Estimating Depth and Global Atmospheric Light for Image Dehazing Using Type-2 Fuzzy Approach

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Introduction and Motivation

- **Problem Statement**: Haze affects image quality in outdoor vision-based algorithms, reducing clarity due to light scattering.
- **Importance**: Clear images enhance performance in vision-based tasks.
- **Existing Solutions**: Multiple image vs. single image dehazing, with single image dehazing gaining popularity for real-time applications.
- The observed hazy image is formed with the combination of attenuation and airlight

$$O_H(m, n) = O_1(m, n) + O_2(m, n)$$

- where, $O_1(m, n)$ and $O_2(m, n)$ represent attenuation and airlight, respectively. These are defined as

$$O_1(m, n) = O_J(m, n)T(m, n)$$

$$O_2(m, n) = L(1 - T(m, n))$$

Motivation

- We need to estimate T(m,n) which can be done from following equation

$$T(m, n) = \exp(-\beta \times D(m, n))$$

- So, now we need to estimate D(m,n) and L which can be estimated using DCP method and then using previous equation we can obtain dehazed image.

Proposed Methodology

- Initial estimate of Depth Map is Minimum channel, as the farthest pixels get more affected in presence of haze as compared to the nearest pixels.
- Then we consider a local path of size k x k for each pixel locations.
- For each patch h-middle means are calculated, using this similarity with each element of patch is calculated using gaussian similarity function.
- We create Type-2 MF based similarity function matrix of size h by k using h middle means and each location of patch.
- To get Depth Map for a pixel, we take weighted average of each patch location which is averaged over h-middle means.
- And we can simply obtain Transmission map from Depth map.
- Then L is estimated using the similarity function matrix by taking minimum of all for a patch and mean over all pixels.

Proposed Algorithm

We can obtain final enhanced image using the following equation.

$$O_H^{enh}(m,n) = \frac{O_H(m,n) - L}{T(m,n)} + L$$

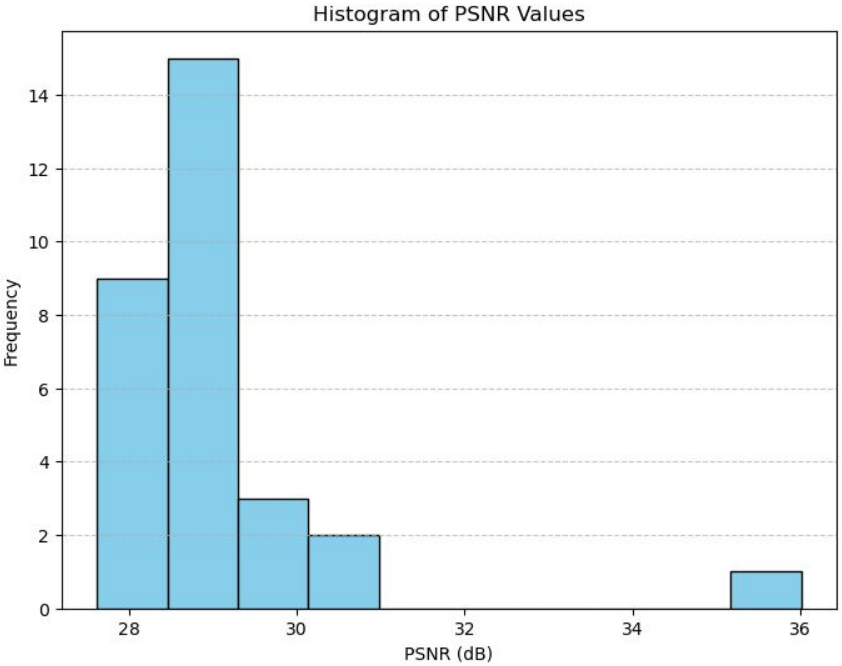
Algorithm 1: Proposed Method for Single Image Dehazing.

Patch Size (Input): $k = 9 \Rightarrow \sqrt{k} \times \sqrt{k} = 3 \times 3$
Min Channel: $O_H^{min}(m,n) = \min_{\tau \in \{\mathrm{R,G,B}\}} O_H^{\tau}(m,n)$
for $O_H^{min}(i,j)$ **do**
  $\Omega_k(i,j) = \{O_H^{min}(i+u, j+v)\} \, \forall u, v \in [-F_{HW}, F_{HW}]$
  Similarity Function Matrix: $\eta_k^h(i,j) = f(\Omega_k, H^h)$
  MF Value: $\eta_k'(i,j)$ by (15)
  Depth map: $D(i,j)$ by (17)
  Scene transmission: $T(i,j)$ by (18)
end for
Global Atmospheric Light: L by (21)
Dehazed Image: $O_H^{enh}(m,n)$ by (22)

Experimental Results and Validation

- **Dataset used** : REalistic Single Image DEhazing (RESIDE)
- To measure Qualitative performance metrics used is Peak Signal to Noise Ratio(PSNR)
- Performed proposed algorithm on 30 images from RESIDE dataset

Experimental Results and Validation



As we can see that most of the dehazed images have 28 to 30 PSNR value which is a good sign means it’s been dehazed as expected and we can also see that some of images have approx 36 PSNR means these images are dehazed almost it’s becomes clear images

Experimental Results and Validation

Hazy Images

Dehazed Images

some images of hazed and dehazed one after applying our algorithm.