Fundamentals of Computer Vision

Assignment 1

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BCS-7B

1. Introduction (The Problem)

Images captured in extremely dark environments often suffer from poor visibility, low contrast, and hidden details. This makes it difficult for both humans and AI models to interpret them accurately. In this project, we apply image enhancement techniques to the ExDark dataset to improve brightness and contrast, making objects more visible and suitable for further computer vision tasks such as classification or detection.

2. Dataset

The **ExDark dataset (Extremely Dark Images)** is a publicly available dataset containing 7,363 low-light images across 12 object categories (e.g., bicycle, car, cat, dog, etc.). The images cover different low-light conditions. Each image is in JPEG format with varying resolutions.

3. Methodology & Justification

Technique 1: Logarithmic Transformation

- **Justification**: Many ExDark images have hidden details in dark regions. Logarithmic transformation expands low pixel values (dark areas), making hidden features more visible.

- **Transformation Function**:

  $s=c \cdot \log(1+r)$

  $c=255/\log(1+Rmax)$

Technique 2: Histogram Equalization

- **Justification**: ExDark images suffer from poor global contrast. Histogram equalization redistributes pixel intensities to span the full range, improving overall visibility and enhancing object boundaries.

Combination (Log + Histogram Equalization)

- **Justification**: Applying log transformation first enhances dark details, while histogram equalization afterward spreads the intensities evenly. This combination yields clearer and more visually informative low-light images, which is crucial for recognition tasks.

4. Results & Analysis

- **Visual Comparison:**
  Side-by-side comparisons of original vs. enhanced images show that:

    - Log transform brightens shadowed areas and reveals hidden structures.
    - Histogram equalization improves contrast globally, making objects stand out.
    - Combination produces the clearest visibility with balanced brightness and contrast.

- **Critical Evaluation:**

    - Log transform works well for extreme darkness but can reduce contrast.
    - Histogram equalization enhances contrast but may amplify noise.
    - Combination gives the best compromise: details in shadows + enhanced contrast.

5. Conclusion

For extremely dark images in the ExDark dataset, the most effective enhancement was the combination of Logarithmic Transformation and Histogram Equalization. The log step revealed hidden details in shadows, while histogram equalization distributed intensities across the full range, increasing global visibility. This combination is recommended for preprocessing low-light images before applying object detection or recognition models.

6. Appendix (Code)

Github: https://github.com/ahtishamdilawar/FCV_Assignment_1_22F-3331/