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DETECTION OF UNFOCUSED RAINDROPS ON CAR WINDSCREEN COMPARATIVE ANALYSIS USING BACKGROUND SUBRACTIONAND AND WATERSHED ALGORTIHM

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ABSTRACT

Use of ADAS in top end cars has been prevalent over past decade. Electronic control and assistance in cars has proven to be a major feature resulting in passenger safety, saving lives as well as preventing fatalities. This system can be trusted or counted upon in clear weather conditions, which by now has been the only limitation questioning the usefulness of ADAS. Current research focuses to strengthen ADAS in rainy climatic conditions. This paper puts forth a novel idea to detect raindrops where ADAS can be used to increase its functionality in rainy condition to control the speed of over-speeding cars. The method basically includes image database on which Background Subtraction and Watershed algorithm are run to find out a numerical data, and to measure performance of both the method. This data can be used to improve ADAS performance in rainy conditions.

KEYWORDS: ADAS; Raindrops; background subtraction; watershed.

INTRODUCTION

Rainy conditions have always brought some difficulty in modes of commutation. Vehicle transport, too, is not an exception. The difficulties faced include low vision, blurred vision, and reduced grip of tiers, lesser traction and difficulty in vehicle control. These difficulties often result in road accidents, and road accidents in rainy weather condition are more since visual effect introduced by rain are complex & reduces visual performance [10]. Advanced Driver Assistance System in vehicle has helped to a great extent in bringing down the number of accidents. Though ADAS is a feature mostly equipped in top end cars, it still has some drawbacks when it comes to rainfall, basically in speed control of vehicle. Detection of raindrops hitting the windscreen can be used as a feedback to understand the severity of rainfall and ultimately improving the behavior of ADAS. In heavy rains the raindrops stays for a short duration (maximum of 500 msec) [7]. Often these raindrops are unfocused and detecting them accurately is a big challenge for the electronic systems. Improvising detection algorithm can be a key for better performance. A system for detecting unfocused raindrops without modifying the camera distinctiveness was developed [1]-[7].

Statistical learning methods as well as image processing algorithms are used to detect the raindrops on car windscreen that can be further used by ADAS systems. Wherein Photometric models were used to detect stationary spherical raindrops and streaks [2]-[8]. Static observer and long temporal integration makes this unsuitable for moving camera scenarios.Few approaches like spatiotemporal method were proposed by Nashashibi et al.[7] suffers from require flexibility & improvement. Martin Roser and Frank Moosmann presented a study to discern several types rainy conditions but their approach cannot localize raindrops within image [4]. Kshitiz Garg and Shree K. Nayar developed correlation model based on comprehensive analysis based on dynamics & photometric properties of raindrops but their algorithm cannot handle steady effect of rain also cannot remove defocused rain streaks [8].M. Roser and A. Geiger proposed photometric model in which they detected raindrops on a single images using photometric properties of raindrops. But their model does not cover all shapes of raindrops [2].Using template matching H. Kurihata, T. Takahashi, I. Ide, Y. Mekada, H. Murase, Y. Tamatsu, and T.Miyahara obtained a good result to detect raindrops on car windshield from video sequence [1].Cord & Aubert detected focused raindrops using pattern recognition technique

[3]. Machine learning approach with raindrop templates, so called Eigen drops was used to detect raindrops on windshields [1]. Results within the sky area were promising, whereas the proposed method produced a large number of false positives within the non-sky regions of the image where raindrop appearance modelling becomes more challenging

In this paper we trying to present two raindrop detection approaches which has been designed to detect raindrops on a car windshield using front view on board camera in a car[11].

EASE OF USE

Background

Many techniques for detection of raindrops on car windscreen have been tested. Detection of the drops while the car is stationary can get accurate results. But for a vehicle in motion, the detection becomes difficult. In heavy rain conditions a single rain drop may affect a larger area than just a single spot. [3].The distorted shape and size requires various odes to detect the raindrops. Photometric property of rainhas helped to create such models which are used to detect raindrops on car windscreen [11].Images captured by the embedded camera (from ADAS) are blurred by the vehicle motion, usually resulting in false detection of the raindrops[7].Rain detection system using raindrops on the windscreen rather than detection of theraindrops falling in the air would be useful task [7].

Raindrop detection

Raindrop hitting the windscreen can result in streaks and drops. Proposed approaches thus differ upon the type to be detected, Streak detection, Tropical Downpour, Thunder shower, drizzle as shown in [Fig.1] .
Our methods are restricted to light strati form and drizzling nature of rain.


a. Light Stratiform b. Tropical Downpour c.Thundershower d. Drizzle e. Drizzle

Fig. 1 Raindrop patterns on windscreen under various rainy conditions

METHODOLOGY

Raindrop on the car windscreen shows various physical features, shape and form of the drop which reflects the optical and statistical properties. Real time processing of raindrops andthe visual effects of water drops involve elaborate physical mechanisms, reflecting their physical, optical, and statistical characteristics. The study of those characteristics has led to numerous applications in the context of real-time rendering of a realistic rainy scene. In this paper we are implementing two methods, background subtraction & watershed algorithm, to detect unfocused raindrops on car windshield using onboard camera. On listed methods we would be applying image processing tools to detect & localize raindrops on car windshield result of this can be fed to ADAS system to improve its behavior.Finally, performance of two methods would be compared on based on detected raindrop count [Fig.2].

Video database was recorded under different rainy conditions (light strati form and drizzle) at a rate of 30fps using cannon T3i camera (600D).

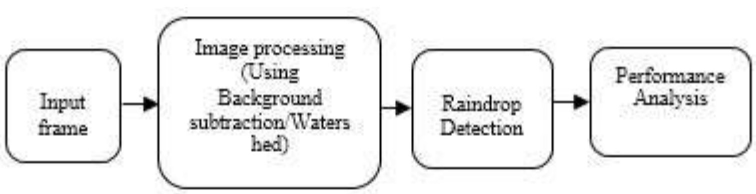

Fig.2 Block Diagram

Step I:
Images has been captured using on board camera for raindrops on car windshield & background (image without raindrops) as shown in [Fig.3].

Background subtraction:
Background subtraction is a technique wherein an image's foreground objects are extracted from input image. Generally an image's regions of interest are objects (humans, cars, text etc.) in its foreground. Here we are using this technique to detect raindrops on car windshield using image from onboard

Fig.3: a) Image with raindrops on car windshield b) Image without raindrops

camera only. Background subtraction is awidely used approach for detecting moving objects in videos from static cameras.

We are opting simple & straightforward technique to detect raindrops using frame differencing followed by segmentation as given below:

Frame Differencing:
A motion detection algorithm begins with the segmentation part where objects of interest are segmented from the background. The simplest way to implement this is to take an image as background (here image without raindrop)shown in [Fig.3] and input image (here raindrop detected image)at the time t, denoted by I (t). Using simple arithmetic calculations, we can segment out the raindrops simply by image subtraction technique for each pixels in I (t),

Take the pixel value denoted by P[I(t)] and subtract it with the corresponding pixels at the same position on the background image denoted as P[B] as shown in Fig,4
In mathematical equation, it is written as:

$$P\,[F\,(t)]=P[I(t)]-P[B(t)]$$

b) Segmentation:

As raindrops appears are brighter than background [7] manual threshold value is chosen to segment raindrops from background.

$$P\,[F\,(t)]=P[I(t)]-P[B(t)] > Threshold$$

Results for background subtraction after thresholding are as shown in Fig.4.

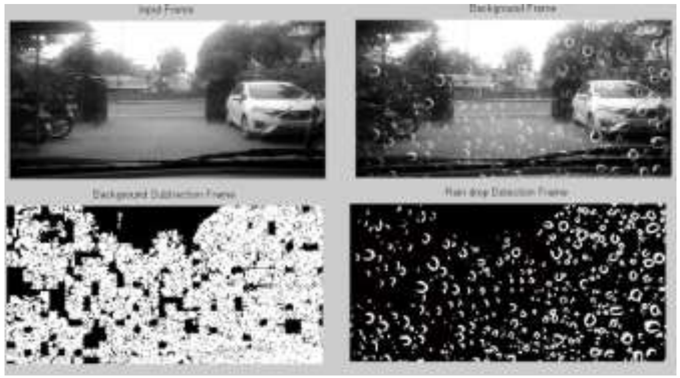

FIG: 4. Background Substraction Results

Watershed algorithm:

The aim of the watershed transform is to search for regions of high intensity gradients (*watersheds*) that divide neighbored local minima (basins).The Watershed Transform is a unique technique forsegmenting digital image that uses a type of regiongrowing method based on an image gradient. Image is visualized in three dimensions: two spatial coordinates versus gray levels using the watershed transform [11]. This interpretation considers three points:

a) Points belonging to a regional minimum.
b) Points at which a drop of water, if placed at the location of any of those points, would fall with certainty to a single minimum.
c) Points at which water would be equally likely to fall to more than one such minimum.

For a particular regional minimum, the set of points satisfying condition (b) is called the *catchment basin* or *watershed* of that minimum. The points satisfying condition (c) form crest lines on the topographic surface and are termed *divide lines* or *watershed lines*. Watershed algorithm is used to detect unfocused raindrops from car windshield using image from onboard camera.We are converting image into grayscale to obtain gradient of image. Raindrops detected using watershed algorithm for various subset are shown in Fig.5

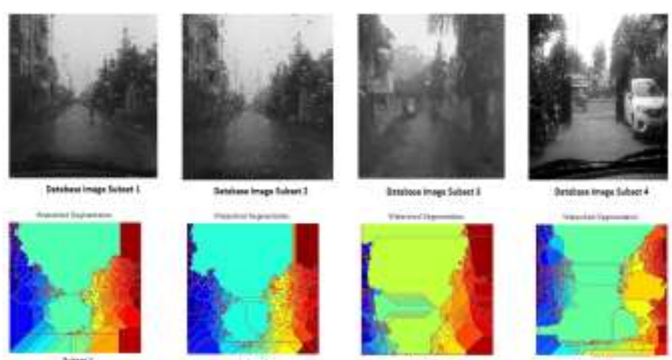

FIG: 5. Raindrops Detected Using Watershed For various Input images with raindrops on car windshield

In future we can go for temporal filtering where we could actually compare successive raindrops detected frames for both background subtraction & watershed algorithm, area detected less than twice can be removed for more accurate results.

RESULTS

Comparitive Analysis:

The Results for background subtraction and watershed were obtained on frames extracted from video frame. First we captured a video database for clear weather condition & rainy weather condition .Then we separated out frames for both the database. These frames are given as input to background subtraction & watershed algorithm & compared results of both based on raindrop count .Results are simulated on Intel(R) Core ™ i3-3110M CPU@240 GHz. using MATLAB.

Table 1: Raindrops detected using watershed algorithm under various rainy conditions.

Rain drop detected Using Watershed	Subset 1	Subset 2	Subset 3	Subset 4
	159	233	99	293

Raindrop hitting the windscreen can result in streaks and drops. Proposed approaches thus differ upon the type to be detected as shown in [Fig.1] .

As our methods are restricted to light strati form and drizzling nature of rain as shown in Table 1. Shows number of raindrop count detected in light strati form and drizzling type of rainfall using watershed.

Comparative analysis of background subtraction & watershed algorithm based on detected raindrop count.

	Background Subtraction	Watershed Algorithm
Rain drop detected	490	
Min size of drop in mm^2	0.264000	0.248500
Min size of drop in mm^2	3.951190	3.872400

Performance Measurement

The raindrop detection performance can calculated using number of true and false positives. Detection is defined as a True positive if the true raindrop center falls into the detectionpatch.For both methods, the correct detection rate (CDR), thefalsepositive per image (FPPI) can be calculated as given below:

1. CDR = $\frac{TP}{P}$
2. FPPI = $\frac{FP}{N}$

Where TP is the number of true positives, FP is the number of false positives, P is the total number of raindrops, and n is the total number of images.[11].

Performance can be measured between background subtraction & watershed algorithm by comparative analysis based on CDR & FPPI.

CONCLUSION

Using onboard camera we detected raindrops on car windshield using two methods as background subtraction & watershed algorithm. The two proposed methods can efficiently detect raindrops on car windshield but watershed can be trusted more as background subtraction cannot be efficiently used in dynamic background conditions else watershed algorithm can be used as shown in FIG 5.

This choice was made to improve the working state of other camera-based ADASs.

Though both methods can be used to detect raindrops on car windshield their performance suffers from lack flexibility in heavy rainfall.

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