Effective Fog Density Calculation Using Colour Filtering

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ABSTRACT

Anything that causes impairment in the visibility of the vehicle driver can lead to a major fatality. The approaches introduced until now to solve the above problem use image processing which at its core applies filters, specially designed to detect fog. Further, other approaches use vehicle template to detect fog. The method introduced in this paper at its core uses colour filtering to single out colour of the source of hindrance in the visibility of the driver. The effective fog density is then calculated by determining the area of coverage of the source of hindrance. The response of the Algorithm in various test cases gave us extremely satisfactory results. The main objective of the research is to provide assistance to the driver so as to reduce the probability of fatality.

INTRODUCTION

Driver assistance and navigation with the aid of computers and sensors are being actively developed. In particular, in-vehicle camera images are commonly utilized since they contain important visual information. Driving becomes a tedious task in extremely adverse weather conditions than in fair conditions and due to the mentioned reason accident rates dramatically increase.

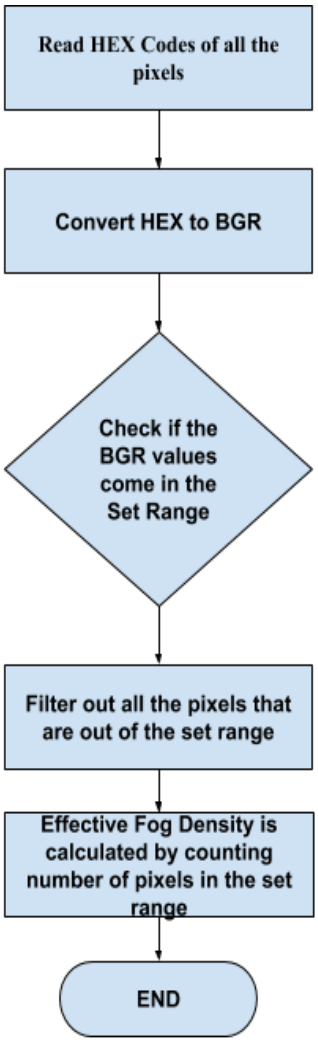
According to the *National Crime Records Bureau (NCRB)*[1], in 2014, 9039 road crashes took place as a result of unfavourable weather conditions, especially fog, killing 5300 people. The numbers kept rising every year making India first in road deaths in the world, in year 2016. A major percentage of fatalities are caused by Fog, Smog, Smoke or anything that basically hinders the visibility of the driver. Due to this reason, a need for vehicle assistance system is required that assists and suggests the driver based on the calculation done by the system.

The purpose of this paper is to develop a system that calculates the effective density of fog and upon further research can be used efficiently to suggest a corresponding speed so as to minimise the chance of fatality.

In this paper Open CV has been used, which is a library of programming functions mainly aimed at real time computer vision originally developed by Intel. Open CV has been used for Image Segmentation.

METHODOLOGY

The methodology used here is quite simple and efficient compared to existing ones. The basic objective here is to determine the density of fog and assist the vehicle driver regarding the corresponding speed. The image processing is done using Open CV which is an Open Source Computer Vision Library, generally coded in Python, C++ and C. The image processing algorithm reads the Hexadecimal Colour Code of all the pixels present in the image captured by the camera. The algorithm then converts the Hexadecimal Colour Code to BGR (Blue, Green and Red contrary to RGB). There is BGR range set in the algorithm that corresponds to various shades of grey that can be captured by the camera during the daytime. The algorithm next uses colour filtering to filter out the colour that come in the set BGR range and delete or black out colours that are out of the BGR Range. The algorithm then counts the total coverage area of the unfiltered colours (Pixel Counting) and outputs a result in percentage that indicates the Effective Fog Density. An important point to note here is about filtering. The filtering process is done using masking which as a process can be explained as laying a mask layer on the unimportant area and producing only the important or required area.



Block Diagram of the Algorithmic Flow

ANALYSIS

On doing a comprehensive review and analysis of tests case samples, it can be observed that all the colours outside of the set colour range are filtered out and the necessary colours are produced in the result frame. It can also be observed that the algorithm is consistent regarding the result produced in result frame in all the different test case scenarios.

Test Case-1: The Top View Image

In this image the BGR range was set to be [105,105,105] to [255,255,255]. Hence, the algorithm filters all the unnecessary colours and as a result of that it provides us with all the pixels that have a colour in the mentioned range. This image was taken when this algorithm was in its infancy. A study of the processed image shows us that still some colours need to be filtered out such as the colour of the path way.

Original Image

Processed Image

Test Case-2: The Floor View Image

In this image the BGR range was set to be [130,130,130] to [255,255,255]. As a result of the updated colour range, it can be clearly observed that the colour of pathway is also blocked and in the processed image and one is left with the required colours.

Original Image

Processed Image

Test Case-3: The Road View Image

In this image the BGR range was set as [170,170,170] to [255,255,255]. The processed image has almost perfectly filtered the unnecessary colours in the range. It can be observed here that the tree, car and the building has been blacked out. Also it can be seen that the road has also been blacked out, since the colour of the road is out of the specified range. The colours which can be seen in the processed image are the ones which are allowed by the programmer.

Original Image

Processed Image

Test Case-4: The Incense Stick Image

The processed image of smoke generated by incense stick can be seen here. The algorithm has completely filtered out the areas that are out of the set colour range ([145,145,145] to [245,245,245]). It can be clearly observed that the area covered by smoke (source of hindrance) is produced in processed image and everything else is blacked out.

Original Image

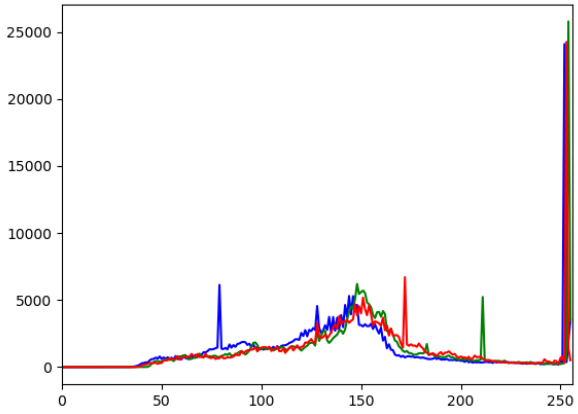
Processed Image

BGR Segmentation

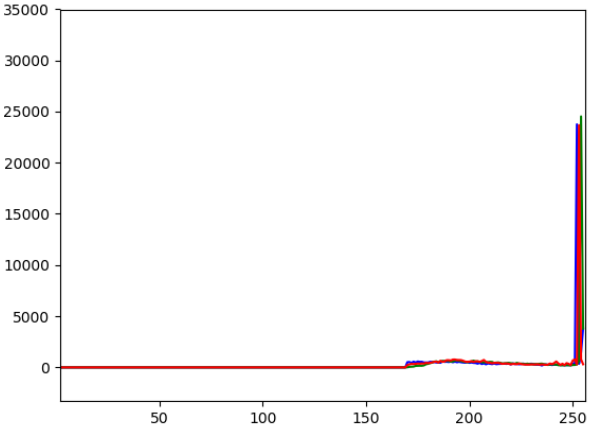
Using BGR Segmentation we have segmented the image in terms of B (Blue), G (Green), R (Red). This can be used to observe patterns. It is observed that by applying colour filtering, we have reduced the data in our dataset by a significant margin, due to this the analysis of data becomes faster and the driver can be assisted more efficiently regarding the speed of vehicle.

In each and every test case we have applied BGR Segmentation on original image and the processed image. Using this segmentation we can observe patterns and develop a system that predicts the behaviour of weather according to the processing of image. [For this we are in the process of creating a database]

Test Case-1: The Top View Image

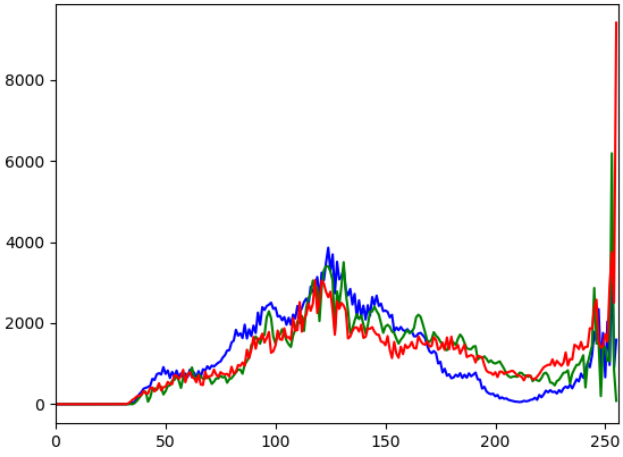


Original Image



Processed Image

Test Case-2: The Floor View Image



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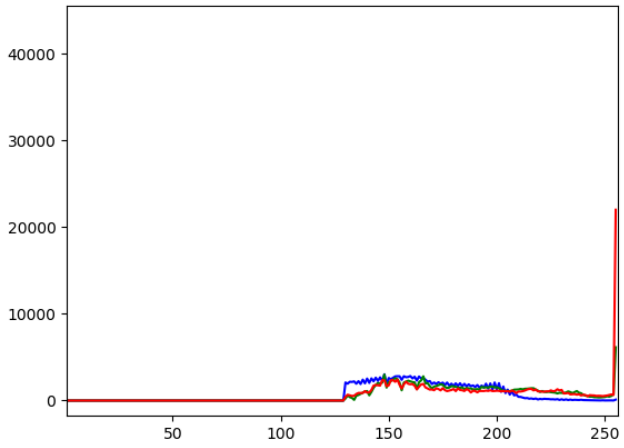
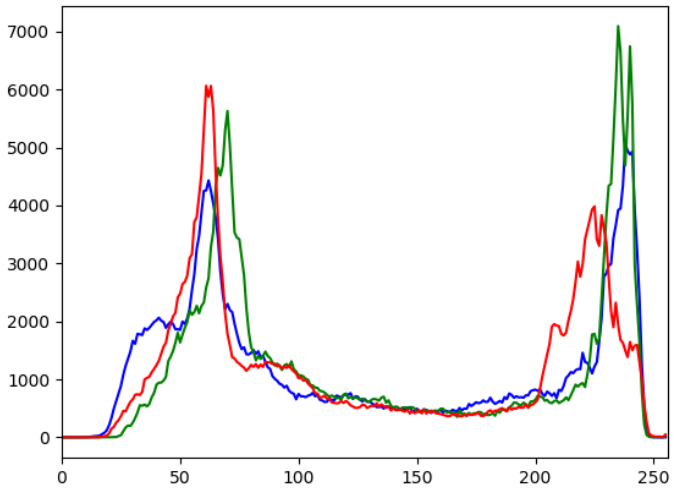


Processed Image

Test Case-3: The Road View Image



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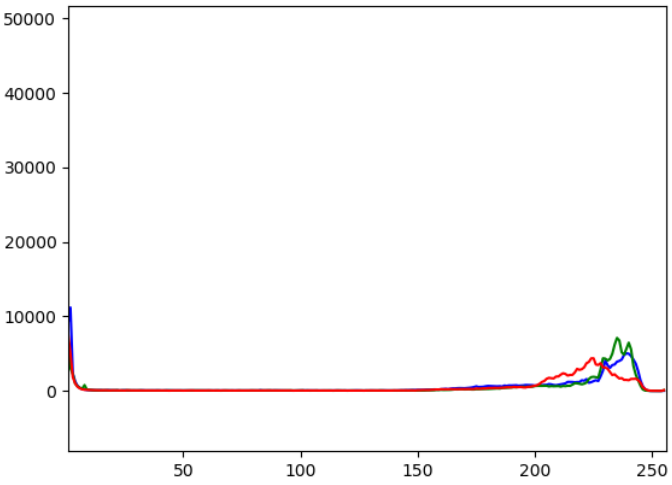
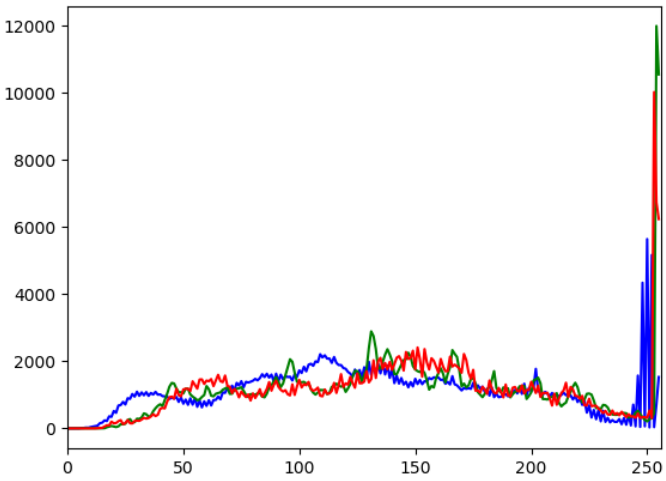
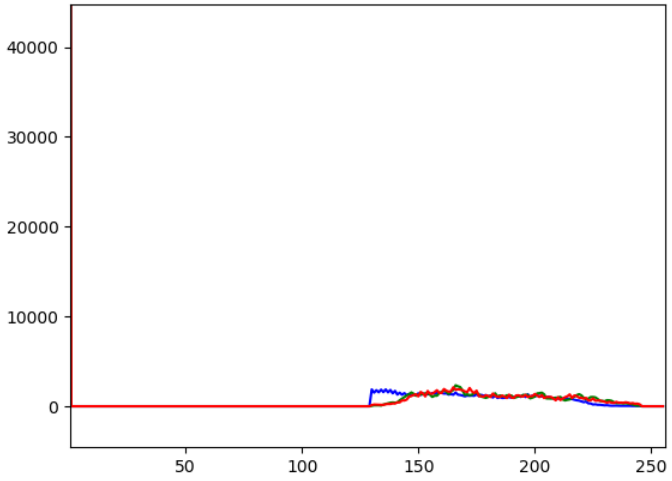


Processed Image

Test Case-4: The Incense Stick Image



Original Image



Processed Image

DISCUSSION

1) Previous Works

The works done by *Mario Palvic, Heidrun Belzner, Gerhard Rigoll and Slobodan Ilic*[2] predicts the presence of dense fog with 94% accuracy but that does not assist the driver in any way regarding preventing a grievous accident. However, the works done by *Laurent Caraffa and Jean-Phillipe Tarel*[3] of Paris-Est University,

France calculate the density estimation using image processing which uses *Koschmieder's Law*, but the reliability of *Koschmieder Law* is itself a topic of Research[4].

2) *Implementation*

The mere detection of fog in no way prevents fatality. The vehicle driver must be assisted accordingly on how to drive in extreme weather conditions. The calculation of effective fog density can be correlated to the corresponding speed according to the calculated density. The system thus suggests the driver an optimum speed according to the weather conditions.

3) *Improvements*

Although, the reaction of algorithm to various test cases is extremely satisfactory but the system can further be improved by using a number of other techniques that have the potential to further improve the quality of processed image.

a) *Adaptive Range*: An improvement in the existing algorithm can be done by making the colour range a variable. Right now, the colour range needs to be set by the programmer according to the visibility conditions. Ideally, the algorithm should be able to perform the following steps:

- Detect the cause of hindrance in visibility.
- Involuntarily set a colour range most appropriate to the visibility conditions.
- Colour Filtering and Calculation.

The detection of the cause of hindrance can be done by using template comparison [5].

b) *Colour Model*: A major reason behind choosing the BGR (Blue, Green, Red) colour model is its simplicity, but with its simplicity the access to a variety of crucial factors is lost, that may produce a better result while applying the same algorithm. There are colour models such as HSL (Hue, Saturation, Lightness) and HSV (Hue, Saturation, Value) which are developed with the motive to analyse an image the way human vision perceives colour-making attributes. It can clearly be seen that, while using BGR one has no access to the intensity of light (or colour) but in models such as HSL or HSV; this factor can be used for its advantage. However, it should be noted that the concept of colour range setting can be efficiently used in colour models other than BGR.

c) *Thresholding*: Thresholding is the simplest method of image segmentation. Usually, thresholding is applied on a grayscale image to convert it into a binary image (consisting of either black or white i.e., (0,0,0) or (255,255,255) in terms of BGR). Thresholding is basically a replacement of colour filtering but uses the same algorithm, but since to obtain a fine image frame that clearly displays Fog Boundary, thresholding must be used multiple times.

4) *Test Cases*

The test cases were chosen to simulate real world setting as closely

as possible. The test cases included the smoke generated by an incense stick/smoke stick as the colour of smoke generated by the mentioned is the closest to fog. Other than that, different colour palettes can be included as the test case to check the reaction of Algorithm on different colours. Ultimately, the algorithm is checked on a normal setting i.e. real world scenario (imagery) without fog.

RESULT

The result from the above discussion can be drawn that the designed system can be successfully used for the effective fog density calculation present in the environment. The system will black out the unnecessary regions and will show only the relevant ones. This approach can be used to detect the obstacles/vehicles even in the foggy region. The system is merely at its preliminary stage and further improvements can be made to it in order to inculcate this system in a Visibility Assistance System (VAS). VAS would assist the driver of the vehicle in detecting any kind of obstacle, which cannot be clearly be observed by the driver.

CONCLUSION

In this paper, the colour filtering algorithm can be demonstrated for various test cases trying to simulate real world scenarios using Open CV. To sum it up, the reaction of algorithm has been extremely satisfactory. The test cases consisted of different colour palettes, smoke generated by various sources (to simulate smog/fog). If this algorithm is included as a part of Visibility Assistance System, it could serve a crucial part in preventing fatalities. Although, still there is a need to test the accuracy and reliability of the algorithm in real world scenarios but the performance of the algorithm in simulations is highly reliable and efficient. Furthermore, an insight is still needed regarding the performance and reliability of sensors and camera in extreme weather conditions.

REFERENCES

[1] National Crime Records Bureau – Report 2014, 2016

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[4] Zhongping Lee, Shaolin Shang "Visibility: How Applicable is the Century-Old Koschmieder Model?"

[5] Tomokazu Takahashi, Kenji Mori, Hiroyuki Kurihata, Ichiro Ide, Hiroshi Murase, Takayuki Miyahara, Yukimasa Tamatsu "Rain and Fog Recognition System Using Multiple In-Vehicle Sensor"