Obstacle Detection and Avoidance System for Collision Avoidance

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***Abstract*—Obstacle detection and avoidance is one of the key features of advanced driver assistance system. Obstacle detection is finding an object or obstacle on a road. Obstacle avoidance use the previously detected obstacles and adjusts itself according to the motion model. In this paper, review of Obstacle detection and avoidance systems developed in the last few years is discussed. Several modalities are considered for Obstacle detection which include vision, LIDAR, SONAR, Ultrasonic sensors. The Obstacle detection and avoidance algorithms is one of the challenging problems in computer vision. Different Obstacle detection techniques are explained in the paper. The performance of different Obstacle detection and avoidance algorithms is also compared and studied.**

***IndexTerms*—Advanced Driver Assistance System, Obstacle Detection, Obstacle Detection Warning, Obstacle Avoidance.**

I. INTRODUCTION

Advanced Driver Assistance System provides safe and better driving. It helps to automate, enhance and adapt the driving experience. Most of the road accidents occur due to careless driving. Advanced Driver Assistance System provides surety of safety and reduces driver workload. Whenever a dangerous situation is occurred, the system either warns the driver also takes active role by performing necessary corrective action to avoid a car accident [10]. Obstacle detection and avoidance is an important module in Advanced Driver Assistance System. In vision based Obstacle detection system, a camera is placed behind the wind shield of the vehicle and images of road are captured. The objects on the road are interpreted and identified. Whenever the dangerous situation is accounted, a warning is given to the driver. for detecting object. Figure 1 represents a block diagram of Obstacle detection and avoidance in a general perspective. Obstacle detection system poses many challenges and issues which includes sensor reliability, environmental conditions, changes in visibility condition. Based on the scenarios, there will be difference in the obstacles. We have to investigate the type of obstacle condition and the challenges in system to solve such Obstacle detection and avoidance problems.

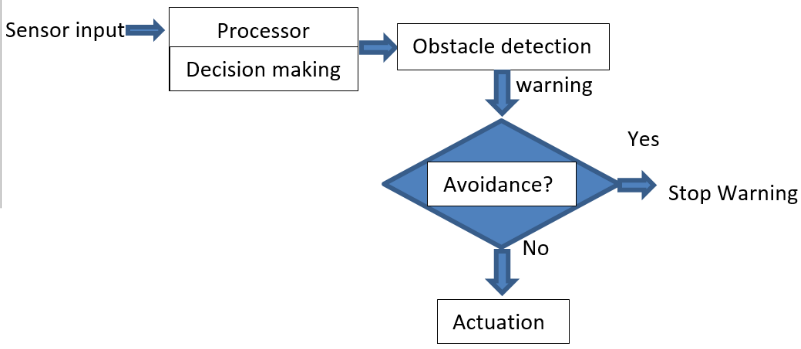

Figure 1 Block diagram of Obstacle detection and avoidance

The organization of the paper is as follows. Section I describes introduction. Section II presents various Obstacle detection and avoidance methods and includes performance analysis of different Obstacle detection and avoidance methods. Section III summarizes the paper.

II. OBSTACLE DETECTION AND AVOIDANCE SYSTEMS

In this section, Obstacle detection and avoidance systems are discussed. Table 1 summarizes and presents a detailed analysis of various Obstacle detection and avoidance systems. This section also investigates the best Obstacle detection and avoidance algorithms that can be selected for a specific condition.

T. Sivkumar[1] proposed in his paper different safety features for the vehicles that are coming into two categories, active and passive features. He also discussed about Crash Avoidance System and Driver Assistance System. He told about Crash Worthy Systems that devices which reduces the degree of injuries when the actual crash happened. The safety features are effective to save the lives during accidents. He discussed about the safety features present in the Indian Scenario. Manufacturers should provide the necessary safety features in all model and all variants of the cars. with a focus on automobile safety then it is sure the accident rate would drop drastically on the roads.

Table 1 Comparison of different Obstacle Detection Systems

Title	Author	Problem Statement	Proposed Work	Advantage	Disadvantage
Robot Path Obstacle Locator using Webcam and Laser Emitter	Shahed Shojaeipoura[8] (2010)	Obstacle Location	Using webcam and Laser pointer	Obstacle distance measurement	Result may change according to reflectivity and surface of the obstacle, low resolution
Distance Measurement of an Object or Obstacle by Ultrasound Sensors using P89C51RD2	A.K. Shrivastava[9] (2010)	Distance Measurement of an Object	by Ultrasound Sensors	Low cost system	Low distance obstacle error.
A methodology to increase driver trust in rear-obstacle warning system with imperfect sensing result- Proposal for warning system using sensor reliability information.	Shigeyoshi Tsutsumi[7] (2011)	warning system using sensor reliability	The improvement by changing threshold value and simultaneous use of warning and calling signals.	Lowering false alarm.	Difficult to focus due to continuously updating data on display. Distraction due to high visual and cognitive workload.
Obstacle Detection and Avoidance for an Autonomous Surface Vehicle using a Profiling Sonar	Hordur K. Heidarsson[4] (2011)	Obstacle Detection and Avoidance	Obstacle Detection and Avoidance using sonar technique	Feasible for obstacle detection close to water-air boundary	For stationary obstacles only.
Moving obstacle avoidance of a mobile robot using a single camera	Jeongdae Kim [5] (2012)	Moving obstacle avoidance	Block (comparison)Based motion estimation.	Measurement resolution is higher.	Sensitive to colors, only for moving or dynamic obstacles, slow speed application.
An Obstacle Avoidance Method of Soccer Robot Based on Evolutionary Artificial Potential Field	Qiushi Zhang [6] (2012)	An Obstacle Avoidance in the Artificial Potential Field	The grid method for obstacle detection and the evolutionary artificial potential field method for obstacle avoidance.	Local minimum global path planning for gaming environment	Need to define obstacles by the repulsive force, i.e. limitation in real life application.
LIDAR and monocular based overhanging obstacle detection	Jeffery Young [2] (2015)	overhanging obstacle detection	The Fusion between active and vision sensors method is proposed for obstacle detection.	Provides better decision for the positional measurement.	Poor for wire or chain detection due to low resolution camera images are used.
Real-Time Obstacle	Ilmi Mohd Ariffin[3]	Mobile Platform Navigation	Navigation algorithm with	Improved (reduced)	No breaking mechanism i.e.

Avoidance for Humanoid-Controlled Mobile Platform Navigation	(2017)		laser range finder sensor is used.	turning radius.	Risk of collision.

Jeffery Young [2] presents an improved method for the obstacle detection in the trajectory of autonomous ground vehicle (AGV). This approach includes fewer calculations, that reduces computational time. Obstacle detection algorithms were designed, in order to perform safe motion control, in an environment which includes unknown overhanging obstacles. He described optimal sensor configurations for mounting a monocular camera to monitor path ahead clearance and a two dimensional (2D) laser sensor application. Two different sensors are used, a scanning laser, a vision sensor and Light Detection and Ranging (LIDAR). LIDAR is used to measure the precise distance to the object, it is unable to detect low objects and overhanging obstacles due to its constant, predefined, scanning angle and height. In contrast, vision sensor provides 2D scenery information with relatively poor distance information. To compensate those drawbacks of these two sensors, the sensor fusion method for detection of obstacle for AGV is proposed. Size expansion cue algorithm also deployed to achieve that goal. The system works in real time with a low resolution camera on a raspberry pi board. The algorithm is capable to discriminate overhanging obstacles with small surface. The sensors configuration, and the mapping and navigation system could drive the golf cart to avoid slim overhanging obstacles accurately and quickly. The system shows the improvement of the speed of the detector. The simplicity and the use of reduced camera images speedy computation. Moreover, the Scale Invariant Feature Transform (SIFT) technique makes the slim obstacles matching in the real time without stopping the AGV.

This project by Ilmi Mohd Ariffina[3] presents a new approach of humanoid-operated mobile platform. He used humanoid robot NAO by Aldebaran Robotics which allows to perform various tasks such as steering through a simple programming algorithm. The Arduino microcontroller interface is used in this system having integration between NAO and the mobile. He used Hokuyo URG-04LX Laser Range Finder in the navigation system and it provides very good result to avoid obstacles while navigating. This obstacle avoidance system is more suitable to fit NAO handling for navigation. There are two microcontrollers used in the navigation system. The first one is an Arduino UNO. The microcontroller receives the LRF (Laser Range Finder) data from the host computer in serial manner and convert the data into a set of binary bits in a serial form. After the conversion, the microcontroller sends forward the data to the second microcontroller, which is an Arduino MEGA. The Arduino MEGA provides decoding for the navigation system. It receives the filtered laser scanner data from Arduino UNO and send them to NAO robot for navigation. According to the data received from the laser sensor, NAO will navigate the platform away if an obstacle is detected.

Hordur K. Heidarsson [4] presented an experimental study of Autonomous Surface Vehicle (ASV) obstacle detection and avoidance using a mechanically scanned profiling sonar. The potential obstacles are detected from echo returns and presented a scanning strategy for sonar in this application. The demonstration with simulations using the data collected in the field for an ASV based on sonar data to navigate and to avoid obstacles in a lake and harbor environment is also presented. While the work provided initial evidence that sonar provides sufficient information for obstacle avoidance. It is necessary to quantify the effects of vehicle pitch and roll as well as expected error rates for commonly found environments. He also addressed the case of dynamic obstacles. He suggested to make system robust to add camera or a laser range finder, to the setup.

The paper by Jeongdae Kim [5] presents the detection of moving obstacles (for walking humans) by the use of a single camera attached to a mobile robot. For the moving camera the moving object detection technique is such as background subtraction or image differencing, which cannot be employed. Thus He detects that the object which moves near the robot by block-based motion estimation. In the method, firstly division of an image is done into small blocks, and then the motion of each block is identified by comparing two consecutive images. If the difference between matching blocks is significantly large, the block in the current image is classified as a moving objects. The spatial distance between the best matched blocks provides a motion vector of an obstacle. The search for the best matched block is limited within a range which is called search window that is the possible range of the motion. The method is useful to quick detect approaching obstacles but sometimes it failed due to number of factors, such as object's color, distance to objects, and reflected light.

Qiushi Zhang [6] investigated in his paper, a technique to solve the problems in determining local minimum path in obstacles, and optimization of the global obstacle avoidance path, this is a new obstacle avoidance method. The grid method is used to describe the information of obstacles environment; it utilizes the evolutionary artificial potential field method to optimize obstacle avoidance path. the proposed method is feasible and effective according to the simulation results. Soccer robot avoids obstacle by searching out a path from starting point to target point in the game environment which is complex, real-time and uncertain. This paper presents a method used to establish the model and generated an obstacle avoidance path is a grid method, then using APF method by generic algorithm the optimized line segment path is evolved. Artificial potential field (APF) method is first used in obstacle avoidance path planning for manipulators, and to realize the real time obstacle avoidance. The main theme of APF method is establish attractive potential field at the target point and establish repulsive potential field at the obstacles. The resulting potential fields together formed a new potential field, that is artificial potential field. It detects the falling direction of potential function to find a collision-free path which is built from the start to target point. In the game field, two virtual forces are present, attractive force and repulsive force. The attractive force is generated for the target and the repulsive forces are generated for the obstacles. The composition of forces directs the robot bypass the obstacles and move to target point. Grid method is used to establish environment space model and to determine global path planning. Then the potential field is feasible for the local path planning, which has lack of ability in planning longer path or planning path in multi-obstacle environment. Algorithms can be used to search path and good adaptability. The path planned by grid method connects all free grids from the starting point to target point where one grid corresponds to one node. In this paper, turning point is defined by the node which had different slope.

Shigeyoshi Tsutsumi[7] presented in his paper the investigation about the improved effectiveness of the "RISK method" by comparing with the conventional warning method with varying workload situations. Either of these warning methods was installed as the Rear Obstacle Warning Systems ROWS. The developed system produces both warning and calling signals according to risk of collision and reliability of sensor information. The warning threshold value is also improved considering both probability of collision and time to collide. The experimental setup involves driver simulator (DS) and 100inch screen for the display. 22inch display is also used for the rearward view in the side view mirror. For warning and calling different color LEDs are used. As the results, Driver's trust was significantly improved under the proposed method setting the WWL (Weighted Workload) was in middle level. This suggesting that the proposed warning method is effective where the traffic situation workload that is in the middle range. The subjective evaluation varied by subjective workload WWL. So, it is necessary to consider the amount of workload when designing warnings. There was no significant difference in driving behaviors. It is also important that the design consider both subjective evaluation and driving behavior.

In the paper by Shahed Shojaeipour[8], a distance measurement method using a laser-pointer is presented. This method computes the distance of the robot from obstacles to enable it to traverse to its target location, to avoid obstacles along the way. Initially Images of the workspace environment are captured using a webcam. Image processing methods are used to identify the existence of obstacles. The distance to obstacles can be calculated using a laser emitter. The system designed for range finding consists of a single robot mounted webcam and a laser-pointer. The program is written in MATLAB with the Image Processing Toolbox. The laser rangefinder is set in the way to point parallel to the camera's viewing direction. The setting of a laser range finder is to get the hitting point near to the center of the image frame. The vertical distance between the laser-pointer and webcam is known, the distance to the object can be determined from the pixel location that is hit by the laser returned from the object. For correct identification of the object by the edges obtained from the image processing steps, the edges are clustered by the k-means technique. The edges obtained from the captured image had passed through the Canny edge detector. The edges are grouped into clusters, according to centroid of each cluster. The centroids are then considered as target points for the laser beam to be emitted. The laser emitter projects a laser beam onto the object which is in the camera field of view. The all set of frames, including the point where the laser beam hits the object, is captured by the camera. Using the band pass filter the laser beam point is then isolated from the rest of the image. The pixel location hate by laser beam is identified. For the computation the triangulation system is used considering height and angle of reflection.

A. K. Shrivastava [9] presented the Distance measurement of an object in the path of a vehicle, equipment, or a person, moving or stationary. It is applicable in a large number of applications such as vehicle control, robotic movement control, medical applications, blind man's walking stick, etc. Measurement using ultrasonic sensors made the system cheaper in cost. The system included distance measurement of an obstacle by using a microcontroller and separate ultrasonic transmitter, receiver. The system is useful for the other devices requiring distance measurement of a moving or stationary object or obstacle. The accuracy is sufficient for normal practical uses.

III. Conclusion

In this review, a detailed analysis of various Obstacle detection and avoidance systems is discussed. The different methodologies investigated by different authors for Obstacle detection and avoidance during the last few years are presented in the paper. Obstacle detection is an inevitable module in the advanced driver assistance systems. In the few years several advancements occurred in the Obstacle detection and avoidance field. Sensor fusion based approach is a very efficient modality for detecting obstacles. Even though lot of progress has been attained in the Obstacle detection and avoidance, there is still scope for enhancement due to the wide range of variability in the obstacle detection scenarios.

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