Report: Real-Time Color Detection Using OpenCV

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1. Introduction

The **Real-Time Color Detection Tool** is a Python-based project that leverages OpenCV to detect, identify, and label colors in a live webcam feed. This tool can draw bounding boxes around detected colors, label them with their names, and provide additional functionalities like HSV color picking and frame saving.

The project is an excellent example of using computer vision for real-time object and feature detection.

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2. Objectives

- To develop a tool that detects and identifies multiple colors in real-time.
- To provide a user-friendly interface for exploring color detection, including HSV value retrieval and frame saving.
- To ensure accurate and efficient detection of a wide variety of colors and their shades.

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3. Features

- **Real-Time Detection**: Detects multiple colors in a webcam feed.
- **Color Labeling**: Draws bounding boxes around detected colors with accurate labels.
- **HSV Color Picker**: Allows users to click on a pixel in the video feed to retrieve its HSV value.
- **Frame Saving**: Saves the current frame with detected colors when the user presses the `s` key.
- **Extensive Color Library**: Detects primary, neutral, and additional colors such as Red, Blue, Pink, Cyan, and Teal.

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4. Methodology

1. **Input Source**:
    - Captures real-time video feed from the default webcam using OpenCV.
2. **Preprocessing**:
    - Converts each frame from BGR to HSV color space for better color segmentation.
    - Applies Gaussian blur to reduce noise and improve mask accuracy.
3. **Color Detection**:
    - Iterates over a predefined dictionary of HSV ranges for different colors.
    - Uses `cv2.inRange` to create a binary mask for each color range.
    - Finds contours of detected regions using `cv2.findContours`.

4. **Postprocessing**:
    - Filters out small contours to avoid false positives.
    - Draws bounding boxes and labels detected regions using `cv2.rectangle` and `cv2.putText`.
5. **User Interactions**:
    - Implements mouse click callbacks for HSV value retrieval.
    - Provides keyboard controls for quitting (`q`) and saving frames (`s`).

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5. Technologies Used

- **Python**: Programming language for implementation.
- **OpenCV**: Library for computer vision tasks, including image processing and contour detection.
- **NumPy**: For efficient numerical operations.

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6. Results and Observations

- The tool successfully detects and labels a wide variety of colors in real-time.
- The Gaussian blur significantly reduces noise, improving detection accuracy.
- The HSV color picker allows users to fine-tune ranges for custom colors.
- Saving frames with detected colors provides a useful feature for documentation and analysis.

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7. Key Components of the Implementation

Color Ranges Dictionary

A predefined dictionary of HSV ranges for detecting primary, neutral, and additional colors, including their shades.

Real-Time Detection

The tool captures live frames, processes them for color segmentation, and overlays bounding boxes with labels.

User-Friendly Features

- Mouse-based HSV color picking.
- Keyboard controls for quitting and saving frames.

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8. Limitations

- Detection is sensitive to lighting conditions; uneven lighting may lead to inaccuracies.
- Smaller regions of color may not be detected due to the contour size filter.
- High computational cost for large resolutions or multiple colors.

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9. Future Enhancements

- Incorporate a deep learning model (e.g., Mask R-CNN) for more robust color detection.
- Add support for detecting patterns or gradients.
- Enable real-time adjustments to HSV ranges through a GUI.
- Optimize performance for higher frame rates.

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10. Applications

- **Education**: Demonstrates the basics of color spaces and computer vision techniques.
- **Industry**: Can be adapted for industrial applications like sorting and object recognition.
- **Creative Tools**: Useful for designers to identify and label colors in real-world settings.

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11. Conclusion

The **Real-Time Color Detection Tool** effectively showcases the power of computer vision to analyze and interpret visual data. By combining OpenCV's image processing capabilities with a user-friendly interface, the tool serves as an excellent starting point for more advanced computer vision projects.

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12. References

- OpenCV Documentation: https://docs.opencv.org
- Python Official Website: https://www.python.org
- NumPy Documentation: https://numpy.org/doc/

Let me know if you need further refinements or additional sections for the report! 😊