AJEENKYA
D Y PATIL UNIVERSITY | THE INNOVATION UNIVERSITY

Leveraging AI for Enhanced Image Clarity

Name: Ankit Kumar

Program: BCA-CT

URN No.:2022-B-09092004A

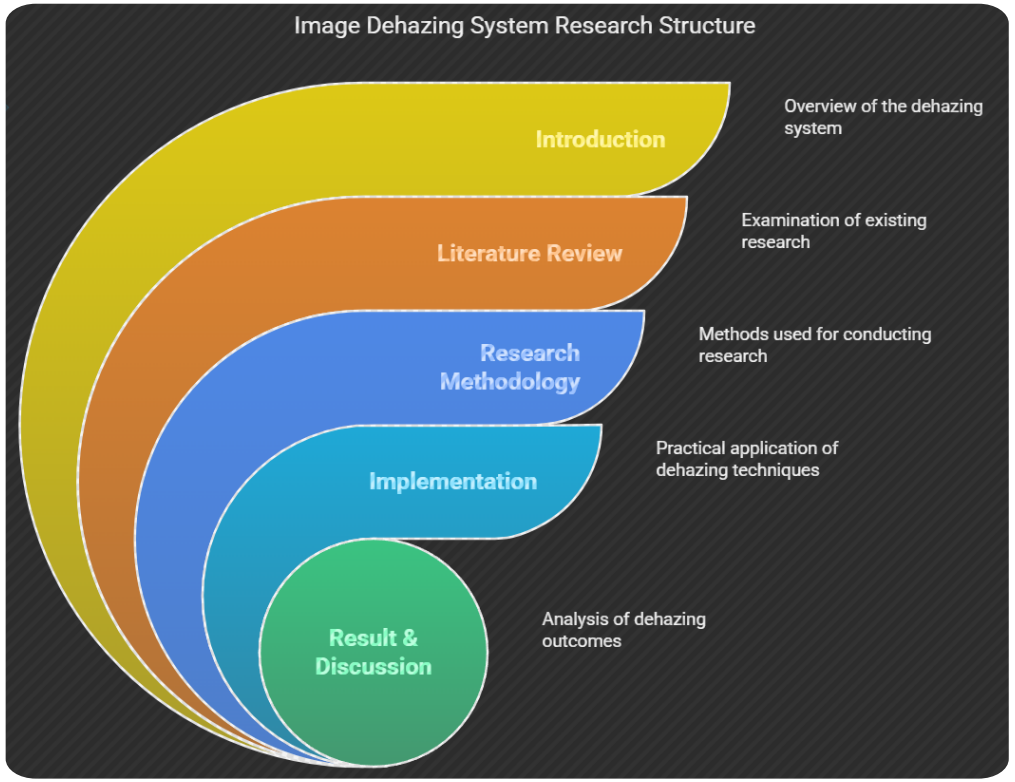
Name: Aman Kumar

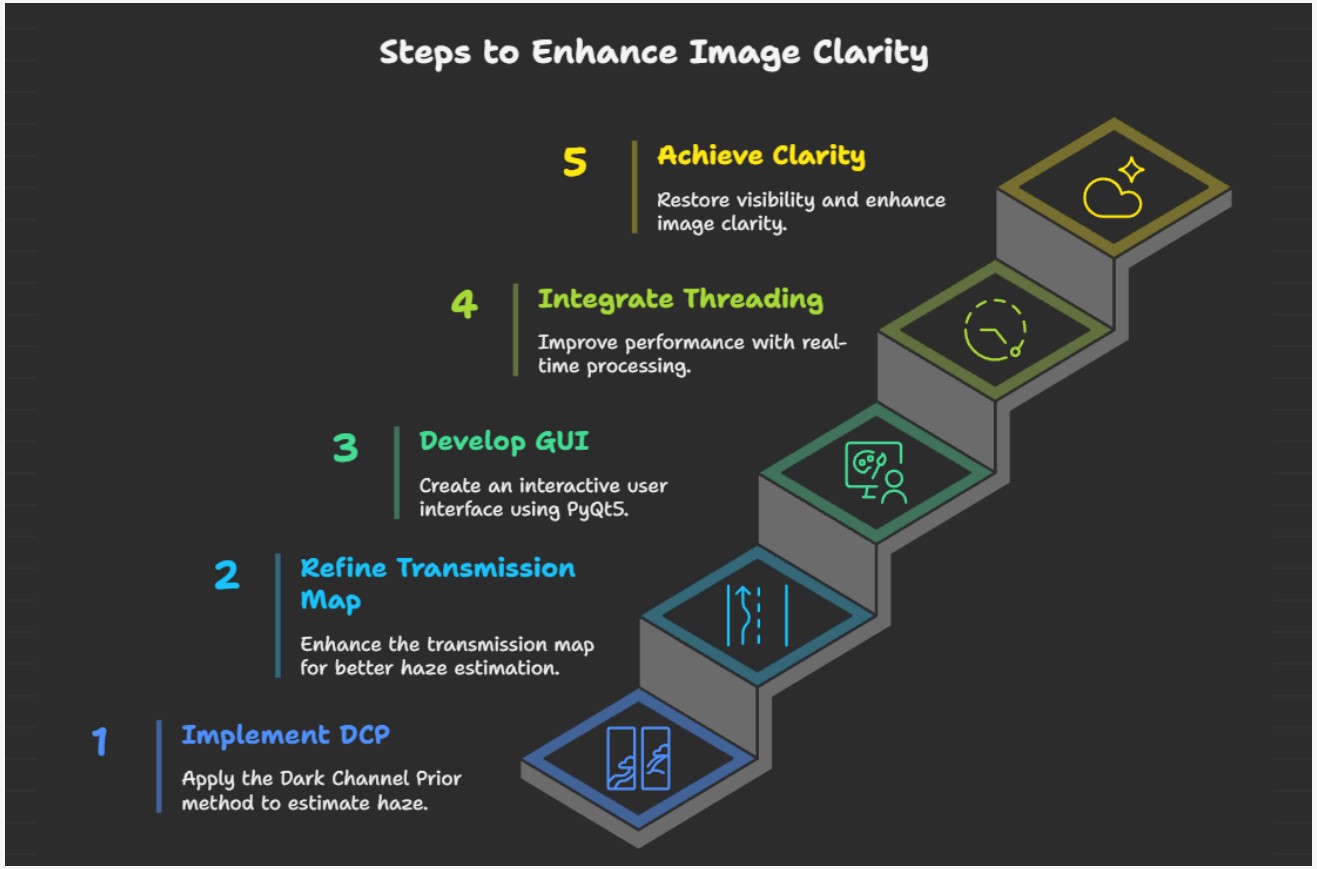
Program: BCA-CT

URN No.:2022-B-09092004B

Guide Name: Prof. Indu Kumari Singh

Table of Content



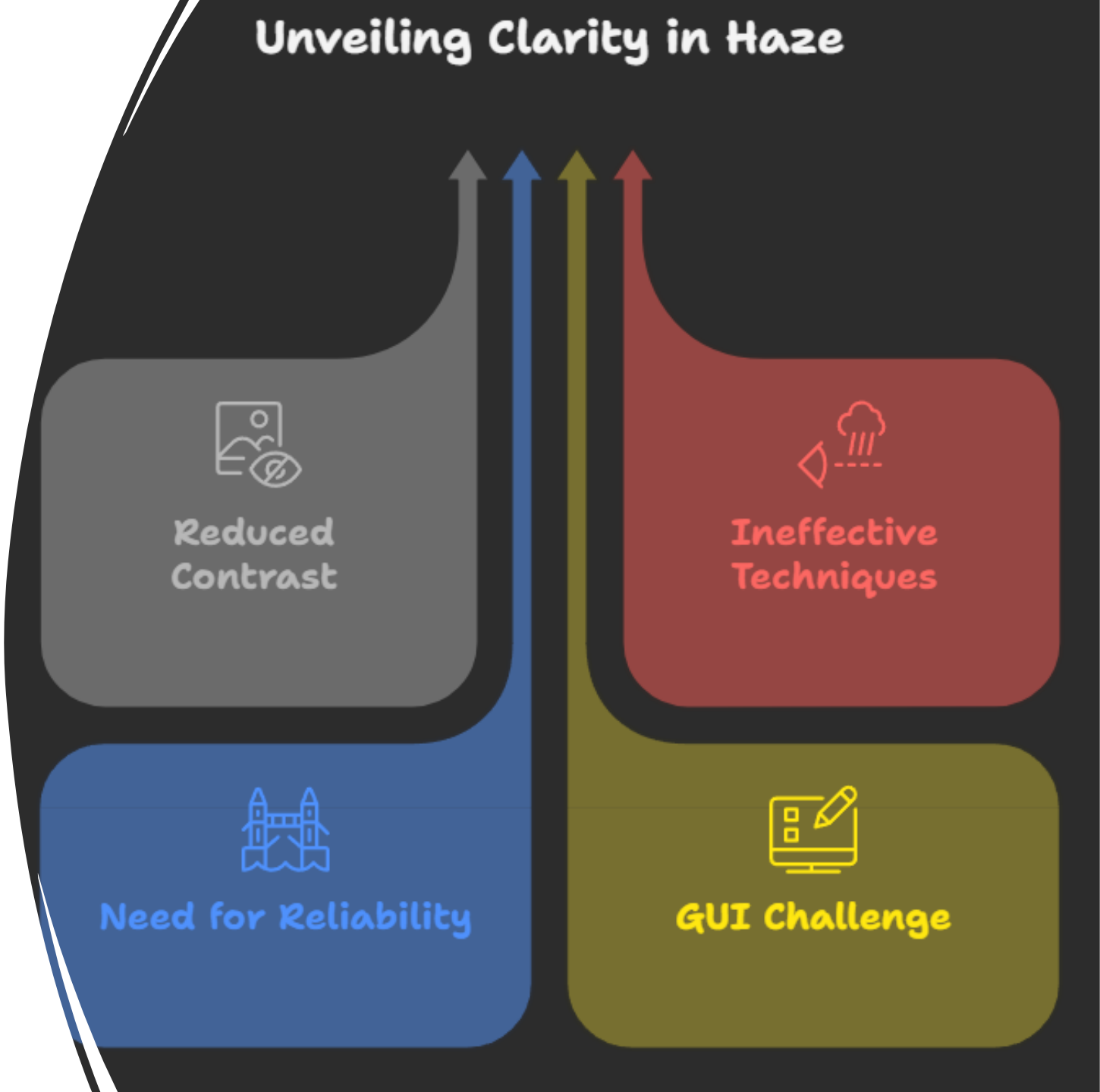


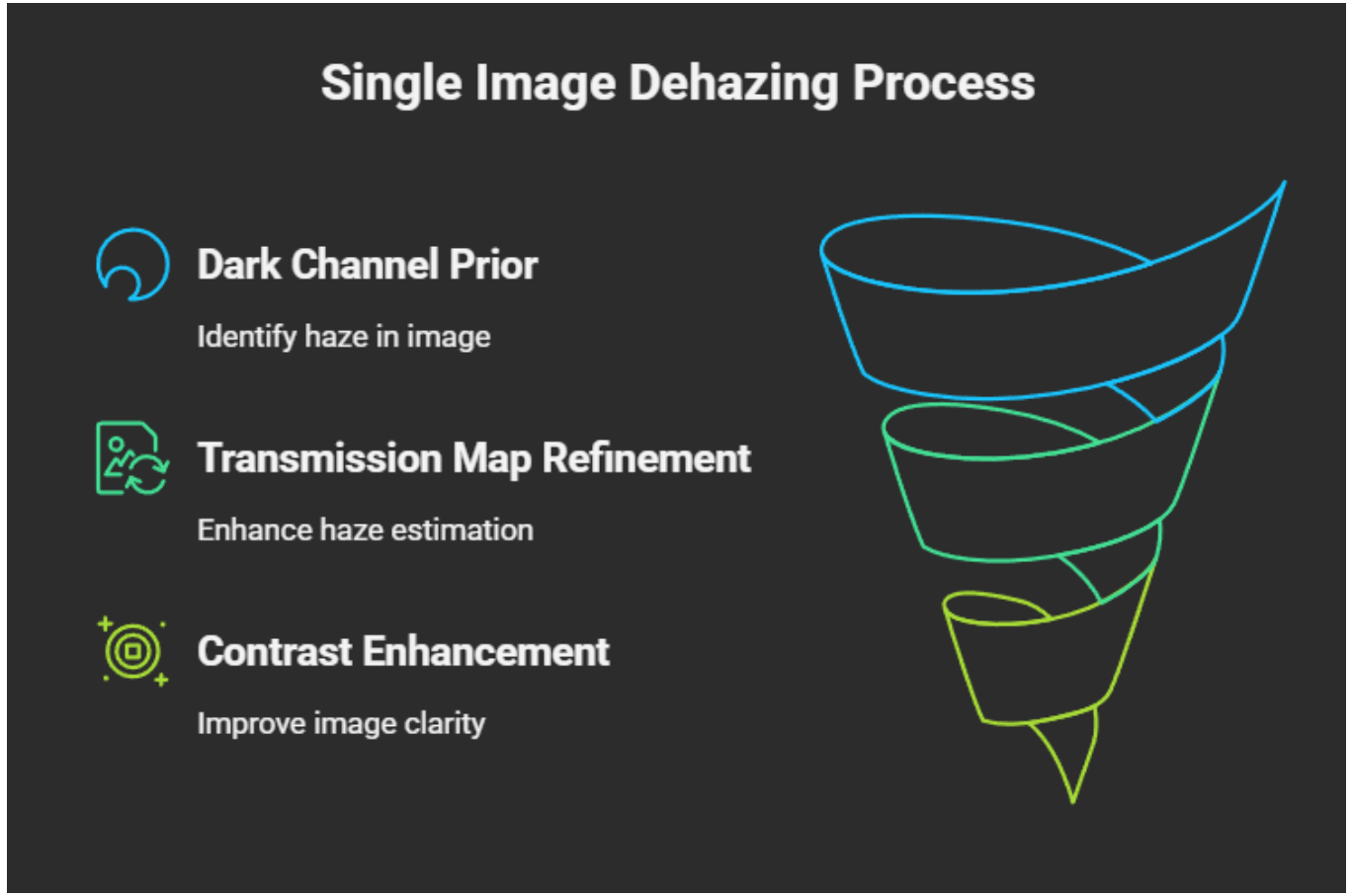
Introduction

- The project implements an image dehazing tool using the Dark Channel Prior (DCP) method, enhanced with contrast and transmission map refinement.
- It uses PyQt5 for GUI development to provide an interactive experience for users.
- The main aim is to restore visibility and enhance clarity in hazy or foggy images.
- Real-time performance and usability improvements are integrated through threaded processing.

Problem Statement

- Hazy images suffer from reduced contrast and poor visibility due to atmospheric particles.
- Traditional image enhancement techniques fail to recover lost details effectively in these conditions.
- There's a need for a reliable and interactive system to remove haze and restore image quality.
- The challenge lies in implementing an efficient algorithm within a user-friendly GUI framework.





Literature Review

- The Dark Channel Prior (DCP) is a widely used approach for single image dehazing proposed by Kaiming He.

- Techniques like Guided Filtering are employed to refine transmission maps for more realistic dehazing.

- Adaptive Histogram Equalization is used in prior studies to enhance contrast in dehazed images.

- Existing dehazing tools often lack interactivity or require high computational resources.

1. Dark Channel Computation

Formula:

$$D(x) = \min_{y \in \Omega(x)} \left(\min_{c \in \{r,g,b\}} I^c(y) \right)$$

Explanation:

- $D(x)$ is the dark channel value at pixel x
- $I^c(y)$ is the pixel intensity of channel c in a local patch $\Omega(x)$
- Implemented using erosion (`cv2.erode`) on the minimum channel of the image

2. Transmission Map Estimation

Formula:

$$t(x) = 1 - \omega \cdot D\left(\frac{I(x)}{A}\right)$$

Explanation:

- $t(x)$ is the transmission map at pixel x
- ω is a constant (typically 0.95)
- A is the atmospheric light
- D is the dark channel of the normalized image $\frac{I(x)}{A}$

4. Image Recovery (Dehazing)

Formula:

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

Explanation:

- $J(x)$: recovered scene radiance (dehazed image)
- $I(x)$: observed hazy image
- t_0: lower bound on transmission (e.g., 0.1 to avoid division by zero)

3. Guided Filter (Refinement of Transmission Map)

Key Equations:

- Linear model:

$$q = a \cdot I + b$$

- Coefficients:

$$a = \frac{\text{Cov}_{I,p}}{\text{Var}_I + \epsilon}$$

$$b = \mu_p - a \cdot \mu_I$$

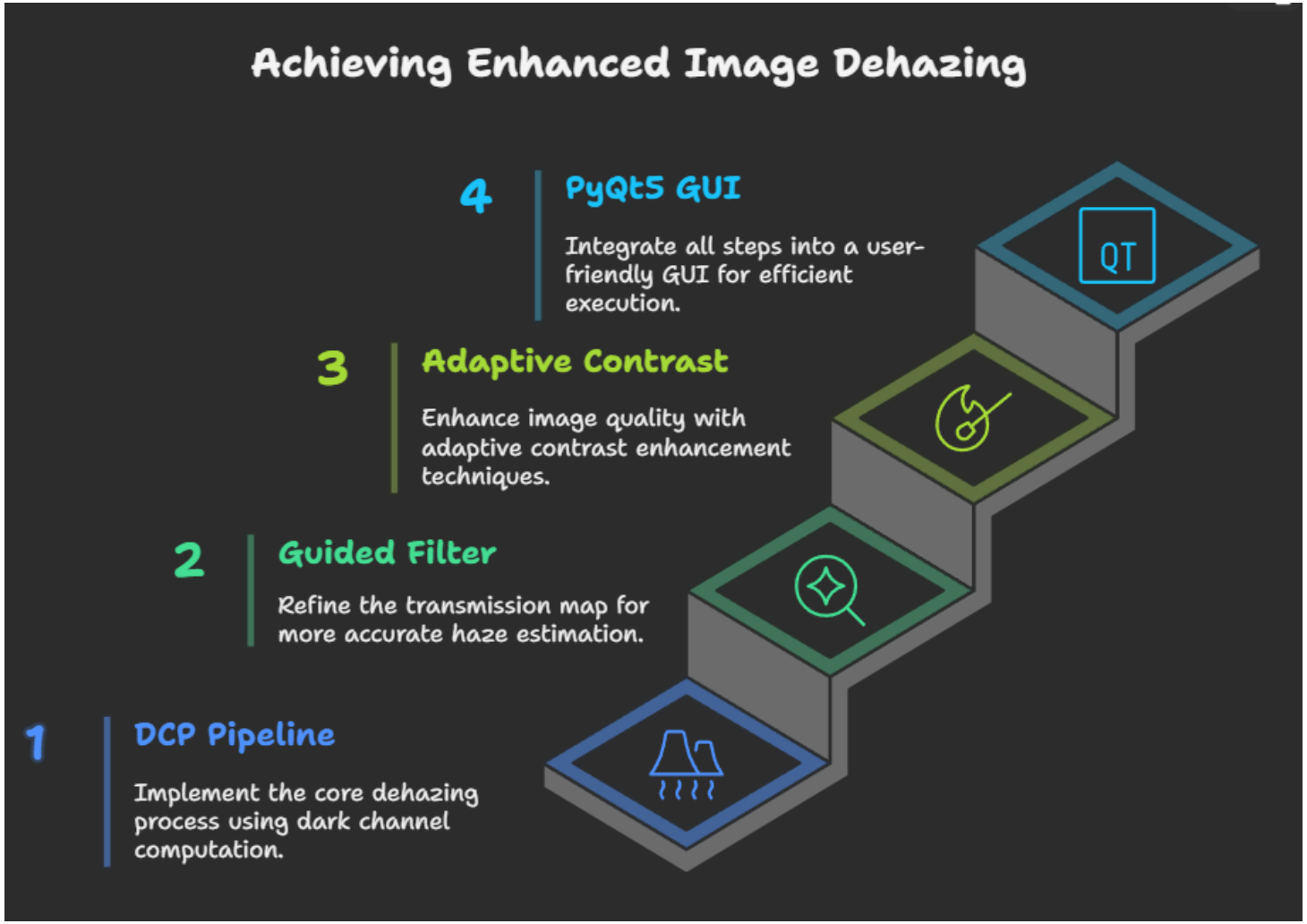
Explanation:

- q: output image (refined transmission)
- I: guidance image (grayscale)
- p: initial transmission map
- μ: local mean, Cov and Var: local statistics over a window
- ϵ: regularization parameter

This is implemented in the `guided_filter()` function.

Research Methodology

- Implement the DCP-based dehazing pipeline involving dark channel computation, atmospheric light estimation, and transmission map calculation.
- Refine the transmission map using a guided filter for more accurate haze estimation.
- Enhance image quality using adaptive contrast enhancement (CLAHE).
- Integrate these processing steps into a PyQt5-based GUI, utilizing multithreading for efficient execution.



Flow Chart

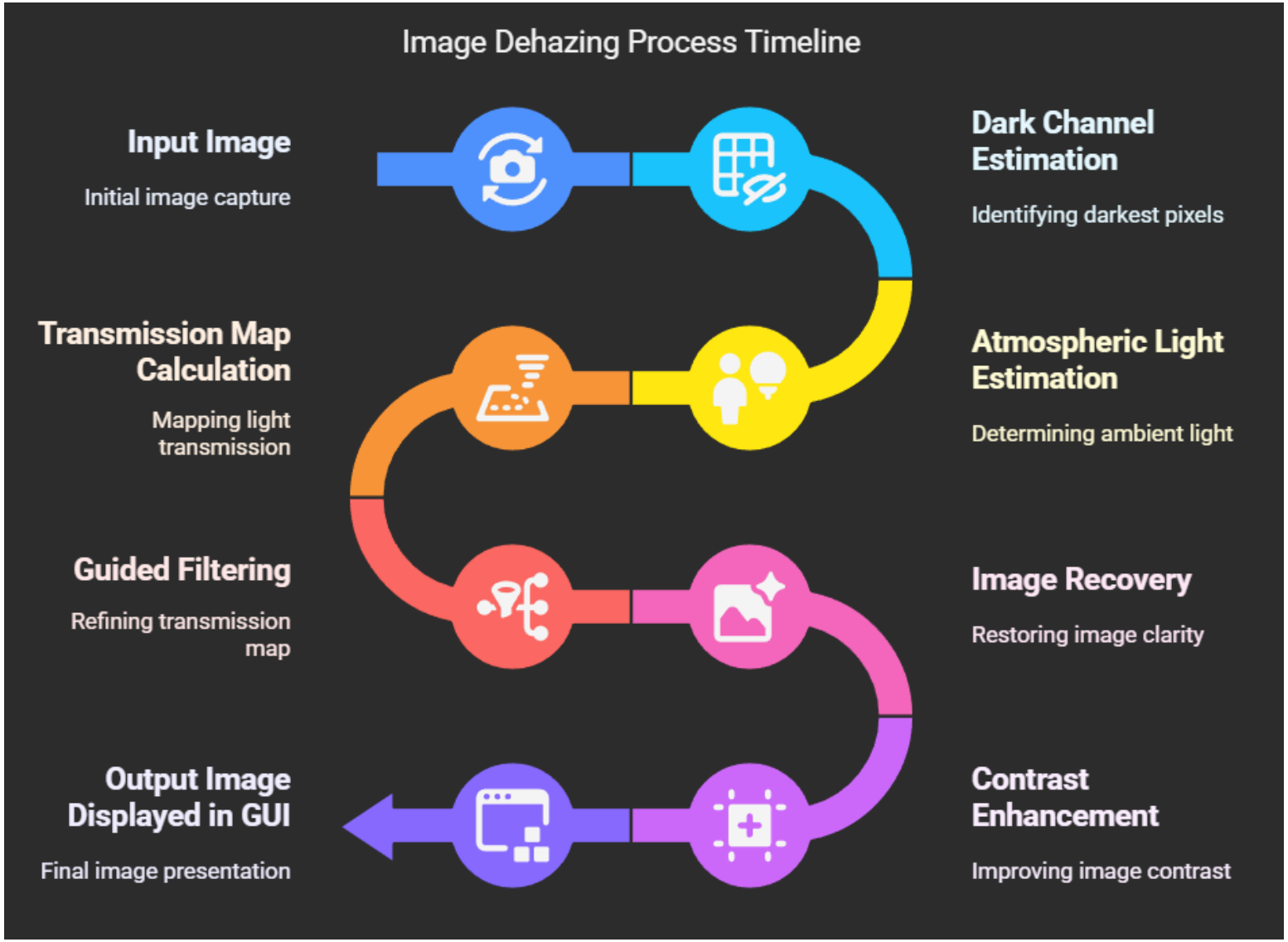
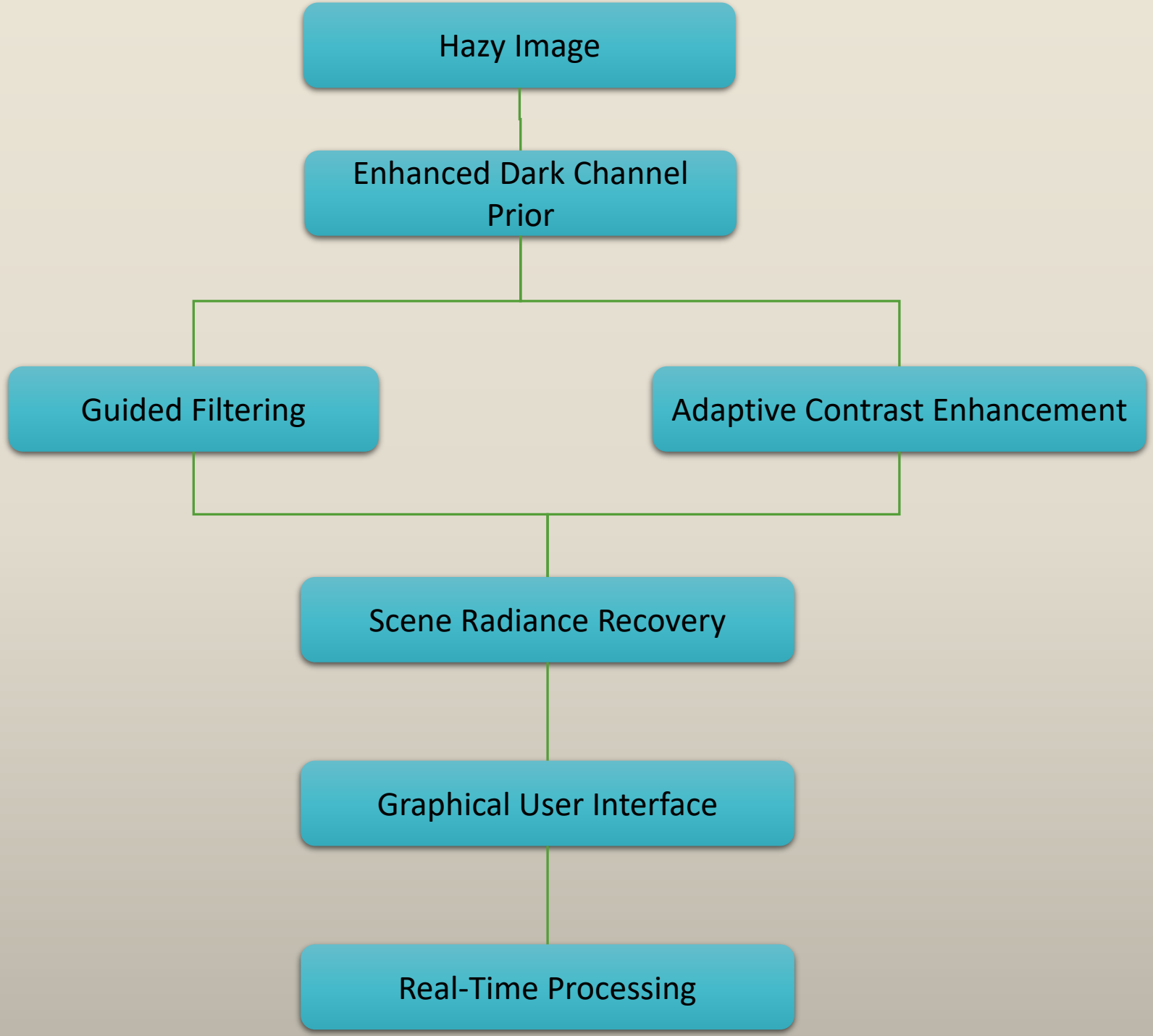


Image Dehazing Process Timeline
Input Image
Initial image capture
Dark Channel Estimation
Identifying darkest pixels
Transmission Map Calculation
Mapping light transmission
Atmospheric Light Estimation
Determining ambient light
Guided Filtering
Refining transmission map
Image Recovery
Restoring image clarity
Output Image Displayed in GUI
Final image presentation
Contrast Enhancement
Improving image contrast


Hazy Image
Enhanced Dark Channel Prior
Guided Filtering
Adaptive Contrast Enhancement
Scene Radiance Recovery
Graphical User Interface
Real-Time Processing

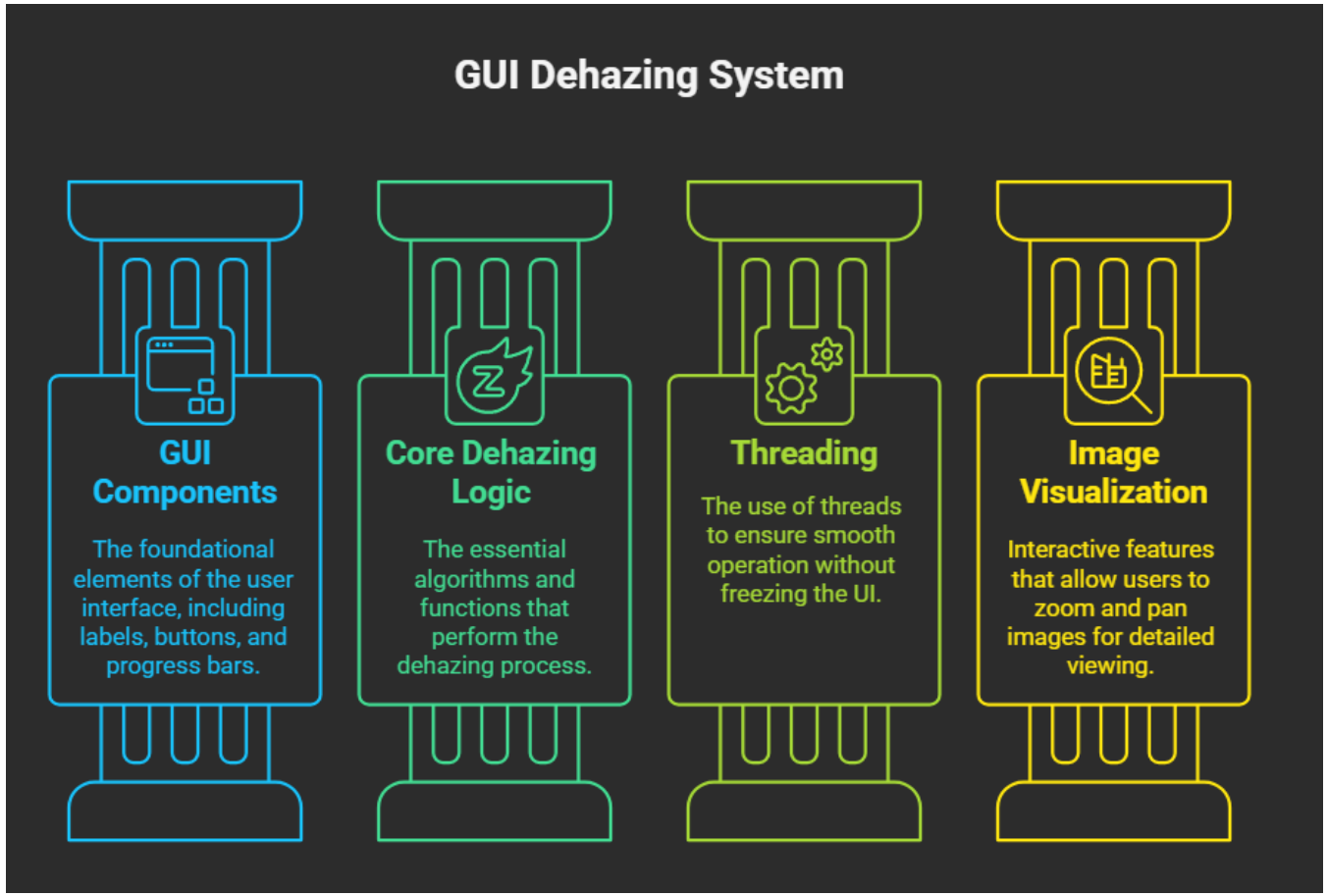
Implementation

- The GUI is created using PyQt5 with components like QLabel, QPushButton, and QProgressBar.

- The core dehazing logic includes functions for dark channel extraction, transmission estimation, and image reconstruction.

- A QThread (DehazingThread) is used to process images without freezing the UI.

- The ImageViewer class provides interactive zoom and pan features for image visualization.



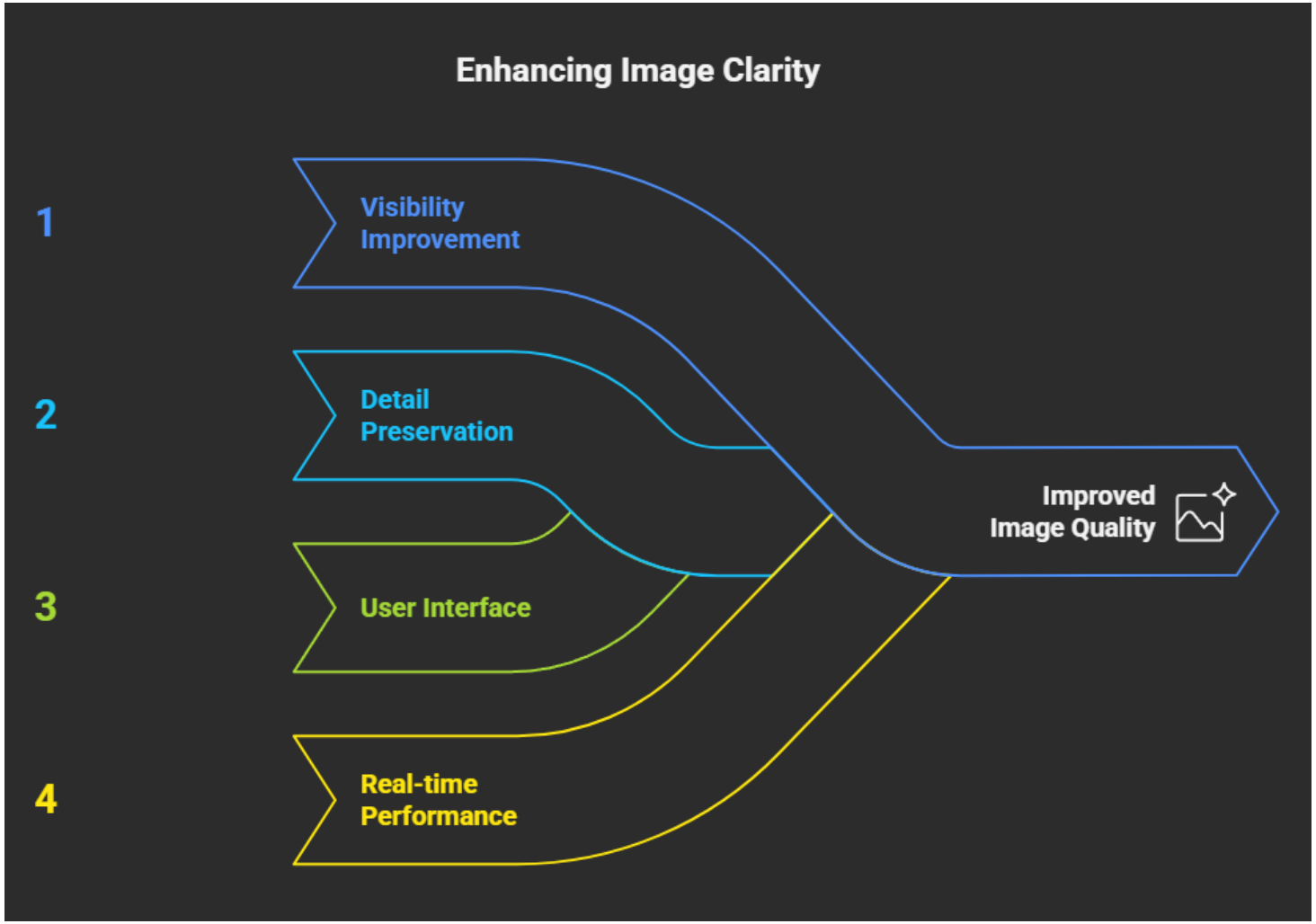
Time to go Live...!

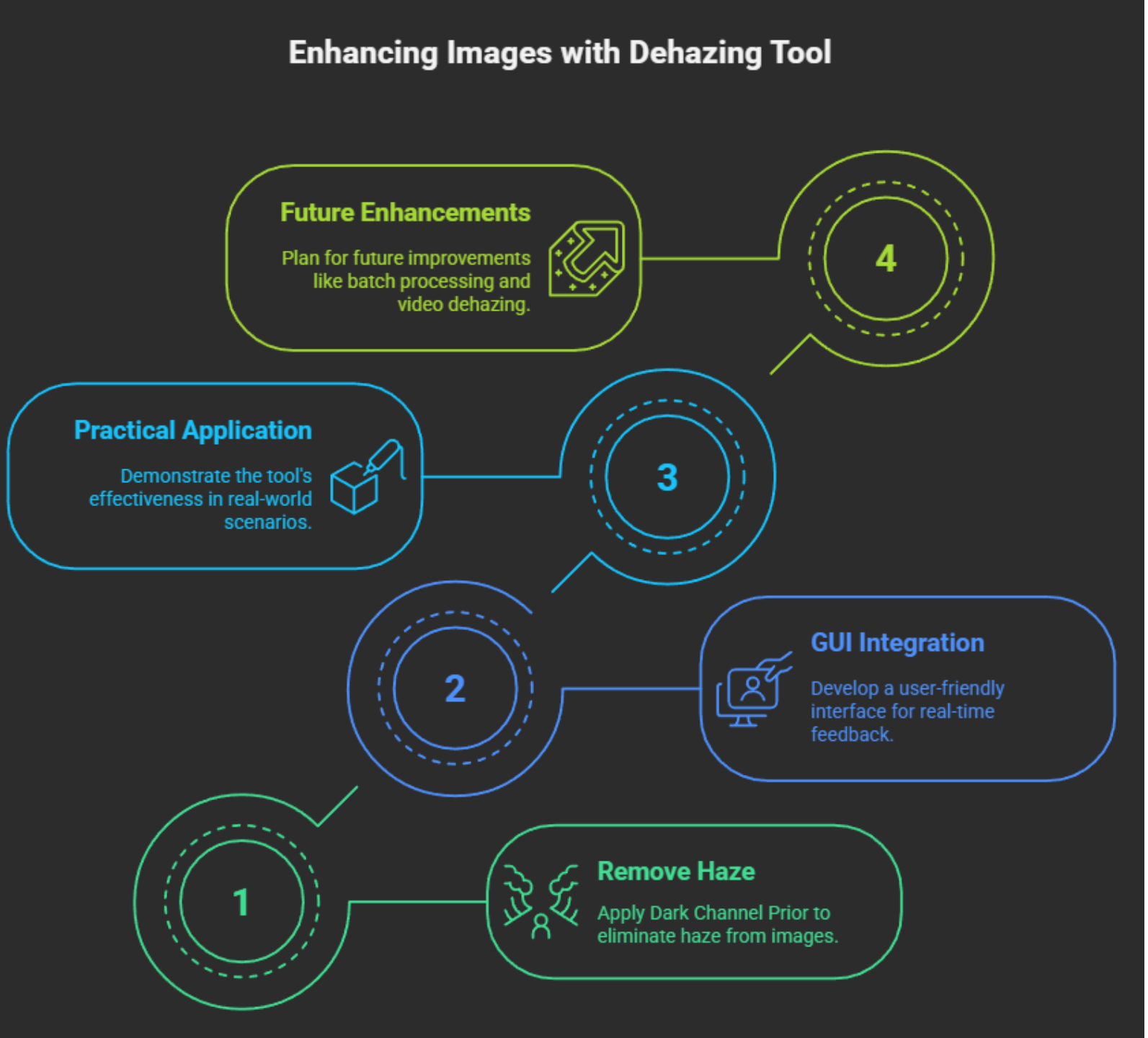
Original Image

Dehazed Image

Result & Discussion

- The dehazed images show significant improvement in visibility and contrast compared to the original.
- The adaptive patch size and guided filter contribute to preserving image details.
- Users can visually compare the original and processed images within the GUI.
- The real-time performance is improved via background threading, enhancing usability.



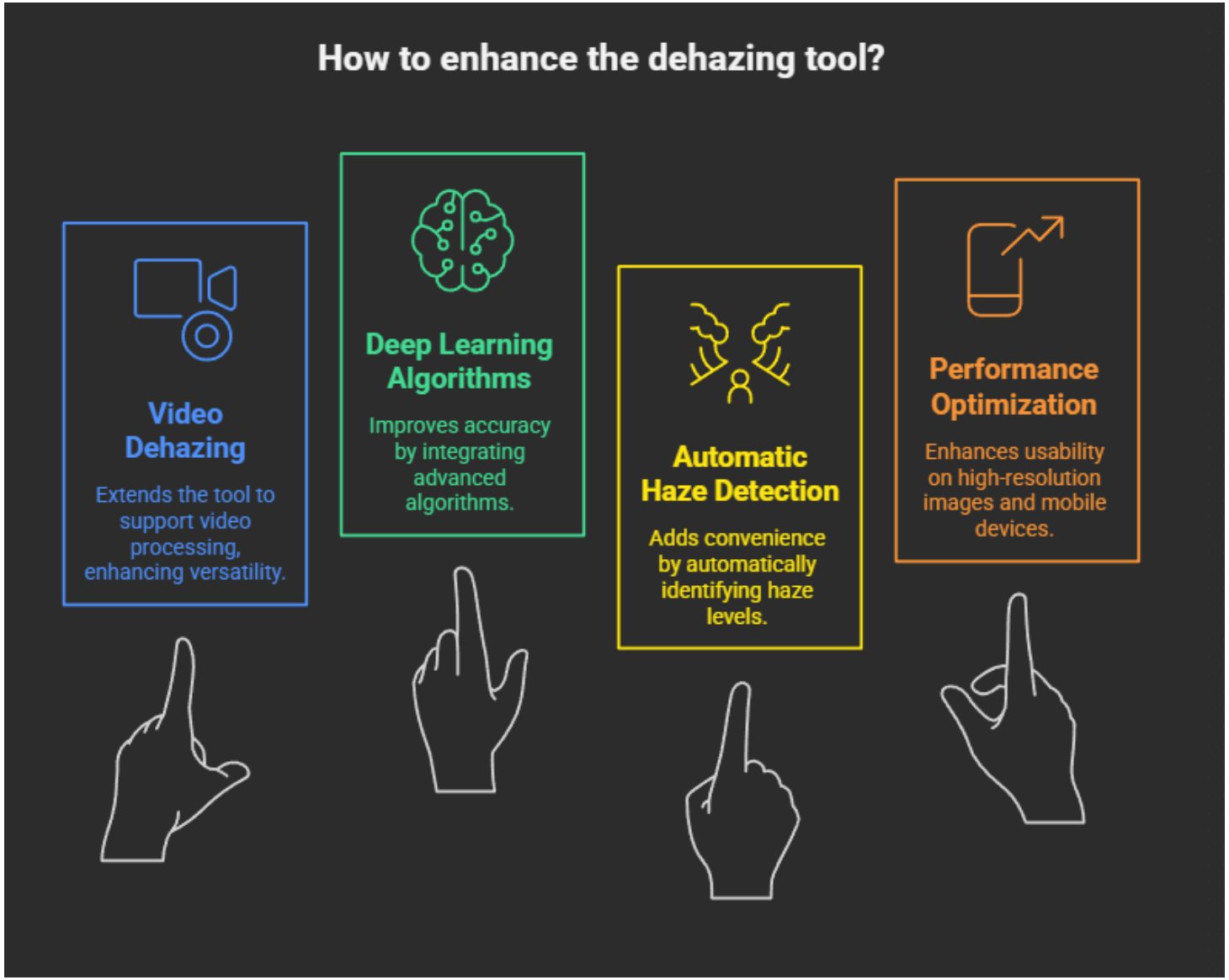


Conclusion

- The tool effectively removes haze and enhances images using the Dark Channel Prior method.
- GUI integration ensures user-friendliness and real-time feedback.
- The project demonstrates the practical applicability of academic algorithms in software tools.
- It can serve as a foundation for future enhancements like batch processing or video dehazing.

Future Scope

- Extend the tool to support video dehazing.
- Introduce deep learning-based dehazing algorithms for further accuracy.
- Add features like automatic haze detection and comparison mode.
- Optimize performance for high-resolution images and mobile platforms.



References

Berman, D., Treibitz, T., & Avidan, S. (2016). Non-local image dehazing. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 1674-1682).

Cai, B., Xu, X., Jia, K., Qing, C., & Tao, D. (2016). DehazeNet: An end- to-end system for single image haze removal. IEEE Transactions on Image Processing, 25(11), 5187 5198.

Engin, D., Genç, A., & Kemal Ekenel, H. (2018). Cycle-dehaze: Enhanced cyclegan for single image dehazing. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition Workshops (pp. 825-833).

He, K., Sun, J., & Tang, X. (2009). Single image haze removal using dark channel prior. In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (pp. 1956-1963).

Thank You