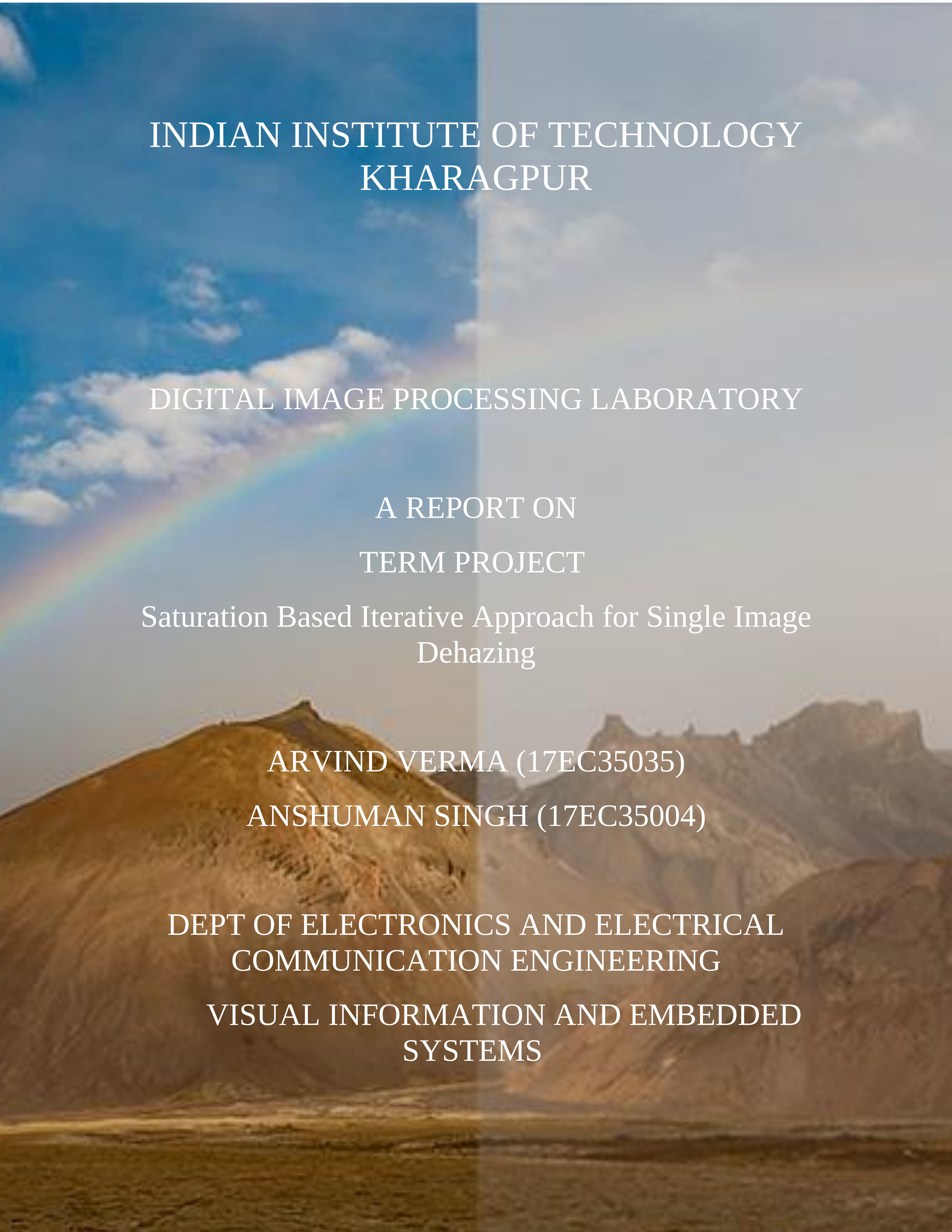

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

DIGITAL IMAGE PROCESSING LABORATORY

A REPORT ON

TERM PROJECT

Saturation Based Iterative Approach for Single Image Dehazing

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Abstract

Image Dehazing

Pictures caught in dim or hazy climate conditions can be genuinely debased by dispersing of environmental particles, which decreases the differentiation, changes the tone, and makes the article highlights hard to recognize by human vision and by some outside PC vision frameworks. Therefore, image dehazing is an important issue and has been widely researched in the field of computer vision. The part of picture dehazing is to eliminate the impact of climate factors to improve the special visualizations of the picture and give advantage to post-handling.

Theory

Under bad climate conditions, like fog and haze, the nature of pictures corrupts seriously because of the impact of particles in the environment. Suspended particles will dissipate light and result in weakening of mirrored light from the scene and the dispersed environmental light will likewise blend in with the light got by the camera and change the picture differentiation and shading.

Accordingly, it is fundamental for computer vision frameworks to improve the enhanced visualizations of the picture and feature picture highlights. Picture dehazing strategy, otherwise called "haze removal" or "defogging" is only the method to lessen or even eliminate obstruction because of haze by uncommon methodologies, to get good enhanced visualizations and acquire more helpful data. In principle, image dehazing eliminates undesirable visual impacts and is regularly considered as an image enhancement strategy. Notwithstanding, it varies from conventional noise removal and contrast enhancement strategies since the debasement to image pixels that is initiated by the presence of haze relies upon the distance between the article and the securing gadget and the local thickness of the haze. The impact of haze on image pixels additionally smothers the dynamic scope of the tones.

- Classification of dehazing algorithms

In view of contrasts in dehazing standards, current techniques can be isolated into three classes: image enhancement-based strategies, image combination-based techniques and image restoration-based strategies. Image enhancement-based strategies don't consider the reason for the image degradation, yet predominantly utilize focused on image handling techniques to improve the contrast and subtleties, and improve the visual impacts of the image. Image combination-based techniques boost the valuable data from numerous source channels to at long last frame a great image, without requiring an actual model. Image restoration-based strategies build up a hazy image degradation model by considering the actual instruments of optical imaging, upset the degradation measures and make up for distortion brought about by these degradation measures to acquire clear images without haze.

In 2008, Tan proposed an effective image dehazing method based on two prior conditions. The second condition is that the attenuation of field spots is a continuous function of distance which should be smooth.

For the most part, the dark channel earlier based technique is as a rule viewed as outstanding amongst other haze evacuation approaches for its straightforwardness and adequacy. By and by, notwithstanding, it has a few inborn challenges. For instance, as called attention to in, dark channel earlier consistently under-gauges the transmission when an object has comparable Gray intensity as the air light which thus causes the situation brilliance over-saturated and unnatural.

Algorithm

Algorithm is divided into the following segments

Input: The Hazy image $I(x)$

Initiation: $k = 0; I_0 = I(x)$

Calculate the following:

- $S_0(x) \ = 1 - \frac{\min_{c\in\{r,g,b\}} I^c(x)}{\max_{c\in\{r,g,b\}} I^c(x)} = 1 - \frac{I_{c,min}(x)}{I_{c,max}(x)}$
- $\beta = 0.1 \ \ and \ \ \alpha = \begin{cases} 0.7 & \text{avg}\big(S_0(x)\big) > 0.1 \\ 0.5 & \text{otherwise} \end{cases}$
- $\varepsilon = \begin{cases} 1.2 & \text{avg}\ (S_0(x)) < 0.1 \\ 0.3 & \text{otherwise} \end{cases}$

Repeat

1. Calculate the saturation $\tilde{S}_k(x)$ via the equation: $\tilde{S} \ = min(S^a(x) + \beta, 1)$ and the coarse transmission via the equation: $\tilde{t}(x) = 1 - \big(1 - \tilde{S}\,(x)\big)\,V(x);$

2. Refine the coarse transmission using guided image filtering;

3. Calculate the atmospheric light;

4. Restore the scene radiance $J(x)$ via the equation:

$$J^c(x) = \frac{I^c(x) - A^c}{max(t(x), t_0)} + A^c, c \in \{r, g, b\};$$

5. $k = k + 1;\ I_k = J(x);\ \ \alpha = max(\alpha - 0.1, 0.5);$

6. Calculate the saturation S_k via the equation:

$$S_k(x) \ = 1 - \frac{\min_{c\in\{r,g,b\}} I^c(x)}{\max_{c\in\{r,g,b\}} I^c(x)} = 1 - \frac{I_{c,min}(x)}{I_{c,max}(x)};$$

Until Equation the following holds: $\left|\frac{\text{avg}(S_k(x))}{\text{avg}(S_0(x))} - 1\right| > \varepsilon$

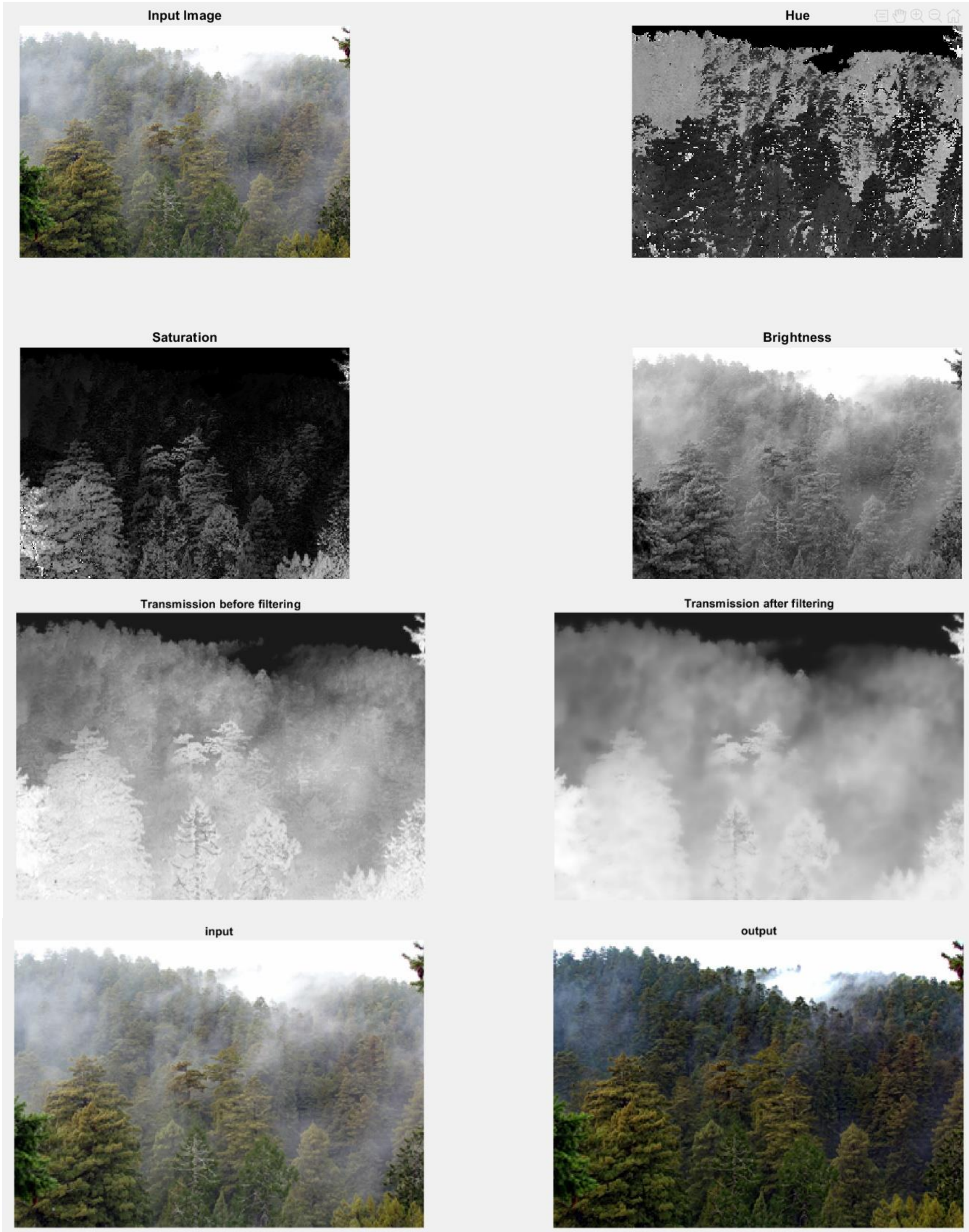
Output: Scene radiance $J(x)$.

Implementation tips

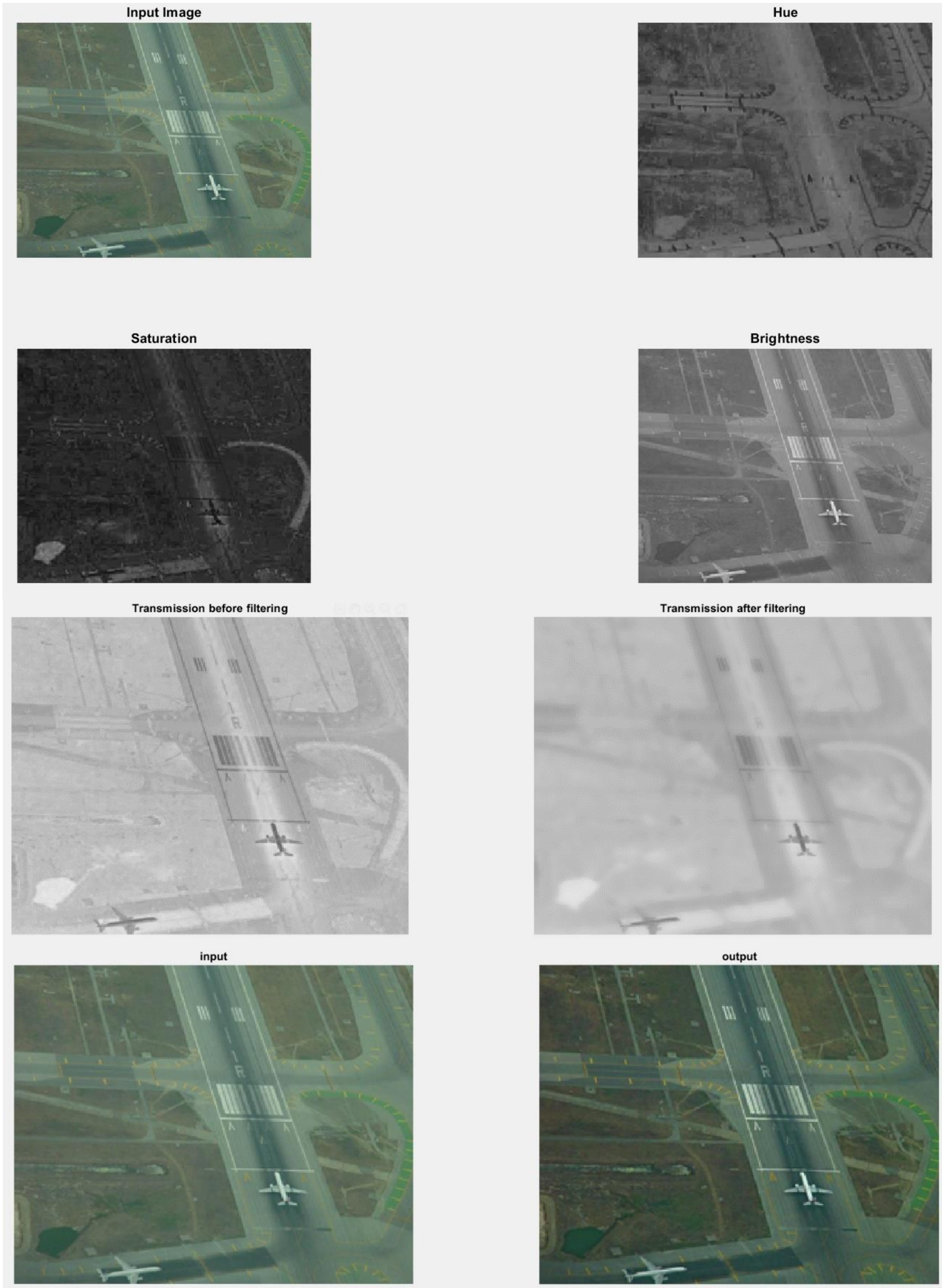
- The implementation of the above algorithm is done in the MATLAB to serve the purpose of avoiding complexities.
- One important feature of this implementation is that it doesn't require calculation of Dark Channel prior.
- For calculation of the Saturation & Brightness inbuilt function hsv2rgb is used.
- Although value of Beta (β) suggested is 0.1 but a lesser value gave better results.
- "im2double" is inbuilt function used to convert image from binary values to double is very handy.
- If size of the image very large than resizing it can reduce the calculation complexity and that part is already included but has been commented.
- For refinement of the coarse transmission inbuilt function "imguidedfilter" used under self-guidance, which means using coarse transmission itself as the guidance image. This filter used for edge-preserving smoothing of the input.

Results

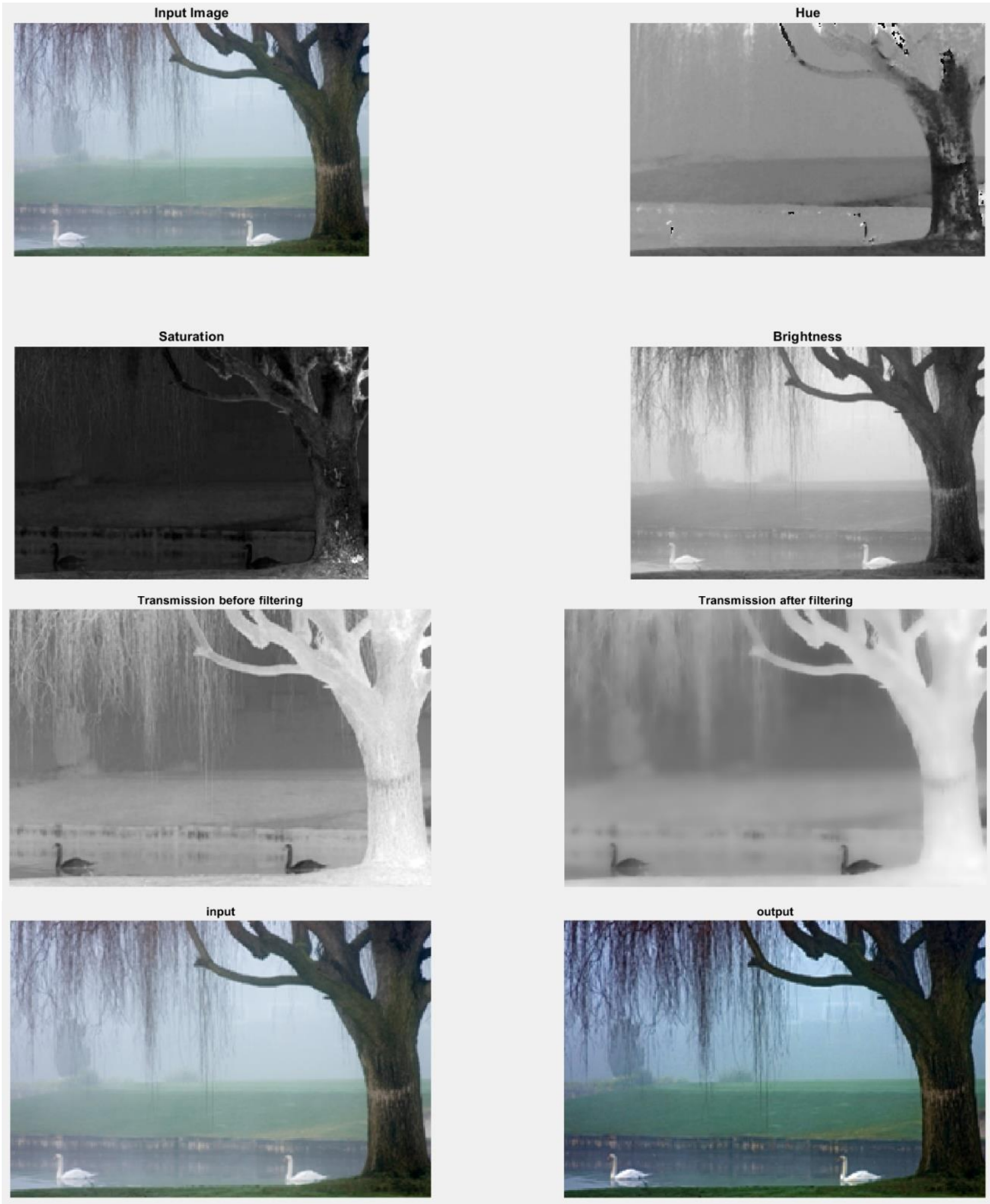
- Image of a foggy forest



- Image of a hazy Runway

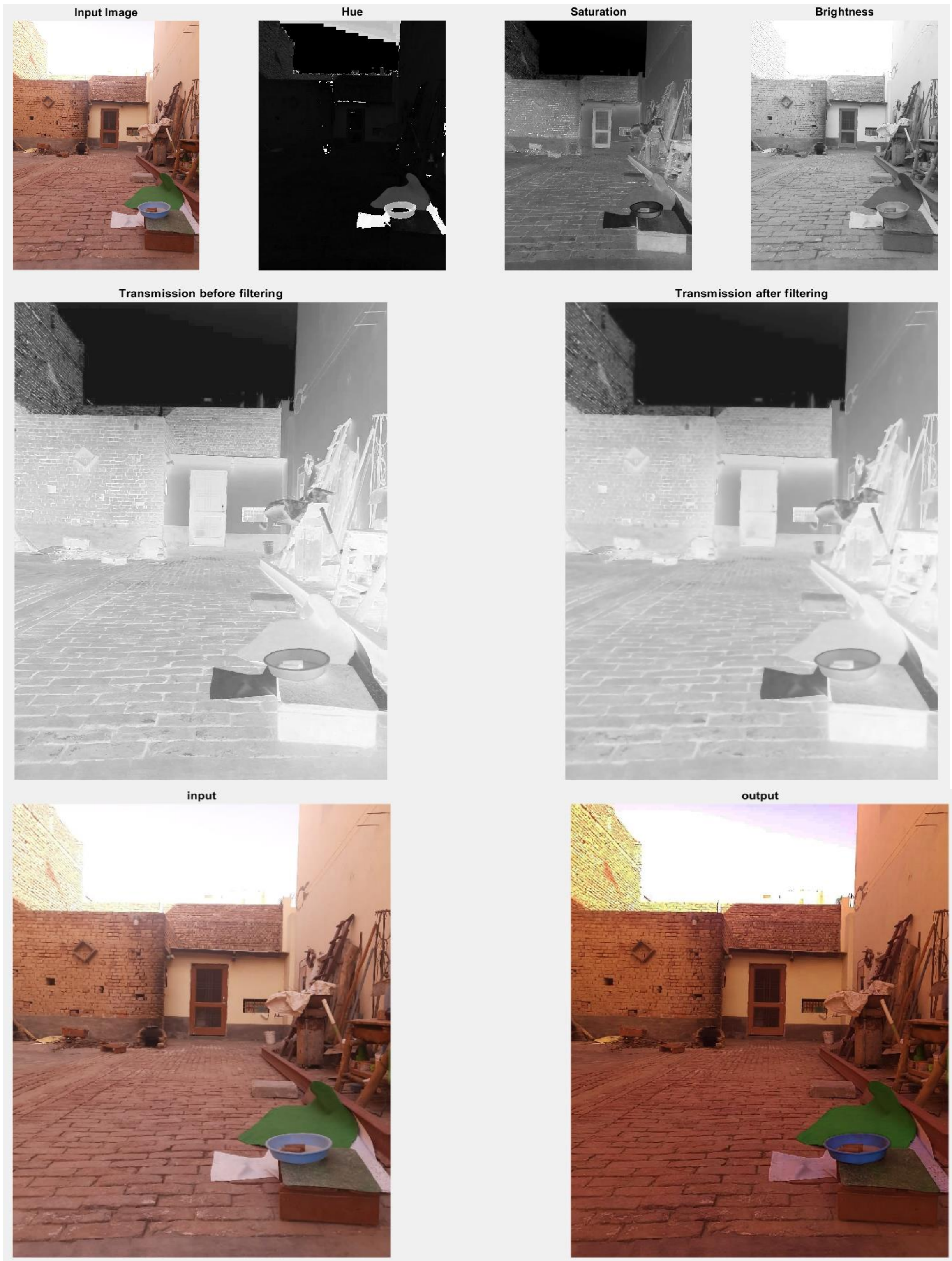


- Image of a lake with haze



- Image of a city with haze

- Image of a house **without haze**



Discussions:

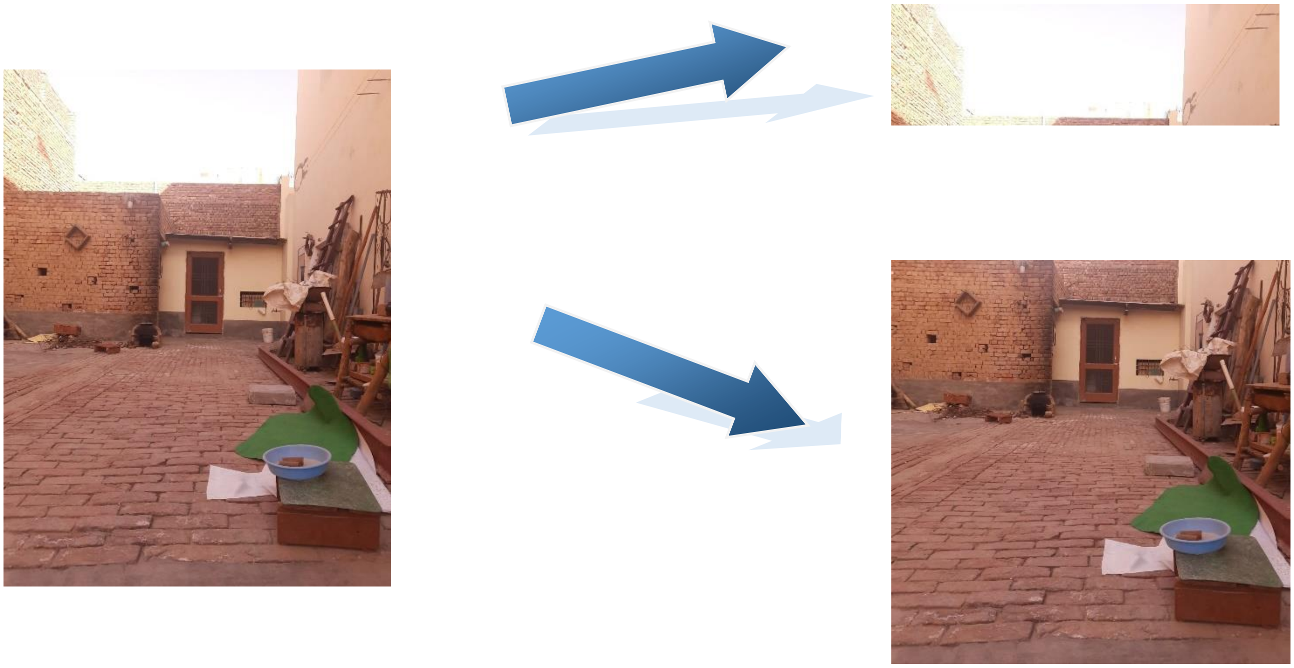
- Since it doesn't involve the calculation of Dark channel prior, it makes it easier to dehaze by altering Saturation and transmission coarse.
- It was observed that for all the images almost 1 iteration was required which makes it comparatively faster than other state of art algorithms.
- Since the transmission is not underestimated hence it requires a smaller number of iterations.
- The beta value was ineffective for our examples, as if reduced it to zero, still results were almost same. (Note we are talking about skipping the addition of beta while updating saturation, on the other hand higher value of beta would be destructive)
- Last example without haze is crucial, here we can see that the color of the output image looks poor than the original this is because atmospheric brightness is very different on sky and rest of the image. We here increased saturation although its not required. So, if we took a hazy image with too much change in atmospheric brightness than results will be poor.

Conclusions & Improvements:

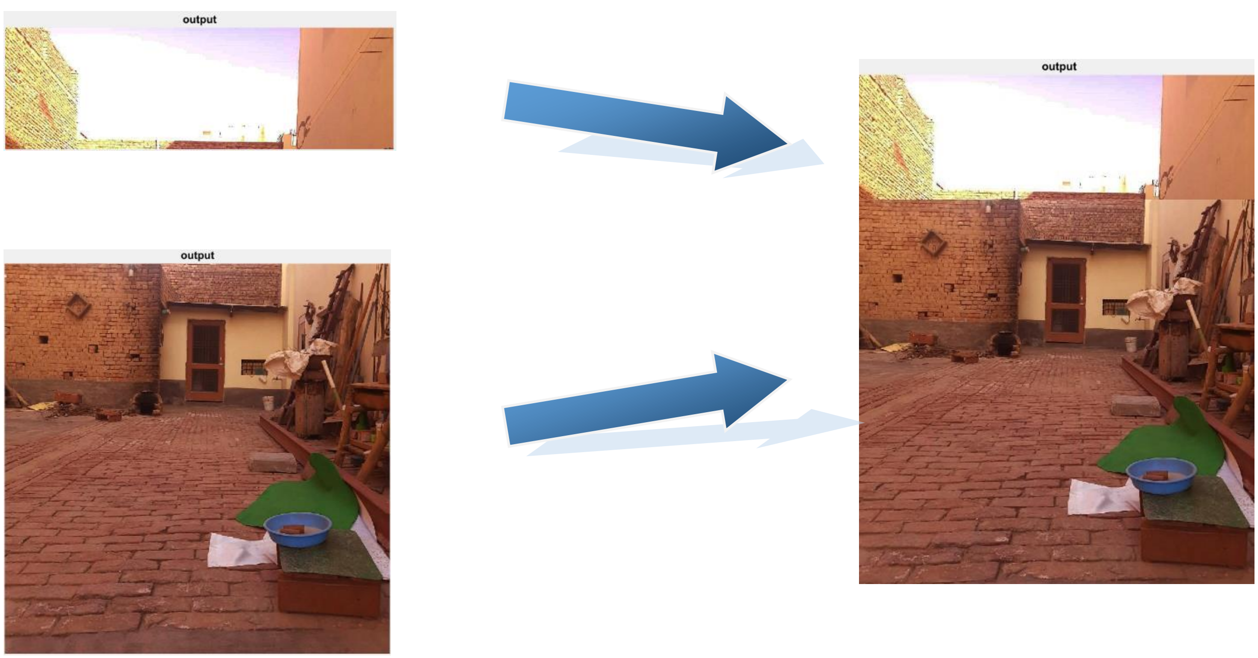
At last, it can be concluded that this algorithm fast, have less complexity in terms of calculations as well as memory than many other states of the art algorithms. The results are fairly good, works almost every time.

If we first segment the image and apply this algorithm to the individual segments and merge all the outputs together. Then the resultant image looks much better but there is a catch that after joining the segments, discontinuity can be seen if somehow it can be overcome then the results will be phenomenal.

Segmenting Original Image and dehazing:



Re-joining Segmented parts after dehaze operation:



Here are the results comparison of with and without segmentation.

Output without Segments	Output with Segments
	

References:

- Images are the curtesy of http://www.google.com
- Saturation Based Iterative Approach for Single Image Dehazing
  Zongwei Lu, Bangyuan Long and Shiqi Yang
  https://ieeexplore.ieee.org/document/9057708
- http://html.rhhz.net/ieee-jas/html/2017-3-410.htm

Contributions:

It here by stated that we both contributed equally in all parts and are not bounded by limiting ourselves to specific sections.

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Thank You

(very much for your assistance, guidance and support)