CUDA Based Fog Removal : Machine Vision For Automotive/Defence Applications

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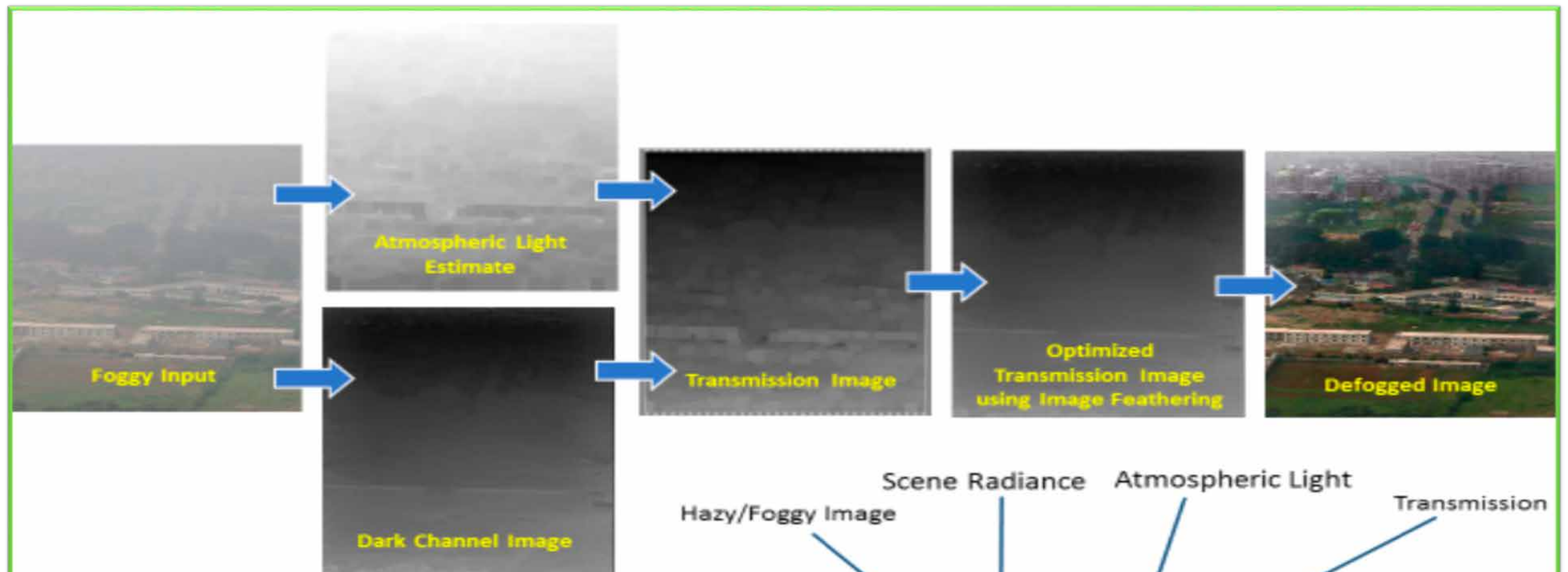
Introduction

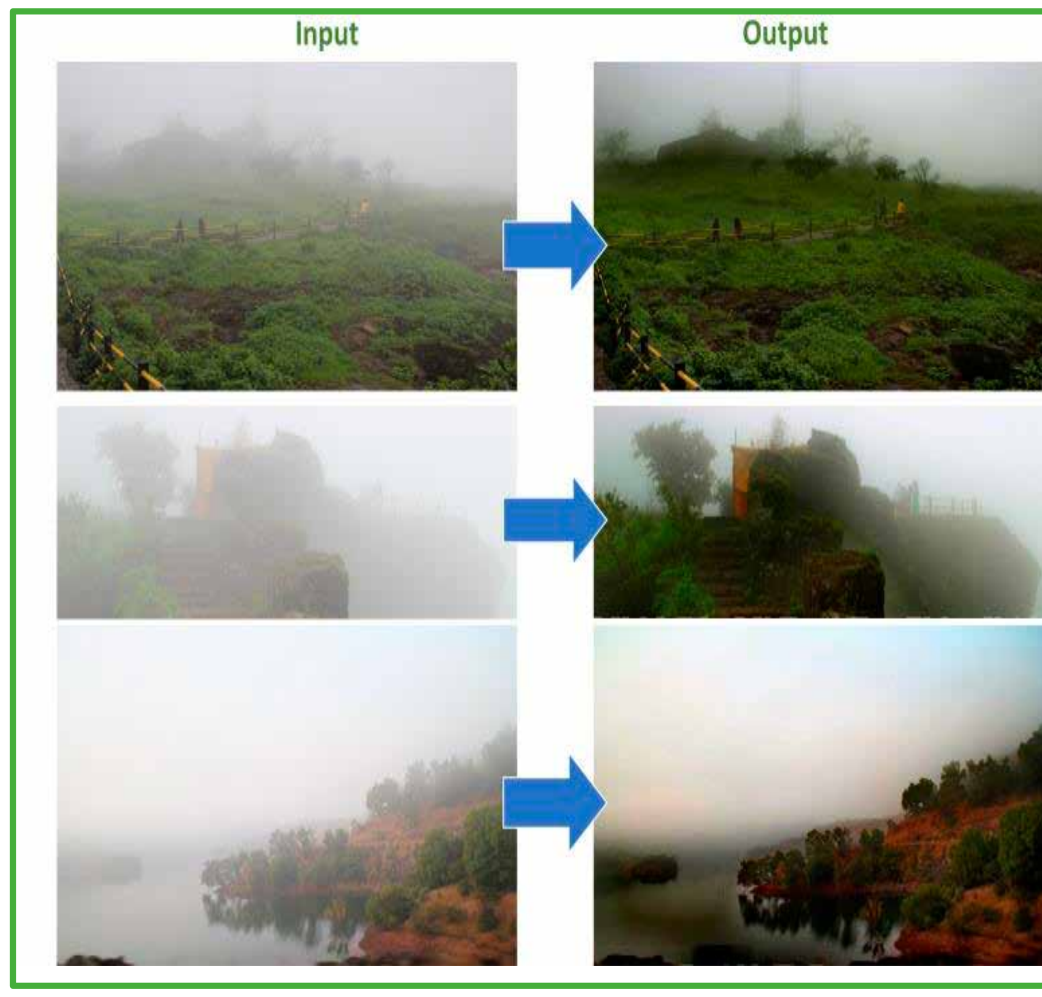
- The Proposed method describes the visibility enhancement of images captured in bad weather (Fog/Haze) conditions using Dark Channel Prior technique.
- It is computationally expensive(involves large number of floating operations).
- Highly Data Parallel algorithm.

Algorithm Overview



Haze Imaging Model : $\mathbf{I} = \mathbf{J} \cdot t + \mathbf{A} \cdot (1-t)$

Results



CUDA Optimized Functions

Dark Channel

- Min (rgb, local patch)
  - Min (r, g, b)
  - Min (local patch) = min filter

$$J^{dark} = \min_{\omega}(\min_{\omega} J^c)$$

- J^c : color channel of J
- J^{dark} : dark channel of J

- 180x speed up over CPU Implementation due to the low latency of the shared memory access.

Transmission Estimation

- **Compute dark channel :**

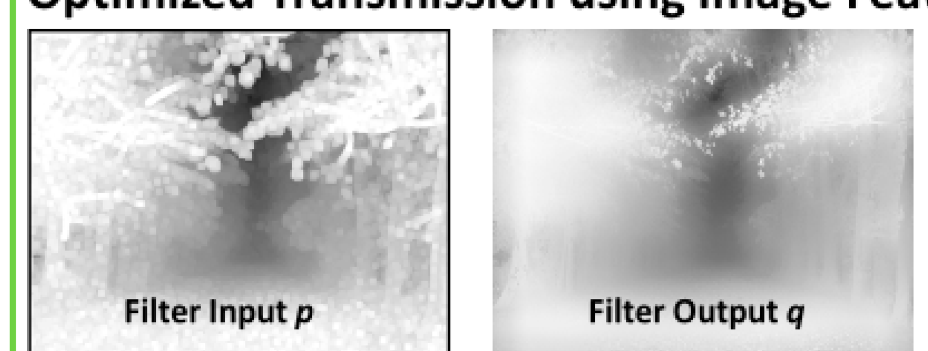
$$\min_{\omega}(\min_c \frac{I^c}{A^c}) = \boxed{\left\{\min_{\omega}(\min_c \frac{J^c}{A^c})\right\}} \cdot t + 1 - t$$

- **Estimate transmission:**

$$t = 1 - \min_{\omega}(\min_c \frac{I^c}{A^c})$$

- High speed floating operations per second of GPU provides almost **800+ x** speed up over CPU implementation .

Optimized Transmission using Image Feathering



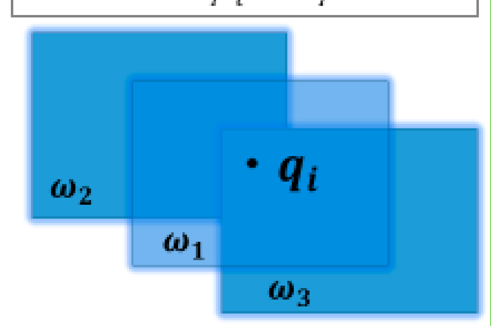
Definition

$$a_k = \frac{Cov_k(I,p)}{Var_k(I)+\varepsilon}$$

$$b_x = \bar{p}_k - a\,\bar{I}_k$$

$$q_i = \frac{1}{|\omega|} \sum_{k|i\varepsilon\omega_k} (a_k I_i + b_k)$$

$$= \bar{a}_i I_i + \bar{b}_i$$



- Extend to the entire Image
  - In all local windows ω_k , compute the linear coefficients
  - Compute the average of $a_k I_i + b_k$ in all ω_k that covers pixel q_i
- The use of Texture fetches for coalesced memory access provides **50x** speed up over CPU implementation.
- Scalable design to increase speed, accuracy and flexibility

Scene Radiance Image Construction

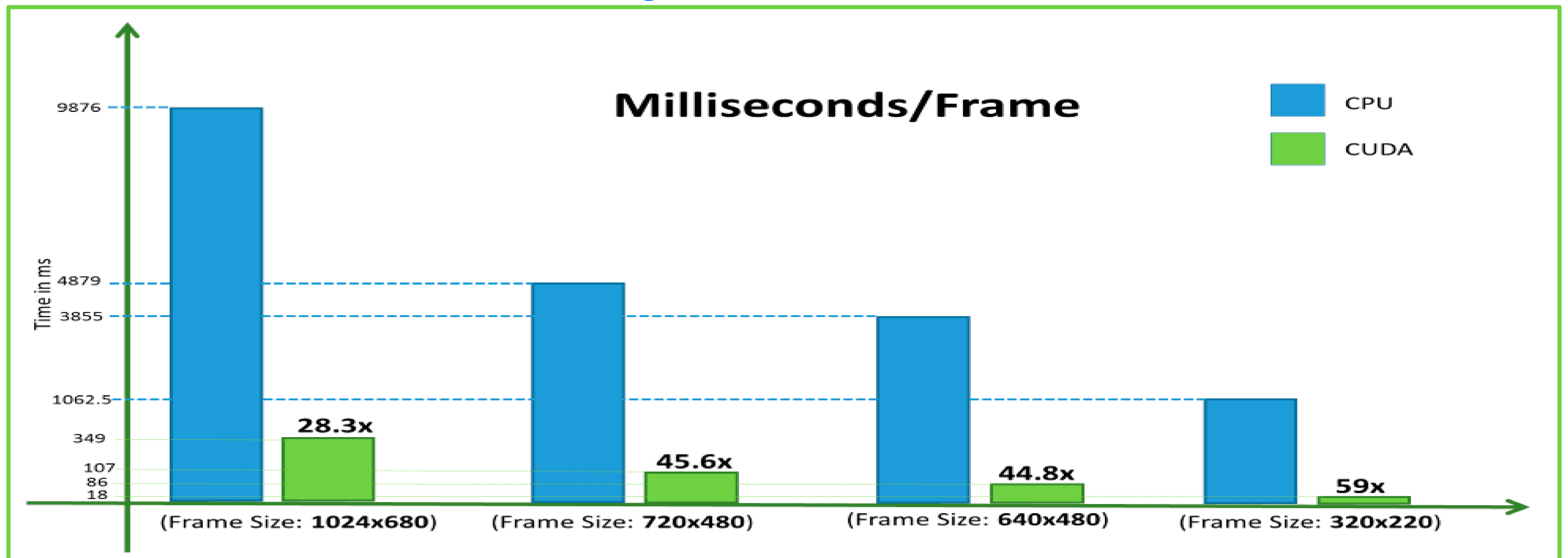
- The final scene radiance ***J(x)*** is recovered by:

$$J(x) = \frac{I(x) - A}{\max(t(x), t_0)} + A$$

t_0 : lower limit of the transmission in order to make J(x) noise free.

- Almost **850+ x** speed up over CPU Implementation due to fast floating point math operations of GPU.

Performance Analysis



References

[1] Kaiming He, Jian Sun, Xiaoou Tang, “Single Image Haze Removal Using Dark Channel Prior”, 978-1-4244-3991-1/09 ©2009 IEEE.

[2] Zhaohua Liu, Yuxia Yang, Jingyu Yang, “Single Aerial Image De-Hazing and Its Parallel Computing”, Journal of Surveying and Mapping Engineering Sep.2013, Vol.1 Iss. 2, PP.33-40.

[3] NVIDIA Corporation, CUDA 5.0 for Windows CUDA 5.0 Programming Guide.

[4] Kaiming He, Jian Sun, and Xiaoou Tang, “Guided Image Filtering”, European Conference on Computer Vision (ECCV) 2010.