Evaluation of Road Condition in Dense Fog using in-vehicle Cameras

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ABSTRACT

Fog is a complex atmospheric phenomenon. It is a visible mass consisting of cloud water droplets or ice crystals suspended in the air at or near the earth's surface. Fog usually occurs by radiational or advectional cooling of moist air, resulting in a high concentration of microscopic airborne water droplets. Camera based methods are used to detect the presence of the fog level and object intensities in the video stream for the evaluation of the road condition using a approach called backscattered veil. Backscattering is the reflection of waves or signals back to the direction from which they came. It can be used to assess the presence of fog around the vehicle which is created by the headlamps. It aims at detecting fog when the vehicle is alone in absence of exterior public lighting. In this aim, a correlation index is computed between the current image and a reference image where the fog density is known. Scattered light does not simply disappear as if it was absorbed by smoke or dust. It simply propagates along different paths, some of which end up into the driver's eyes. It results in an added luminance which impairs visibility by reducing contrasts. Applying backscattered veil detection technique for extracting the region where the obstacles found and analysis the same under positive environment.

INTRODUCTION

Fog is defined as a cloud that touches the ground and causes a visibility range of less than 1,000 m. The visibility range thereby describes the longest distance at which a black object of adequate size can be observed towards the horizon. while night driving only represented 10% of total traffic, it represented 47% of fatalities at 2011 in France. Moreover, accident severity during nighttime increases by a factor of 1.7 as compared with daytime[1]. Among the factors that explain these figures, drowsiness[2] , speed[3] , and reduced visibility[4] are frequently cited. To address this issue, emphasis is put on the development of smarter lighting strategies for vehicles[5]. Advanced systems are being developed to automate and adjust the operation of vehicle lights to maximize visibility while preventing glare for oncoming drivers.

Among the embedded sensors that drive these systems, video cameras are most promising since they have low cost and serve different purposes. In particular, adverse weather conditions, such as rain or fog, are major concerns. First, they directly affect the safety of a driver by reducing his safety margin, i.e., low visibility distance or low friction. Second, they reduce the reliability of camera-based systems by altering image quality. For these two reasons, detecting, characterizing, and mitigating the effects of adverse weather conditions, particularly fog, is a challenge for camera-based advanced driver assistance systems (ADASs).

RELATED WORK

I. Image based fog detection in vehicles

Camera based driving assistance systems are one of the core technology trends in intelligent vehicles. Well known applications. The author in the paper [6] addressed the problem of fog detection. Previous camera based fog detection systems analyze therefore distinct objects in the image or image regions like the road region or the horizon i.e. the position where the sky touches the road. However, these approaches are not reliable for everyday use, because the road or the horizon is often occluded by other objects like vehicles or bridges, while the features like lane markings can be of different quality.

The only stable information that can always see in images of foggy weather conditions is a decrease in contrast and blurring in the whole image. For that reason the author propose a new method to detect such an event by using global image features. Thereby analyzing the power spectrum being the squared magnitude of the Fourier transform of the image that holds information about the frequencies in the image discarding spatial information.

The first step is to normalize the input image i (x; y) in a pre filtering step. Afterwards perform a feature extraction that is based on the calculation of the power spectrum of the image followed by two-stage feature reduction done in terms of a Gabor filter bank sampling and Principal Components Analysis (PCA). Finally Support Vector Machine (SVM) to perform the classification task.

II. Nighttime Visibility Analysis and Estimation Method in the Presence of Dense Fog

Compared with daytime, a larger proportion of road accidents happens during nighttime. The altered visibility for drivers partially explains this situation. It becomes worse when dense fog is present. The author in this paper[7] define a standard night visibility index, which allows specifying the type of fog that an advanced driver assistance system should recognize. A methodology to detect the presence of night fog and characterize its density in images grabbed by an in-vehicle camera is then proposed. The detection method relies on the visual effects of night fog.

A first approach evaluates the presence of fog around a vehicle due to the detection of the backscattered veil created by the headlamps. In this aim, a correlation index is computed between the current image and a reference image where the fog density is known. It works when the vehicle is alone on a highway without external light sources. A second approach evaluates the presence of fog due to the detection of halos around light sources ahead of the vehicle. It works with oncoming traffic and public lighting. Both approaches are illustrated with actual images of fog. Their complementarity makes it possible to envision a complete night-fog detection system. If fog is detected, its characterization is achieved by fitting the different correlation indexes with an empirical model.

III. A Semi-Analytic Model of Fog Effects on Vision

Dense fog drastically impairs visibility, causing important traffic safety issues, particularly

in the field of ground transportation. The author in this paper[8] first introduces basic notions about the nature of fog and review the microphysical models which usually serve to describe its droplet size distribution. Second explains how light interacts with fog droplets, and the optical descriptors which describe scattering and extinction phenomena. Third, analyzes how contrast is impaired by these phenomena in the image of the environment perceived by a vision system, and a semi-analytic model of the visual effects of fog.

In order to design and assess solutions for detecting and counterbalancing the loss of visual information in foggy weather conditions, the use of simulation can hardly be avoided, since field experiments are made very difficult by the lack of control over the time and place where fog will occur. Two approaches are possible for simulating the image of a scene observed in fog: computer graphics and image processing.

The first consists in simulating all radiative transfers between emitting and reflecting surfaces, taking into account the interactions with the participating medium. It involves global illumination calculations which are generally time-consuming. The other approach consists in simulating the perturbations caused in the image of the environment by the interactions of light with the scattering medium . Originally designed for remote sensing, this approach has only recently found applications for horizontal visibility problems because of the depth-dependency of fog visual effects.

Proposed Method

This paper introduces an approach to determine the visibility range under foggy weather conditions from images of stationary traffic management systems. The image line, upon which no contrast higher than 5% appears, defines the visibility range in the camera image. From the known camera configuration relative to the road a transformation from image to world coordinates was done. In the range from 300 to 1000m the proposed system outputs a visibility range in 50m steps, in the range of less than 300 m in 10 m steps. Camera based methods are used to detect the presence of the fog level and object intensities in the video stream for the evaluation of the road condition using a approach called backscattered veil. The proposed approach consists of five steps as shown in the figure 1, such as:

I. Image Acquisition , II. Image Layer Decomposition, III. Layer Enhancement, IV. Feature Extraction, V. Backscattered veil Detection.

I. Image Acquisition

The image acquisition layer acquires data from the stream of video frames or stilled images. Data acquisition is through direct methods that are MATLAB built in functions IMREAD and IMLOAD. In this step the camera is going to fetch video stream continuously and it start recording when something stuck or any obstacles found, then it acquires the data from the processor for data preprocessing and quality check. After checking the quality of the image the sorted image will be send to the next level such as image layer decomposition.

II. Image Layer Decomposition

The input from the first layer that is from image acquisition the input data will be fed in to the image layer decomposition. In this step the input image streams have been fragmented and given for pre processing. In pre processing the image will be get smoothen then the detection of image edge and lastly it includes removal of noise ratio by using region of interest detection with trigal approaches. Further image segmentation will be taken place in the image layer analysis. The filtered images will be transmitted for the layer enhancement that is for the next level.

III. Layer Enhancement

Enhancement module concentrate on the input module results from the previous levels it takes the input as filtered images where the segmentation is done for the filtered images then Region of Interest detection and observation will done in the images for the detection of the objects or obstacles then ROI extraction will be done for the segmented images which focuses the value of the extracted region and then freeze the extracted region and that extracted layer will be taken for the layer analysis if the region is not found or else if the region is satisfied then that region will be fetched for the next step.

IV. Feature Extraction

The input samples are in the form of the videos or still images after preprocessing under module second which is appended with feature extraction technique. Feature extraction completely depends upon the Region of Interest and elimination ratio. Fog feature extraction technique is the proposed algorithm with enhance parameters for the extraction of the pattern. Feature extraction is supported with the pattern recognization output with a sample data. Pattern recognization is appended with machine learning concept.

V. Backscattered veil Detection

Backscattering is the reflection of waves or signals back to the direction from which they came. It can be used to assess the presence of fog around the vehicle which is created by the headlamps as shown in the figure 1. It aims at detecting fog when the vehicle is alone in absence of exterior public lighting. In this aim, a correlation index is computed between the current image and a reference image where the fog density is known. Applying backscattered veil detection technique for extracting the region where the obstacles found and analysis the same under positive environment. The outcome of the module five is fed as input to module three that is layer enhancement as shown in the figure 2 and thus the following results is computed.

1. Level of fog detection and intensity.
2. Obstacles detection under the intensity of the fog.
3. Overall fog detected layer is computed

IMPLEMENTATION

The implementation work is discussed based on the algorithm the work flow is as shown below: the work flow begins with the step 3 because initially the detection of fog is important then the evaluation of road condition.

Step 1:
Frames{ROI 1 to end of ROI n}
Step 2:
K: density of obstacles
L: initial distance (from frame ROI to current frame)
Step 3: Computing Fog Environment
a) Image Enhancement

```
        if(Threshold value>300m)
        {
                Normal Fog
        }
        else
        if(Threshold value<100m)
        {
                Medium(low alert)
        }
        else
        High alert, Speed reduced
        }
```

Step 4: Based on alert
If{ L < threshold value}
Then { Low Alert} //but positive environment
else

High Alert (reduce speed)

Go back to step 1

Step 5: High alert, Reduced Speed + Positive ROI

Feature detection

(Attributes extraction)

Exit

The Region of Interest will be identified using Layer Enhancement as shown in the figure 3. The frames will be taken for identifying the regions to determine the patterns.

POSSIBLE OUTCOMES

Fog is defined as a cloud that touches the ground and causes a visibility range of less than 1,000m. The possible outcome is the detection of fog level and object intensities and the Input frame feature extraction under machine learning approach and finally Applying backscattered veil detection technique for layer extraction and analysis under positive environment.

CONCLUSION

The paper discusses about some of the techniques used to detect the dense fog using in-vehicle cameras for the evaluation of road condition. Camera based driving assistance systems are one of the core technology trends in intelligent vehicles. Well known applications are, for example, the lane departure warning, the road sign detection or the high beam assistance. All these systems detect tangible objects in the camera images like lane markings, road signs, light sources of the vehicles ahead or forthcoming vehicles. Detecting context information describing the environment surrounding, like fog, rain or snow. A methodology to detect the presence of night fog and characterize its density in images grabbed by an in-vehicle camera is then proposed. The detection method relies on the visual effects of night fog.

A novel approach evaluates the presence of fog around a vehicle due to the detection of the backscattered veil created by the headlamps. In this aim, a correlation index is computed between the current image and a reference image where the fog density is known. It works when the vehicle is alone on a highway without external light sources.

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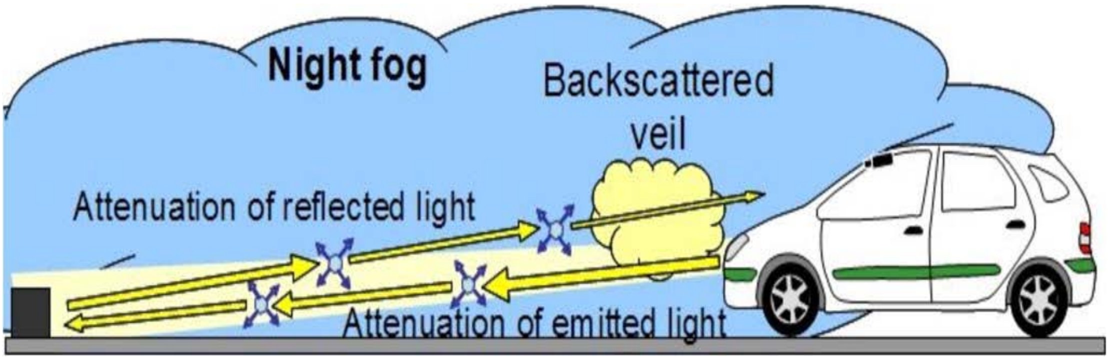

Fig. 1. Different effects of fog on light propagation in a driving scene

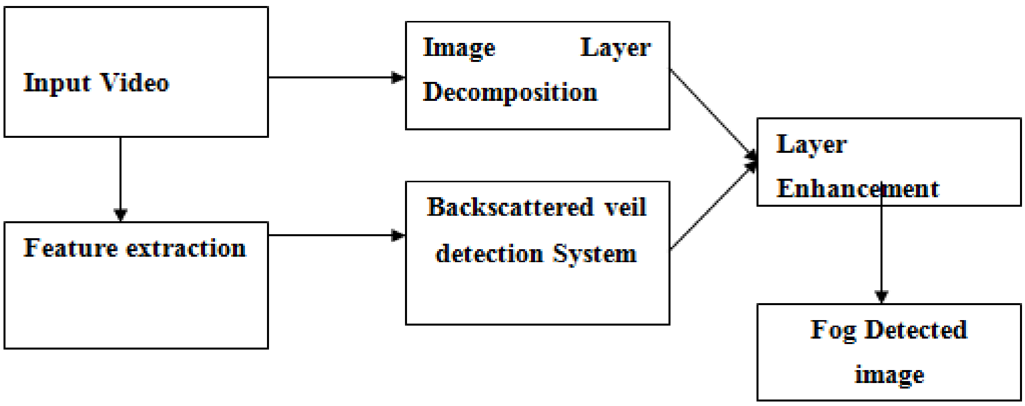

Figure 2: System Architecture

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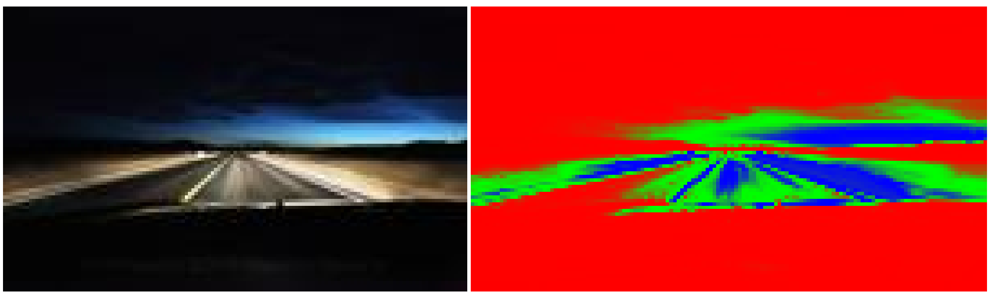

Figure 3: Identification of ROI