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Robotic Model for Autonomous Car based on AI

Dr. Krishnareddy K R
Prof. Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
krkrishnareddy69@gmail.com

Prof. Ramesh B E
Asso. Prof. Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
be.ramesh@gmail.com

Dr. Aravinda T V
Prof. Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
sjmitplacement@gmail.com

Bhagya Shree N
Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
bhagyan05122002@gmail.com

Rohit
Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
rohitpawar9160@gmail.com

Sharath J
Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
sharath.j2002@gmail.

Usha B
Dept of CSE
SJM Institute of Technology
Chitradurga (Kar), India 577501
ushabudarba@gmail.com

***Abstract*—**The integration of robotics and artificial intelligence (AI) has revolutionized the automotive industry, particularly in the development of autonomous vehicles. This project proposes a novel robotic model for an autonomous car, leveraging advanced AI techniques to enhance navigation, decision-making, and overall safety. These models enable the car to recognize and interpret complex traffic scenarios, pedestrian movements, and road signs. Deep neural networks process sensor data to make informed decisions, such as route planning, obstacle avoidance, and adaptive control. The project aims to contribute to the ongoing advancements in autonomous vehicle technology, showcasing the potential of combining robotic models with state-of-the-art AI to create a reliable and safe autonomous driving experience. The results from simulations and real-world testing shall demonstrate the effectiveness of the proposed system in achieving accurate navigation, efficient decision-making, and enhanced overall performance in autonomous driving scenarios.

Keywords—Self-driving car, real-time navigation, convolutional neural network, lane detection, Signal detection, Stop sign detection, machine learning, monocular vision.

I. INTRODUCTION

Road recognition is a critical issue for both road services and smart vehicles. Every year, a considerable amount of labour and budget is spent on road maintenance A typical way to profile the pavement is to use a car equipped with certain devices to control the pavement change. These devices can be both visual, vibratory, and sensory. The 3D reconstruction approach relies on laser 3D scanning to create accurate surface models. In this approach, a laser 3D scanner uses reflected laser pulses to create accurate digital 3D models of existing objects. Haq et al.and Staniek use two digital cameras that capture images for the road surface. The visual approach relies on image processing, using texture extraction. Koch et al. uses a high-speed wide-angle camera, which is mounted at the rear of the car and tilted down the road. Using vibration-based methods, the data collected is usually in the form of acceleration. The data collected can be obtained from professional equipment or mobile sensors.

Self-driving car (also known as a robot car, autonomous car, or driverless car) is a robotic vehicle that is designed to travel between destinations without human intervention.[6] It is capable of sensing environment and navigate without human input. Autonomous cars must have control systems that are capable of analysing sensor data to distinguish between different cars on the road. The potential benefits of autonomous cars include reduced mobility and infrastructure costs, increased safety, increased mobility, increased customer satisfaction and reduced crime. Specifically, a significant reduction in traffic collisions; the resulting injuries; and related costs, including less need for insurance. Autonomous cars are predicted to increase traffic flow; provide enhanced mobility for children, the elderly and disabled; [7] review travellers from driving and navigation chores; lower level fuel consumption; significantly reduce needs for parking space; and facilitate business models for transportation as a service, especially via the sharing economy. This shows the vast disruptive potential of the emerging technology.

In Spite of the various potential benefits to increased vehicle automation, there are unresolved problems, Such as safety, technology issues, disputes concerning liability, resistance by individuals to forfeiting control of their cars, customer concern about the safety of driverless cars, [8] implementation of a legal framework and establishment of government regulations; risk of increased suburbanization as travel becomes less costly and time consuming. Many of these issues arise because autonomous objects, for the first time, would allow computers to roam freely, with many related safety and security concerns.

II. LITERATURE SURVEY

In literature [1], in this paper, they have presented an Concern regarding the nature of accidents has grown as the frequency of traffic incidents has increased. It happens frequently as a result of human mistake. In order to assist drivers, lane detection systems are currently being created with the primary aim of identifying lanes and warning drivers about potential lane departures. There are multiple techniques for detecting lanes, with many focusing on straight lanes. This project main goal is to examine the drawbacks of various lane detecting algorithms and suggest a solution that does away with

them. This work uses artificial intelligence to recognize lanes using OpenCV, NumPy, and digital image processing (noise removal, edge detection, Hough transformation).

Fig1. Lane detection by autonomous car

In literature [2], This paper discusses about researching an automated robot car using artificial intelligence; training its neural network using Alex Net model, using YOLO (you only look once algorithm) for object detection phase and for practical deduction and judging component we have used Open Neural Network Exchange (ONNX) format. Our Robot Car model is agile and cost efficient. It detects objects efficiently in front of it and movement of it is smooth. It moves through sensors in motors which makes it different than other models in the world.

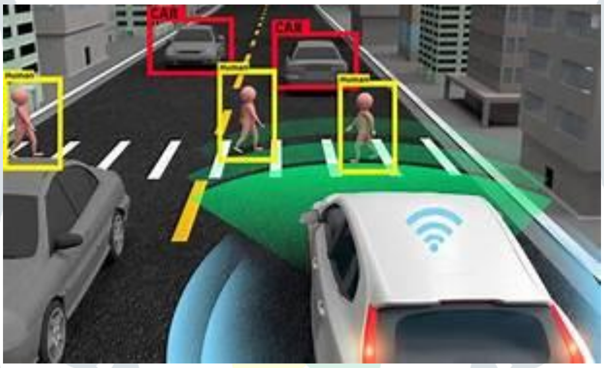

Fig 2. Object detection and obstacle avoidance.

In literature [3], This research presents an overview of the Automated Guided Vehicle System (AGVS) technology, reviews recent technological breakthroughs, and details certain formulations in order to control the traffic within industrial work spaces. A comprehensive assessment of the existing body of previous research served as the methodology for this research. The findings of this study indicate that human error is responsible for ninety percent of all car accidents, and that the best drivers are about ten times superior than the average driver on the road. The safety of automated vehicles is very important, and users are demanding an acceptable risk level that is one thousand times lower.

Fig 3. Traffic signal detection

In literature [4], The immense growth and research in modern technology have led to convenience and comfort becoming mankind's demand and first priority in any technology presented to them. With this, automation has become the need of the hour. The use of automation in cars is one such area that is getting more and more importance and recognition around the world. Driving demands total attention from the driver in activities such as lane-keeping and lane changing, slowing down at turns, keeping a watch on traffic lights and traffic signs, and handling the car in traffic. The smallest lapse in concentration can also prove to be very dangerous. Self-driving cars aim at making use as many features as possible and leave the driver to do. The main motive of the research work will be to develop a model of the software part needed for the efficient working of a driver assistance system on cars on real-time data and simulate it.

In literature [5], This paper proposes potholes are a structural damage to the road with hollow which can cause severe traffic accidents and impact road efficiency. In this paper, we propose an efficient pothole detection system using deep learning algorithms which can detect potholes on the road automatically. Four models are trained and tested with preprocessed dataset, including YOLO V3, SSD, HOG with SVM and Faster R-CNN. In the phase one, initial images with potholes and non-potholes are collected and labeled. In the phase two, the four models are trained and tested for the accuracy and loss comparison with the processed image dataset. Finally, the accuracy and performance of all four models are analyzed. The experimental results show that the YOLO V3 model performs best for its faster and more reliable detection results.

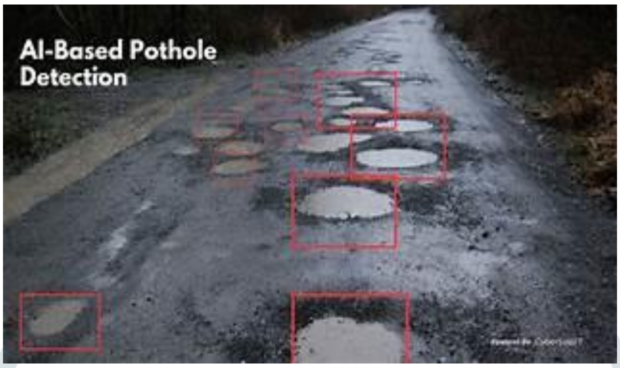

Fig 4. Pathole detection.

III . Problem Statement

The advent of autonomous vehicles powered by Artificial Intelligence (AI) has ushered in a new era of transportation, promising improved safety, efficiency, and convenience. However, as we push the boundaries of innovation in developing a robotic model for autonomous cars, several challenges and unexplored territories emerge, necessitating focused attention and solutions . Despite advancements, ensuring the absolute safety of autonomous cars remains a paramount challenge. Unpredictable road conditions, the dynamic nature of traffic, and the need for split-second decision-making by AI algorithms introduce complexities that demand a comprehensive approach to address potential safety lapses. The successful integration of robotics and AI in autonomous cars requires careful consideration of how these vehicles interact with human drivers, pedestrians, and other road user

While the learning capability of AI in autonomous cars is a strength, there is a need to enhance adaptability to diverse driving conditions. Current models may struggle to quickly adapt to novel situations, hindering their ability to navigate complex environments with confidence. The widespread adoption of autonomous cars necessitates seamless integration with existing transportation infrastructure. The development of standardized communication protocols, road signage recognition, and collaboration with smart city initiatives presents a challenge in ensuring a harmonious coexistence between autonomous vehicles and conventional traffic.

VI. Proposed System

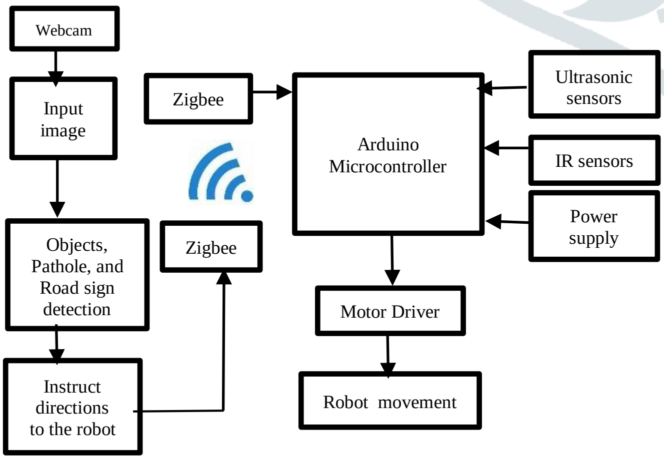

Fig. 5 . Block Diagram of the Proposed System

This development aims to build a monocular vision autonomous car prototype using Laptop with Arduino as a processing chip. An HD camera along with an ultrasonic sensor is used to provide necessary data from the real world to the car. The car is capable of reaching the given destination safely and intelligently thus avoiding the risk of human errors. Many existing algorithms like lane detection, obstacle detection are combined together to provide the necessary control to the car.

Project aims to develop a cutting-edge robotic model for an autonomous car, leveraging the power of artificial intelligence. The system will integrate a suite of advanced sensors including cameras for comprehensive environment perception. Using CNN algorithms, the perception module will detect and classify objects, recognize lanes and traffic signs, and build real-time, while control systems utilizing PID and adaptive cruise control will ensure safe and efficient driving. Through rigorous testing, continuous machine learning refinement, and adherence to safety standards, the goal is to create a reliable, intelligent, and road-ready autonomous driving solution."

At the heart of our system lies a fusion of advanced sensors these sensors collectively provide a 360-degree view of the vehicle's surroundings, offering precise detection and ranging capabilities. The perception module, powered by deep learning algorithms, processes data from these sensors in real-time.

The perception module, driven by deep learning models such as YOLO (You Only Look Once) and SSD (Single Shot MultiBox Detector), processes sensor data in real-time. Through object detection, segmentation, and classification, it creates a rich understanding of the car's dynamic environment.

Proposed robotic model for an autonomous car harnesses the latest advancements in AI, robotics, and sensor technologies. With a focus on safety, efficiency, and adaptability, our system aims to redefine the future of transportation. By seamlessly integrating perception, mapping, planning, and control systems, we create a reliable and intelligent driving companion capable of navigating complex urban environments with precision and safety.

V. FLOWCHART

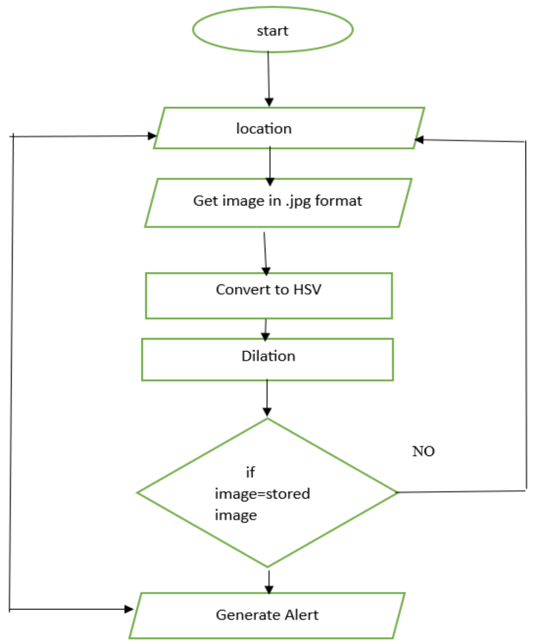

Fig 6. Flowchart for Lane detection.

The camera captures the image of the road continuously through Open C V in RGB form. Then it converts the image from RGB form to HSV by image processing technique. It is then dilated for image enhancement of the concentrated region.

The obtained image is then compared with the stored pothole reference image in the database. If, the captured image matches with stored image, then the Laptop with Arduino sends the location of the pothole to the municipal officials through E-mail along with the captured image.

The HSV color model can be considered as a different view of the RGB cube. Hence the values of HSV can be considered as a transformation from RGB using geometric methods. The diagonal of the RGB cube from black (the origin) to white corresponds to the V axis of the hex cone in the HSV model. For any set of RGB values, V is equal to the maximum value in this set. The HSV point corresponding to the set of RGB values lies on the hexagonal cross section at value V. The parameter S is then determined as the relative distance of this point from the V axis. The parameter H is determined by

calculating the relative position of the point within each sextant of the hexagon. The values of RGB are defined in the range [0, 1], the same value range as HSV. value H is the ratio converted from 0 to 360 degree.

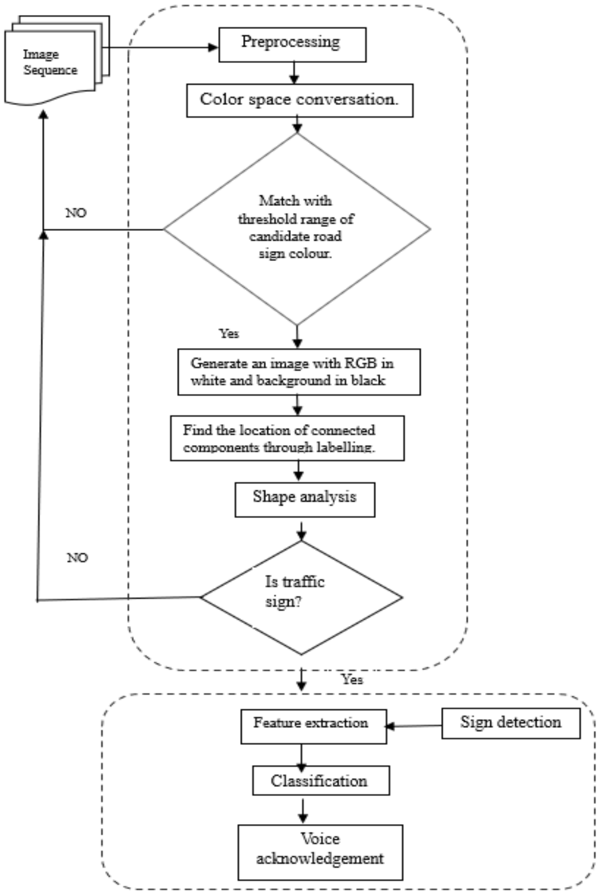

Fig 7. Flowchart for Traffic light signal detection.

Traffic regulation is an important concept in the modern society. For maintaining safety in the flow of traffic, government all over the world have taken steps to develop certain rules, known as traffic rules. Some of the traffic rules are directly displayed on roads in terms of traffic signs. Traffic signs are those that use a visual/symbolic language about the road ahead that can be interpreted by drivers for making driving safe and convenient. This paper proposes an autonomous traffic sign detection, which would detect, recognize and interpret the meaning of the traffic signs for the driver and will provide a great help in reducing the road accidents and the deaths caused by it.

The system mainly has two phases, 1) Sign detection, 2) Recognition. In detection phase a two stage algorithm is performed (i) detection through color image segmentation using HSV color space on color-images (ii) Validation of the obtained region of interest taking advantage of the shape properties of the road signs.

The pothole model is derived from the assumption that any strong dark edge within the extracted road surface is deemed a pothole edge if it adheres to certain size constraints. By inspecting Figure. it can be seen that one of the characteristics describing the potholes is a large dark shadow area. At this point, potholes that do not have dark edges and only have different color variations within them like sand or dirt are disregarded and will be studied in future work. The size

constraints were obtained using the selection of images withheld for parameter tuning. Any shape of contour that meets these conditions is deemed a pothole by the algorithm.

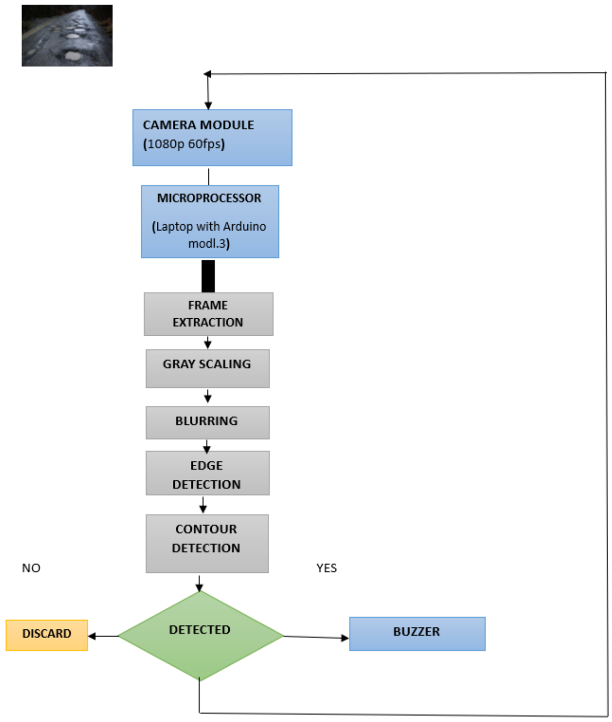

Fig 8. Flowchart for Pothole detection.

Camera is used to collect database either video and image of the livestock in real-time for training set data and testing data which are used during the image processing techniques. The image that is sent by the camera is received by the PC for classification of animal. Database is created and the set of sample images are stored in it. The program consists of functions such as index Image, image Set and retrieve Image. The Image Set is used to hold a collection of images. Index Image is used to create an image search index. Index Image is used with the retrieved image function to search for images. The captured image is given as a query image to the processing system. The retrieve image function takes two arguments, a query image and the image stored in the database. The resultant is the indices corresponding to images index that are visually similar to the query image. The image ID’s output contains the indices in ranked order, from the most to least similar match. The value match range is from 0-1. If the value is 0, then the image is not matched. If it is 1, then the query image is same as that of the stored image. If the value is between 0-1 then the query image falls under the category of the stored image i.e., the contents in the query image are same as that of the stored image. If the name of the image matches with that of the regular expression of the image then the animal is our livestock otherwise it is an intruder animal. If the score is in the range of 0.1 to 0.9, then the image is matched with that of the stored image.

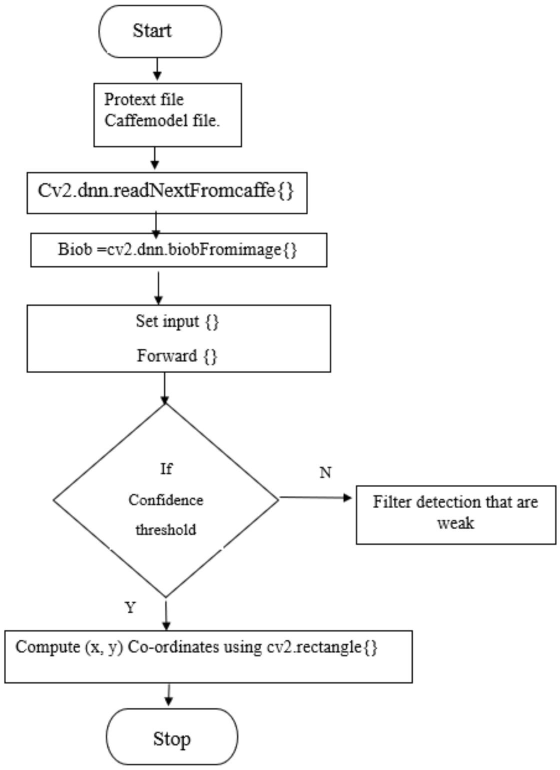

Fig 9. Flowchart for Object detection.

VI. CONCLUSION

The different hardware components along with software and neural network configuration are clearly described. With the help of Image Processing and Machine Learning a successful model was developed which worked as per expectation. Despite the inherent benefits, autonomous vehicle technology must overcome many social barriers. Much like the issue faced by the first automobiles, the influence of metal models can impede the advancement of technology. However new legislation is creating opportunities for these cars to prove their viability. As more states legalise the driverless cars, the social obstruction will give way, allowing for the largest revolution in personal transportation since the introduction of automobiles.

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