Fog Vision for Vehicles using Computer Vision and Deep Neural Network Algorithms

Varun Totakura   
*UG Scholar, CSE,*  
*Guru Nanak Institutions Technical Campus,* India

totakura.varun@gmail.com

ORCID: 0000-0002-5114-5205

Madhusudhana Reddy. E   
*Professor, CSE,*  
*Guru Nanak Institutions Technical Campus,*  India e\_mreddy@yahoo.com

ORCID:0000-0001-5316-5798

**Abstract:**

Low visibility is one of the leading causes of vehicle accidents on roads across the world. In foggy weather, the contrast of images grabbed by in-vehicle cameras in the visible light range is drastically degraded, which makes the current applications very sensitive to weather conditions. So, the usage of Infrared - Thermal vision camera will help to overcome those drawbacks. In this paper, we have proposed a methodology for clear vehicular visibility during the bad weather conditions for the safety of the passengers. A Deep Neural Network model i.e., a Convolutional Neural Network (CNN) model was proposed for the safety driving and auto breaking system for the vehicle. The data grabbed by the Infrared-Thermal vision camera will undergo pre-processing using the Computer Vision algorithms i.e., Gaussian Blur filters and Edge Detection and then the prediction of the objects will be processed by the proposed CNN model. The accuracy achieved by the proposed CNN model is around 96% and can be used in the real world for the auto breaking system in vehicles.

**Keywords:** Convolutional Neural Network, Deep Learning Model, Infrared-Thermal cameras, Gaussian blur, Canny Edge Detection, Auto Breaks, Vehicles.

**Introduction:**

Due to the increase in the pollution the weather conditions across the world is becoming very much worse than it used to be in earlier days. As per the records the no. of accidents is increasing gradually as the time increases. For example, in 2016 the number of accidents due to fog run was around 9317 and it has increased to 11090 in the year 2017. In the night times and rainy weather conditions the situation will be even worse. Moreover, the pollution is increasing gradually over the years and has even reached the extreme levels in some of the places. Due to the increase in pollutions the visibility in the normal times also has decreased which is also becoming a reason for the accidents. To overcome this situation across the world there should be some remedy. The remedy should be cost effective and easy to install in all kind of vehicles and should be common to all. Many of the researchers across the globe has made their domain to be fog-vision as in the coming year or future the situation will be out of control due to increase in pollution and extreme weather conditions.

The usage of the Thermal-Infrared cameras will be the best option in all kind of weather condition and any time. They will detect temperature and also captures different levels of infrared light which has become the main reason for their usability. This light is invisible to the naked eye, but can be felt as heat if the intensity is high enough. All objects emit some kind of infrared radiation, and it's one of the ways that heat is transferred. And they are not harmful because everything gives off infrared radiation, and thermal imaging cameras merely detect this existing radiation (rather than emit anything).

With the combination of the data which was capture with those cameras the prediction of the action will become easier when the CNN model is used. The CNN is a deep neural network algorithm which is specially designed for the prediction and classification of the images. Due to the advantages of the CNN they are been used in various kind of applications which will help the humans to make the work easier. In this paper a CNN model is proposed which will be used to predict the action form the given image data.

This paper will clearly explain about the usage of the Thermal-Infrared cameras for the fog-vision in all the times for the vehicular drivers to assist them in their vision and also to predict the appropriate actions according if the driver is not able to make the necessary action.

**Related Works:**

In the paper published by Nicolas Et Al. [1], they have presented an effective method for measuring the visibility distance using a single camera placed on-board a motor vehicle. Based on the visibility level detected by the camera placed on the vehicle their method enables estimating the “meteorological visibility distance”. But the main drawback of their proposed model is that their model cannot run the night time or in the dark places which will be again burden for the drivers in the case of visibility.

Manish Et Al. [2] has proposed a model which is used specifically for the aviation or the fire fighter for their visibility in the attack as the place of their attack will place a major role for a military operation. They have used deep CNN to develop their model and have also used the infrared thermal vision cameras for the data feed to their proposed deep CNN model.

In the publication of Bronte Et AL. [3], they have proposed a model using the computer vision techniques firstly for the detection of the fog in the weather around the vehicle which has the capacity to predict up to 85% accurate result. They have even mentioned about the fog-visibility by their proposed model was not up to the mark in some cases which they have mentioned in their conclusion part of their paper.

Romain Et Al. [4] has published a paper related to the Night fog detection using the multipurpose in vehicle cameras. Their work is all about the use of simple camera for the detection or the visibility to the driver in the vehicle. They did not provide any specific algorithm or method for the detection at the night times. Their proposed methodologies were based on the Advanced Driver Assistant Systems (ADAS) algorithm.

In the paper published by Ankit Et Al. [5] they have proposed the object detection model using the night vision camera data which was converted to thermal camera image. They have used Histogram of Oriented Gradients and features from accelerated segment test algorithms were used to develop their model and achieve greater accuracy.

Yingfeng Et Al. [6] has proposed a deep learning model for the night-time vehicle detection using visual saliency. Their work was based on the ADAS algorithm and they have proposed a far-infrared image vehicle detection algorithm based on visual saliency and deep learning in which they have achieved around 92.5% accuracy with the training dataset of 6000 images.

In the paper presented by Mayank Et Al. [7], the object detection algorithm with using some of the filters was proposed. They have mainly concentrated on the Indian roads rather than generalization to all the climates and roads. Their proposed model has achieved an accuracy of 85.28% with low light conditions.

The paper Improving Night Time Driving Safety Using Vision-Based Classification Techniques was presented by Jong Et Al. [8], in which they have used ADAS concept for their proposed method. They have also proposed upgraded Multi-Scale Retinex algorithm which was used for the improvement of the accuracy of the model when used on the night time data.

Park Et Al. [9] has presented a paper regarding the person detection using Infrared images for night time intrusion warning systems using the CNN model. Their accuracy had reached 90% in object level-detection for all kind of objects.

**Problem Statement:**

Due to raise in the pollution and drastically changes in the weather conditions, now a day the climatic conditions are becoming very worse. At that times the fog or the mist will become a very problematic situation for the drivers of the vehicle. This could even lead to the accidents and lives of the most innocent people will be lost. As per the modern study it was proved that most of the accidents that were happed in the foggy areas are just because the drivers will not have the clear vision on the road. If this situation comes in the night times, then the situation will become even worse so to overcome this a methodology was proposed in this paper. In the proposed methodology, the Infrared – Thermal vision cameras are used to grab the data and feed to the trained CNN model for the classification for auto-breaking system. So, if there is any obstacle which is in the middle of the road then the auto breaking system will be activated and the vehicle stops to avoid accidents. Real time Infrared-Thermal vision camera data in the Audi car is as shown in figure – 1.

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Figure – 1: Real time Infrared-Thermal vision data

**Proposed Methodology:**

The Convolutional Neural Networks are the game changers at the times where the computer vision comes into the play. The CNNs are specifically designed for the image feed where the image will be trained using the Convolutions that were produced after the pooling in the image pixels. So, to use the advantages of the CNNs the proposed model is also designed using a CNN that will help to find accurate classified result. Each result and its accuracy will be most important as the result is used to make a decision that will save the innocent people in and out of the vehicle.

The proposed methodology will work in a flow as sown in figure – 2. The pictures that were taking by the Infrared – Thermal vision cameras which were installed in the vehicle will be given after pre-processing as feed to the proposed CNN model.

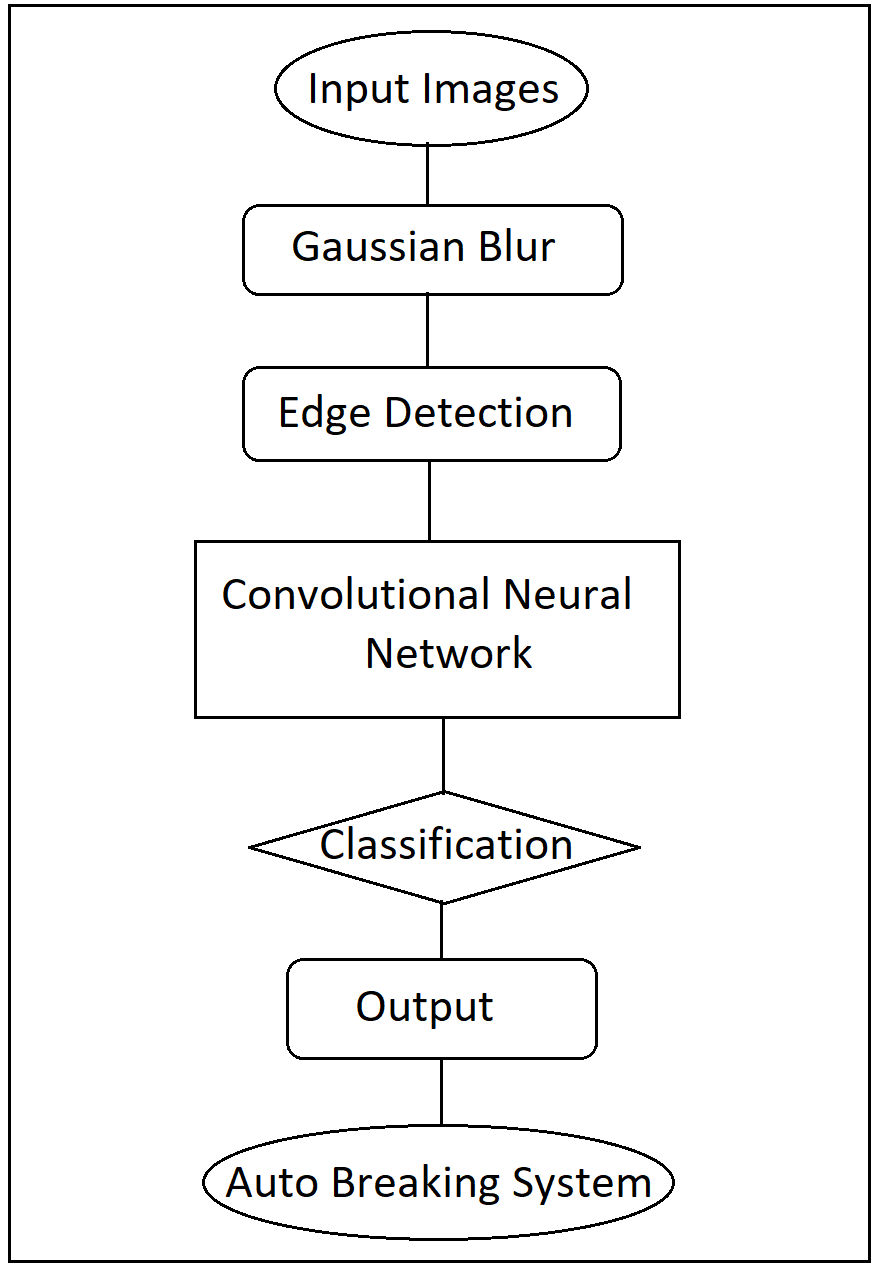
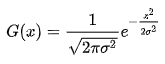
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Figure – 2: Proposed System Workflow

In the pre-processing phase the images will be gone through the Gaussian blur filter which is used to normalize the pixels and produced the even images at every time. A Gaussian blur filter is a type of filter which uses Gaussian function which uses the normal distribution to normalize the data. The equation that is been used by the Gaussian blur filter for one pixel is as shown below.



The equation of the two-dimensional data is shown below.



After the Gaussian Blur filters the data will be passed through the Canny Edge detection algorithm which is a multi-stage algorithm. The examples of the Canny edge detection algorithm were given as shown in the following figures. The original image was displayed in the left figures and the edge detected using canny algorithm is displayed in the right hand side of the following figures – 3, 4, 5.

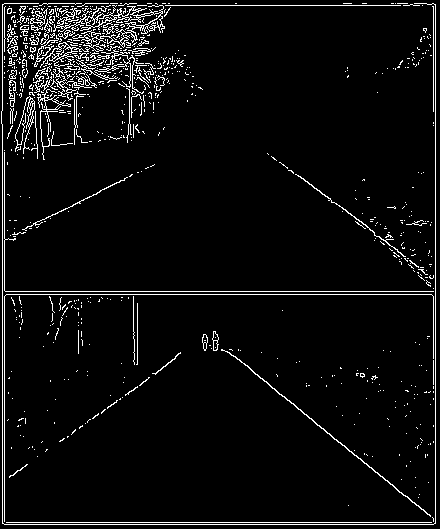
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Figure – 3: Canny Edge Detection Example 1.

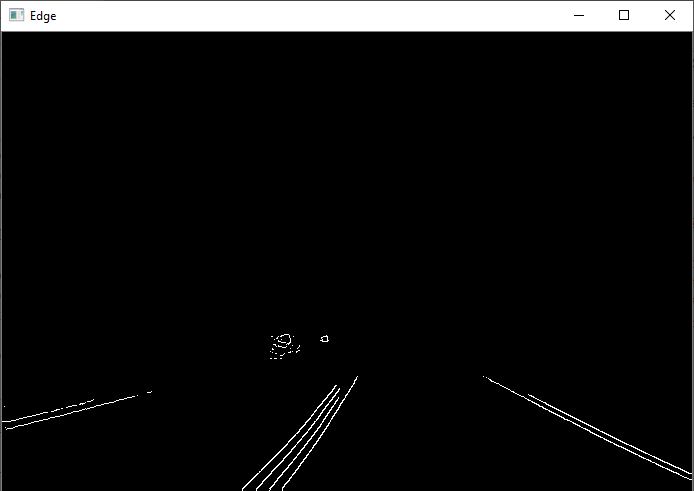
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Figure – 4: Canny Edge Detection Example 2.

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Figure – 5: Canny Edge Detection Example 3.

These images are feed to the proposed CNN model for the further prediction which will be given as the input to the auto-breaking system installed in the vehicles. The proposed CNN model is a sequential network of 3 convolutional layers with the 64, 128, 128 neurons at the respective layers. The first layer will get the image of the size (-1, 80, 80, 1) and the remaining layers will get the output of the previous layer as the input. For every Convolutional layer there is a Max-pooling layer which will help to search in the image pixels. And after the third convolutional layer the out will be given as the input to the series of flatten layers with 512, 128, 128 layers of the neurons which will help to flatten the network for the final output. The whole model is compiled with the Adan Optimizer for about 50 iterations or the 50 epochs for the better accuracy with the sparse categorical entropy as the loss function to measure the loss percentage. At last the model has achieved 96% accuracy and was tested on the real time data which has shown the accurate results in all the scenarios. The proposed model is ready to deploy on the real car for the passenger safety.

**Conclusion and Future Work:**

In this paper the advantages of using the Infrared-Thermal cameras are discussed along with the usage of those cameras for the fog and night vision is implemented using a Deep Learning Convolutional Neural Network. The result which was obtained by the proposed network is shown figure – 6. The figure contains details about the accuracy and loss of the CNN model. The model was trained with 50 epochs in which the loss was decreased up to 0% from 45 epochs and the accuracy reached 90% above from 35 epochs. At last the validation accuracy of the model has reached around 96%.

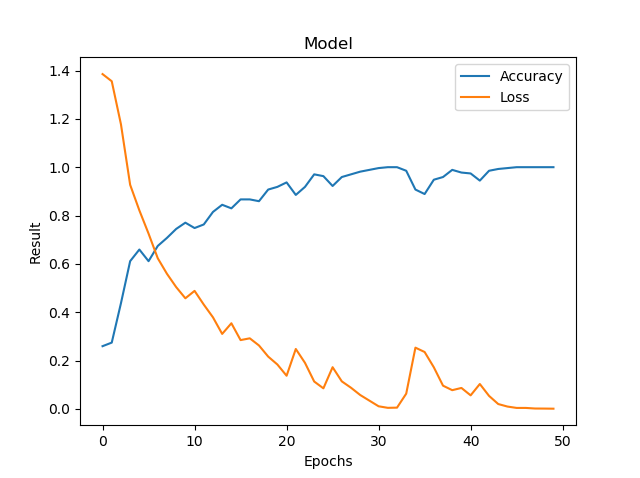
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Figure – 6: Accuracy of the proposed CNN model.

In future the accuracy of the model can be increased to 100% which will help the people to be safe in all the times. And the network can be upgraded with self-learning methods where if there are any mistakes then the model can update itself and the same mistake or the same kind of mistake will not happen again.

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