Deep learning for dehazing: Benchmark and analysis

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Abstract

We compare a recent dehazing method based on deep learning, Dehazenet, with traditional state-of-the-art approach, on benchmark data with reference. Dehazenet estimates the depth map from a single color image, which is used to inverse the Koschmieder model of imaging in the presence of haze. In this sense, the solution is still attached to the Koschmieder model. We demonstrate that this method exhibits the same limitation than other inversions of this imaging model.

Introduction

Dehazing aims at improving visibility in images captured in a presence of haze. In general, methods can be classified in two categories. One category aims at the inversion of the Koschmieder model $J(x) = I(x)t(x) + A_\infty(1 - t(x))$, which states that the image captured at a position x yields $J(x)$ that is a linear combination of the radiant image $I(x)$ and the contribution of the airlight A_∞ weighted by a transmission factor $t(x)$. A_∞ is defined as the light sent to the camera by an object at infinite distance, i.e. the diffusion of the light by the haze. The transmission factor is $t(x) = \exp(-\beta d(x))$, where β is the scattering coefficient of the haze and $d(x)$ the distance of the object from the camera. This is performed by estimating $t(x)$ and A_∞ separately or jointly. The other category is based on image enhancement paradigm, and is usually instances of local histogram equalization.

Recently, solutions using deep learning have been introduced. They belong to the first category. For instance Dehazenet [1] focuses in the estimation of t(x), and AOD [2] focuses of the joint estimation of $t(x)$ and A_∞. Two limitations can be observed: 1-the Koschmieder model seems to have a limited validity for heavy amount of haze (See Jessica El Khoury PhD [3]), 2-Networks are trained on simulated material based on the Koschmieder model, which impacts generalization capabilities and thus may limit performance levels on real data. We perform a quantitative analysis of the first point and compare Dehazenet with the state of the art on the CHIC benchmark database [4].

Evaluation

The CHIC database contains color images of the same scene seen through different levels of haze. We applied dehazing state-of-the-art methods, DCP [5], FAST [6], CLAHE [7] and Dehazenet, on different level of haze. We then compute a selection of metrics for dehazing evaluation [8], which mostly indicates how well edges are recovered or enhanced (e, r, FADE and VSI). We perform a color analysis of the results based on a color checker, which indicates how well color are recovered (similar to [9]). We investigate also how well dehazenet estimates the parameters of the Koschmieder model ($t(x)$).Note that A_∞ is measured on the dataset and given evenly to all the algorithms.

Conclusion

Deep learning to invert the Koschmieder model is efficient, but still faces limitation of this model. This approach may generate an optimal inversion, but more investigations are required to create a breakthrough in performance.

References

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