

Reduction of vehicle speed based on Fog or Rain density in different weather conditions

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree
in
Computer Science and Engineering

By
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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Subasree.N** (Reg.No.37110738) who carried out the project entitled **Reduction of vehicle speed based on Fog/Rain density in different weather conditions** under my supervision from Dec 2020 to March 2021.

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DECLARATION

I, **Subasree.N (Reg.No:37110738)** hereby declare that the Project Report entitled **Reduction of vehicle speed based on Fog or Rain density in different weather conditions** done by me under the guidance of Dr.**Ulagamudhalvi M.E., Ph.D.**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Computer Science and Engineering.

DATE:

PLACE:

SIGNATURE OF THE CANDIDATE

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ABSTRACT

Images taken in poor weather conditions have a high amount of fog/rain in it. It degrades the visibility and clarity of the image. In this project, we propose the technique to estimate the fog density for control the vehicle speed. Usually, the estimation of the amount of fog/rain in the scene image allows to greatly improve the image processing, and thus to better perform the observation task. The fog estimation technique used here is Dark Channel and Guided Filter. Multiscale image decomposition is proposed for extract the rain streak density. After that, based on fog/rain density vehicle speed was controlling. As per the amount of fog/rain, our proposed method can alert the drivers for prevent the accident by controlling vehicle speed. Also, fog removal and rain removal is implemented based on heavy fog and rain. An overall accuracy of almost high is achieved regarding fog/rain estimation and removal of fog and rain using our proposed method.

CHAPTER 1 INTRODUCTION

INTRODUCTION

Nowadays public areas are monitored by several cameras in order to increase public order and safety. For most applications, trained and experienced human operators can do this monitoring very well. However, watching multiple camera images at the same time is not only too expensive but also practically impossible. Moreover, surveillance video data is currently used only “after the fact” as a forensic tool, thus losing its primary benefit as an active, real-time medium. The goal of visual surveillance is not only to put cameras in the place of human eyes, but also to accomplish the entire surveillance task as automatically as possible. Thus intelligent visual surveillance(IVS) becomes an active research topic in computer vision.

Detection of foreground objects of interest from a surveillance video sequence is a key step for an intelligent visual surveillance system. In the literature there are various algorithms proposed for object detection. All of these approaches assume that the input images have clear visibility, thus they can achieve satisfying results under clear weather conditions. Unfortunately, this is not always true, such as when videos are taken under bad weather conditions, such as on a foggy day. The image suffers degradation and severe contrast loss. These low quality images are

nuisance for conventional object detection algorithms.

Similarly, Murk is a thick cloud of tiny water droplets suspended in the atmosphere which obscures visibility. Diverse weather situations such as murk, smoke, rain or snow will cause multifaceted visual effects of spatial or temporal domains in images or video. Such artifacts may appreciably humiliate the performances of outdoor vision systems relying on image/video feature extraction or visual attention modelling such as event detection, object detection, tracking and recognition, scene analysis and classification, image indexing and retrieval. They generally fail to correctly detect objects due to low scene visibility. In order to get clear surveillance frames, enhancing visibility is an inevitable task. In recent years, as an active research topic in computer vision, considerable work has been done on haze removal techniques.

What Is Image Processing?

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image. Usually Image Processing system includes treating images as two dimensional signals while applying already set signal processing methods to them.

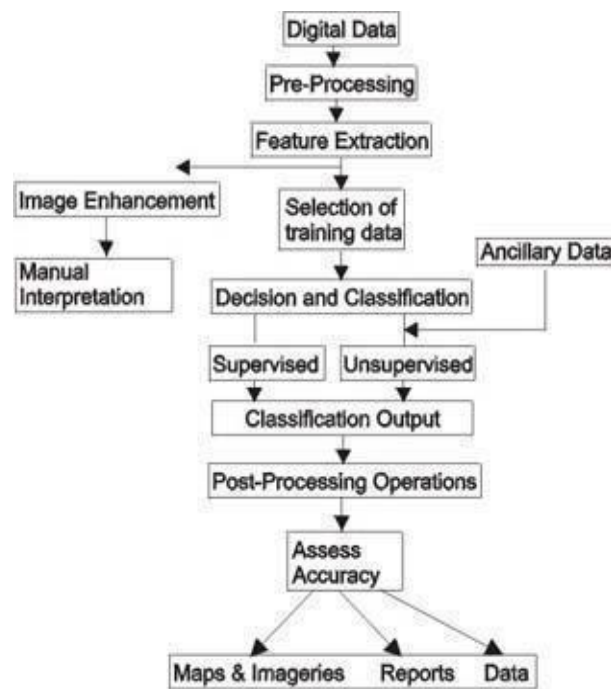
It is among rapidly growing technologies today, with its applications in various aspects of a business. Image Processing forms core research area within engineering and computer science disciplines too.

Types of Image Processing:

The two types of methods used for Image Processing are Analog and Digital Image Processing. Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques. So analysts apply a combination of personal knowledge and collateral data to image processing.

Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Pre- processing, enhancement and display, information extraction.

Working diagram of Image Processing:



Characteristics of Image Processing:

Before going to processing an image, it is converted into a digital form. Digitization includes sampling of image and quantization of sampled values. After converting the image into bit information, processing is performed. This processing technique may be, Image enhancement, Image restoration, and Image compression.

Image enhancement:

It refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis. This process does not increase the inherent information content in data. It includes gray level & contrast manipulation, noise reduction, edge crispening and

sharpening, filtering, interpolation and magnification, pseudo

coloring, and so on.

Image restoration:

It is concerned with filtering the observed image to minimize the effect of degradations. Effectiveness of image restoration depends on the extent and accuracy of the knowledge of degradation process as well as on filter design. Image restoration differs from image enhancement in that the latter is concerned with more extraction or accentuation of image features.

Image compression:

It is concerned with minimizing the number of bits required to represent an image. Application of compression are in broadcast TV, remote sensing via satellite, military communication via aircraft, radar, teleconferencing, facsimile transmission, for educational & business documents, medical images that arise in computer tomography, magnetic resonance imaging and digital radiology, motion, pictures, satellite images, weather maps, geological surveys and so on.

- Text compression – CCITT GROUP3 & GROUP4
- Still image compression – JPEG
- Video image compression - MPEG

Advantages of Image Processing:

- The processing of images is faster and more cost-effective. One needs less time for processing, as well as less film and other photographing equipment.
- It is more ecological to process images. No processing or fixing chemicals are needed to take and process digital images. However, printing inks are essential when printing digital images.
- When shooting a digital image, one can immediately see if the image is good or not.
- Copying a digital image is easy, and the quality of the image stays good unless it is compressed. For instance, saving an image as jpg format compresses the image. By resaving the image as jpg format, the compressed image will be recompressed, and the quality of the image will get worse with every saving.
- Fixing and retouching of images has become easier. In new Photoshop 7, it is possible to smoothen face wrinkles with a new Healing Brush Tool in a couple of seconds.
- The expensive reproduction (compared with rastering the image with a repro camera) is faster and cheaper.
- By changing the image format and resolution, the image can be used in a number of media.

CHAPTER-2

LITERATURE SURVEY

- Gagandeep Singh¹ and et.al has proposed Evaluation Of Various Digital Image Fog Removal Algorithms. This paper is a review on the various fog removal algorithms. Fog removal otherwise called visibility restoration refers to diverse systems that suppose to lessen or evacuate the degradation that have happened while the digital picture was being acquired. In this paper, various fog removal techniques have been analysed. It has been shown that each fog removal technique has its own features and drawbacks.
- Wu Sijiu, Zhang Haiyan has proposed a Research for Image Haze-Removal
- Algorithm Using the Dark-Channel Prior Based on Wavelet Transform In this paper, having compared the image haze-removal algorithms for image restoration and image enhancement, the principle of image haze- removal algorithm using dark channel prior is analyzed and discussed. The shortcomings of the algorithm are pointed out.
- J.P. Oakley ; B.L. Satherley has proposed Improving Image Quality in Poor Visibility Conditions Using a Physical Model for Contrast Degradation. In daylight viewing conditions, image contrast is often significantly degraded by atmospheric aerosols such as haze and fog.
- This paper describes the image processing algorithm and presents an analysis of the signal-to-noise ratio (SNR) in the resulting enhanced image. This analysis shows that the SNR decreases exponentially with range. A temporal filter structure is proposed to solve this problem. Results are

presented for two image sequences taken from an airborne camera in hazy conditions and one sequence in clear conditions.

- Li-Wei Kang, Chia-Wen Lin and et.al has proposed Automatic Single-Image-Based Rain Streaks Removal via Image Decomposition. Rain removal from a video is a challenging problem and has been recently investigated extensively.
- Siyuan LI, Wenqi Ren, et.al has proposed the concept of Fast Single Image RainRemoval via a Deep Decomposition-Composition Network. Rain effect in images typically is annoying for many multimedia and computer vision tasks. For removing rain effect from a single image, deep learning techniques have been attracting considerable attentions.
- Experimental results on both synthetic and real images are conducted to reveal the high-quality recovery by our design, and show its superiority over other state-of-the-art methods.
- Narasimhan and S. Nayar, has proposed a theory of Contrast restoration of weather degraded images. Images of outdoor scenes captured in bad weather suffer from poor contrast. Under bad weather conditions, the light reaching a camera is severely scattered by the atmosphere. The resulting decay in contrast varies across the scene and is exponential in the depths of scene points.
- R. Tan has constructed a theory of Visibility in bad weather from a single image. Bad weather, such as fog and haze, can significantly degrade the visibility of a scene. Based on this model, a few methods have been proposed, and most of them require multiple input images of a scene,

which have either different degrees of polarization or different atmospheric conditions.

- This method is based on two basic observations: first, images with enhanced visibility (or clear-day images) have more contrast than images plagued by bad weather; second, airlight whose variation mainly depends on the distance of objects to the viewer, tends to be smooth.
- R. Fattal discussed about the Single image dehazing. In this paper we present a new method for estimating the optical transmission in hazy scenes given a single input image. Based on this estimation, the scattered light is eliminated to increase scene visibility and recover haze-free scene contrasts.
- A similar principle is used to estimate the color of the haze. Results demonstrate the new method abilities to remove the haze layer as well as provide a reliable trans-mission estimate which can be used for additional applications such as image refocusing and novel view synthesis.
- First surveillance video under foggy weather is defogged, leveraging a physics- based image restoration approach. Secondly, we exploit a novel background maintenance algorithm based on the Unscented Kalman Filter(UKF) to subtract the background from the defogged video. Finally, moving objects are segmented by background differencing. Evaluations are performed to verify the effectiveness and practicality of this approach. Experimental results show that our method can be applied in real time surveillance systems.

3.1. SYSTEM REQUIREMENTS:

The requirements specification is a technical specification of requirements for the software products. It is the first step in the requirements analysis process. It lists the requirements of particular software system including functional, non-functional and performance requirements. The requirements also provide usage scenarios from a user, an operational and administrative perspective. The purpose of software requirements specification is to provide a detailed overview of the software project, with its parameters and goals. This describes the project audience and its user interface, hardware and software requirements. It defines how the client, team and audience see the project and its functionality.

HARDWARE REQUIREMENTS

The hardware requirements may serve as the basic element in implementing the system proposed and should be therefore be a complete and consistent specification of the whole system. The below posted requirements are subjected as “Minimum” to availability.

SYSTEM REQUIREMENTS:

HARDWARE REQUIREMENTS:

1. MICRO CONTROLLER
2. LCD
3. RELAY
4. POWER SUPPLY
5. DC MOTOR
6. SPEED CONTROL
7. ZIBEE

SOFTWARE REQUIREMENTS:

1. MATLAB
2. Embedded C

3.3 SOFTWARE REQUIREMENTS

OVERVIEW OF MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Typical uses include

- I. Math and computation
- II. Algorithm development
- III. Data acquisition
- IV. Modeling, simulation, and prototyping
- V. Data analysis, exploration, and visualization
- VI. Scientific and engineering graphics
- VII. Application development, including graphical user interface building

3.3.2 KEY FEATURES

- Image enhancement, filtering, and deblurring. Image analysis, including segmentation, morphology, feature extraction, and measurement
- Spatial transformations and image registration
- Image transforms, including FFT, DCT, Radon, and fan-beam projection
- Workflows for processing, displaying, and navigating arbitrarily large images
- Modular interactive tools, including ROI selections, histograms, and distance measurements
- ICC color management
- Multidimensional image processing
- Image-sequence and video display
- DICOM import and export

CHAPTER 4 SYSTEM DESIGN

EXISTING SYSTEM:

- In existing, they proposed murk/haze removal by using CLAHE and object detection using Curvelet Transform.
- Initially the RGB image is converted to gray scale image.
- The gray scale image is then filtered using median filter.
- The filtered image is enhanced using CLAHE.
- Finally the enhanced image is segmented by Curvelet Transform.

DISADVANTAGES OF EXISTING SYSTEM:

- In existing less amount of haze/murk removal in image is proposed.
- The rate of detection accuracy was less.
- And fog density estimation is not implemented in existing for alert the driver to control the speed of vehicle.

PROPOSED SYSTEM:

The proposed model follows dark channel and guided filter for

estimation of fog level and multiscale image decomposition for estimation of rain level. It consists of five steps.

Step 1: Collecting the test images from public database.

Step 2: Dark channel is used to extract the fog region in foggy image. After that, guided filter is implementing to further enhance the estimation of fog region.

Step3: Similarly multiscale decomposition model i.e. Anisotropic Diffusion Filter is used for estimate the rain streak in rainy image.

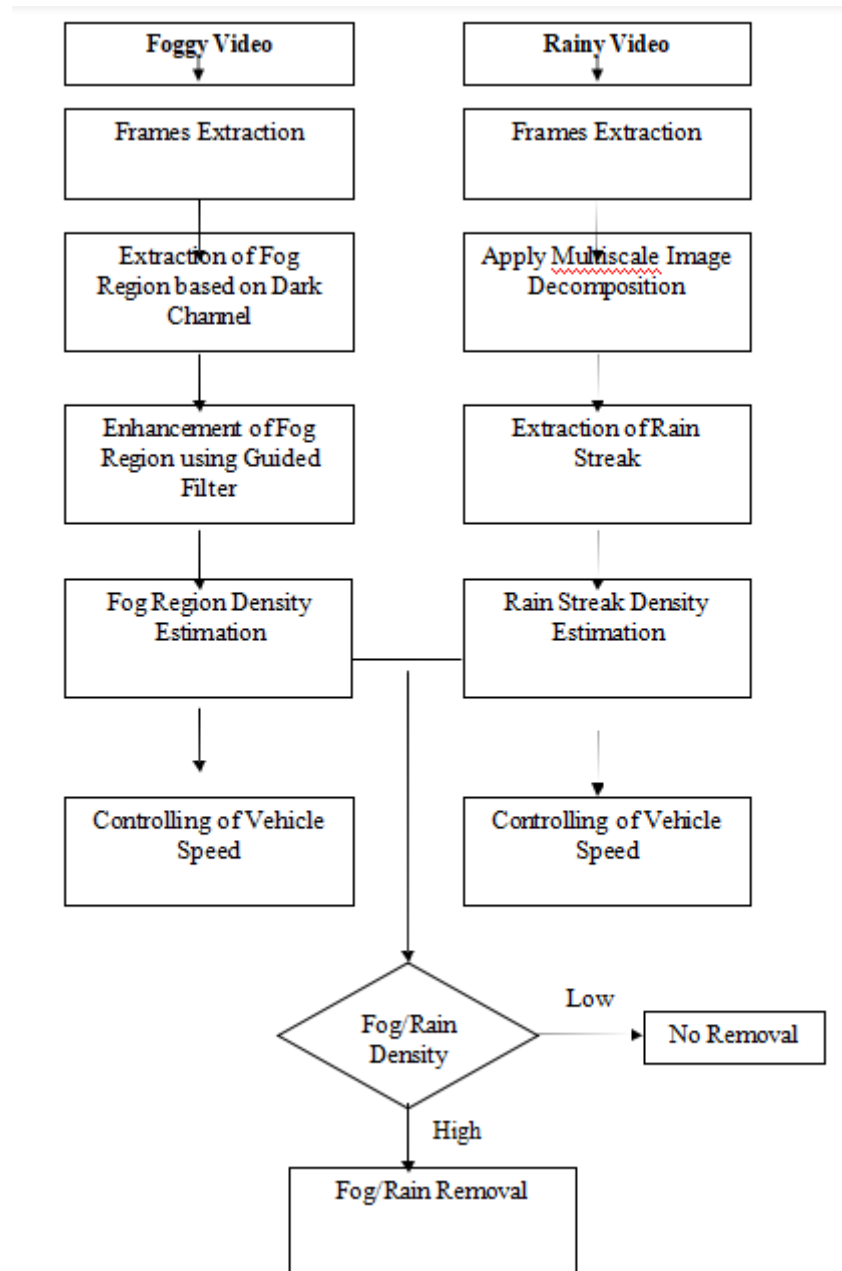
Step 4: Finally based on the fog/rain density, some alert system provided to drivers to control the vehicle speed.

Step 5: Atlast, we implement fog removal and rain streak removal from image to get improved visual quality image. Dark channel prior is used for remove the fog in image. And for further enhancement, bilateral and guided filter is proposed for restore the dehazed image. Optical flow estimation is proposed for rain removal.

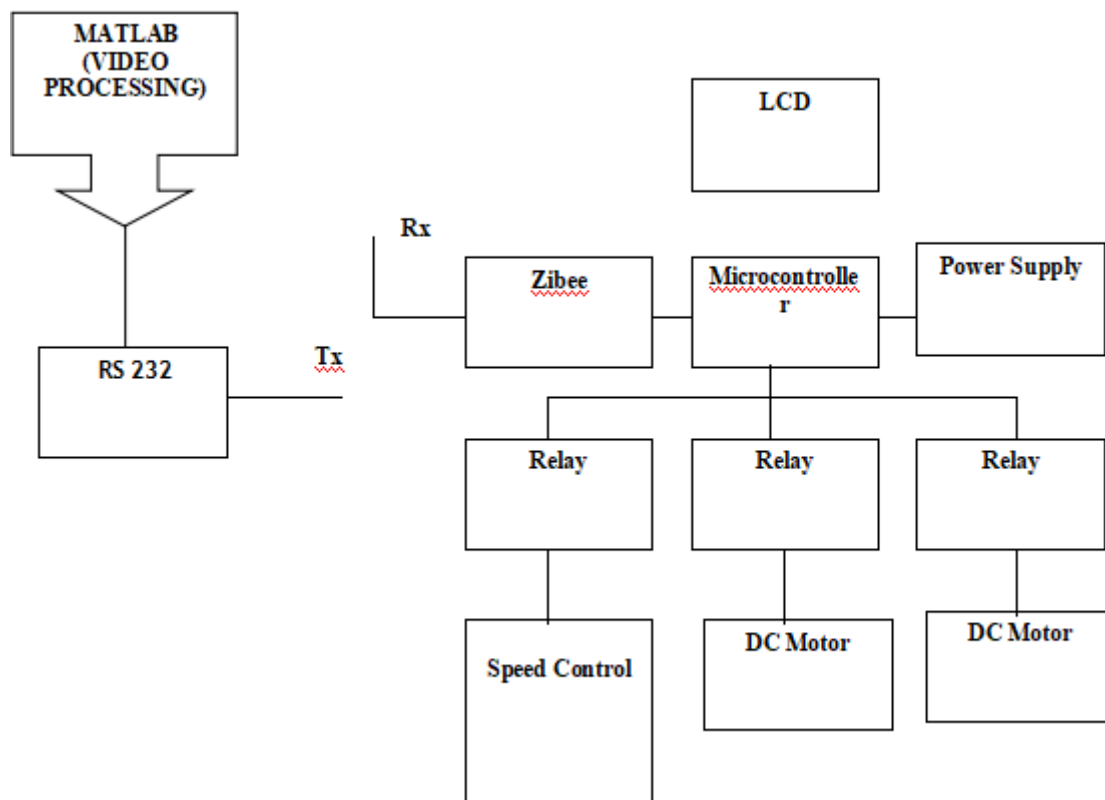
ADVANTAGES OF PROPOSED SYSTEM:

- The high level of performance occurs in estimation of fog/rain density.
- The rate of estimation accuracy is high.
- Vehicle speed controlling is implementing to avoid the accident.

SYSTEM ARCHITECTURE



CONTROL OF VEHICLE SPEED



MODULES:

1. Video Acquisition & Frames Extraction
2. Fog Density Estimation
3. Rain Density Estimation
4. Controlling of Vehicle Speed
5. Fog Removal/Rain Removal

MODULE DESCRIPTION:

1. Video Acquisition & Frames Extraction:

- Test foggy/rainy videos are collecting from public database.
- After the video acquisition, frames extraction is performed.

2. Fog Density Estimation:

- In this module, we implement the fog density estimation.
- First extract the fog region from foggy image based on dark channel.
- Second, extracted fog region is enhanced by using guided filter.
- Finally, we extract the statistical feature i.e. mean feature; it is used for calculate fog density from the enhanced fog region.

3. Rain Density Estimation:

- In this module, we implement the rain density estimation.
- First multiscale image decomposition like anisotropic diffusion filter is used to extract the background layer.
- Second, rain streak is extracted by subtracting of background layer by original rainy frame.
- Finally, we extract the statistical feature i.e. mean feature; it is used for calculate rain streak density from the rain streaks.

4. Controlling of Vehicle Speed:

- In this module, vehicle speed controlling is implemented based on fog/rain density.
- Based on the density result, two kinds of messages (indication) are given to the driver i.e. go to slow and go to normal/high speed.

5.Fog Removal/Rain Removal

i. Fog Removal

- In this module, image is enhanced in terms of fog removal by image decomposition, initial fog removal and detail part enhancement/restoration. The aim of image decomposition is to decompose the image **I** into its low frequency part **LF** and its high frequency part **HF**, namely, $I = LF + HF$. Image decomposition process done by using our novel method. The method is *bilateral* filter that is used for decompose of image in image decomposition.
- Bilateral filter first extract the base layer that is called as low frequency part image (smoothed image). It's almost less fog free image but usually blurred, while *HF* contains details of the image. The detail layer or high frequency part image obtained as $HF = I - LF$. After that guided filter is proposed for enhance the detail part of image.
- Next, initial fog removal is implemented by using dark channel

prior. Dark channel prior is used for extract the transmission map and guided filter is proposed for smooth the transmission map. Finally we restore dehazed image by combining of smoothed transmission map and enhanced detail part.

ii. Rain Removal

- In this module, we implement rain removal based on anisotropic diffusion filter and optical flow estimation.
- That filter is used for extract the background layer. Rain streak is extracted by subtracting of background layer by original rainy image.
- Finally, optical flow estimation is used to remove the rain streaks.

CHAPTER 5

SYSTEM DESIGN SPECIFICATION

SYSTEM DESIGN

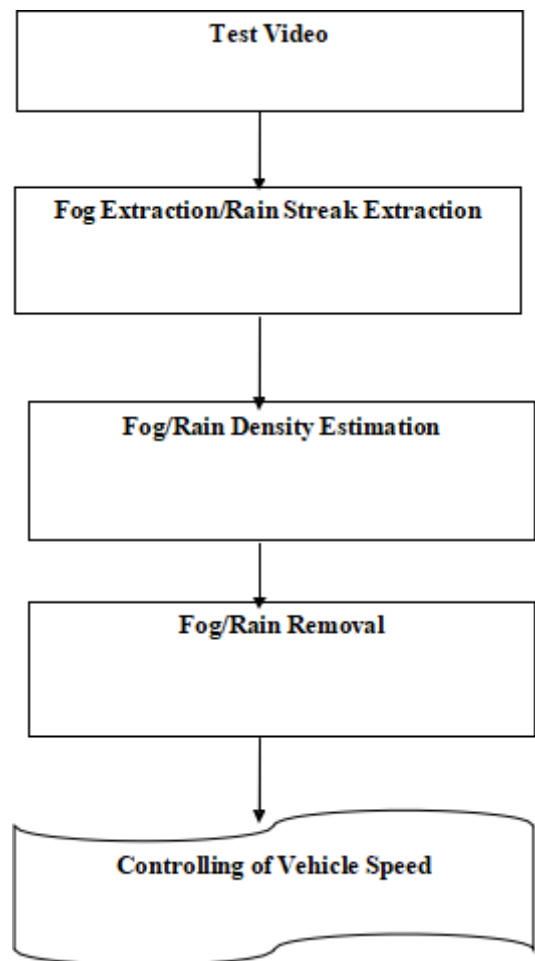
DATA FLOW DIAGRAM:

1. The DFD is also called as bubble chart. It is a simple graphical formalism that can be used to represent a system in terms of input data to the system, various processing carried out on this data, and the output data is generated by this system.
2. The data flow diagram (DFD) is one of the most important modeling tools.

It is used to model the system components. These components are the system process, the data used by the process, an external entity that interacts with the system and the information flows in the system.

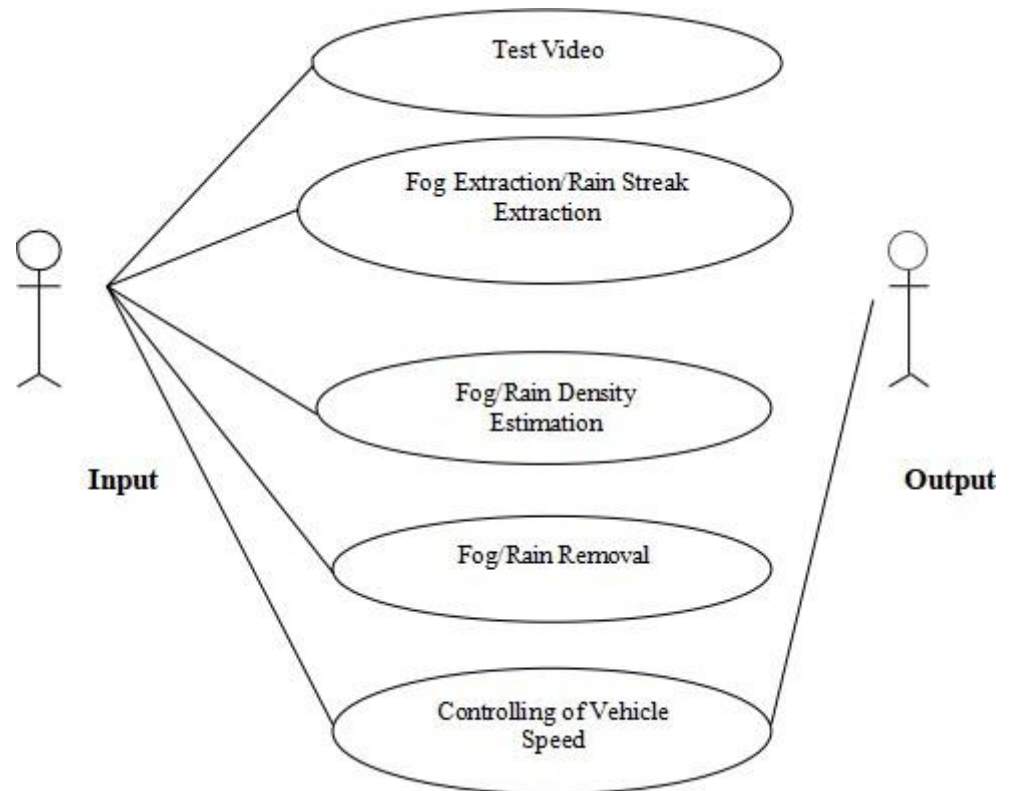
3. DFD shows how the information moves through the system and how it is modified by a series of transformations. It is a graphical technique that depicts information flow and the transformations that are applied as data moves from input to output.

4. DFD is also known as bubble chart. A DFD may be used to represent a system at any level of abstraction. DFD may be partitioned into levels that represent increasing information flow and functional detail.



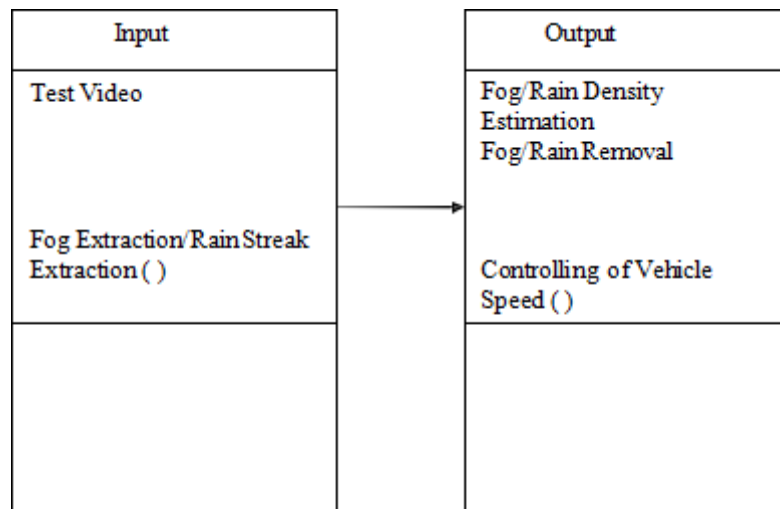
USE CASE DIAGRAM:

A use case diagram in the Unified Modeling Language (UML) is a type of behavioral diagram defined by and created from a Use-case analysis. Its purpose is to present a graphical overview of the functionality provided by a system in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The main purpose of a use case diagram is to show what system functions are performed for which actor. Roles of the actors in the system can be depicted



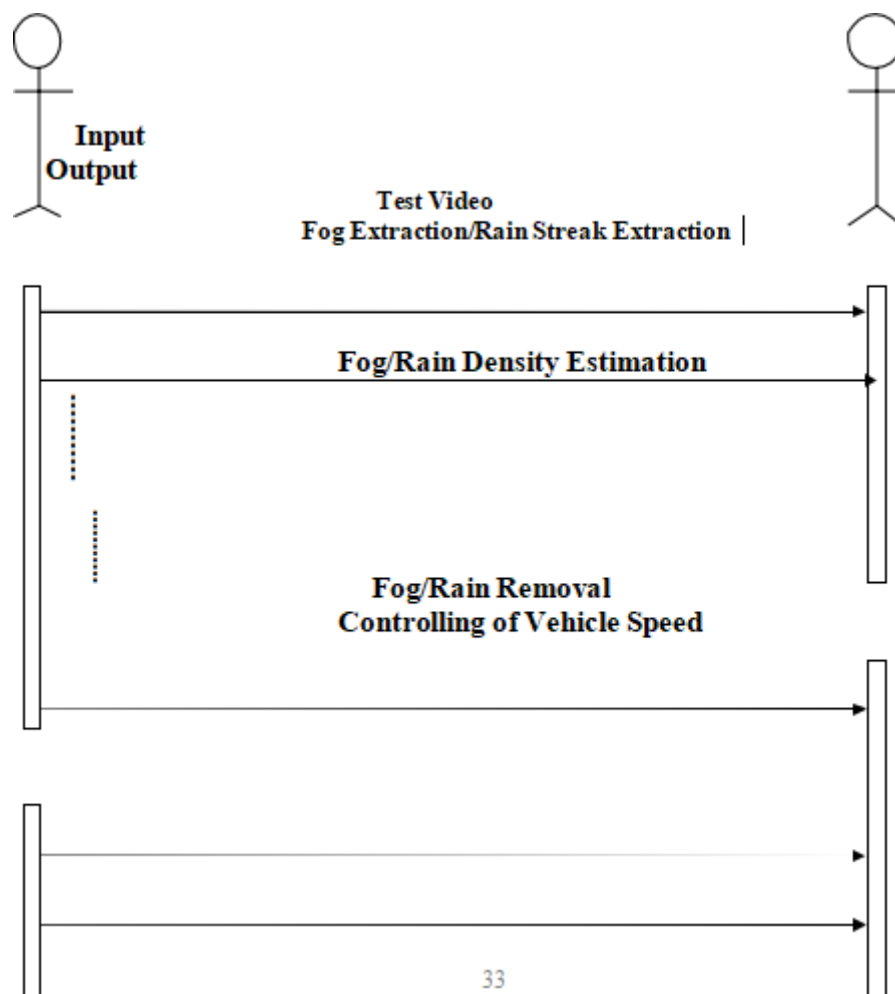
CLASS DIAGRAM:

In software engineering, a class diagram in the Unified Modeling Language (UML) is a type of static structure diagram that describes the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes. It explains which class contains information.



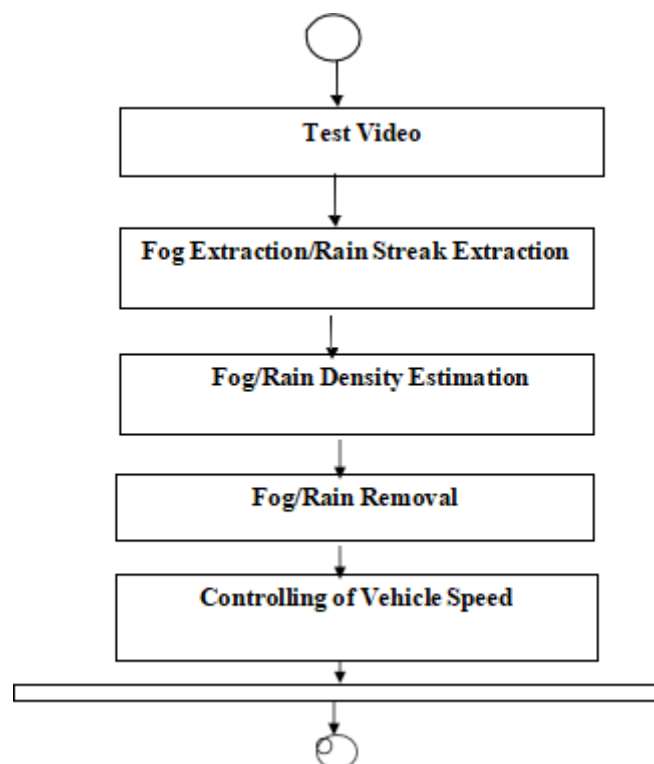
SEQUENCE DIAGRAM:

A sequence diagram in Unified Modeling Language (UML) is a kind of interaction diagram that shows how processes operate with one another and in what order. It is a construct of a Message Sequence Chart. Sequence diagrams are sometimes called event diagrams, event scenarios, and timing diagrams.



ACTIVITY DIAGRAM:

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams can be used to describe the business and operational step-by-step workflows of components in a system. An activity diagram shows the overall flow of control.



CHAPTER 6 CONCLUSION

In this work, we proposed the vehicle speed controlling based on density level of fog and rain. Fog density estimation done by followed as, fog region extraction, enhancement of fog region, statistical feature extraction. Dark Channel and guided filter is used for fog region extraction and enhancement. Similarly rain density extraction based on multiscale image decomposition i.e. anisotropic diffusion filter. And also we proposed fog and rain removal based on amount of fog and rain. Thus our model makes the alert system to driver interms of slow speed and high speed based on fog/rain density.

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APPENDIX 1 CODING

```
function varargout = final(varargin)
gui_Singleton = 1;
gui_State = struct('gui_Name',
mfilename, ...

                                'gui_Singleton', gui_Singleton,

...

                                'gui_OpeningFcn', @final_OpeningFcn, ...

                                'gui_OutputFcn', @final_OutputFcn, ...

                                'gui_LayoutFcn', [] , ...

                                'gui_Callback',

[]); if nargin && ischar(varargin{1})
    gui_State.gui_Callback = str2func(varargin{1});

end

if nargout
```

```
[varargout{1:nargout}] = gui_mainfcn(gui_State,  
varargin{:});
```

else

gui_mainfcn(gui_State, varargin{:});

end

% End initialization code - DO NOT EDIT

% --- Executes just before final is made visible.

function final_OpeningFcn(hObject, eventdata,
handles, varargin)

% This function has no output args, see OutputFcn.

% hObject handle to figure

% eventdata reserved - to be defined in a future version of
MATLAB

% handles structure with handles and user data
(see GUIDATA)

% varargin command line arguments to final (see
VARARGIN)

```
handles.output = hObject;
```

```
function varargout = final_OutputFcn(hObject,  
eventdata, handles)  
  
varargout{1} = handles.output;
```

```
[file,fPath] = uigetfile('*.avi','pick an video');
```

```
videoObj = VideoReader(file);
```

```
numFrames = videoObj.NumberOfFrames;
```

```
for i1 = 1:numFrames  
frames =  
read(videoObj,i1);  
axes(handles.axes1);  
imshow(frames);  
title('Test Video')
```

end

handles.videoObj=videoO
bj;
handles.numFrames=num
Frames;

videoObj=handles.videoO
bj;
numFrames=handles.num
Frames;

CC=1;

for i=1:1:numFrames

Vid=read(videoObj,i);

```
axes(handles.  
axes2);  
imshow(Vid);
```

```

caption = sprintf('Testing Frame %d', CC);
title(caption);
CC=CC+1;

image=(double(Vid)/
255); win_size = 15;
[m, n, ~] = size(image); pad_size
= floor(win_size/2);
padded_image = padarray(image, [pad_size pad_size], Inf);
dark_channel = zeros(m, n);

for j = 1 : m

    for i = 1 : n

        patch = padded_image(j : j + (win_size-1),
i : i +
(win_size-1), :);

        dark_channel(j,i) = min(patch(:));
    end
end
end

```

```
axes(handles.axes3);  
imshow(dark_channel);  
title('Fog Region Extraction'); r  
= 10;  
res = 0.001;
```

```
EFR = guided_filter(dark_channel,dark_channel, r, res);  
  
axes(handles.  
axes4);  
imshow(EFR);  
title('Fog Region Enhancement');  
fog_density=mean2(EFR)  
set(handles.edit1,'string',fog_density);
```

```
if fog_density <=  
    0.38  
    A='Low';  
    set(handles.edit2,'string',A);  
  
    msgbox('Density is Low so No Need for  
Removal');
```

else

```
A='High';  
set(handles.edit2,'string',A);  
image=(double(Vid)/255);  
omega = 0.85;  
win_size = 15;
```

```
r = 10;
```

```
res = 0.001;
```

```
[m, n, ~] = size(image);
```

```
dark_channel = get_dark_channel(image, win_size);  
atmosphere = get_atmosphere(image, dark_channel);  
trans_est = get_transmission_estimate(image,  
atmosphere, omega, win_size);  
x = guided_filter(rgb2gray(image), trans_est, r, res);  
transmission = reshape(x, m, n);
```

```
% Image Restoration
```

```
radiance = get_radiance(image, (transmission),  
atmosphere); % Initial fog removed image
```

```
axes(handles.  
axes5);  
imshow(radia  
nce);  
title('Initial Fog Removal by DCP');
```

```
% Low frequency Part
```

```
Extraction original =  
double(Vid); original = original /  
255; BilateralParam = 2;  
w = 5;
```

```
sigma = [2 0.1] * BilateralParam;
```

```
LF1 = bfilter2(original(:,:,1), w, sigma);
```

```
LF2 = bfilter2(original(:,:,2), w, sigma);
```

```
LF3 = bfilter2(original(:,:,3), w, sigma);
```

```
LF=cat(3,LF1,LF2,LF3);
```

```
% High Frequency Part
Extraction HF=original-LF;
axes(handles.axes6);
imshow(HF);
title('Detail Part from Bilateral Filter');
```

```
%% Detail Part Enhancement based on Guided Filter eps =
0.1^2;
n1=3;
```

```
detail1 = guided_filter(HF(:,:,1),HF(:,:,1), 2,
eps);
```

```
detail2 = guided_filter(HF(:,:,2),HF(:,:,2), 2,
eps);
```

```
detail3 = guided_filter(HF(:,:,3),HF(:,:,3), 2,
eps);
```

```
detail=cat(3,detail1,detail2,detail3);
```

EDP = n1 * detail;

```
axes(handles.  
axes6);  
imshow(EDP)  
;  
title('Enhanced Detail Part by GF');
```

```
%% Reconstruction
```

```
R =radiance +  
EDP;  
axes(handles.  
axes7);  
imshow(R);  
title('Final Fog Removed Frame');
```

```
end
```

```
end  
msgbox('Com  
pleted');  
% Update handles  
structure
```

```
guidata(hObject,  
handles);  
function edit1_Callback(hObject, eventdata,
```

handles)

% hObject handle to edit1 (see GCBO)

% eventdata reserved - to be defined in a future version of
MATLAB

% handles structure with handles and user data
(see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit1 as text

% str2double(get(hObject,'String')) returns
contents of edit1 as a double

% See ISPC and COMPUTER.

if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))

 set(hObject,'BackgroundColor','white');

end

function edit2_Callback(hObject, eventdata,
handles)

```
% Hints: get(hObject,'String') returns contents of edit2 as text
```

```
if ispc && isequal(get(hObject,'BackgroundColor'),  
get(0,'defaultUicontrolBackgroundColor'))
```

```
    set(hObject,'BackgroundColor','white');
```

```
end
```

```
function radiobutton3_Callback(hObject, eventdata, handles)
```

```
% hObject          handle to radiobutton3 (see GCBO)
```

```
% eventdata reserved - to be defined in a future version of  
MATLAB
```

```
% handles          structure with handles and user data  
(see GUIDATA)
```

APPENDIX 2 EXPERIMENTAL RESULTS

