SATELLITE IMAGE ENHANCEMENT

AI MINI PROJECT REPORT

18CSC305J - ARTIFICIAL INTELLIGENCE

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BONAFIDE CERTIFICATE

Certified that Mini project report titled **"SATELLITE IMAGE ENHANCEMENT"** is the bona fide work of **A.M.S Supreeth, V. Pranathi, A. Anji** who carried out the minor project under my supervision. Certified further, that to the best of my knowledge, the work reported herein does not form any other project report or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

SIGNATURE

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ABSTRACT

In this research endeavor, we delve into the critical realm of disaster management, recognizing the indispensable role that satellite imagery plays in facilitating timely response and mitigation efforts. Yet, a persistent challenge arises from the often subpar quality of these images, which can impede effective analysis and interpretation. To address this issue head-on, we propose a groundbreaking methodology aimed at enhancing the quality of satellite imagery specifically tailored for disaster management applications. Our approach is multifaceted, involving a series of sophisticated digital image pre-processing techniques meticulously designed to extract the maximum utility from the original low-quality satellite data. By meticulously implementing procedures such as noise reduction, contrast enhancement, color balancing, and spatial resolution enhancement, we endeavor to transform these raw images into vibrant RGB colored intensity representations. The resultant imagery not only boasts improved visual fidelity but also promises to significantly augment the accuracy and depth of analysis achievable in disaster management scenarios. To validate the efficacy of our methodology, we undertake a comprehensive evaluation employing both qualitative and quantitative metrics. Through this rigorous assessment, we conclusively demonstrate substantial enhancements in image quality and information clarity. Ultimately, our pioneering approach stands poised to revolutionize the landscape of satellite imagery utilization in disaster management, furnishing stakeholders with an invaluable toolset to bolster preparedness, streamline response efforts, and expedite recovery endeavors in the face of both natural and man-made disasters.

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ABBREVIATIONS

DIP : **Digital Image Processing**
RGB : **Red Green Blue**
HSL : **Hue Saturation Lightness**

INTRODUCTION

Satellite imagery stands as a cornerstone in contemporary weather monitoring systems, serving as a vital source of data for forecasting, tracking, and analyzing weather phenomena. Despite its indispensable role, the raw data retrieved from satellites often necessitates refinement to unlock its full potential accurately. Enter image enhancement techniques, a suite of methodologies geared towards elevating the visual quality of satellite imagery, amplifying specific features, and mitigating noise. These enhancements, in turn, empower meteorologists with sharper insights, enabling them to make more precise predictions and assessments. The process of enhancing satellite images unfolds across a multi-faceted journey, traversing through preprocessing, enhancement, and post-processing stages. At the outset, preprocessing steps lay the foundation by undertaking radiometric and geometric corrections, rectifying distortions, and ensuring the faithful representation of atmospheric conditions. Subsequently, enhancement techniques take center stage, orchestrating improvements in clarity, contrast, and interpretability, particularly amplifying weather-related elements such as clouds, precipitation, and atmospheric dynamics. Through this intricate interplay of techniques and stages, the realm of satellite imagery metamorphoses into a rich tapestry of insights, empowering meteorologists to navigate the complexities of weather forecasting with unparalleled precision and efficacy.

PROBLEM STATEMENT

Satellite imagery is integral to environmental monitoring, yet its visual quality often falls short in discerning crucial land features, vegetation, and environmental changes. The challenge lies in the need for a robust digital image processing solution that can effectively enhance satellite images. The goal is to develop a solution that significantly improves the visual clarity and discrimination of land features and vegetation, enabling better monitoring of environmental changes. This solution must address issues such as image noise, contrast, and resolution to provide accurate and detailed representations of environmental data. By enhancing the visual quality of satellite images, the solution aims to empower environmental monitoring efforts, facilitating more informed decision-making and resource management.

LITERATURE SURVEY

EXISTING DESIGN:

TITLE: Satellite Image Enhancement Using Histogram Equalization

Authors: Ibrahim Goni, Y. M. Malgwi, A. S. Ahmadu

Dataset: https://www.semanticscholar.org/paper/Satellite-Image-Enhancement-Using-Histogram-Goni-Malgwi/3406531e82cbfe1df3d844d6c01990e43b780dbe%20

Methods: Histogram equalization

Remarks: Color mapping can be included for intensity analysis.

PROPOSED DESIGN:

The proposed design aims to leverage architecture for efficient and automated image enhancement, through color mapping.

This approach improvise the interpretability and utility of satellite imagery in cyclone monitoring and forecasting.

By leveraging advanced color mapping techniques tailored to cyclonic features, meteorologists can gain deeper insights into cyclone dynamics, enhancing preparedness and resilience in vulnerable coastal regions.

Further research and experimentation are warranted to refine and validate the proposed model across diverse cyclone scenarios and satellite platforms, ultimately advancing our ability to mitigate the impact of cyclones on society and the environment.

SYSTEM ARCHITECTURE DESIGN

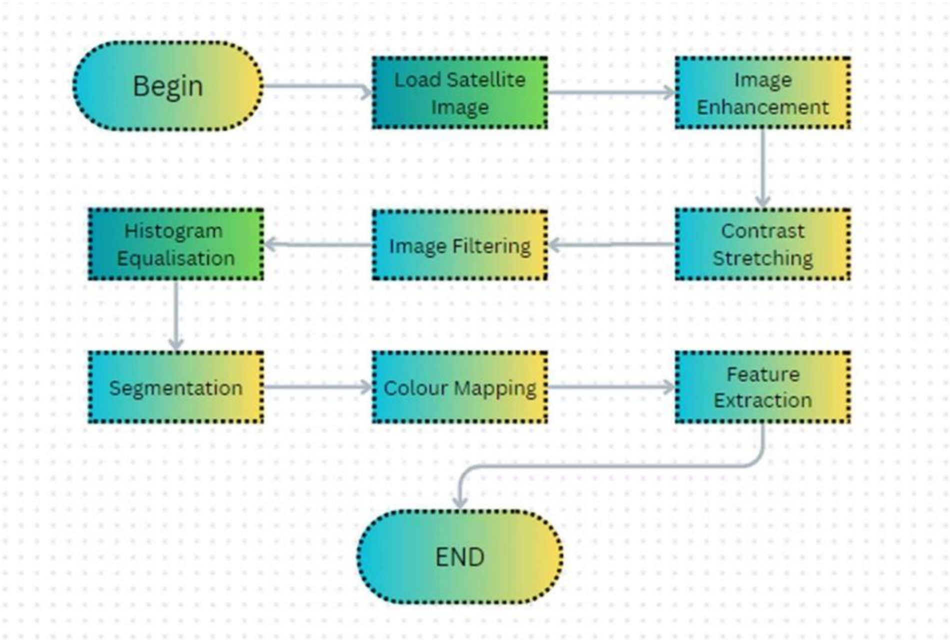

Figure 1: Architecture diagram

DESCRIPTION OF COMPONENTS

1. IMAGE ACQUISITION: Image acquisition is the process of capturing visual information from the real world to generate digital images. This involves the use of imaging devices, such as cameras, scanners, or sensors, to convert optical signals or scenes into digital representations. The goal of image acquisition is to faithfully capture and digitize the visual content for further processing, analysis, and interpretation.

2. IMAGE PRE-PROCESSING Image preprocessing is a crucial step in the field of computer vision and image analysis that involves the application of various techniques to enhance the quality of digital images before they undergo further analysis or are used as input to machine learning algorithms. The primary objectives of image preprocessing are to improve the interpretability of images, reduce noise, correct distortions, and make images suitable for specific applications, such as object recognition, segmentation, and classification.

3. CONTRAST STRETCHING: Contrast stretching is a process that transforms the intensity values of an image to a new range, usually [0, 255] for 8-bit images. The goal is to increase the contrast between the darkest and brightest pixels, while preserving the relative differences among the intermediate values.

4. APPLYING FILTER: Gaussian high pass filter has the same concept as ideal high pass filter, but again the transition is smoother as compared to the ideal one.

5. HISTOGRAM EQUALIZATION: Histogram equalization is a technique in image processing that aims to adjust the distribution of pixel intensities in an image to improve its overall contrast and enhance visibility of details. The method involves transforming the intensity values of the pixels in such a way that the resulting histogram becomes more uniform. By redistributing the pixel intensities, histogram equalization effectively stretches the dynamic range of the image, making it more visually appealing and facilitating better image analysis.

6. IMAGE SEGMENTATION: Image segmentation is a computer vision process that involves dividing an image into meaningful and semantically homogenous regions or segments. The goal of image segmentation is to simplify the representation of an image into parts that are easier to analyze. Each segment typically corresponds to a specific object or region of interest, making it a fundamental step in various computer vision applications, including object recognition, scene understanding, and medical image analysis.

7. COLOR MAPPING BASED ON INTENSITY: Color mapping based on intensity is a visualization technique where different colors are assigned to different intensity levels in an image. This technique is often used to enhance the visual representation of grayscale images by associating unique colors with varying pixel intensities.

CODING AND TESTING

Image Acquisition:

CODE: #image acquisition

```
from google.colab import files uploaded =
files.upload()
!pip install opencv-python import cv2
import numpy as np import
matplotlib.pyplot as plt
# read an image img = cv2.imread('cyclonee.jpg')
# Let's see how the image looks like
plt.imshow(img)
```

INPUT IMAGE:

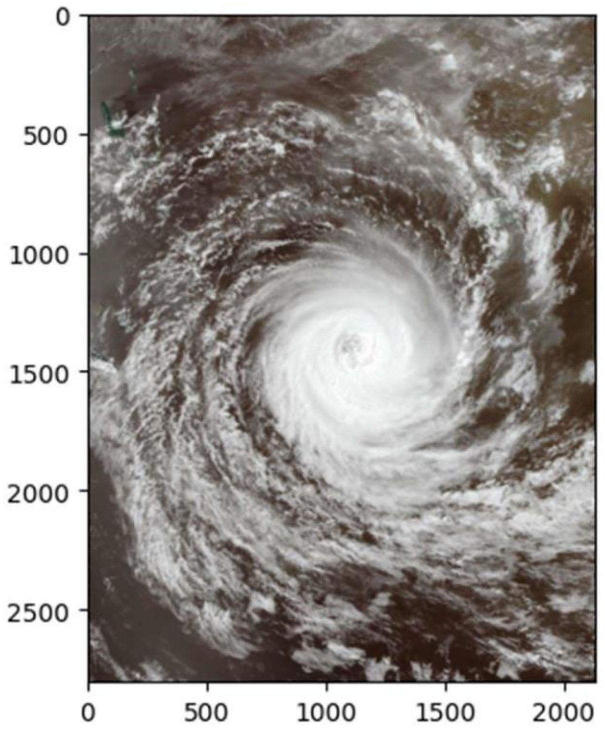

Figure 2: Input cyclone image

Image Pre-Processing:

CODE: #image preprocessing

```
gray_img = cv2.cvtColor(img, cv2.COLOR_BGR2GRAY)
# have to convert grayscale back to RGB for plt.imshow(), since plt.imshow expects a 3d array
# try plotting the same directly with gray_img and see the result for yourself
plt.imshow(cv2.cvtColor(gray_img, cv2.COLOR_GRAY2RGB))
```

OUTPUT: GRAYSCALE IMAGE

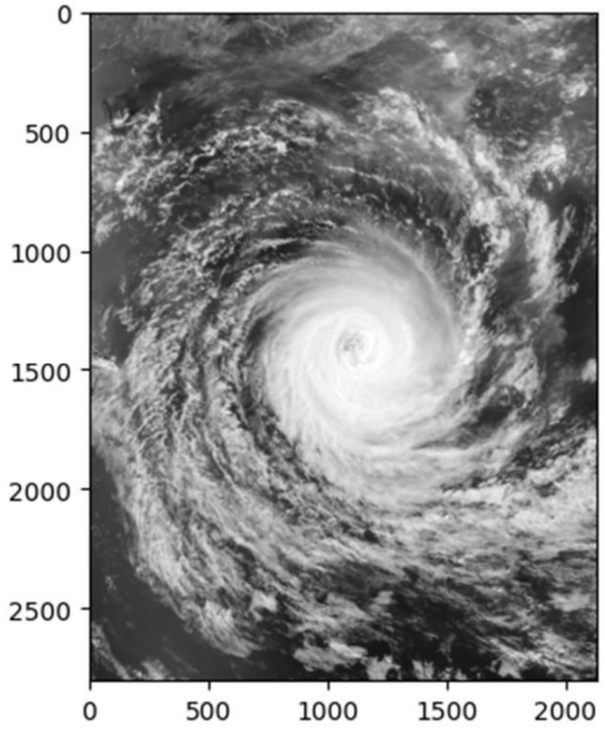

Figure 3: Grayscale image

Applying Filters: Gaussian Low Pass Filter

CODE: #gaussian lp filtering

```
img = cv2.imread('cyclonee.jpg')
assert img is not None, "file could not be read, check with os.path.exists()"
blur = cv2.GaussianBlur(img,(5,5),0)
 plt.subplot(121),plt.imshow(img),plt.title('Original')
 plt.xticks([]), plt.yticks([])
 plt.subplot(122),plt.imshow(blur),plt.title('Blurred')
plt.xticks([]), plt.yticks([])
plt.show()
```

OUTPUT:

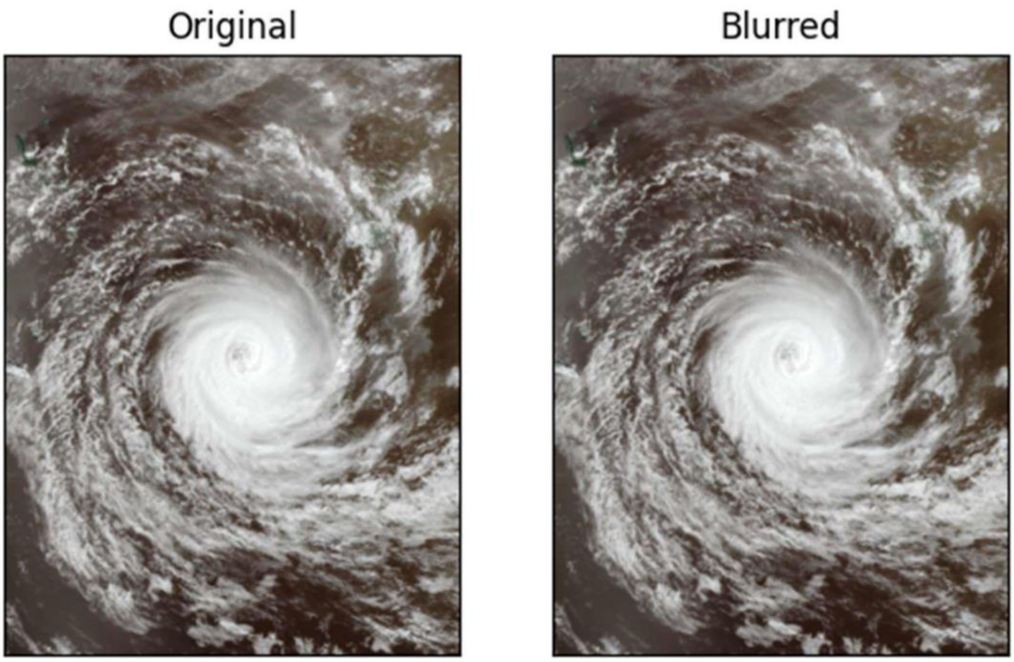

Figure 4: Output image after applying Gaussian Low Pass filter

Contrast Stretching:

```
CODE: import cv2
import numpy as np
import matplotlib.pyplot as plt
# Load the image
image_path = 'cyclonee.jpg'
original_image = cv2.imread(image_path, cv2.IMREAD_GRAYSCALE)
# Check if the image is loaded successfully
if original_image is None:
    print("Error: Could not read the image")
    exit()
# Define the parameters for high-contrast stretching
alpha = 1.5  # Adjust this parameter for different levels of contrast
# Apply high-contrast stretching
stretched_image = cv2.convertScaleAbs(original_image, alpha=alpha)
# Display the original and high-contrast stretched images
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(original_image, cmap='gray')
plt.axis('off')
plt.subplot(1, 2, 2)
plt.title('Contrast Stretched Image')
plt.imshow(stretched_image, cmap='gray')
plt.axis('off')
plt.show()
```

OUTPUT:

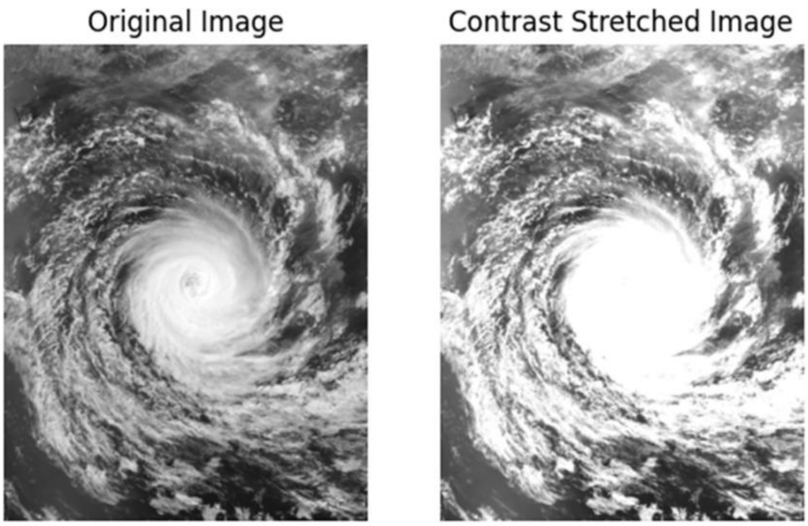

Figure 5: Output image after applying Contrast Stretching

Histogram Equalisation:

CODE:

```
import cv2
import matplotlib.pyplot as plt
# Load the image
image = cv2.imread('cyclonee.jpg', cv2.IMREAD_GRAYSCALE)
# Check if the image is loaded successfully
if image is None:
    print("Error: Could not read the image")
    exit()
# Perform histogram equalization
equalized_image = cv2.equalizeHist(image)
# Display the original and equalized images side by side
plt.subplot(1, 2, 1)
plt.title('Original Image')
plt.imshow(image, cmap='gray')
plt.subplot(1, 2, 2)
plt.title('Equalized Image')
plt.imshow(equalized_image, cmap='gray')
plt.show()
```

OUTPUT:

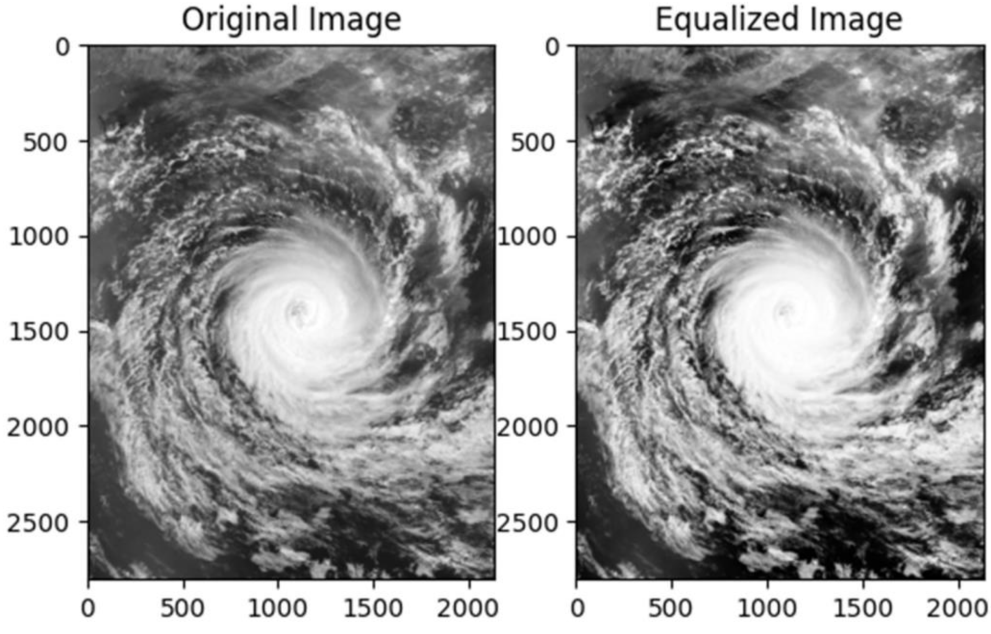

Figure 6: Output image after Histogram Equalization

Image Segmentation:

CODE: #edge detection (segmentation)

assert img is not None, "file could not be read, check with os.path.exists()" edges = cv2.Canny(img,100,200) plt.subplot(121),plt.imshow(img,cmap = 'gray') plt.title('Original Image'), plt.xticks([]), plt.yticks([]) plt.subplot(122),plt.imshow(edges,cmap = 'gray') plt.title('Edge Image'), plt.xticks([]), plt.yticks([]) plt.show()

OUTPUT:

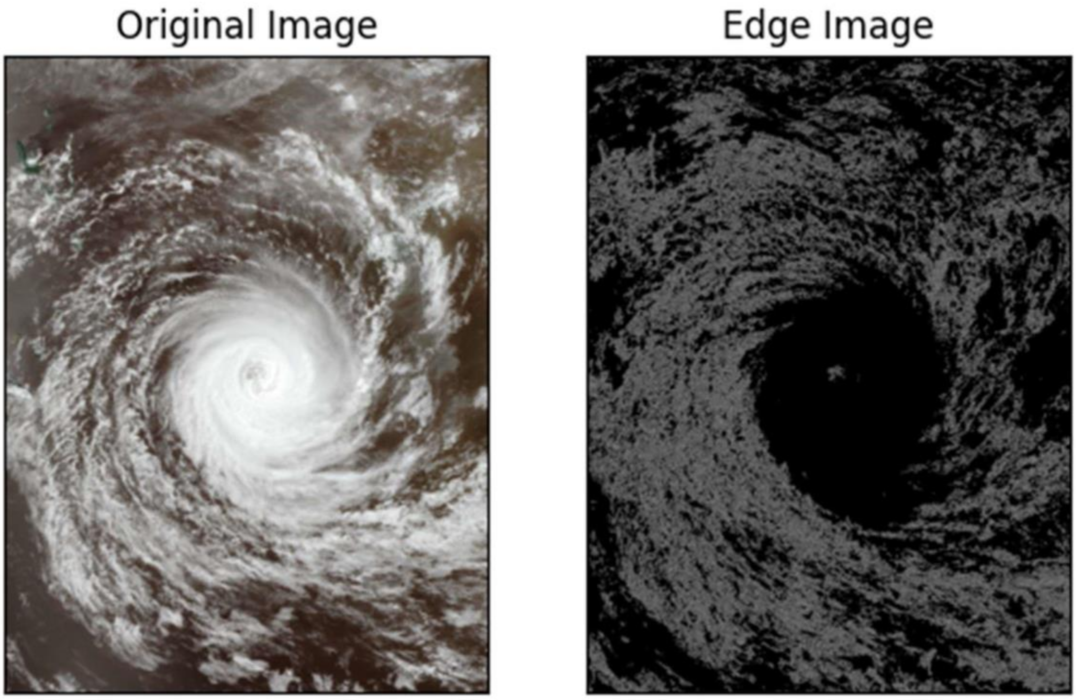

Figure 7:Output image after Segmentation or Edge detection

Colour Mapping Based On Intensity:

CODE: import cv2

```
import matplotlib.pyplot as plt # Load the cyclone image image_path = 'cyclonee.jpg'
cyclone_image = cv2.imread(image_path) # Check if the image is loaded successfully if
cyclone_image is None:
        print("Error: Could not read the image")        exit()
# Convert the image to grayscale gray_image = cv2.cvtColor(cyclone_image,
cv2.COLOR_BGR2GRAY) # Apply a color map for visualization (you can choose a
different colormap)
color_mapped_image = cv2.applyColorMap(gray_image, cv2.COLORMAP_JET)
# Display the original and color-mapped images plt.subplot(1, 2, 1) plt.title('Original Cyclone
Image') plt.imshow(cv2.cvtColor(cyclone_image, cv2.COLOR_BGR2RGB)) plt.axis('off')
plt.subplot(1, 2, 2) plt.title('Color-Mapped Image')
plt.imshow(cv2.cvtColor(color_mapped_image, cv2.COLOR_BGR2RGB)) plt.axis('off')
plt.show()
```

OUTPUT:

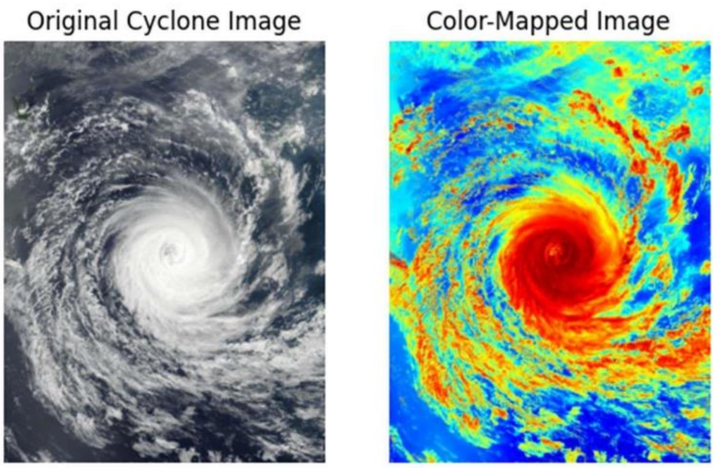

Figure 8: Color Map based on Intensity

RESULT

Our groundbreaking methodology enhances satellite imagery for disaster management, refining low-quality data through advanced processing techniques. Evaluation reveals a clear intensity color mapping of a cyclone: red for high intensity, yellow for medium, green for low, and blue for absence. This transformation significantly improves image quality and clarity, offering stakeholders invaluable insights for disaster preparedness and response. Our approach revolutionizes satellite imagery utilization, empowering efficient response and recovery efforts in the face of disasters.

CONCLUSION AND FUTURE ENHANCEMENT

Conclusion: Through the application of digital image pre-processing techniques, it is possible to enhance low-quality satellite images and generate RGB colored intensity images that can significantly aid disaster management efforts. By improving the clarity and detail of satellite imagery, emergency responders can more accurately assess the extent of damage, identify critical areas for intervention, and allocate resources effectively. This process can greatly enhance situational awareness and decision-making during disaster response and recovery operations.

Future Enhancements:

Integration of Machine Learning Algorithms: Incorporating machine learning algorithms for image enhancement can further improve the quality of the generated RGB colored intensity images. These algorithms can learn from a large dataset of satellite images and automatically adapt their parameters to different types of disasters and environmental conditions.

Real-time Processing: Developing real-time processing capabilities can enable emergency responders to receive enhanced satellite images promptly during ongoing disaster events. This would require optimizing algorithms for efficiency and leveraging cloud computing resources for rapid image processing.

Semantic Segmentation: Implementing semantic segmentation techniques can help to classify different objects and structures within the satellite imagery, such as buildings, roads, and vegetation. This additional information can provide valuable insights for disaster assessment and response planning.

Integration with Geographic Information Systems (GIS): Integrating the generated RGB colored intensity images with GIS platforms can enable spatial analysis and visualization of disaster-affected areas. This integration can facilitate better coordination among emergency response teams and support decision-making at various levels of management.

User-friendly Interfaces: Designing user-friendly interfaces for accessing and interpreting the enhanced satellite imagery can make the technology more accessible to a wider range of stakeholders involved in disaster management, including government agencies, non-profit organizations, and local communities. By implementing these future enhancements, the utility of generating RGB colored intensity images from low-quality satellite imagery for disaster management can be further enhanced, ultimately contributing to more effective and efficient response efforts.

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