboard computers are used. In order to sense environmental movement, stereo and monocular cameras with range detecting sensors are used. These range detecting sensors could be RADAR or LiDAR sensor. For sensing motion of the vehicle inertial and odometry sensors supported mainly by GPS are used. For distributed and centralized processing on board computer system are required. This computer system must be real- time capable. This is important for system safety check and vehicle control algorithms. For providing brake, throttle control and closing control loop for steering wheel, actuators are used.

III.PROPOSED WORK

For modeling the steering wheel control module the block diagram proposed is shown in fig 1. The figure consists of four units. These units are supply unit, sensor unit, processing unit and motor unit. Supply unit consists of battery and voltage regulator circuit (VRC). Battery would provide required supply voltage to the steering wheel control module. The voltage regulator circuit (VRC) would be used to provide regulated voltage to the processing unit. Sensor unit will consist of array of sensors. These sensors would be used to provide distance between the vehicle and the obstacle.

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These distance measuring sensors could be RADAR, LiDAR etc. The sensor unit will provide sensed data to the processing unit. The processing unit will consist of processor like microcontroller. CAN controller, PID controller etc. which will process the sensed data and decide how the vehicle should move in presence of an obstacle. This decision would be given to the motor unit. The motor unit consists of motor driver circuit and steering wheel motor. The motor driver circuit would drive the motor of the steering wheel according to the decision taken by the processing unit. The motor of the steering wheel would cause the rear wheels of the vehicle to move accordingly as steering wheel is attached to their axis. An display unit can also be added to show the distance between obstacle and vehicle.

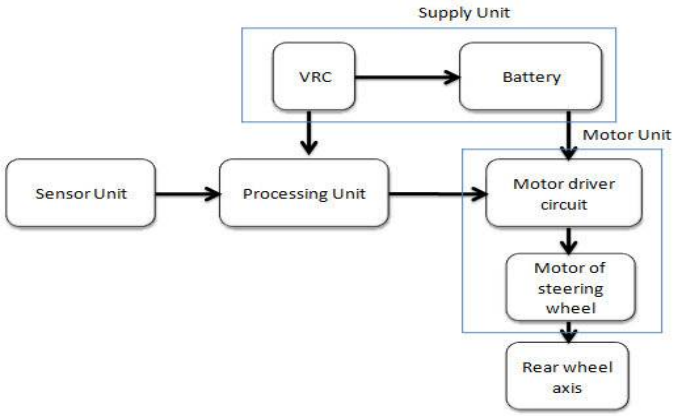

Fig. 1 Block diagram of proposed work

IV.DISTANCE MEASUREMENT

In this project for measuring the distance between obstacle and vehicle, ultrasonic sensors are used. The ultrasonic sensor consists of two parts. One part is an emitter which is used to emit high frequency sound wave of the order of 40kHz. The second part consists of detector which detects high frequency sound wave of the order of 40kHz. When trigger signal is applied to the ultrasonic sensor by processing unit, it starts sending sound waves. This sound wave after hitting any obstacle is returned back to the ultrasonic sensor as echo signal. This is explained in fig 2. This returned sound wave has apparent shift in its frequency produced by either moving obstacle or stationary obstacle. This is known as Doppler effect. Processing unit receives this echo signal and determines the apparent frequency shift to calculate the time length required for the sound wave which was generated by the emitter to travel the distance to the obstacle.

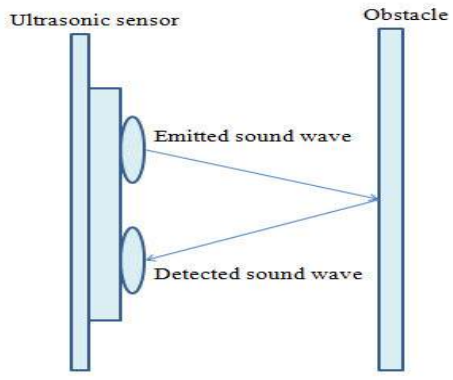

Fig. 2 Working of ultrasonic sensor

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In order to calculate the distance between the object and the vehicle, the processing unit uses the following formula,

$$\text{Distance} = \frac{\text{round trip delay x speed of sound}}{2}$$

Round trip delay is the time in seconds taken by the sound wave to travel the distance to the object.

The distance measurement circuit with single ultrasonic sensor is shown in fig 3 below. The number of sensors to be used depends upon the shape and size of the ground vehicle. It also depends upon the angular range of the ultrasonic sensor.

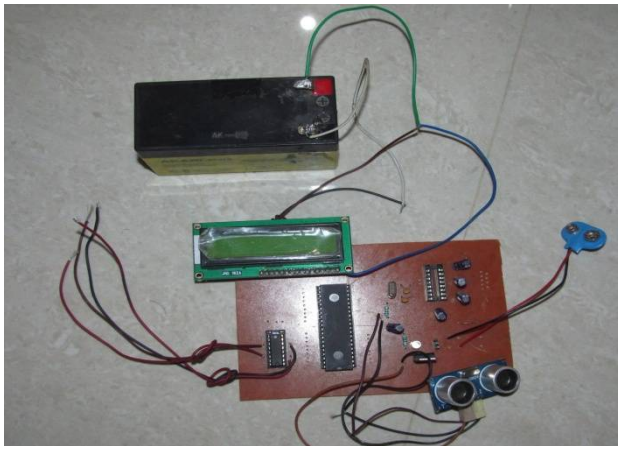

Fig. 3 Distance measurement using one ultrasonic sensor.

V. STEERING WHEEL MECHANISM

The steering wheel mechanism describes the mechanism by which the wheels of the vehicle are rotated or steered for turning the vehicle. There are several such mechanism out of which rack and pinion method is the basic method. This method of rack and pinion is used in the presented work. The rack and pinion method of steering wheel comprises of one gear i.e pinion gear which is attached to the shaft of steering wheel. There are set of teeth on a metal rack which are compatible with the teeth of pinion gear. Two wheels are attached at the ends of the rack. This is shown in fig 4.

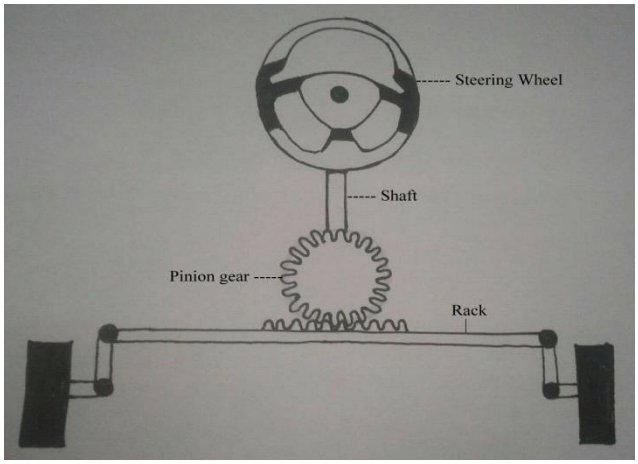

Fig. 4 Rack and Pinion method

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When steering wheel is rotated the pinion gear rotates in accordance with it. This pinion gear makes the rack to move linearly. Here rotary motion of steering is converted into linear motion due to which wheels of vehicle turn linearly. Both this wheels do not point in same direction. This is because for smooth turning of a vehicle the inner wheel has to turn in smaller radius as compared to the outer wheel radius. This is explained in fig 5.

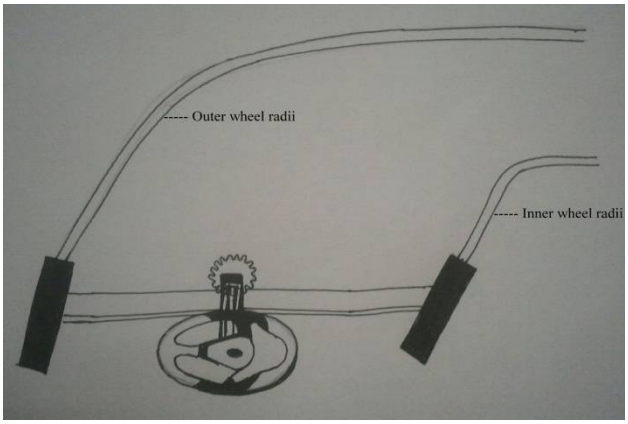

Fig. 5 Inner wheel radii and Outer wheel radii

VI. RESULT AND DISCUSSION

Table 1 shows the resultant distance obtained in presence of an obstacle using four ultrasonic sensors. The table also shows the actual distance of the obstacle from the unmanned ground vehicle.

Sr. No	Actual Distance (inch)	Sensor I Distance (inch)	Sensor II Distance (inch)	Sensor III Distance (inch)	Sensor IV Distance (inch)
1.	5	2	2	1	2
2.	7	8	8	8	8
3.	9	10	10	9	11
4.	12	14	14	11	14
5.	15	19	19	19	18
6.	20	25	25	25	25
7.	24	31	30	30	30
8.	28	36	36	36	36
9.	34	45	44	45	45
10.	38	47	48	50	51

Table 1 Distance of obstacle from the vehicle using four ultrasonic sensors.

When the vehicle was navigated in real environment results shown in fig .6 were obtained. Here A,B,C,D are obstacles. Certain threshold was set and the sensors when show reading less than the threshold the vehicle takes turn. For obstacle A vehicle took right turn, for obstacle B left turn was taken. The vehicle stopped when obstacle C and D were approached.

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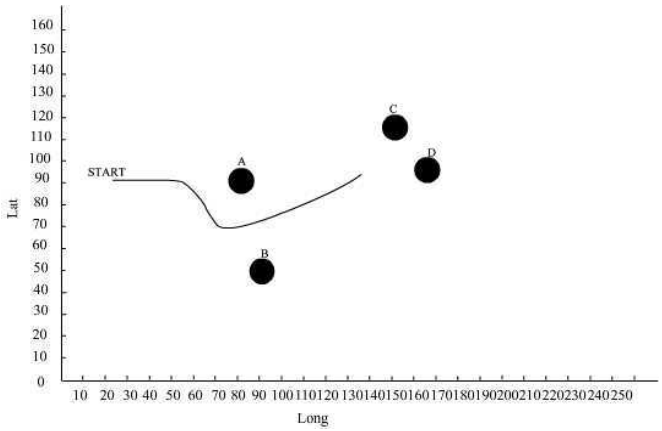

Fig. 6 Vehicle navigation in real environment.

VII.CONCLUSION

The vehicle navigated without hitting the obstacle in real environment. Hence measuring the distance between obstacle and vehicle can be one of the efficient working mechanisms of unmanned ground vehicle or driverless car.

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