A REVIEW OF RAINDROPLET DETECTION AND REMOVAL TECHNIQUES

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Abstract—**Bad weather condition decrease the surveillance video and the driving assistance system efficiency and accuracy. The impact of rain drop in the single images can make it difficult to distinguish the objects. Furthermore, a high quality single image is needed in numerous areas such as in object recognition and detection noise removal and weather condition removal. Rainy weather outdoor images and videos reduce the visibility, performance of computer vision algorithms, which use for extracting features and information from images. This paper will present a review of restoration raindrop detection and removal from single image which has different techniques of used in video.**

Keywords— raindrop, bad weather, Rain drop removial,.

I. INTRODUCTION

Image processing and computer vision research has a great history where many areas are addressed [1] like image compression, object detection and its performance, enhancement in image in many domains like medical, industrial, surveillance and weather forecasting [2]. Aim of this paper is to summarize the classification bad weather in computer vision, types of noise created by rain drops, and its removal technique& its performance.

Before discussing about the rain drop and bad weather, let us discuss the image enhancement by removing the noise. Depending on the requirement the image enhancement can treat an image to increase the quality of the image through removing the blurred, noise or balancing the contrast or brightness. In 1969, Huage [3] describe the image enhancement parameters likecrispening, contrast enhancement, noise removal and inverse filtering with mathematical operations. From than the digital image quality degrade by blurring, noise, incorrect color balance and poor quality [4] which taken through image quality devices such as scanner, cameras and video recorder. To improve quality of digital images, various steps are required.

The step involves

i) Color correction to adjust the color of the image using color models or Color balancing method.
ii) Light illumination &Contrast enhancement to adjust the brightness.
iii) Image smoothing by removing noise.
iv) Image sharpening technique.

Image enhancement is always a subjective evaluation means judgment is purely depend on viewer [5]. Image enhancement has many domains such as underwater vision [6], biomedical images [7], and outdoor vision [8].

II. BAD WEATHER

The aim of getting knowledge about the weather is to design a weather free vision of surveillance and outdoor imaging [9, 10]. To design such a system is a challenging problem. The quality of an image or video in outdoor scene degraded due to the noise introduced by different environment efforts such as haze, fog, snow and rain [10].

The bad weather conditions can be of two types:

1. Steady or static Condition which introduce noise due to fog and haze in a regular pattern.
2. Dynamic condition which introduce noise due to rain and snow in an irregular pattern.

Type and size of the particles and their concentration in space describe the noise in the image or video. [10] Asspecified in Table 1.

Table 1 Weather condition & association type and size

Condition	Particle Type	Radius(μm)
Air	Molecule	10^{-4}
Haze	Aerosol	$10^{-2} – 1$
Fog	Water droplet	1 - 10
Cloud	Water droplet	1 - 10
Rain	Water droplet	10^{2} - 10^{4}

A. HAZE

Haze is traditionally an atmospheric phenomenon in which dust, smoke, and other dry particulates obscure the clarity of the sky. The term "haze", in meteorological literature, generally

is used to denote visibility-reducing aerosols of the wet type. Such aerosols commonly arise from complex chemical reactions that occur as sulfur dioxide gases emitted during combustion are converted into small droplets of sulphuric acid. The reactions are enhanced in the presence of sunlight, high relative humidity, and stagnant air flow. A small component of wet haze aerosols appear to be derived from compounds released by trees, such as terpenes. For all these reasons, wet haze tends to be primarily a warm-season phenomenon. Large areas of haze covering many thousands of kilometers may be produced under favorable conditions each summer.

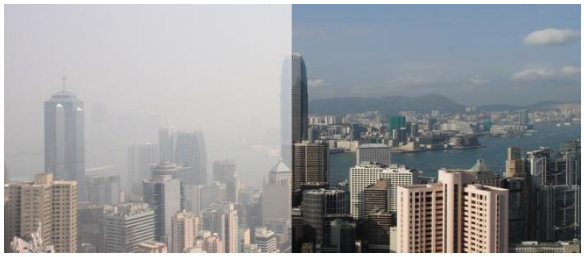

Fig.1 Effect of Haze

B. FOG

Fog consists of visible cloud water droplets or ice crystals suspended in the air at or near the Earth's surface. Fog can be considered a type of low-lying cloud and is heavily influenced by nearby bodies of water, topography, and wind conditions. In turn, fog has affected many human activities, such as shipping, travel, and warfare.

Fig.2 Effect of Fog

C. *Rain*

Rain is liquid water in the form of droplets that have condensed from atmospheric water vapor and then becomes heavy enough to fall under gravity. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the Earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation.

Fig.3 *Effect of Rain*

The overall picture of the bad weather image vision is classified as below:

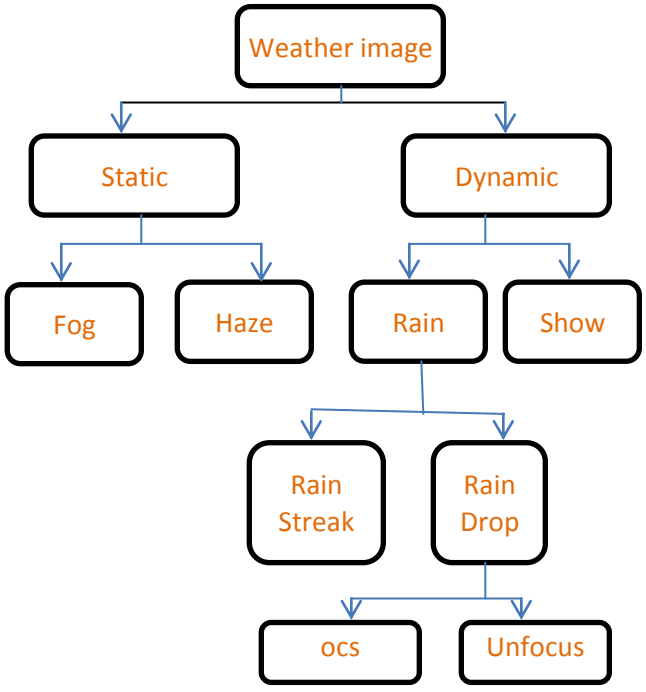

Fig.4 Bad Weather classification

III. LITERATURE SURVEY

Single image restoration or enhancement of bad weather outdoor image mostly in rainy weather, it is an open research field with many problems. We focus in some of the related work on raindrop and

streaks remove from images in rainy environment as in Table 2

Table 2 Algorithms of detection and rain removal

L. No.	Author	Algorithm/ Technique	Year
1	Chen, DuanYuet al	Framework guided image filter, low-frequency and a high frequency dictionary learning with sparse coding.	2014
2	Pei, SooChang et al	Framework Merge Saturation and Visibility, High Pass Filter, Orientation Filter, Threshold.	2014
3	Sun, ShaoHua et a	Incremental Dictionary learning-based method	2014
4	Zhen g, Xianhui et al	Using low frequency for single image and guided filter	2014
5	Eigen , David et al	Neural network	2013
6	Kim, JinHwan, et al	Adaptive nonlocal means filter.	2013
7	Chen, DuanYu et al	Guided image filter, then performing dictionary learning and sparse coding	2012
8	Xu, Jing et al	Guided filter	2012
9	Huan g, DeAn, et al	Dictionary learning-based framework	2012
10	LiWei Kang et.al	Framework based on morphological component analysis (MAC), bilateral filter, dictionary learning and sparse coding	2012
11	Jing Xu et. al	Refined guidance image	2012
12	Qi Wu et. al	Visual Salient Features	2012
13	Fu, YuHsiang et. al	Analyze an image into low frequency and high frequency via a bilateral filter and performs dictionary learning with sparse coding.	
14	Sugimoto et. al	Improved RIGSEC	2012
15	Roser et. al	Bezier Curves	2011
16	Nomoto et. al	Epipolar Geometry	2011
17	Ching-Lin Yang	Intersection operation	2011
18	Nashashibi et. al.	Intensity variation & contour verifications	2010
19	Schwarxlmuller et. Al.	Support Vector Machine	2010
20	Roser& Geiger	Improved RIGSEC	2009
21	Halimeh&Roser [	RIGSEC	2009
22	Yamashita et. al	Template matching	2008
23	Miyahara et. al	Principle Component Analysis (eigendrops)	2008
24	Kurihata et. al	Time-series	2007

IV. RAINDROP CHARACTERISTICS

Rain is a random shaped and sized water droplet traveling with high speed [11]. It is due to two reasons

I. Initial differences in particle size
II. Different rates of coalescences.

The characteristics of raindrops are [12]

- Edges that feature an outline of a raindrop
- Blurry edges
- Refraction of light
- Consists of dark and bright region
- Appears in circular form on windshield
- Texture varies since the background varies
- Causes blurring

A. SIZE OF A RAINDROP

The physical properties of rain have been extensively explored in atmospheric sciences and transportation. The size of a raindrop typically varies from 0.1 mm to 3.5 mm.

B. SHAPE OF RAINDROP

The shape of a drop can be expressed as a function of its size. Smaller raindrops are generally spherical in shape while larger drops resemble oblate spheroids.

C. VELOCITY OF A RAINDROP

` During a normal rainfall, most of the drops are less than 1 mm in size. Hence, most raindrops are spherical. Therefore, this approximation in size is used to model the raindrops. As a drop falls through the atmosphere, it reaches a constant terminal velocity.

V. CONCLUSION

This article briefly describes preliminary study of the research fields in image processing and computer vision, more specific on image enhancement for weather degraded image. The main aim is to develop an algorithm to enhance image that can efficiently remove (raindrop) outdoor image within real-time processing.

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