International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 04 | April – 2026 SJIF Rating: 8.659 ISSN: 2582-3930

A Modified Singular Value Decomposition (MSVD) Approach for the Enhancement of CCTV Low Quality Images

Mr.k Sunil Kumar [1], M. Sravani [2], M. Venkata Pavani[3], B. Sai Prasad[4], J. Naveen Sapthagiri[5], N. Meghanadh Reddy[6]

[1]Assistant Professor, Dept. Of ECE, PBR VITS, Kavali, Nellore District, Andhra Pradesh, India
[2-6]UG Students, Dept. Of ECE, PBR VITS, Kavali, Nellore District, Andhra Pradesh, India

---***---

Abstract - This Project proposes an efficient method for enhancing low-quality CCTV video frames using a Modified Singular Value Decomposition (MSVD) technique. The process begins with the acquisition of input videos from a university database, which are recorded at a resolution of megapixels. These videos are then converted into 2D frames with a standardized resolution of pixels using MATLAB, enabling consistent image processing. Singular Value Decomposition (SVD) is applied to decompose each frame into three matrices: left orthogonal, sigma, and right orthogonal matrices. For enhancement, the diagonal sigma values of low-quality frames are replaced with those from good-quality frames, effectively transferring quality features to degraded images. The final step involves reconstructing enhanced images from the modified SVD matrices and evaluating their performance using six key metrics: Peak Signal-to-Noise Ratio (PSNR), Entropy, Mean Squared Error (MSE), Contrast, Time Computation, Structural Similarity Index (SSIM). This approach not only enhances visual clarity but also ensures improved performance metrics, demonstrating the effectiveness of MSVD in CCTV video enhancement tasks. The proposed method is particularly useful for applications requiring high-quality visual outputs from surveillance systems, making it a valuable tool for modern video processing applications.

Keywords: Dataset, Image Processing Techniques, Modified Singular Value Decomposition (MSVD) and PSNR.

1. INTRODUCTION

This Project introduces an efficient approach for improving the quality of low-resolution CCTV video frames through a Modified Singular Value Decomposition (MSVD) technique. The method starts with video acquisition where the videos are recorded at a resolution of megapixels. These videos are then converted into 2D frames with a standardized resolution of pixels using MATLAB, ensuring uniformity for further image processing. Singular Value Decomposition (SVD) is employed to decompose each frame into three matrices: left orthogonal, sigma, and right orthogonal matrices. To enhance the quality, the diagonal values in the sigma matrix of low-quality frames are replaced with those from higher-quality frames, effectively transferring the quality features to the degraded images. The reconstructed enhanced images are evaluated using six key performance metrics, including Peak Signal-to-Noise Ratio (PSNR), Entropy, Mean Squared Error (MSE), Contrast, Time Computation, and Structural Similarity Index (SSIM). The results demonstrate a significant improvement in both visual clarity and performance metrics, showcasing the potential of the MSVD technique in enhancing CCTV video quality. This method is particularly valuable for surveillance applications, where high-quality visual output is essential for accurate monitoring and analysis.

2. LITERATURE SURVEY

2.1 Q. Huang, J. Ninić, and Q. B. Zhang, ''BIM, machine learning and computer vision techniques in underground construction: Current status and future perspectives,'' Tunnelling Underground Space Technol., vol. 108, Feb. 2021, Art. no. 103677.

2.2 V. Arya, H. Choubey, S. Sharma, T.-Y. Chen, and C.-C. Lee, ''Image enhancement and features extraction of electron microscopic images using sigmoid function and 2D-DCT,'' IEEE Access, vol. 10, pp. 76742–76751, 2022.

2.3 M. Sahnoun, F. Kallel, M. Dammak, O. Kammoun, C. Mhiri, K. Ben Mahfoudh, and A. Ben Hamida, ''A modified DWT-SVD algorithm for T1-w brain MR images contrast enhancement,'' IRBM, vol. 40, no. 4, pp. 235–243, Aug. 2019.

3. EXISTING SYSTEM

This Project introduces an efficient method for enhancing low-quality CCTV video frames using a Modified Singular Value Decomposition (MSVD) technique. The process starts with the acquisition of input videos from database, recorded at megapixel resolution. These videos are converted into 2D frames with a standardized resolution of pixels using MATLAB, allowing for consistent image processing. Singular Value Decomposition (SVD) is applied to each frame, decomposing it into three matrices: left orthogonal, sigma, and right orthogonal matrices. For enhancement, the diagonal sigma values of low-quality frames are replaced with those from high-quality frames, effectively transferring the quality features of good frames to the degraded ones.

Key Disadvantages of the Existing System:

- Poor contrast enhancement
- Noise amplification
- Loss of image details
- Not suitable for low-light images
- Over-enhancement / over-saturation
- Uniform processing (no adaptability)
- Cannot handle blur effectively
- Degradation of edges and structures
- Low PSNR and SSIM values
- High computational complexity (for some methods)

4. PROPOSED SYSTEM

The Non-Local Means (NLM) algorithm is a widely used method for denoising images and videos, which works by averaging pixels based on their similarity to a given pixel rather than their spatial proximity. In the context of video processing, NLM identifies patches within a frame that resemble a target patch, regardless of their location within the image, and uses these similar patches to calculate a weighted average to reduce noise. This approach is particularly effective for removing random noise, such as Gaussian noise, while preserving fine details and edges. The main advantage of NLM lies in its ability to handle noise without significant blurring of the image, making it a popular choice for video denoising tasks. However, the method can be computationally expensive, especially for large video frames, as it requires searching the entire image for similar patches. Despite this, it remains a reliable and efficient choice for noise removal in videos.

Hardware Requirements

The hardware requirements for this project are moderate and do not require very high-end systems. A computer system with at least an Intel i3 processor or equivalent is sufficient to run MATLAB efficiently. A minimum of 4GB RAM is required, but 8GB RAM is recommended for better performance, especially when processing high-resolution CCTV images. The system should have at least 2GB of free storage space for installing MATLAB and storing datasets. A standard display monitor is enough for viewing and analyzing images. Overall, the project can be executed on a normal personal computer or laptop without the need for specialized hardware.

Software Requirements

The software requirements mainly include MATLAB, which is the core platform used for designing and implementing the image enhancement algorithm. MATLAB provides a powerful environment for matrix operations, which is very important for Singular Value Decomposition (SVD). Along with MATLAB, the Image Processing Toolbox is required to perform operations such as image reading, filtering, enhancement, and visualization. Additional toolboxes like Signal Processing Toolbox and Computer Vision Toolbox may also be used for noise removal and advanced analysis. The software should preferably run on Windows (Windows 10 or 11), as it is user-friendly and widely supported, although it can also work on Linux or macOS.

Solution to Existing System Limitations

The limitations of existing image enhancement methods such as poor contrast, noise amplification, and loss of details are effectively addressed using a modified Singular Value Decomposition (SVD) approach. In this method, the input CCTV image is first preprocessed (converted to grayscale and normalized), and then SVD is applied to decompose the image into three matrices. Instead of uniformly enhancing the entire image, the singular values are selectively modified to improve brightness and contrast while preserving important structural information. This helps in avoiding over-enhancement and maintains the natural appearance of the image. Additionally, noise effects are reduced by integrating filtering techniques before or after the SVD process, which prevents noise amplification. The method is also adaptive, meaning it can handle different lighting conditions in various regions of the image, making it highly suitable for low-light CCTV footage. Furthermore, edge details and textures are preserved due to controlled manipulation of singular values, resulting in improved clarity. Overall, this approach produces higher quality images with better PSNR and SSIM values, making it more effective and reliable compared to traditional enhancement techniques.

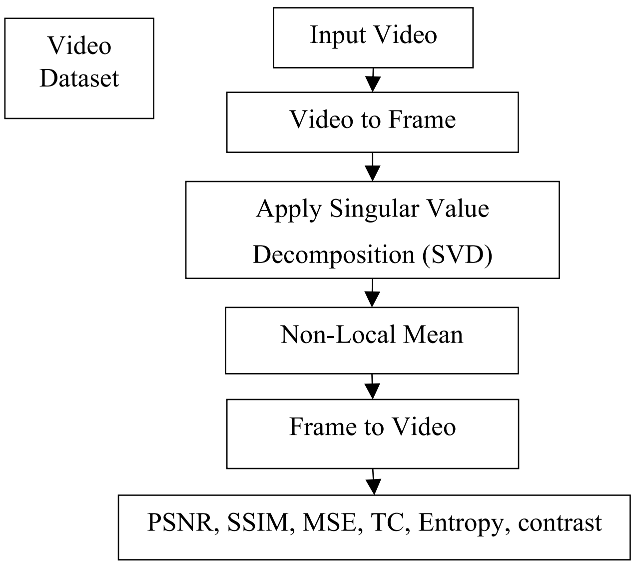

Fig 4.1: Block Diagram of the Proposed System

The Non-Local Means (NLM) algorithm is a powerful image denoising technique that preserves fine details and textures while effectively removing noise. Implementing the NLM algorithm in MATLAB involves leveraging its capability to calculate the similarity between patches in an image and replacing each pixel value with a weighted average of similar patches across the image.

The algorithm starts by defining parameters such as the size of the search window, the size of the patch, and the filtering parameter, which controls the trade-off between noise reduction and detail preservation. For each pixel in the image, a patch centered around the pixel is extracted, and its similarity to patches within the search window is computed. The similarity measure typically relies on the Gaussian-weighted Euclidean distance between patches, emphasizing closer spatial patches while maintaining sensitivity to texture similarity.

ADVANTAGES

- Improved contrast enhancement
- Better brightness adjustment
- Reduces noise amplification
- Preserves edges and fine details
- Suitable for low-light CCTV images
- Adaptive enhancement (region-based improvement)

APPLICATIONS

- CCTV surveillance systems (improving low-quality footage)
- Face recognition and identification systems
- Traffic monitoring and vehicle number plate detection
- Security and crime investigation analysis
- Night-time and low-light video enhancement
- Medical image enhancement (X-rays, MRI, CT scans)
- Satellite and remote sensing image processing

5. RESULTS AND DISCUSSIONS

The proposed Modified Singular Value Decomposition (SVD) based image enhancement method was implemented using MATLAB and tested on various low-quality CCTV images. The results demonstrate a significant improvement in image quality compared to existing enhancement techniques. The enhanced images show better contrast, improved brightness, and clearer visibility of objects, especially in low-light conditions. Unlike traditional methods, the proposed approach effectively preserves important details such as edges and textures while avoiding over-enhancement.

Quantitative analysis was carried out using performance metrics such as PSNR (Peak Signal-to-Noise Ratio), MSE (Mean Square Error), SSIM (Structural Similarity Index), and entropy. The results indicate higher PSNR and SSIM values, which confirm better image quality and structural preservation. At the same time, MSE values are reduced, indicating lower error between the original and enhanced images. The entropy values also increase, showing improved information content in the enhanced images.

Furthermore, the method proves to be adaptive and efficient for different types of CCTV images, including noisy and low-contrast scenes. The combination of SVD with preprocessing techniques helps in reducing noise and enhancing overall visual clarity. Therefore, the proposed method provides a reliable and effective solution for enhancing low-quality CCTV images and performs better than conventional enhancement techniques.

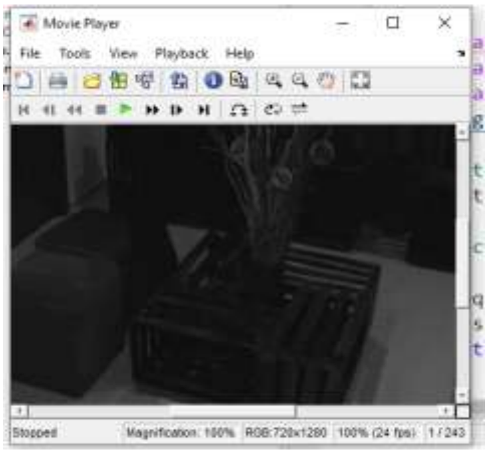

Fig. 5.1: Input Video Frame1.

fig 5.1 Input video frame 1”, indicating that this is the first frame extracted from the input video dataset. Overall, the image serves as an example of a raw input frame before enhancement, likely used in an image processing project. It highlights issues such as low brightness, poor contrast, and noise, which justify the need for enhancement techniques like filtering, contrast adjustment, or advanced methods (e.g., svd or non-local means**).**

Fig. 5.2: Output Video Frame 2

“Fig 5.2 Output Video Frame 2” presents a screenshot from a Movie Player application, similar to the previous sample, but this time displaying an enhanced output frame. Compared to the earlier input frame, the video image is significantly clearer and brighter. The objects in the scene are now more visible and distinguishable.

6. CONCLUSION AND FUTURESCOPE

In conclusion, this Project presents a robust and efficient approach for enhancing low-quality CCTV video frames using the Modified Singular Value Decomposition (MSVD) technique. By leveraging the replacement of diagonal sigma values from degraded frames with those of high-quality frames, the method achieves significant improvements in visual clarity and overall image quality. The process, implemented in MATLAB, standardizes video frames to ensure consistent processing and applies advanced matrix decomposition and reconstruction techniques.

The future scope of this project focuses on improving and extending the proposed image enhancement method for better performance and wider applications. In the future, advanced techniques such as deep learning can be incorporated to achieve more accurate and efficient results. The method can be further optimized to support real-time video processing, making it suitable for live CCTV surveillance systems. It can also be integrated with AI-based object detection for intelligent monitoring and security applications. Additionally, the approach can be enhanced to work effectively in extremely low-light conditions and for high-resolution images, including 4K videos.

ACKNOWLEDGEMENT

The authors express sincere gratitude to Mr. K Sunil Kumar Assistant Professor, Department of ECE, PBR VITS, Kavali, for his timely guidance and support. Heartfelt thanks to Dr. R. Sravanthi, Professor and Head of Department of ECE, and Principal Dr. V. Anil Kumar for providing the necessary infrastructure and facilities for completion of this project work.

REFERENCES

[1] M. Q. Huang, J. Ninić, and Q. B. Zhang, ''BIM, machine learning and computer vision techniques in underground construction: Current status and future perspectives,'' Tunnelling Underground Space Technol., vol. 108, Feb. 2021, Art. no. 103677.

[2] V. Arya, H. Choubey, S. Sharma, T.-Y. Chen, and C.-C. Lee, ''Image enhancement and features extraction of electron microscopic images using sigmoid function and 2D-DCT,'' IEEE Access, vol. 10, pp. 76742–76751, 2022.

[3] M. Sahnoun, F. Kallel, M. Dammak, O. Kammoun, C. Mhiri, K. Ben Mahfoudh, and A. Ben Hamida, ''A modified DWT-SVD algorithm for T1-w brain MR images contrast enhancement,'' IRBM, vol. 40, no. 4, pp. 235–243, Aug. 2019.

[4] X. Liu, M. Pedersen, and R. Wang, ''Survey of natural image enhancement techniques: Classification, evaluation, challenges, and perspectives,'' Digit. Signal Process., vol. 127, Jul. 2022, Art. no. 103547. [

5] J. M. Caplan, L. W. Kennedy, and G. J. J. O. E. C. Petrossian, ''Police monitored CCTV cameras in Newark, NJ: A quasi-experimental test of crime deterrence,'' J. Exp. Criminol., vol. 7, no. 3, pp. 255–274, 2011.

[6] A. Alshammari and D. B. Rawat, ''Intelligent multi-camera video surveillance system for smart city applications,'' in Proc. IEEE 9th Annu. Comput. Commun. Workshop Conf. (CCWC), Jan. 2019, pp. 0317–0323.

[7] S. G. Narasimhan and S. K. Nayar, ''Removing weather effects from monochrome images,'' in Proc. IEEE Comput. Soc. Conf. Comput. Vis. Pattern Recognit. (CVPR), Dec. 2001, p. 2.

[8] M. S. Pillai, G. Chaudhary, M. Khari, and R. G. Crespo, ''Real-time image enhancement for an automatic automobile accident detection through CCTV using deep learning,'' Soft Comput., vol. 25, no. 18, pp. 11929–11940, Sep. 2021.

[9] J. Shen, G. Li, W. Yan, W. Tao, G. Xu, D. Diao, and P. Green, ''Nighttime driving safety improvement via image enhancement for driver face detection,'' IEEE Access, vol. 6, pp. 45625–45634, 2018.

[10] L. Liu, Z. Jia, J. Yang, N. Kasabov, and F. IEEE, ''A medical image enhancement method using adaptive thresholding in NSCT domain combined unsharp masking,'' Int. J. Imag. Syst. Technol., vol. 25, no. 3, pp. 199–205, Sep. 2015.

[11] D. Vijayalakshmi, M. K. Nath, and O. P. Acharya, ''A comprehensive survey on image contrast enhancement techniques in spatial domain,'' Sens. Imag., vol. 21, no. 1, p. 40, Dec. 2020.

[12] G. Singh and A. Mittal, ''Various image enhancement techniques-a critical review,'' Int. J. Innov. Sci. Res., vol. 10, no. 2, pp. 267–274, 2014.

[13] L. Zhan, Y. Zhuang, and L. Huang, ''Infrared and visible images fusion method based on discrete wavelet transform,'' J. Comput., vol. 28, no. 2, pp. 57–71, 2017.