Prediction of perceived fog density and defogging of natural foggy images

Lark Kwon Choi[1,3]*, Jaehee You*[2]*, and Alan C. Bovik*[1,3]

[1]Department of Electrical and Computer Engineering, The University of Texas at Austin
[2]Department of Electronic and Electrical Engineering, Hongik University
[3]Center for Perceptual Systems, The University of Texas at Austin

The perception of outdoor natural scenes is important for successfully participating in visual activities. When fog is present, however, visibility can be severely degraded. We have created a perceptual fog density index that seeks to predict the degree of visibility of a foggy scene using 'fog aware' features learned from a representative database of foggy and fog-free images. The features that define the fog density index derive from a spatial natural scene statistics (NSS) model and from observed characteristics of foggy images. We have found that the statistics of fog aware features consistently change as a function of fog density. A perceptual fog density model was derived by collecting patches from natural foggy and fog-free images, then computing pertinent NSS fog aware features from these patches to develop a perceptual fog density prediction model. A multivariate Gaussian (MVG) distribution is used to form a probabilistic feature model. In practice the perceived fog density of an arbitrary test image is predicted using a Mahalanobis-like distance measure between the 'fog aware' statistics of the test image and the MVG models obtained from the natural foggy and fog-free images. We also conducted a human study of perceived fog density. When applied to 100 natural foggy images, the predicted perceived fog density was found to correlate well with the human judgments of fog density. We have also found that the fog aware statistical features can be used to defog and thereby enhance the visibility of foggy scenes. We first produced white-balanced and contrast-enhanced images from a foggy image using the predicted visibility degree. We then selectively filtered these images with fog aware weighted maps representing distances from the statistics of fog-free images at each fog aware feature. Finally, we applied a Laplacian multi-scale pyramidal refinement to achieve a halo-free defogged image.

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