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HYBRID & INNOVATIVE APPROACH TO ENHANCE THE LOW-LIGHT IMAGES FOR DETECTION OF OBJECTS USING MACHINE LEARNING AND DEEP LEARNING MODELS.

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ABSTRACT

In recent years, significant progress has been made by researchers and scholars in the domains of video and image processing, leading to numerous discoveries and innovations concerning resolution and sensitivity. Nonetheless, several challenges persist, particularly in the realm of capturing high dynamic range images and videos in low-light situations, especially when lighting is scarce. Conventional de-noising methods often struggle when noise levels exceed the signal. To address this problem, a variety of techniques have been introduced to enhance video quality in low-light conditions; however, issues such as low contrast and noise continue to obstruct the creation of visually appealing videos in these settings. The challenge of recording images at social events, concerts, parties, musical performances, in dimly lit forests, and for security surveillance remains largely unresolved. Improving low-light image quality in these contexts is a complex and demanding endeavor. Also the object detection in low-light conditions presents a significant challenge within the field of computer vision. This study introduces a hybrid approach that merges machine learning and deep learning strategies to improve the quality of low-light images, thereby enhancing detection accuracy. The proposed system use CNN, GAN and color sensing algorithms to improvise the readability in the low light images. Additionally, an image resolution model is used to smoothen the enhance images so that it will be more readable and untestable in term of object detection among the images. This paper presents a novel approach to image enhancement, with ongoing research focused on identifying methods that enhance images visibility along with object detection for better understanding of the image.

Keywords: Low-light image enhancement, Video Enhancement, quality assessment, enhancement algorithm, low light images, noise, filter, image enhancement Evaluation metric, deep learning, Comprehensive review

I. Introduction

Modern digital cameras encounter significant challenges in capturing high dynamic range images, particularly in low-light environments [1,2]. Noise in images presents a considerable obstacle to image quality, often resulting in substantial residual errors after motion compensation. While typical digital cameras can achieve a dynamic range of thousands, issues such as overexposure in bright areas and underexposure in darker regions can lead to poor visibility in videos [1-5]. Many algorithms used in processing low-light videos tend to overlook the dynamic range, which is a critical aspect. Although it is expected that digital cameras should operate effectively across various lighting and weather conditions, many struggle in low-light situations, resulting in inferior image and video quality. Improving low-light image quality in these contexts is a complex and demanding endeavor. Additionally, object detection in low-light settings presents a significant challenge within the field of computer vision. This study proposes a hybrid methodology that integrates machine learning and deep learning techniques to enhance low-light image quality, thereby increasing detection accuracy. The proposed system utilizes convolutional neural networks (CNN), generative adversarial networks (GAN), and color sensing algorithms to improve the clarity of low-light images [2,5,8,9]. Furthermore, an image resolution model is employed to refine the enhanced images, making them more legible and suitable for object detection. This paper presents an innovative approach to image enhancement, with ongoing research focused on identifying techniques that

improve image visibility and support better object detection for a more comprehensive understanding of the images [1-5, 8,9].

II. PROPOSED METHODOLOGY

System Architecture for low light image Enhancement: This paper presents a method for improving low-light image quality to enhance visibility in the final output. To accomplish this, it will enhance the quality of the input image by traditional, ML & deep learning and image resolution models. This work classification of frames into two categories: degraded frames and quality frames [1-2].

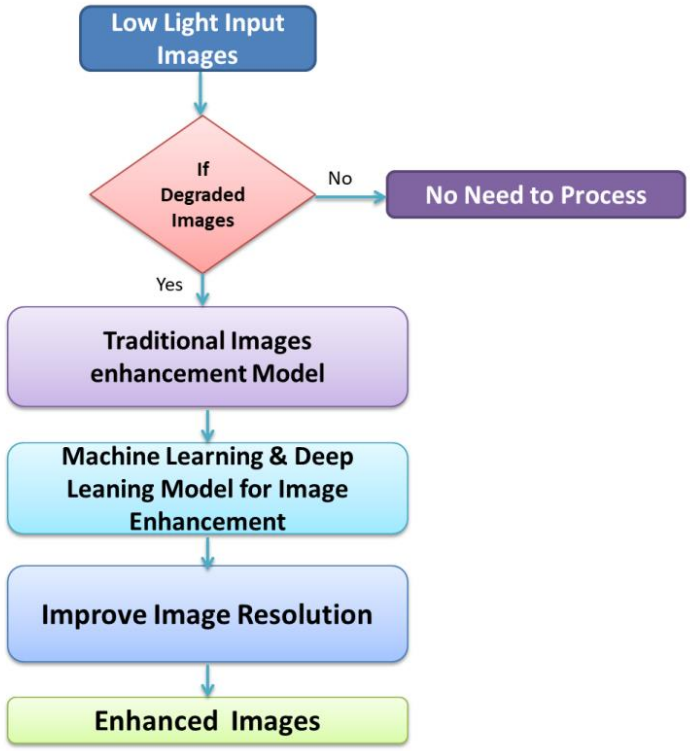

Figure 1: System Architectural Diagram

B. Functional Diagram of low light image Enhancement: This system accepts an uncompressed low light image as an input and segregate into two segments: degraded images and quality images, based on the level of darkness (noise) present in each images. Once the classification is complete, the enhancement model will start their work started with traditional model and end with images resolution model. The ML& Deep learning model specifically used to deal with the lacuna present after the traditional model working [1-10].

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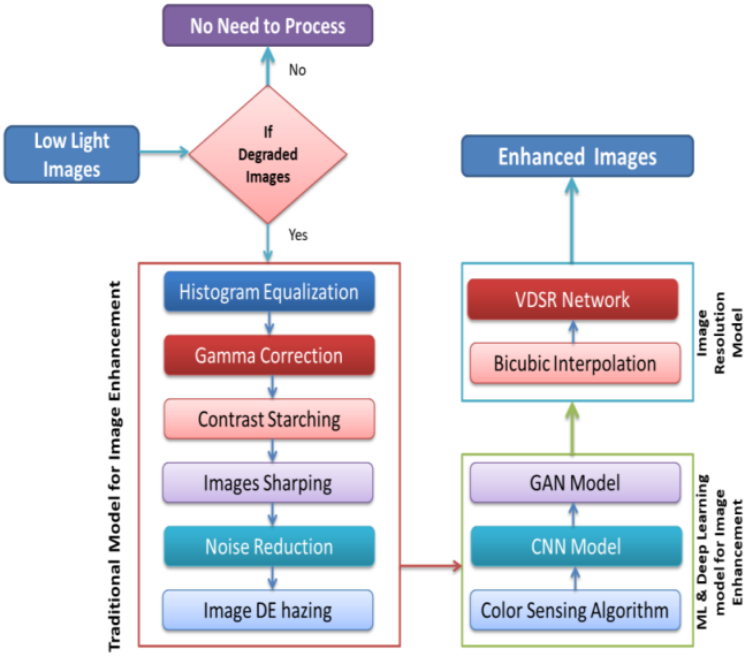

Figure 2: Functional Diagram of Low Light Image Enhancement

C. Enhancement Model: Traditional Model

I. **Gamma correction** is a nonlinear method employed in image processing to modify the brightness of images and videos, taking into consideration the way cameras record light and how it is perceived by the human eye. This process is essential for enhancing the display quality of digital media on screens [5,8,9,12].

II. **Histogram Equalization** is an image enhancement technique that increases the contrast of an input image by stretching its histogram. This method is particularly favored for enhancing the contrast in digital images and videos. To achieve a more pronounced effect on an input image, the histogram distribution must be amplified [1-2]. It is a widely adopted enhancement technique in digital image processing due to its ability to improve the quality of the output, particularly in refining the edges of objects within an image. Histograms can process color images, providing separate representations for the red, green, and blue color channels, or they can be applied to grayscale images. The proposed algorithm focuses on selecting frames that have undergone enhancement through a temporal noise reduction method, applying the blue color channel of the histogram to these frames, which has been determined through a trial and error approach [1-10].

III. **Contrast stretching** is a technique used in image enhancement that improves the contrast of an image by adjusting the range of digital values assigned to each pixel. This method is also referred to as normalization [1-2].

D. **Enhancement Model: Machine Learning & Deep Learning Model**

I. **CNN**: Convolutional Neural Networks (CNNs) are employed in various computer vision applications, including image generation and classification, as well as object and pose recognition. Historically, these challenges were addressed using traditional neural networks like Multilayer Perceptron (MLPs) and a range of heuristic approaches [10-20].

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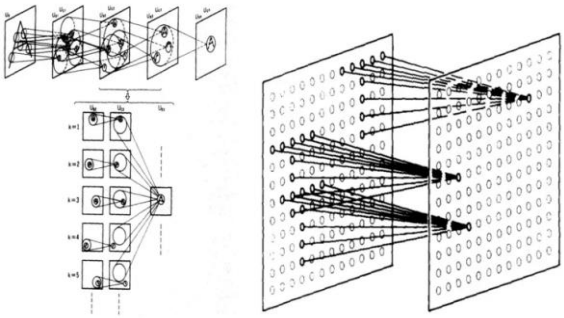

$$f[x,y] * g[x,y] = \sum_{n_1=-\infty}^{\infty} \sum_{n_2=-\infty}^{\infty} f[n_1,n_2] \cdot g[x-n_1, y-n_2]$$

Figure 3: CNN model

II. **GAN:** A generative adversarial network (GAN) is a sophisticated deep learning framework that involves the training of two neural networks in a competitive manner to produce increasingly realistic data based on a specified training dataset. The term "adversarial" reflects the dynamic between the two networks, where one is responsible for generating new data by altering an input sample as extensively as possible, while the other evaluates whether the generated output is part of the original dataset. Essentially, the evaluating network's role is to discern between authentic and synthetic data [15-20]. The process continues until the generating network produces data that the evaluating network can no longer differentiate from real data. Additionally, GANs have applications in image enhancement, such as upgrading low-resolution images to high resolution or transforming black-and-white images into color. They can also be utilized to create images representing subsurface structures by analyzing the relationship between surface data and underground formations [21-26].

C. **Enhancement Model: Image resolution Model**

I. **Improve Image Resolution Using Bi-cubic Interpolation:** Bi-cubic interpolation improves upon bilinear interpolation by taking into account the nearest 4×4 pixel neighborhood, totaling 16 pixels. In this method, pixels that are closer to the target pixel receive greater weight, while those that are farther away are assigned less weight [1-15]. As a result, the pixels that are most distant contribute minimally to the final estimation. The outcomes of Bi-cubic interpolation significantly surpass those produced by nearest neighbor or bilinear methods, likely due to the inclusion of a larger set of known pixel values in the estimation process [22-26].

$$h(x) = \begin{cases} (a+2)|x|^3 - (a+3)|x|^2 + 1 & 0 \le |x| < 1 \\ a|x|^3 - 5a|x|^2 + 8a|x| - 4a & 1 \le |x| < 2 \\ 0 & 2 \le |x| \end{cases}$$

II. **Improve Image Resolution Using VDSR Network**: The concept of Very Deep Super Resolution (VDSR) is examined. VDSR utilizes a deep learning methodology to upscale images, featuring 20 weight layers, significantly deeper than the Super-Resolution Convolutional Neural Network (SRCNN), which comprises only 3 layers [1-26].

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III. RESULT ANALYSIS & FINDINGS

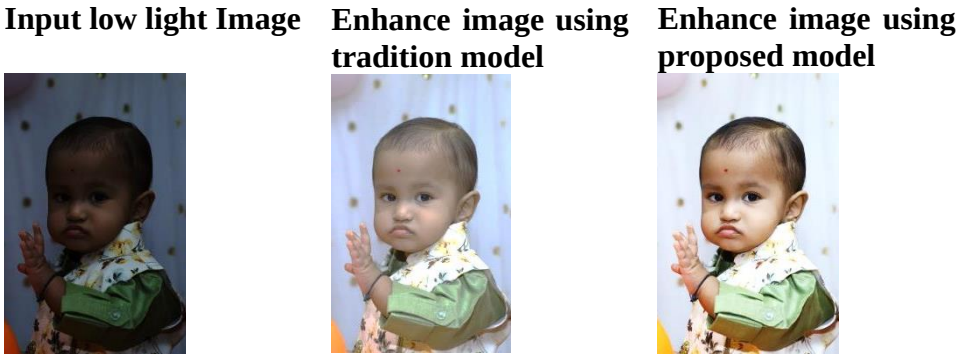

Figure 4: Result Comparison & Findings

	Low light Image		Enhanced image using Proposed System			
	Mean Intensity	Entropy	Mean Intensity	Entropy	MSE	PSNR
Image 1	0.3100	5.5625	0.3456	8.3048	3453.65	9.673
Image 2	0.2278	4.6725	0.3986	8.2266	4123.39	10.582
Image 3	0.2318	5.6873	0.3987	8.3134	4566.98	11.134

Table 1: Compartaive analysis

IV. CONCLUSION

This paper introduces a novel approach to image enhancement with showcasing a new framework that classifies input images into two categories: degraded frames and quality frames, based on the noise characteristics present in the input. The proposed system enables enhancement to be applied exclusively to the degraded frames, utilizing the model such as traditional, ML & deep learning and image resolution for the better readability of the images and their objects present inside the images. The suggested system employs Convolutional Neural Networks (CNN), Generative Adversarial Networks (GAN), and color sensing algorithms to improve the readability of images captured in low light conditions. Furthermore, an image resolution model is integrated to refine the enhanced images, making them more legible and suitable for object detection. This paper introduces an innovative method for image enhancement, with continuous research aimed at discovering techniques that improve image visibility and facilitate better object detection for a clearer interpretation of the images and it has been proved with the results demonstrate in this paper which is presenting the significant improvement in the output quality when compared to existing and old frameworks and methods.

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