Video Post Processing: Combating Bad Weather

Abstract

Current vision systems are designed to perform in normal weather condition. However, no one can escape from bad weather conditions. Bad weather reduces scene contrast and visibility, which results degradation in the performance of various computer vision algorithms such as object tracking, segmentation and recognition. Thus current vision systems must include some mechanisms that enable them to perform up to the mark in bad weather conditions such as rain and fog. Rain causes the spatial and temporal intensity fluctuations in images or video frames. This intensity fluctuations are due to the random distribution and high velocities of the raindrops. Fog causes low contrast and whiteness in the image and leads to the shift in the color. This thesis has studied rain and fog from the perspective of vision. The thesis has two main goals: 1) removal of rain from videos captured by moving and static camera, 2) removal of fog from images and videos captured by moving single uncalibrated camera system.

The thesis begins with the literature survey. Pros and cons of the prior art algorithms are described and a general framework for the development of an efficient rain removal algorithm is explored. Temporal and spatiotemporal properties of rain pixel are analyzed and using these properties, two rain removal algorithms for the videos captured by static camera are developed. For the removal of rain, temporal and spatiotemporal algorithms require less number of consecutive frames which reduces buffer size and delay. Proposed algorithms do not assume the shape, size and velocity of raindrops which makes it robust to different rain conditions (i.e. heavy rain, light rain and moderate rain). In practical situation there is no ground truth available for rain video, thus no reference quality metrics are very useful in measuring the efficacy of the rain removal algorithms. Temporal variance and spatiotemporal variance are proposed in this thesis as no reference quality metrics.

An efficient rain removal algorithm using meteorological properties of rain is also developed. The relation among the orientation of the raindrops, wind velocity and terminal velocity is established. This relation is used in the estimation of shape based features of the raindrop. Meteorological properties based features helped to discriminate the rain and non rain pixels.

It is noted that most of the prior art algorithms are designed for the videos captured by the static camera. It is demonstrated that with the use of global motion compensation, all rain removal algorithms designed for videos captured by static camera results in better accuracy for videos captured by moving camera. Qualitative and quantitative results confirm that proposed temporal, spatiotemporal and meteorological algorithms outperformed other prior art algorithms in terms of the perceptual quality, buffer size, execution delay and system cost.

In order to remove fog, an efficient fog removal algorithm using anisotropic diffusion is developed. Proposed fog removal algorithm uses new dark channel assumption and anisotropic diffusion for the initialization and refinement of the airlight map respectively. Use of anisotropic diffusion helps to estimate the better airlight map estimation. The proposed fog removal algorithm requires single image captured by uncalibrated camera system. The proposed anisotropic diffusion based fog removal algorithm can be applied in both RGB and HSI color space. This thesis shows that use of HSI color space reduces the complexity further. Proposed fog removal algorithm requires pre- and post-processing steps for the better restoration of the foggy image. These pre- and post-processing steps have either data driven or constant parameters which avoid the user intervention. Proposed fog removal algorithm is independent of the intensity of fog, thus even in case of heavy fog proposed algorithm performs well. Qualitative and quantitative results confirm that proposed fog removal algorithm outperformed previous algorithms in terms of perceptual quality, color fidelity and execution time.

At present there is no algorithm which is specifically designed for the removal of fog from videos. Application of single image fog removal algorithm over each video frame is a time consuming and costly affair. It is demonstrated that with the intelligent use of temporal redundancy, fog removal algorithms designed for single image can be extended to the real time video application. Results confirm that proposed framework used for the extension of the fog removal algorithms for images to videos can reduce the complexity to a great extent with no loss of perceptual quality. This paves the way for real life application of video fog removal algorithm.

The work presented in this thesis can find wide application in entertainment industries, transportation, tracking and consumer electronics.

Keywords : Bad weather, rain, raindrop, probabilistic classifier, intensity waveform, outdoor vision and weather, meteorological properties, motion estimation, video enhancement, image enhancement, fog, attenuation, airlight, atmospheric visibility, anisotropic diffusion, image contrast, temporal redundancy.