Real-Time Color Detection and Labeling System for Colorblind Individuals

MTH 2245
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Lumens

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Abstract

- **Color Vision Deficiency (CVD)**, affecting around **300 million** patients worldwide, impairs color differentiation, impacting daily activities.
- To assist CVD patients, we introduce an **augmented reality** (**AR**) system that identifies and labels indistinguishable colors in real-time.
- By applying the **Automated Perona-Malik** equation for anisotropic diffusion, the system enhances image smoothness, isolates critical color regions, and performs edge detection. **OpenCV** ensures accurate labeling of target colors, delivering superior results compared to unprocessed detection.

Problem Defination

- CVD affects **1 in 12 men** (**8%** of males) and **0.5%** of females worldwide. Results from malfunctioning retinal cones, causing difficulty in distinguishing colors in their everyday life.
- It can be congenital or acquired, impacting **daily tasks, navigation, and career choices.**
- Existing solutions for CVD are often **ineffective** or scams. These limitations make it harder for patients to integrate into society and manage daily life.
- Our proposed solution offer an **AR** system designed to aid CVD patients in effectively identifying colors of interest by either labeling or recoloring.
- Features a **user-friendly interface**, allowing users to select the most suitable color detection method.

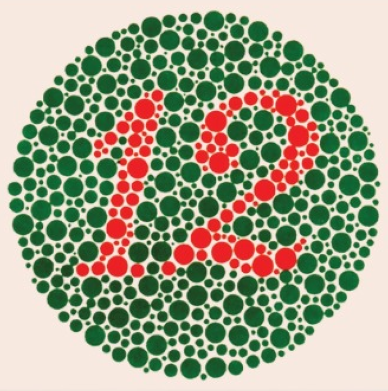


Figure 1

Methodology

- The system utilizes the **OpenCV** library for efficient color detection and image manipulation, identifying target color regions in camera frames with the **"inRange"** method. Users can enhance usability by labeling or recoloring detected regions or selecting a color to view the percentage match for precise identification. Integrated with **Perona-Malik** filtration, this approach provides real-time feedback, particularly benefiting **CVD** patients.

- OpenCV Library :

- To further enhance detection accuracy, the system applies anisotropic diffusion via the Perona-Malik equation with a finite difference solution, improving color detection and segmentation. Additionally, the **"Canny"** function is used to create an edge-only mask, enabling the isolation of detected objects and preventing overlaps during detection.

OpenCV

- Canny function & edge detection :

- We utilize the "canny" function to make a mask of the edges only. Then,depending on those edgesthe system isolates the objects detected to prevent the overlapping during detection

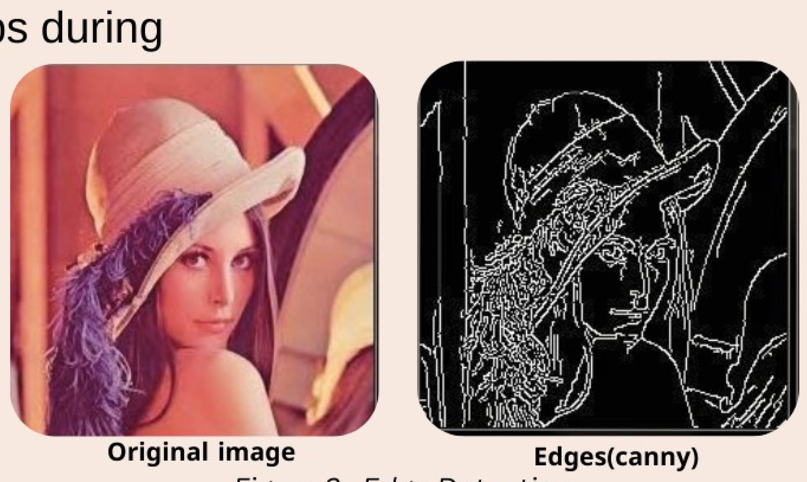


Figure 2: Edge Detection

Automated Perona-Malik

- We used the **Automated Perona-Malik** (APM) equation for image processing, which outperformed methods like Guo, Wicket, and traditional Perona-Malik in noise removal and edge enhancement. APM's key advantage is the **automated calculation** of the shape constant K and tuning parameter λ, removing the need for manual adjustments.

$$\frac{\partial u}{\partial t} = div\left(\frac{1}{(1+(\frac{|\nabla u|}{K})^2)}\nabla u\right) - \lambda(u-f)$$

- Where : $\lambda = \frac{1}{|\Omega|\nu}\int_{\Omega}(u-f)[div(\frac{1}{(1+(\frac{|\nabla u|}{K})^2)}\nabla u)]dx$ • $K = 1+\sqrt{s}$

- We use the **finite difference explicit method** to solve this equation numerically to calculate the next version for u as:

$$u^{(n+1)}_{(i,j)} = u(i.j)^{(n)} + \tau\left(\Theta^{(n)}_{(i,j)} - \lambda\left(u^{(n)}_{(i,j)} - f^{(n)}_{(i,j)}\right)\right)$$

We do this process in each iteration.

Work Flow

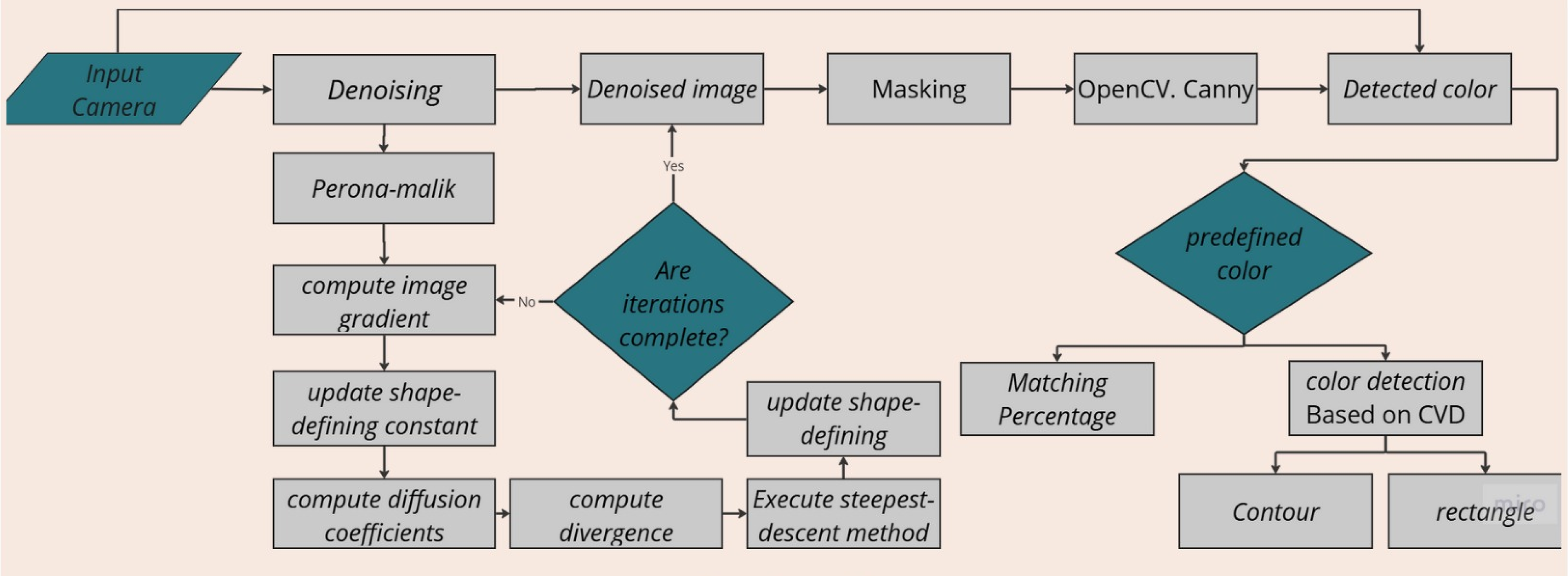
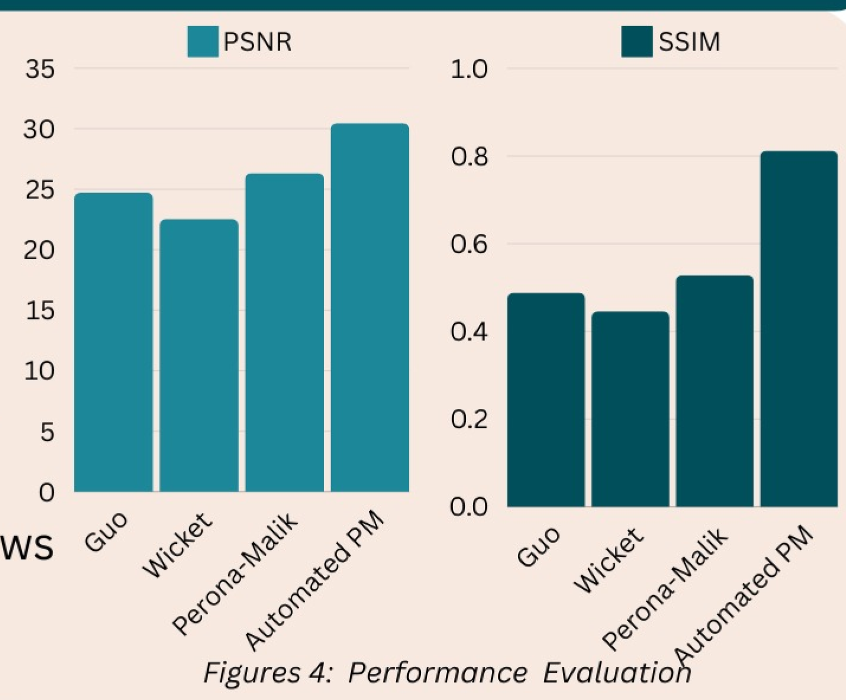


Figure 3: work flow

Results

- The system's performance was evaluated using **Peak signal-to-noise Ratio** (**PSNR**) and **Structural Similarity Index Measure** (**SSIM**) metrics, which are standard measures for assessing noise reduction and image quality enhancement. Results show improvement in the image denoising compared with the other methods .
- The output image from different methods shows further enhancement in the image denoising



Figures 4: Performance Evaluation

Figure 5: Denoising Methods Comparison

- Applying the system on real-time image processing resulted in better detection of colors and overlapping prevention of the detected objects .

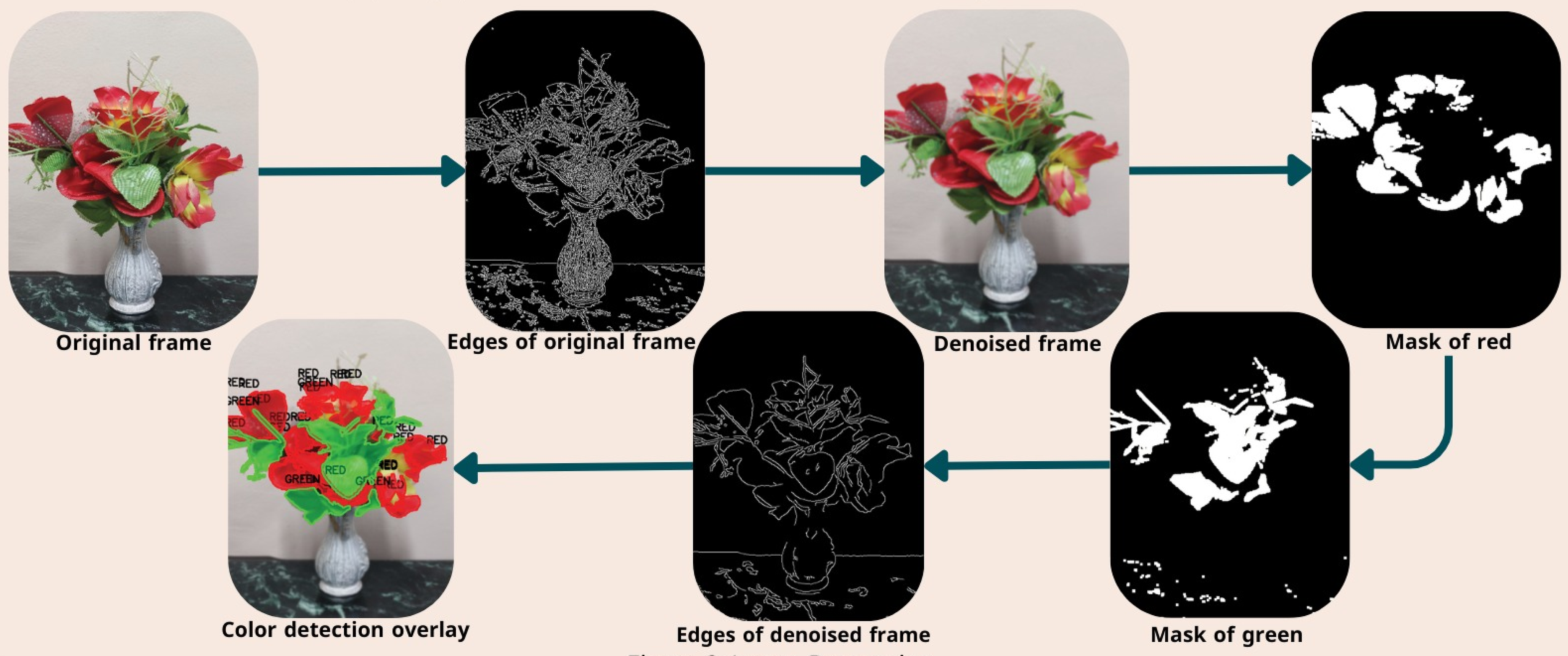


Figure 6: Image Processing

Conclusion

- we developed a system designed to assist individuals with **color vision deficiency** (CVD) using an intuitive interface and advanced image processing. The system adapts to the user's specific type of color blindness.
- Employing **Automated Perona-Malik (APM)** equation for image denoising
- **OpenCV** is used to preserve strict edges and separate detected color objects, followed by identifying pixel ranges corresponding to colors the user cannot perceive.

Scan for full detailed report

References

- Maiseli, B., Msuya, H., Kessy, S., & Kisangiri, M. (2018). Perona–Malik model with self-adjusting shape-defining constant. In Information Processing Letters (Vol. 137, pp. 26–32). Elsevier BV.
- Li, T., Li, C., Zhang, X., Liang, W., Chen, Y., Ye, Y., & Lin, H. (2021). Augmented reality in ophthalmology: Ap-plications and challenges .Frontiers in Medicine, 8, Article733241

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