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## Unfocused Raindrop and Fog Detection

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**ABSTRACT:** In the world of increase demand for vehicle the driver is up held by camera based advanced driver assistance system (ADAS) which are a key part for further enhancements in well being and driving solace. Imaging sensors in ADAS are performing well under great climate conditions, their proficiency reduce in unfavorable condition like rain, haze, fog. To handle such optical dangers and to improve data nature of cameras the method aim to detect raindrop and fog from set of images. The project exhibit a novel approach that goes for recognizing raindrops on an auto windshield and fog in surrounding environment utilizing just pictures from an as a part of vehicle camera. In view of the photometric properties of raindrops, the calculation depends on picture preparing techniques to highlight raindrops. Its outcomes can be further utilized for picture rebuilding and vision upgrade and consequently it is a significant apparatus for ADAS.

**KEYWORDS:** Traffic safety, visibility, average grey value, DWT, Advance driver assistance system, unfocused raindrop, Defogging.

### I. INTRODUCTION

To detect and characterize degraded visibility conditions, in particular due to the rain and fog, aims both at generating new driving assistances (switching on wiper and adapting their speed, alerting the driver if his behavior is inappropriate to visibility conditions) and to characterizing the operating domain of any driving assistance system relying on an optical sensor. Using extracted information, it is possible to adapt sensor functioning, to improve signal quality and to dynamically adjust system settings. Current onboard rain and fog detection systems are based on dedicated sensors. It is a combination of infrared emitter and receptor that uses the windshield glass as wave guide. A water drop and fog particles located on the sensor is deflecting a part of the infrared light allowing the detection. The reliability of such sensors is not questioned however they present some drawbacks. First, the water detection is localized on a small part of the windshield. Secondly, they do not provide quantified information on the water density on the windshield. Finally, those sensors may occupy a large place on the center of the windshield and decrease the driver visual comfort. To find an answer to those difficulties, we propose a new approach for rain and fog detection relying on a video camera. Assistance Systems (ADAS) based on video camera tends to be generalized in today's automotive. However, if most of these systems perform nicely in good weather conditions, they perform very poorly under adverse weather particularly under rain. We present a novel approach that aims at detecting raindrops on a car windshield using only images from an in-vehicle camera. Based on the photometric properties of raindrops, the algorithm relies on image processing techniques to highlight raindrops. Its results can be further used for image restoration and vision enhancement and hence it is a valuable tool for ADAS. Adverse weather conditions directly impact the driver's safety, by both reducing the visibility distance and increasing the stopping distance. To detect and characterize those conditions is becoming a major concern for advanced driving assistance systems. Among expected in on board sensors, camera is one of the most promising because it is not expensive and may be shared by other applications for

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 6, June 2016

instance, obstacle detection or lane departure warning. An increasing number of vehicles are equipped with onboard cameras. As perception sensors, they scan the surrounding field and supply data to the Advanced Driver Assistance Systems (ADAS) which generates an environmental model by employing computer vision techniques. Camera based ADAS support the driver with timely risk identification to prevent accidents, e.g. by realizing an adaptive cruise control (ACC), traffic sign recognition, blind spot detection or even performing an emergency brake. While imaging sensors are performing well in good weather conditions, their efficiency suffers under adverse environmental influences such as heavy rain, fog, snow, glare of the sun, sandstorm and occlusion caused by dirt or other objects covering the windscreen such as ice. As a consequence, a vision based ADAS may produce information of poor quality and the environmental model also becomes faulty. Driving a car in reduced visibility conditions can easily lead to severe accidents. Fog has huge impact on the visual range. A system which is able to alert the driver about this risk and automatically controls head- and tail-lights or reduces the speed of the vehicle might save lives. Furthermore, future vehicles may drive autonomously without driver interaction in environments with reduced complexity such as highways without cross-roads. These vehicles will make use of on-board cameras and need to trust their sensor inputs or, in doubt; hand over the vehicle control to the driver. To address this security issue, an increasing number of research groups are focusing on self-diagnosis mechanisms for camera based advanced driver assistance systems. The project helps us to perform different image processing operation on the distorted images to get a clear image. In this project there are two parameters, raindrop and fog on which the image processing algorithm is applied. Two methods that aim to detect unfocused raindrops and fog on a car windshield using only images from an in-vehicle camera are used here. Based on the photometric properties of raindrops and fog, the algorithms rely on image processing techniques to highlight them. The results will be used to improve ADAS behavior under rainy and fog conditions. The methods are based on the photometric properties of the raindrops and fog: brightness and blur.

## Optical Threats

In case of an optical ADAS, the most common threats leading to a degraded camera sight can be separated in following general classes with similar symptoms but different causes:

- 1) View blocked due to lens occlusion or blockage, e.g. caused by partial iced windscreen (partial) sensor faults
- 2) View blurred due to lens soiling or dirt optical faults caused by altering or damage
- 3) View range reduced due to adverse weather conditions such as fog, heavy rain, snowfall etc.

## II. OBJECTIVE AND SCOPE

The main objectives of the project are-

1. To obtain images from the on board camera fitted on car windshield. To make sure that the images collect have blur raindrop region and fog region (unfocused).
2. To find out the most powerful edges (dominant) by using Gaussian filtering.
3. To develop algorithms which are based on image processing techniques depending on the photometric property of the images taken (brightness and blur) of raindrop and fog.
4. To remove the fog from the image containing fog, raindrop and to get a clear image which will help to improve advance driver assistance systems (ADAS) behavior

# International Journal of Innovative Research in Science, Engineering and Technology

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5. To detect and characterize degraded visibility conditions, in particular due to the rain and fog , aims both at generating new driving assistances (switching on wiper and adapting their speed, alerting the driver if his behavior is inappropriate to visibility conditions)
6. To characterizing the operating domain of any driving assistance system relying on an optical sensor. Using extracted information, it is possible to adapt sensor functioning, to improve signal quality and to dynamically adjust system settings.

### III. RELATED WORK

The aim of this section is to give a short overview of related published work on dealing with optical threats resulting in a reduced viewing range of on-board cameras, in particular fog and rain .Precise classification of a blocked or blurred view within a single image is straightforward for a human observer due to ages of training, but highly sophisticated - or even impossible - if restricted to use real-time filters for embedded systems. This is because of the high variability of street scenes. In case of surveillance cameras, there is usually a trusted system start or reference frame, which can be used to track changes over time to detect anomalies of the camera, such as spray painting, blockage, defocusing and redirecting (see Wang et al. [2]). Contrary to that, the start scene captured by an ADAS camera is manifold open road, dark garage, completely iced windscreen etc.

Garg and Nayar [11]–[13] proposed an accurate photometric model for stationary spherical raindrops and the detection of rain streaks based on the drops' motion. However, even if this research is fundamentally interesting, the static observer and the long temporal integration (30 frames) make the approach unsuitable for moving camera scenarios.

Yamashita et al. [14] and Tanak et al. [15] proposed several approaches for detecting and removing raindrops or mud blobs from multiple camera images. By comparing different images of the same background, they identified raindrop areas in one image and replaced them with a region extracted from another image. Then, they proposed a spatio-temporal approach [16] with a fixed camera position. In these approaches, the drops are required to be almost focused, because the impact of a strongly unfocused raindrop would hide too much of the image.

Kurihata et al. [1] used a single onboard camera. Based on a statistical learning method, so-called eigendrops, they identified raindrop characteristics by their circular shape on a large documented database. This approach requires the raindrops to be clearly visible and sharp. Even though results on the sky area are encouraging, it still shows a large number of false detections within complex environments such as urban scenes. This is very restrictive for a vehicle application.

Roser and Mossman [2] and Yan et al. [3] proposed indentifying rainy conditions, relying on a global analysis of the image. Because of statistical learning, they weighted different image characteristics (colour, contrast, and sharpness) to detect the presence or the absence of rain. These approaches do not localize the raindrops within the image.

Gormer et al. [4] proposed a specific onboard camera adaptation. Relying on a set of mirror lenses and near infrared light, the bottom of the field of view is focused on the windshield. In this area, the raindrops are easily detectable, and this allows the quantitative measurement of the rain intensity.

Nashashibi et al. [10] presented the first approach to detect strongly unfocused raindrops on the windshield. Combining raindrop features in the images with a temporal approach, they detected the appearance of raindrops in real time. As they admitted in [10], their algorithm may suffer from a lack of flexibility and thus needs improvements to be fully reliable.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

Tanaka et al. [1] use a couple of cameras capturing the same scene with two slightly different point of view, as in a stereovision system. This approach allows to detect image perturbations coming from drops and to reconstruct the image by removing this perturbation. It is mainly dedicated to outdoor surveillance cameras. Its main drawbacks are the heavy computation time and the need to install two synchronized onboard cameras.

Based on Koschieder's law

In [4] Hautie`re presents an approach for fog detection and the estimation of the visibility range based on Koschieder's law in images captured by an on-board camera. Their first step is the detection of the vanishing point (ref. Tai and Kittler [12]) and the horizon line in the image. Afterwards, the target region is defined with a region growing algorithm based on similar luminance while possible borders of the region are detected with an edge detection algorithm. For each line, a measurement bandwidth is declined and the median luminance is calculated.

Another approach using the Koschieder's law is presented by Bronte in [13]: First, a separation between sunny images and those with high or moderate fog is done by using a Sobel edge detector, as in sunny images edges are more abrupt than in foggy images. A subsequent Hough transform is employed to estimate the edge lines of the road and to calculate the Cartesian coordinates of the vanishing point. After finding the vanishing point, a segmentation process to define the sky and the road height is performed. To realize this, two region growing algorithms are started. The first one is used to find the sky height. The second algorithm starts from the bottom of the image in the supposed road area.

Based on Global image features

An approach for fog detection using global image features instead of separating road and sky areas was published by Pavli`c et al. [7]. This algorithm is based on the decrease in contrast and blurring in the whole image in foggy scenes, leading to a low pass filter effect. To detect this effect, a power spectrum analysis of the normalized input image is computed. Afterwards a Gabor sampling is used to divide the different bandwidths of an image and to gain features for the subsequent classification process. The images will be divided into four classes of different visibility range with a radial basis function kernel via a support vector machine (SVM).

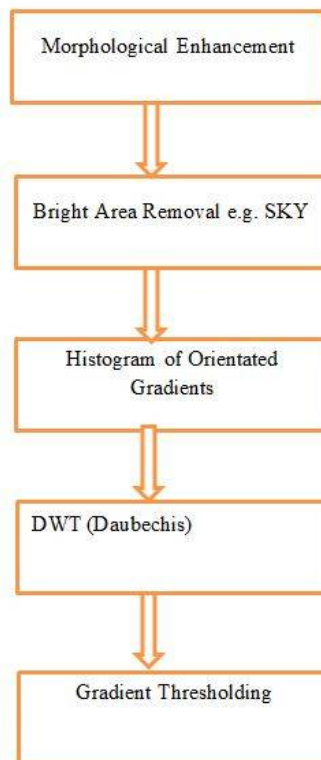
# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

## IV. PROPOSED SYSTEM DESIGN

### 1. UNFOCUSED RAINDROP DETECTION



**Fig.1 Flow of Unfocused Raindrop Detection**

To design a code for detecting raindrop region in the image. And develop an image processing software system that will work on the unfocused raindrop images by implementing code for different image processing tools which are Morphological enhancement, Bright area removal e.g. SKY, Histogram of Orientated Gradients, DWT (Daubechis) and Gradient Thresholding. These algorithms will help to detect the rain drops finally testing the system for different types of images like light, moderate, heavy rain. Analyzing the results and making a conclusion.

#### Explanation

##### a. Morphological Enhancement

Morphology is a technique of image processing based on shape and form of objects. Morphological methods apply a structuring element to an input image, creating an output image at the same size. The value of each pixel in the input image is based on a comparison of the corresponding pixel in the input image with its neighbours. By choosing the size and shape of the Neighbour, you can construct a morphological operation that is sensitive to specific shapes in the Input image. The morphological operations can first be defined on greyscale images where the Source image is planar (single-channel). The definition can then be expanded to full-colour Images.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

### b. Bright Area Removal e.g. SKY

To detect the unfocused raindrop Noise is always presents in digital images during image acquisition, coding, transmission, and processing steps. Noise is very difficult to remove it from the digital images without the prior knowledge of noise model. That is why, review of noise models are essential in the study of image de-noising techniques. In this paper, we express a brief overview of various noise models. These noise models can be selected by analysis of their origin. In this way, we present a complete and quantitative analysis of noise models available in digital images.

### c. Histogram of Orientated Gradients

To detect the unfocused raindrop the essential thought behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions. The image is divided into small connected regions called cells, and for the pixels within each cell, a histogram of gradient directions is compiled. The descriptor is the concatenation of these histograms. For improved accuracy, the local histograms can be contrast-normalized by calculating a measure of the intensity across a larger region of the image, called a block, and then using this value to normalize all cells within the block. This normalization results in better invariance to changes in illumination and shadowing. The HOG descriptor has a few key advantages over other descriptors. Since it operates on local cells, it is invariant to geometric and photometric transformations, except for object orientation. Such changes would only appear in larger spatial regions. Moreover, as Dalal and Triggs discovered, coarse spatial sampling, fine orientation sampling, and strong local photometric normalization permits the individual body movement of pedestrians to be ignored so long as they maintain a roughly upright position. The HOG descriptor is thus particularly suited for human detection in images

### d. DWT (Daubechis)

The discrete wavelet transform (DWT) is an implementation of the wavelet transform using a discrete set of the wavelet scales and translations obeying some defined rules. In other words, this transform decomposes the signal into mutually orthogonal set of wavelets, which is the main difference from the continuous wavelet transform (CWT), or its implementation for the discrete time series sometimes called discrete-time continuous wavelet transform (DT-CWT). The wavelet can be constructed from a scaling function which describes its scaling properties. The restriction that the scaling functions must be orthogonal to its discrete translations implies some mathematical conditions on them which are mentioned everywhere e. g. the dilation equation

$$\phi(x) = \sum_{k=-\infty}^{\infty} a_k \phi(Sx - k). \tag{1}$$

where S is a scaling factor (usually chosen as 2). Moreover, the area between the function must be normalized and scaling function must be orthogonal to its integer translates e. g.

$$\int_{-\infty}^{\infty} \phi(x) \phi(x + l) dx = \delta_{0,l} \tag{2}$$

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

## e. Gradient Thresholding

To detect the unfocused raindrop Adaptive thresholding typically takes a grayscale or color image as input and, in the simplest implementation, outputs a binary image representing the segmentation. For each pixel in the image, a threshold has to be calculated. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value. There are two main approaches to finding the threshold: (i) the Chow and Kaneko approach and (ii) local thresholding. Chow and Kaneko divide an image into an array of overlapping subimages and then find the optimum threshold for each subimage by investigating its histogram. The threshold for each single pixel is found by interpolating the results of the subimages. The drawback of this method is that it is computational expensive and, therefore, is not appropriate for real-time applications. An alternative approach to finding the local threshold is to statistically examine the intensity values of the local neighborhood of each pixel. The statistic which is most appropriate depends largely on the input image. Simple and fast functions include the mean of the local intensity distribution

## 2. FOG DETECTION

To design a code for detecting and fog region in the image and develop an image processing software system that will work on the foggy images by implementing code for different image processing tools like sobel edge detector, Gaussian filter, Harris corner detector, defogging algorithm. These algorithms will help to detect the fog. Testing the system for for different types of images like light, moderate, heavy fog. Analyzing the results and making a conclusion.

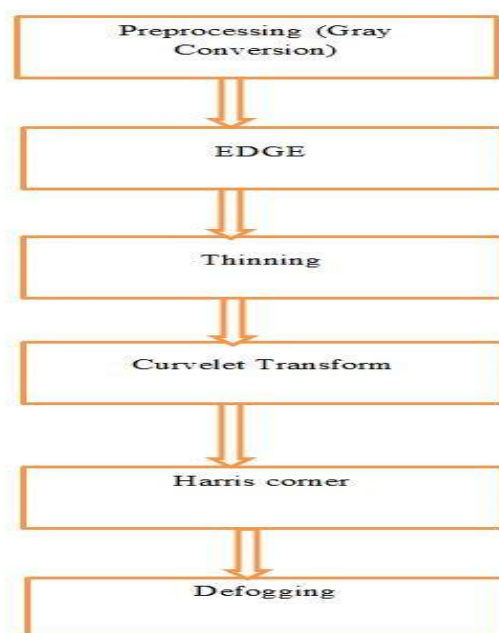


Fig.2 Flow of Fog Detection

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

## a. Preprocessing (Gray Conversion)

To detect Fog and rainfall we use gray conversion method In image processing is processing of images using mathematical operations by using any form of signal processing for which the input is an image, a series of images, or a video, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image.<sup>[1]</sup> Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it. Images are also processed as three-dimensional signals where the third-dimension being time or the z-axis. Between. Converting to gray scale is not necessary for image processing, but is usually done for a few reasons: Simplicity, compressing the size of data without losing data, needs less space etc

## b. Sobel edge detection

To detect Fog Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction.<sup>[1]</sup> Sobel edge detection is an image processing technique to discover the boundaries between regions in an image. It's an important part of detecting features and objects in an image. Simply put, edge detection algorithms help us to determine and separate objects from background, in an image. An image gradient is a change in intensity (or color) of an image (I'm over simplifying but bear with me). An edge in an image occurs when the gradient is greatest and the Sobel operator makes use of this fact to find the edges in an image. The Sobel operator calculates the approximate image gradient of each pixel by convolving the image with a pair of 3x3 filters. These filters estimate the gradients in the horizontal (x) and vertical (y) directions and the magnitude of the gradient is simply the sum of these 2 gradients.

## c. Thinning

Thinning is a morphological operation that is used to remove selected foreground pixels from binary images, somewhat like erosion or opening. It can be used for several applications, but is particularly useful for skeletonization. In this mode it is commonly used to tidy up the output of edge detectors by reducing all lines to single pixel thickness. Thinning is normally only applied to binary images, and produces another binary image as output. The thinning operation is related to the hit-and-miss transform, and so it is helpful to have an understanding of that operator before reading on. Like other morphological operators, the behavior of the thinning operation is determined by a structuring element. The binary structuring elements used for thinning are of the extended type described under the hit-and-miss transform (i.e. they can contain both ones and zeros). The thinning operation is related to the hit-and-miss transform and can be expressed quite simply in terms of it. The thinning of an image  $I$  by a structuring element  $J$  is:

$$\text{thin}(I, J) = I - \text{hit-and-miss}(I, J) \dots\dots\dots(3)$$

## d. Curvelet Transform

Curvelets are a non-adaptive technique for multi-scale object representation. Being an extension of the wavelet concept, they are becoming popular in similar fields, namely in image processing and scientific computing.



## International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016

### e. Harris Corner

Corner detection is an approach used within computer vision systems to extract certain kinds of features and infer the contents of an image. Corner detection is frequently used in motion detection, image registration, video tracking, image mosaicing, panorama stitching, 3D modeling and object recognition. Corner detection overlaps with the topic of interest point detection.

- Let's look for corners. Since corners represent a variation in the gradient in the image, we will look for this "variation".
- Consider a grayscale image  $I$ . We are going to sweep a window  $w(x, y)$  (with displacements  $u$  in the  $x$  direction and  $v$  in the right direction)  $I$  and will calculate the variation of intensity.

$$E(u, v) = \sum_{x,y} w(x, y) [I(x + u, y + v) - I(x, y)]^2 \quad \dots\dots\dots (4)$$

Where:

- $w(x, y)$  is the window at position  $(x, y)$
- $I(x, y)$  is the intensity at  $(x, y)$
- $I(x + u, y + v)$  is the intensity at the moved window  $(x + u, y + v)$
- Since we are looking for windows with corners, we are looking for windows with a large variation in intensity. Hence, we have to maximize the equation above, specifically the term:

$$\sum_{x,y} [I(x + u, y + v) - I(x, y)]^2 \quad \dots\dots\dots (5)$$

### f. Defogging

Fog reduces contrast and thus the visibility of vehicles and obstacles for drivers. Each year, this causes traffic accidents. Fog is caused by a high concentration of very fine water droplets in the air. When light hits these droplets, it is scattered and this results in a dense white background, called the atmospheric veil. As pointed in [1], Advanced Driver Assistance Systems (ADAS) based on the display of defogged images from a camera may help the driver by improving objects visibility in the image and thus may lead to a decrease of fatality and injury rates. In the last few years, the problem of single image defogging has attracted attention in the image processing community. Being an ill-posed problem, several methods have been proposed however, a few among of these methods are dedicated to the processing of road images.

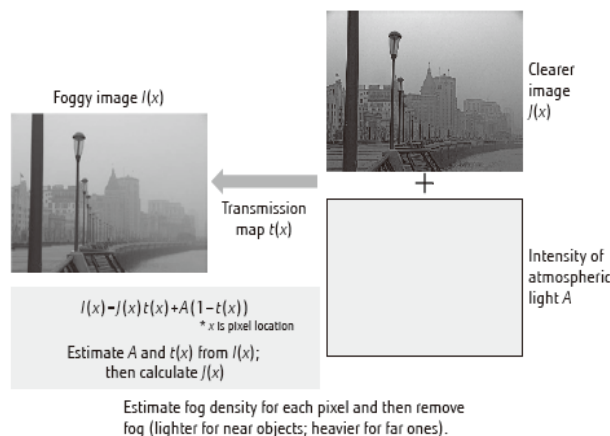


Fig. 3 Defogging model

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 6, June 2016



Fig.4 Data set: collection of foggy image and raindrop images

## V. CONCLUSION & FUTURE WORK

Thus Sobel edge detection finds out the edges. Gaussian filter applied to the sobel edge detected image gives us the point detection and dominant points. This technique is efficient to find powerful edges. Further the Harris corner of the objects like branches, road sky etc is found. Segmentation method using gradient thresholding for detecting raindrop is fast and simplified method .By using image of high resolution an image with high accuracy can be obtained. The Moreover, the proposed method runs in real-time on a standard PC.

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