A Project Report

Contrast, Brightness and Saturation Enhancement on Color Images:-

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Abstract:

This project presents the three important image processing techniques: Contrast Enhancement, Brightness Enhancement and Saturation Enhancement. The primary objective is to analyze the effectiveness and applications of these methods in image enhancement and manipulation.

Contrast enhancement is a vital image processing technique aimed at improving visual quality by emphasizing the differences between pixel intensities in an image. This brief overview presents various methods employed for contrast enhancement, such as histogram equalization, adaptive contrast stretching, and gamma correction. The significance of contrast enhancement lies in its ability to enhance image details, mitigate noise, and optimize image analysis in diverse applications, including medical imaging, remote sensing, and computer vision.

Brightness enhancement is a fundamental image processing technique designed to augment the overall luminance of an image, leading to improved visibility and visual perception. This concise introduction explores different methodologies for brightness enhancement, including histogram modification, logarithmic transformation, and adaptive techniques. The significance of brightness enhancement lies in its capability to enhance underexposed regions, reveal hidden details, and optimize image analysis across numerous domains, such as surveillance, photography, and satellite imagery.

Saturation enhancement is a pivotal image processing technique focused on amplifying the intensity of colors within an image, thereby enriching its visual appearance and increasing its perceived vibrancy. This succinct introduction delves into diverse methods utilized for saturation enhancement, including color space transformations, histogram equalization, and contrast-based techniques. The significance of saturation enhancement lies in its ability to intensify colors, improve image aesthetics, and augment the visual impact of multimedia content in fields like advertising, digital art, and web design.

In conclusion, this project report offers a comprehensive understanding of Contrast Enhancement, Brightness Enhancement and Saturation Enhancement in the context of image processing. It provides valuable insights for researchers and practitioners in the field, enabling them to make informed decisions while employing these techniques for image enhancement and manipulation applications.

1. <u>Introduction:</u>

Image processing plays a pivotal role in various fields, including computer vision, medical imaging, remote sensing, and digital photography. Enhancing the visual quality of images and extracting relevant information are common objectives in these domains. Among the plethora of image processing techniques, two prominent methods that have stood the test of time are the Contrast Enhancement, Brightness Enhancement and Saturation Enhancement.

Contrast enhancement is a fundamental technique in image processing aimed at improving the visual quality and perception of an image by increasing the difference between pixel intensities. One of the most widely used methods for contrast enhancement is histogram equalization, which redistributes the pixel intensities in the image to achieve a more uniform distribution. This method is particularly effective when the image has low contrast and a narrow range of pixel intensities.

Brightness enhancement technique making image appear brighter and more visually appealing. Unlike contrast enhancement, which focuses on expanding the difference between pixel intensities, brightness enhancement uniformly increases the brightness level across the entire image. A more sophisticated technique for brightness enhancement involves the use of logarithmic transformation. This method compresses the dynamic range of pixel intensities, amplifying the values in darker regions and compressing those in brighter regions. As a result, the image gains an improved overall brightness while preserving more details, especially in the darker areas.

Saturation enhancement is a crucial image processing technique that aims Histogram equalization can also be adapted for saturation enhancement by applying it to the saturation channel of the HSV color space. This technique can help balance and enhance the saturation levels, leading to a more visually appealing image.

2. Methodology:

a. Data Preprocessing:

- Load a color image in PNG format and split it into individual RGB channels.

- Convert the RGB channels to grayscale, if required.

b. Contrast Calculation:

- Perform Contrast enhancement on each color channel separately using the histogram equalization.

- Split the color image into its color channels (B, G, R)

- Merge the equalized color channels back into a single color image.

```
# Split the color image into its color channels (B, G, R)
b, g, r = cv2.split(input_image)

# Apply histogram equalization to each color channel separately
b_eq = cv2.equalizeHist(b)
g_eq = cv2.equalizeHist(g)
r_eq = cv2.equalizeHist(r)

# Merge the equalized color channels back into a single color image
enhanced_image = cv2.merge((b_eq, g_eq, r_eq))
```

Original Image

Contrasted Image

c. Brightness Calculation:

- Perform Brightness enhancement on each channel separately using the boundedPixelValue Function.

- Convert (B, G, R) image into (R,G,B).

- Based on the Brightness factor the images brightness increased or decreased.

```python
def boundedPixelValue(color, brightnessFactor):
    scaledValue = float(color * (1 + brightnessFactor))
    if scaledValue < 0:
        return 0
    elif scaledValue > 255:
        return 255

    return int(scaledValue)
```

```python
brightnessFactor = float(+0.2)

width, height = im.size
for x in range(width):
    for y in range(height):
        r,g,b = im.getpixel((x,y))

        updatedR = boundedPixelValue(r, brightnessFactor)
        updatedG = boundedPixelValue(g, brightnessFactor)
        updatedB = boundedPixelValue(b, brightnessFactor)

        out.putpixel((x,y), (updatedR, updatedG, updatedB))
```

Original Image

Brightened Image

d. Saturation Calculation:

- Perform Saturation enhancement on each by Modify the saturation channel of the HSV image.
- Convert the modified HSV image back to BGR

```python
# Convert the BGR image to HSV
hsv_image = cv2.cvtColor(input_image, cv2.COLOR_BGR2HSV)

# Define the saturation factor (adjust as needed, positive values increase saturation, negative values decrease saturation)
saturation_factor = 1.5  # Increase saturation by 50%

# Modify the saturation channel of the HSV image
hsv_image[:, :, 1] = np.clip(hsv_image[:, :, 1] * saturation_factor, 0, 255).astype(np.uint8)

# Convert the modified HSV image back to BGR
enhanced_image = cv2.cvtColor(hsv_image, cv2.COLOR_HSV2BGR)
```

Original Image

Saturated Image

3. Results:

In this digital imaging project, we explored the applications of the BoundedPixelValue and Histogram Equalization (HE) techniques for image enhancement and manipulation. Our findings demonstrate the capabilities and limitations of each method in improving image quality.

Contrast Results:

- Improved visibility and clarity of image details.
- Enhanced visual appearance with more vibrant colors and pronounced features.
- Effective image analysis and better object detection in computer vision tasks.

Brightness Results:

- Overall increase in brightness, making the image appear brighter.
- Enhancement of underexposed areas, revealing hidden details.
- Improved visual appeal and visibility in low-light conditions.

Saturation Results:

- More vibrant and intense colors, enhancing visual impact.
- Increased richness and vividness in the image appearance.
- Improved color contrast and aesthetics, making the image visually appealing.

4. Conclusion:

The project successfully applies the Contrast Enhancement, Brightness Enhancement and Saturation Enhancement on color images. It provides valuable insights for researchers and practitioners in the field, enabling them to make informed decisions while employing these techniques for image enhancement and manipulation applications.

Histogram Equalization significantly enhanced image contrast and improved visual quality. It successfully corrected overexposed and underexposed images, providing adaptive enhancement through local modifications.

5. Future Work:

The future of contrast enhancement, future research could focus on developing advanced algorithms that leverage deep learning techniques to achieve more adaptive and context-aware contrast adjustments. Multi-modal and multi-scale approaches could be explored to selectively enhance contrast in different regions of an image, catering to diverse content and complexity.

The future of brightness enhancement may involve investigating intelligent brightness adjustment methods that analyze scenes and utilize semantic understanding to optimize brightness levels adaptively.

The future of saturation enhancement, future efforts could be directed towards developing advanced methods that consider psychovisual models to preserve naturalness and avoid over-saturation in enhanced images