AI-DRIVEN SYSTEM FOR PAVEMENT DISTRESS AND OBSTACLE CLASSIFICATION

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ABSTRACT

Monitoring the road condition has acquired a critical significance during recent years. A few major factors add up to the importance of current research : the information retrieved may support the decision-making process of drivers to the use or avoidance of certain highways, smooth road surface causes less damage to the vehicle chassis and suspension system, the dependability of the vehicles control system remains, valid information on the road surface quality is the basis for updating the knowledge base of the road management companies and organizations and thus challenges them for regular surface reviews and repairs. The tool considered in the paper is the real-time IoT-complex with Android application that automatically collects the data from the mobile triaxial accelerometer and gyroscope, shows the road trace on a geographic map using GPS and sends all recorded entries to the cloud-based computation algorithms. Different types of artificial neural networks are applied to training data to classify road segments and build the model. The experimental results show a consistent accuracy of 90 and higher percent. Using this approach the expected output is the visualization of the road quality map of a selected region. Hence, the constructive feedback may be provided to drivers and local authorities. The long-term benefit from this system is the performing of the road network state comparison throughout various time intervals and checking up on the road construction projects, whether or not they meet the assigned quality prerequisites.

Keywords- Road condition monitoring, IoT, Artificial neural networks, Road quality map, Machine learning.

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 vehicle 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. The visual approach relies on image processing, using texture extraction. 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 vehicle (also known as a robot vehicle, autonomous vehicle, or driverless vehicle) is a robotic vehicle that is designed to travel between destinations without human intervention.It is capable of sensing environment and navigate without human input.Autonomous vehicles must have control systems that are capable of analysing sensor data to distinguish between different vehicles on the road. The potential benefits of autonomous vehicles 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 vehicles are predicted to increase traffic flow; provide enhanced mobility for children, the elderly and disabled; 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 vehicles customer concern about the safety of driverless vehicles, 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

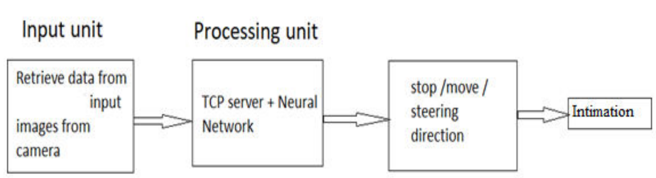


Fig 1:System Architecture

II. RELATED WORK

Title	Authors	Year	Contributions
Pavement Distress Detection, Classification and Analysis using Machine Learning Algorithms: A Survey	Kothai R., Prabakaran N., Y.V. Srinivasa Murthy, Linga Reddy Cenkeramaddi, and Vijay Kakani	2024	Surveyed various machine learning algorithms for detecting and classifying pavement distress, offering insights into algorithmic choices for practical use.
Machine Learning Applications in Road Pavement Management: A Review, Challenges and Future Directions	T. Tamagusko, M.G. Correia, and A. Ferreira	2024	Reviewed machine learning applications in road pavement management, outlining challenges and future directions for the field.
Intelligent pixel-level pavement marking detection using 2D laser pavement images	Z. Dong, H. Zhang, A. Zhang, et al.	2023	Developed a pixel-level detection method for pavement markings using 2D laser pavement images, enhancing accuracy in road maintenance.
Machine learning algorithms for monitoring pavement performance	S. Cano-Ortiz, P. Pascual-Muñoz, D. Castro-Fresno	2022	Reviewed various machine learning algorithms used for monitoring pavement performance and their effectiveness.
RDD2020: An annotated image dataset for automatic road damage detection using deep learning	D. Arya, H. Maeda, S.K. Ghosh, et al.	2021	Proposed an annotated image dataset for automatic road damage detection using deep learning methods.

This paper deals with the dramatically increasing role in roads maintenance held by AI and ML. It would aim to present how these technologies might be perceived to be added into the enhancement of management in road infrastructure. Finally, Tamagusko et al. (2024) presented an evaluation of the challenges and future directions for the applications of machine learning in road pavement management. They showed that this area of application has yet to require much innovation. All these studies depict how machine learning can revolutionize monitoring and management in the process of road pavements.

Kothai et al. (2024) discusses a review on machine learning applied algorithms for classification and analysis as well as their detection of pavements distress in the article

In addition, Dong et al. (2023) presented the most innovative method related to pavement marking detection using an intelligent pixel-level analysis of 2D laser pavement images. They focused efforts on making the detection in high-accuracy, high-efficiency pavement markings as much as high regarded in relation to road safety. From that work, this paper contributes in progress towards road surface markings autonomous real-time monitoring.

Due to the integration with machine learning and deep learning techniques, monitoring and damage detection of road pavement has reached an entirely advanced level. Recently, Arya et al. (2021) have proposed a novel dataset in the form of an annotated image dataset known as RDD2020 devoted to automatic deep learning-based road damage detection. It has come in quite handy in the development of algorithms used in road damage detection because this dataset represents a pretty good source for the training and validating models that can help detect defects on roads. Similar to that is the use of machine learning algorithms in monitoring the performance of pavement, where Cano-Ortiz et al. (2022) looked at:. Their study is related to the development of models that may predict the pavements' conditions so that effective road maintenance planning and resource usage can be attained.

III. IMPLEMENATION

To obtain (correct) predictions from deep neuralnetworks you first need to preprocess your data.In the context of deep learning and image classification, these preprocessing tasks normally involve:

1. Mean subtraction

2. Scaling by some factor

OpenCV's new deep neural network module contains two functions that can be used for preprocessing images and preparing them for classification via pre-trained deep learning models.

Step 1: Image/video acquisition from the camera

Step 2: Convert video to frames.

Step 3: Store images of each animal as database which is used as training set for our program

Step 4: Compare camera captured frames with the database.

Step 5:Use image read function to read the image and Preprocessing is done on that image. Perform Blob detection on the frame and blobs are matched with images from training database images.

Step 6: And check if it is matching or not.

Step 7: To identification of that animal is desired or not. An array is created and program is written for each animal to be identified.

Step 8: Intimation or alert

CAPTURING PHASE:

To detect motion, we first have to capture live images of the area to be monitored and kept under surveillance. This is done by using camera

CAMPARING PHASE:

Comparing the current frames captured with previous frames to detect motion: for checking whether any motion is present in the live images, we compare the live images being provided by the web cam with each other so that we can detect changes in these frames and hence predict the occurrence of some motion.

PRE-PROCESSING:

Pre – Processing Is heavily dependent on feature extraction method and input image type. Some common methods are:

Denoising: applying a Gaussian or simple box filter for denoising.

Contrast enhancement: if gray level image is too dark or bright.

Down sampling to increase speed.

Morphological operations for binary images.

Scaling by some factor.

Image Segmentation:

In the images research and application, images are often only interested in certain parts. These parts are often referred to as goals or foreground (as other parts of the background). In order to identify and analyze the target in the image, we need to isolate them from the image. The image segmentation refers to the image is divided into regions, each with characteristics and to extract the target of interest in the process.

The image segmentation used in this is a threshold segmentation. To put it simply,the threshold of the grey scale image segmentation is to identify a range in the image of the compared with the threshold and accordingly to the results to the corresponding pixel is divided into two categories, the for ground and background.

Threshold segmentation has two main steps:

- Determine the threshold T
- Pixel value will be compared with the threshold value T

In the above steps to determine the threshold value is the most critical step in partition. In the threshold selection, there is a best threshold based on different goals of image segmentation. If we can determine an appropriate threshold, we can correct the image for segmentation.

Hardware Implementation:

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.

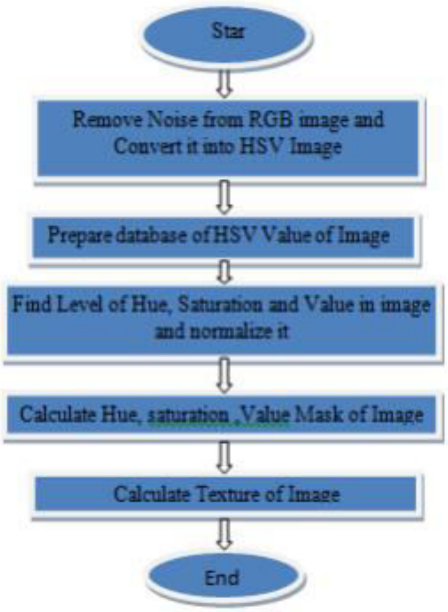
Software Implementation:

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.

IV. ALGORITHMS USED

HSV ALGORITHM:

We evaluate the content based image retrieval HSV color space of the images in the database. The HSV stands for the Hue, Saturation and Value, provides the perception representation according with human visual feature. The HSV model, defines a color space in terms of three constituent components: Hue, the color type Range from 0 to 360. Saturation, the "vibrancy" of the color: Ranges from 0 to 100%, and occasionally is called the "purity". Value, the brightness of the color: Ranges from 0 to 100%. HSV is cylindrical geometries, with hue, their angular dimension, starting at the red primary at 0°, passing through the green primary at 120° and the blue primary at 240°, and then back to red at 360°.



HT ALGORITHM

The HT is a feature extraction technique used in digital image processing. To extract features from digital images, it is useful to be able to find simple shapes - straight lines, circles, ellipses and the like - in images. HT is a 2D non-coherent operator which maps an image to a parameter domain. The Hough Transform (HT) method is to detect lines, using the parametric representation of a line: From equation , the variable r is the distance from the origin to the line along a vector perpendicular to the line.

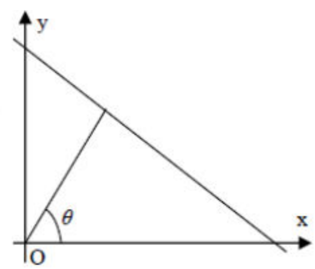
$$r = x * \cos(\theta) + y * \sin(\theta)$$

HT algorithm uses an array called accumulator to detect the existence of a line. For each pixel and its neighborhood, HT algorithm determines if there is enough evidence of an edge at that pixel.

A voting procedure is carried out in the parameter domain. The number of dimensions of the parameter space equals to the number of parameters needed to fully define the curve or line as seen in equation that line is represented by two parameters r and theta.. The circle is mathematically expressed using equation

$$(x - x_0)^2 + (y - y_0)^2 = r^2$$

Parametric representation of a straight line



V. RESULTS

Fig 1 : Detection of Traffic Sign Location

Fig 2 : Image after processing

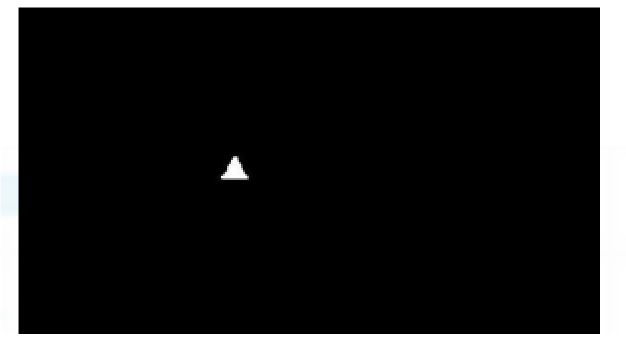


Fig 3 : Image after noise removal

Fig 4 : Traffic Sign Detected

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 vehicles to prove their viability.

As more states legalize the driverless vehicles, the social obstruction will give way, allowing for the largest revolution in personal transportation since the introduction of automobiles.

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