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MANIPAL
(A constituent unit of MAHE, Manipal)

DEPARTMENT OF MECHATRONICS ENGINEERING

TITLE OF THE PROJECT

Image Dehazing

Synopsis

Submitted by

STUDENT NAME	REG. NO.	E-MAIL ID	CONTACT NO.
Abu Bakr Siddiq	170929098	abu.bakr@learner.manipal.edu	8494945140
Razeem Akthar	170929194	razeem.p@learner.manipal.edu	9739230355

Under the guidance of
NAME OF THE GUIDE: Munendra Singh
Designation: Assistant Professor
Department of Mechatronics Engineering
MANIPAL INSTITUTE OF TECHNOLOGY, MANIPAL

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1. Introduction

Image quality is of prime importance for many applications, but lot of factors contribute to make a image among which one of the keys is contrast. The project aims to understand the process of hazing through atmosphere scattering model, study dehazing algorithms, evaluate performance of different algorithms and propose an original architecture which would provide good and fast performance outdoors.

Hazing is caused due to when impurities in air lead to loss of clarity in image formed. The process can be understood through the atmosphere scattering model which describes the formation of hazy images considering factors such as transmission map, scene radiance etc. The are many approaches taken to solve the image hazing problem, such as polarization, contrast enhancement, Dark channel prior etc., but our focus will be to solve the problem using deep learning method.

2. Literature Review

The first step to take in training any deep learning model is to find a good dataset, for this purpose we went through many datasets and singled out the RESIDE dataset discussed in [1]. Since we choose to concentrate on outdoor dehazing this dataset provides us with ample training set images (around 300,000). [1] discusses the atmospheric scattering model for single image dehazing, since it is difficult to provide ground truths and the hazy image sample as the same scene cannot be captured with and without haze the paper relies on synthetic hazing. The paper also explains about the absence of a reference image in quantifying the output dehazed image. The paper further goes on to discuss the performance comparison of various dehazing algorithms such as Dark channel prior, DehazeNet, All in one dehazing network etc.

The second step in solving the dehazing problem is to find suitable metrics to evaluate the quality of dehazed image. Since there is absence of reference image, we opt for reference less image quality evaluation metrics. For this purpose, we studied [2]. [2] is based on natural scene statistic (NSS), it involves local mean subtraction and contrast normalization (MSCN). There are total of 12 fog aware features which are calculated on a pXp partition of the image, then the features are aggregated and a multivariate gaussian (MVG) of the features is then calculated. The distance between this MVG and the MVG calculated on fog free images gives the quality of image.

As a part of our study we went through different SOTA architectures and shortlisted 4 based on the performance (from site www.paperswithcode.com) we choose paper that had good performance and had some novel concepts incorporated in them. Below we have discussed 4 different architectures.

[3] proposes an end-to-end gated context aggregation network GCANet for image dehazing, in which the smoothed dilated convolution is used to avoid the gridding artifacts and a gated subnetwork to fuse the features of different levels. [3] uses a gated fusion sub network which helped it fuse high level features. The paper uses 3 conv. blocks followed by smoothed dilation resBlocks then a deCov block to convert features into images and lastly some more conv. Blocks. The network in [3] obtains a better performance in terms of PSNR and SSIM in comparison with DCP, DehazeNet and AOD-Net.

[4] proposes a end-to-end feature fusion attention network. [4] surpasses all the previous methods by a very high margin. It supersedes the previous algorithm with its powerful advantage of superior result in thick haze region. Includes a FA module which mixes both channel attention and pixel attention mechanism which helps it focus more on thick haze part . Local residual learning and feature attention (FA) each has a separate block which helps the model to process the image in the thin haze region through many skip connection. Attention-based feature fusion (FFA) structure, it can process thin hazed region with by running it through multiple deep layers which helps it outperform every other feature fusion method.

[5] uses FRIDA and D-HAZY datasets. The contributions are CycleGAN architecture for single image dehazing via adding cyclic perceptual consistency loss besides cycle-consistency loss, the index is a non-reference image index which does not need the ground truth image, the model benefits from Laplacian pyramid, the model is a generalized model so it can be used for various scenarios. [5] uses an L1 loss function. Uses Laplacian upscaling to create high quality dehazed image. They implemented data augmentation for more accurate result.

[6] implements a pyramid convolution which dehazes in multiple layers of scales. [6] Uses a UNet block which extract new and complex features from the input image without the loss of any local or global information.[6] It uses end-to-end deep learning method which makes it as a generalized model resulting it to be more versatile comparing to other model. The whole of the algorithm is an extensive experimentation. It uses a combination of MSE (L2 loss), adversarial loss, content loss, and structural similarity loss LSSIM. Although the iterative UNet block which gives global and local information, output information for different sized objects is not reflected in the global and local structural. To overcome this issue, we have used a novel pyramid convolution technique. Earlier pyramid pooling has been used in to leverage the global structural information.

For further inspiration we looked at [7] which implements a Cyclic-DesmokeGAN to aid in laparoscopic surgery. Since dehazing and desmoking are both quite similar processes the architecture proposed in relies on the power of multi-Scale residual blocks. [7] considers a weighted loss function which is a combination of adversarial, cycle-consistency, contrast and unsharp regularization loss. In the evaluation step the paper considers Contrast-Distorted Images

Quality (CEIQ), Naturalness Image Quality Evaluator (NIQE) and Fog aware density evaluator (FADE). We hope to use some of the same metrics in our work.

3. Problem Definition

Air pollution has resulted in increase of particulate matter in air which have caused serious visibility problems in cities like Delhi, what we hope to achieve through this project is provide a novel dehazing model to increase visibility in such conditions. Visibility is a key factor in many applications, but the problem of driving was the one that he really looked at closely. The reduced visibility presents a big problem to drivers, and in recent time there has been a upward trend in number of accidents.

Our main emphasis is to make the model capable of good real time performance so that it can be incorporated into a smart lens kind of device that can enhance visibility. The dehazing algorithm can also be used in the image perception pipeline of autonomous cars thereby improving its performance in bad weather conditions.

4. Objectives

- To compare various SOTA dehazing algorithms and compare them using common performance metrics.
- To develop an original architecture incorporating the learnings of the compared algorithms.
- Extend the application of the model from single image dehazing to sequence of image dehazing (Video dehazing).
- Analyse different areas of application for the algorithm and suggest the most suitable area of use.
- To present the new architecture, and a suitable metric as a research article.

5. Methodology

- Methodology may be design approach, analysis technique, reference for validation, standards followed for experimental works, details of fabrication etc.

- The current standard for image dehazing is studied and the algorithms are implemented using Python programming language, using deep learning frameworks such as TensorFlow and PyTorch.
- The algorithms are modified so that they output a common metric such as FADE (Fog Aware Density Evaluator) and compared.

- The learning from the present SOTA algorithms are put in developing a new architecture.
- The new model is trained on datasets such as RESIDE, and evaluated on a weighted metric which is a combination of metrics like Fog aware density evaluator, Naturalness Image Quality Evaluator etc.

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Name of the Guide with contact details and email address:

Munendra Singh
9634398499
Munendra.singh@manipal.edu

Date of commencement of the project: 23/01/2021

Signature of Guide