Forensic Analysis of Device-Induced Motion Blur and Image Tampering Detection Using Amped Five Software

Damini Thakur[1], Rashmi Raman[2], P.N. Ramakrishnan[3]

[1,2]*Forensic Professional, Central Forensic Science Laboratory, Directorate of Forensic Science Services, Ministry of Home Affairs, Government of India, Chandigarh -160036*

[3]*Deputy Director & Scientist-D, Central Forensic Science Laboratory, Directorate of Forensic Science Services, Ministry of Home Affairs, Government of India, Chandigarh -160036*

Abstract—In most modern camera devices, particularly those used for video surveillance such as CCTV systems and body-worn cameras, shutter speed is automatically controlled to adapt to varying lighting and environmental conditions. As a result, motion blur frequently occurs in surveillance footage, notably in cases involving moving vehicles, where critical details such as number plates and object boundaries become unclear. This poses significant challenges for forensic analysis and the reliability of digital evidence. For the experimental spade work, casually captured images of a parked vehicle taken using an unknown-pixel mobile camera were analyzed to simulate real-world challenges that arises majorly while examining the forensic cases. This study addresses the problem of motion blur caused by automatic shutter limitations by applying forensic image deblurring and enhancement techniques using Amped FIVE PROFESSIONAL software (Amped SRL) having Built date 20170302. Experimental results demonstrate that appropriate deblurring and enhancement workflows can substantially improve the interpretability of motion-blurred CCTV footage. Special attention was given to EXIF information, including camera model, camera aspect ratio, timestamp accuracy, geolocation entries, and other device-specific markers.

Index Terms—Amped FIVE, CCTV footage, filters, metadata, motion blur.

I. INTRODUCTION

In the field of digital image and video analysis, one frequently encounters challenges related to low resolution, inadequate lighting conditions, and excessive distance of key objects within the captured media. These factors significantly degrade the visual quality and hinder the accurate identification, recognition, or analysis of crucial elements present in the frame. Such issues are particularly critical in applications like forensic image enhancement, surveillance analysis, object motion blur detection, and facial recognition, where clarity and detail are essential for reliable interpretation.

Therefore, the problem addressed in this work is the enhancement and restoration of low-quality blurred images affected by poor lighting, low resolution, or long-distance capture, with the objective of improving the visibility, sharpness, and recognizability of key objects using suitable computational and image processing techniques.

Motion blur is a visual distortion that occurs when a camera or the subject moves during the exposure time of an image or video frame. Because the sensor continues to record light while motion is happening, moving objects appear smeared or stretched along the direction of movement rather than sharply defined. In imaging and video forensics, motion blur is commonly encountered in CCTV and mobile camera footage, especially in low-light conditions where the camera automatically uses a slower shutter speed. Fast-moving subjects such as vehicles, people, or handheld cameras are particularly prone to this effect. Motion blur can obscure critical details like faces or vehicle number plates, making identification difficult. Forensic analysis often involves estimating the blur direction and extent, then applying filter like Levels and Unsharp Mask along with deblurring or enhancement techniques using Forensic Software to improve visibility while preserving the evidentiary integrity of the original image.

Amped FIVE Professional (Forensic Image and Video Enhancement) is a specialized forensic software

designed for law enforcement, intelligence agencies, and forensic experts to analyze, process, and enhance images and videos for investigative and evidential purposes. The software supports hundreds of image and video formats, including proprietary surveillance and mobile recordings, and offers a comprehensive suite of tools for verification, correction, enhancement, and presentation. With its intuitive, filter-based interface, users can perform complex forensic tasks such as deblurring, denoising, stabilization, measurement, and authentication without altering the original evidence. Amped FIVE is widely recognized for bridging the gap between forensic science and digital investigation, ensuring accuracy, transparency, and reliability in visual evidence analysis. The tools outlined below represent the most widely used enhancement features in Amped FIVE software-

1.1. Verify

- Verification tools in Amped FIVE are used to confirm the authenticity and integrity of an image or video before any enhancement is performed. The File Info/Metadata tool provides essential technical details such as EXIF data, encoding format, and header information. Hash and integrity checks ensure that the file has not been altered by comparing MD5 or SHA-1 values. Additional tools like format conversion and timestamp extraction help preserve original content while accessing embedded time data for forensic documentation.

1.2. Measure

- The Measure tools in Amped FIVE are used to obtain accurate forensic measurements from images and video frames. Perspective Correction is applied first to remove distortion so that objects appear in their true shape for precise analysis. Tools like Ruler and Scale allow investigators to measure distances or object sizes directly between selected points. Additional functions such as Angle/Area Measurement and Calibration ensure that all measurements are converted from pixel values to real-world units using a known reference scale.

1.3. Sharpen

- Sharpen tools in Amped FIVE are used to enhance fine details and edges that have been blurred due to motion or poor focus. The Unsharp Mask filter increases edge contrast while keeping the natural appearance of the image intact. Adaptive Sharpen automatically adjusts its strength depending on the content, ensuring optimal clarity without excessive noise. The High-Pass Filter further enhances high-frequency details, making edges and small features more visible for forensic analysis.

1.4. Denoise

- Denoise filters in Amped FIVE are used to remove noise caused by low light, compression, high ISO levels, or sensor limitations, all of which can obscure crucial details such as faces, text, and number plates. Core tools like Temporal Denoise, Spatial Denoise, and FFT Denoise address various noise types by using multi-frame averaging, edge-preserving smoothing, or frequency-domain filtering. Additional filters such as Averaging, Gaussian, Wiener, Bilateral, Median, and Deblocking provide targeted noise reduction depending on whether the distortion is random, Gaussian, impulse-based, or compression-related. These methods help produce clearer, more reliable forensic images while preserving important details needed for identification and analysis.

1.5. Deblurring

- Deblurring in Amped FIVE is used to restore images affected by motion or defocus while maintaining forensic integrity by avoiding artificial detail creation. The main filters include Motion Deblurring for correcting linear movement, Optical Deblurring for lens-related defocus, Nonlinear Deblurring for mixed or irregular blur patterns, and Blind Deconvolution for situations where the blur kernel is unknown. Motion Deblurring works by estimating the length and angle of the blur streak and reversing it, making it useful for restoring smeared faces or number plates in CCTV footage. Optical Deblurring uses a Point Spread Function (PSF) to reverse out-of-focus blur, sharpening edges in

surveillance images that were captured beyond the focal range. Nonlinear Deblurring applies adaptive algorithms to handle complex blur combinations, such as those from handheld or drone footage. Blind Deconvolution automatically estimates the blur function through iterative refinement, making it effective when the cause of blur motion, defocus, or both—is uncertain.

1.6. Stabilization

- Stabilization tools in Amped FIVE are used to correct shaky or unstable video footage, ensuring smoother and more reliable analysis. The Video Stabilization feature tracks unintended camera movement and compensates for it, producing a steadier sequence. Rolling Shutter Correction addresses distortions caused by CMOS sensors, which often appear as wobbling or skewing in fast-motion scenes. Frame Alignment aligns consecutive frames, providing a stable reference for further enhancement or accurate comparison.

1.7. Integrate

- Integrate tools in Amped FIVE are used to combine multiple frames or image sources to improve overall clarity and reduce noise. Frame Averaging or Super Resolution merges several frames to create a cleaner, higher-quality composite with enhanced detail. Image Stacking aligns and integrates similar frames to reveal information that may not be visible in a single image. Frame Selection helps identify and use only the best-quality frames, ensuring that the integration process produces the most accurate and detailed result.

1.8. Presentation

- Presentation tools in Amped FIVE are used for the final visualization, explanation, and documentation of forensic enhancements. Annotation and Labeling features allow investigators to add arrows, text, or markers without altering the original image. Split View or Side-by-Side display helps compare the original and enhanced versions for clear visual evaluation. Export and Report Generation create professionally formatted, court-admissible reports that include the filter chain, parameter settings, and all steps taken during the enhancement process.

1.9 Brightness and Contrast

- Brightness and contrast–related filters in Amped FIVE improve overall visibility by adjusting lightness, tonal range, and luminance distribution. Tools like Brightness/Contrast, Levels, Histogram Equalization, and Gamma Correction enhance dark, overexposed, or low-contrast CCTV footage by redistributing pixel values or correcting mid-tones. Shadow/Highlight correction further balances uneven lighting, while Auto Levels and Auto Contrast provide quick automatic enhancement. Color Balance and Grayscale Conversion emphasize luminance details, making features like faces and number plates clearer for forensic analysis.

Table 1: Summary of the filters applied for image processing in AMPED FIVE

S.No	Filters	Sub-Filters	Primary Function	Forensic Use
1.	Verify		Confirms the authenticity and integrity of image or video files.	Ensures that evidence has not been tampered with and maintains the chain of custody.
2.	Measure		Allows accurate measurement of distances, angles, and dimensions within an image.	Used in accident reconstruction, crime scene analysis, and object size estimation.
3.	Sharpen		Enhances edge contrast to improve visibility of fine details.	Used to make blurred or low-contrast objects (like number plates or faces) clearer.
4.	Denoise	Averaging Filter	Smooths the image by replacing each pixel with the average of its neighborhood.	Removes random noise and minor artifacts from surveillance footage.

		Gaussian Filter	Applies a weighted smoothing that preserves general structure while reducing noise.	Commonly used for noise reduction prior to edge detection or sharpening.
		Wiener Filter	Restores degraded images by minimizing mean square error between original and processed image.	Useful for motion blur and noise reduction in forensic enhancement.
		Bilateral Filter	Smooths images while preserving edges by considering both spatial and intensity differences.	Enhances images where edge preservation is critical, such as text or license plates.
		Median Filter	Replaces each pixel with the median value in its neighborhood, effectively removing salt-and-pepper noise.	Ideal for removing impulsive noise from CCTV images.
		Deblocking	Reduces block artifacts caused by video compression (e.g., from MPEG, H.264).	Restores compressed CCTV footage for clearer evidence presentation.
5.	Deblurring	Motion Deblurring	Compensates for linear motion blur due to camera or object movement.	Clarifies moving subjects like vehicles or persons in motion.
		Optical Deblurring	Corrects blur caused by optical aberrations or defocus.	Useful when footage is out of focus due to poor camera calibration.
		Nonlinear Deblurring	Corrects complex or irregular motion blur using user-defined PSF splines.	Recovers details from fast-moving vehicles or rotating objects.
		Blind Deconvolution	Estimates both the blur kernel and original image without prior knowledge of the blur.	Used when blur characteristics are unknown or unpredictable.
6.	Stabilization		Removes frame-to-frame jitter caused by camera shake or vibration.	Stabilizes shaky surveillance video for accurate analysis of motion or events.
7.	Integrate		Combines multiple frames or sources into one enhanced image.	Enhances detail and reduces noise by averaging multiple video frames.
8.	Presentation		Prepares enhanced images or videos for reporting and court submission.	Ensures clear and standardized presentation of forensic evidence.
9.	Equalizer	Brightness / Contrast	Adjust overall lightness, contrast, and tonal balance of images.	Enhances visibility and readability of dark or low-contrast footage.
		Levels	Adjusts tonal range and histogram distribution.	Balances light and shadow to reveal hidden image details.
		Histogram Equalization	Redistributes intensity values to enhance global contrast.	Reveals obscured patterns and details in low-contrast footage.
		Gamma Correction	Adjusts image brightness nonlinearly without losing detail	Enhances dark regions while maintaining highlights.
		Shadow / Highlight Correction	Selectively corrects underexposed or overexposed areas.	Recovers information from bright sunlight or poorly lit environments.
		Auto Levels /Auto Contrast	Automatically adjusts tonal range and color balance.	Quick enhancement of poorly lit or washed-out images.
		Color Balance / Grayscale Conversion	Adjusts color tone or converts color images to grayscale for clarity.	Used to emphasize text or details where color may distract or reduce visibility.

II. REVIEW OF LITERATURE

2.1. Mišel Gvozdanović et al.his study highlights the analysis of video footage from security cameras using the Amped FIVE professional tool specifically for the identification of vehicle license plates. This paper describes problems of improving security cameras' video footage for forensic investigation. When processing records, one encounters problems with low resolution, poor lighting, or excessive distance of a key object in an image or video. Using the Amped FIVE Professional tool, forensic scientists create videos and analyze and process the record itself using various filters. Record quality demands a choice of video filters. The use and selection of filters show the improvement of the record itself to the level to which useful information can be obtained in this case of vehicle license plates. The presented roadmap can be used as the base for further video forensic research.

2.2. S. Milani M. Fontani et al., "An overview on video forensics The paper aims at providing an overview of the existing video processing techniques, considering all the possible alterations that can be operated on a single signal and also the possibility of identifying the traces that could reveal important information about its origin and use.

2.3. Zohair Al-Ameen, "Computer Forensics and Image Deblurring-An Inclusive Investigation This article addresses the field of computer forensics with image deblurring as the latent details that are indeed present in the captured images are concealed due to the blurring artifact. The purpose of this paper is to deliver a better understanding of deblurring images in the area of forensic science"

2.4. Qin Zhang, "Digital image forensics of non-uniform deblurring, The experimental results demonstrate that the proposed approach successfully localize the deblurred regions with a satisfactory performance".

2.5. Jie Li et al., "Blind image motion deblurring with L0-regularized priors This paper focuses on motion deblurring problem, and the process of motion blur is generally modeled as a latent image convolved with a motion blur kernel. This paper propose a natural image motion deblurring model based on -regularized prior and introduces an efficient optimization algorithm".

2.6. Pan, Jinshan & Hu, Zhe & Su, Zhixun & Yang, Ming-Hsuan. (2014), "Deblurring Face Images with Exemplars. 47-62. 10.1007/978-3-319-10584-0_4. We propose a novel exemplar-based deblurring algorithm for face images that exploits the structural information. The proposed method uses face structure and reliable edges from exemplars for kernel estimation without resorting to complex edge predictions".

2.7. Joshi et al. and Cho et al., "This study highlights the direct use of the restored sharp edges from a blurred image for kernel estimation. Cho and Lee utilize bilateral filters together with shock filters to predict sharp edges. The blur kernel is determined by alternating between restoring sharp edges and estimating the blur kernel in a coarse-to-fine manner. As strong edges extracted from a blurred image are not necessarily useful for kernel estimation."

2.8. Xu and Jia, "This study was used to develop a method to select informative ones for deblurring. Despite demonstrated success, these methods rely largely on heuristic image filtering methods (e.g., shock and bilateral filters) for restoring sharp edges, which are less effective for objects with known geometric structures".

2.9. Nishiyama et al. "This review explains the use of subspaces from blurred face images with known blur kernels for recognition. As the set of blur kernels is pre-defined, the application domain of this approach is limited".

2.10. Zhang et al. "The purpose of this study is a joint image restoration and recognition method based on sparse representation prior. However, this method is most effective for well-cropped face images with limited alignment errors and simple motion blurs".

2.11. HaCohen et al. "In this study a deblurring method which uses a sharp reference example for guidance. The method requires a reference image with the same content as the input and builds up dense correspondence for reconstruction. It has shown decent results on deblurring specific images, however,

the usage of the same-content reference image restrains its applications".

III. PROBLEM FORMULATION

In real-world forensic scenarios, images of vehicle licence plates are often captured using handheld mobile devices under uncontrolled conditions. In the present case, a parked vehicle's licence plate was photographed using a handheld mobile phone with an unknown camera sensor resolution and pixel characteristics. Due to low-lighting conditions, the camera's shutter speed was automatically reduced, increasing the exposure time. Minor involuntary movement of the operator's hand during image capture resulted in motion blur, causing the licence plate characters to appear smeared and partially illegible.

The challenge lies in enhancing such a blurred image to improve the readability of the licence plate without introducing artifacts or altering the original evidentiary content. Since camera parameters such as pixel size, resolution, and shutter speed are unknown, conventional restoration approaches are limited. Therefore, this study focuses on the application of forensic image enhancement techniques using Amped FIVE Professional software, including deblurring, noise reduction, and brightness–contrast optimization, to recover maximum possible visual information. The problem is to evaluate the effectiveness and limitations of these enhancement methods in producing a clearer, forensically reliable representation of the licence plate from a motion-blurred image captured under low-light conditions using an unknown handheld mobile camera.

IV. METHODOLOGY

This spade work aims on forensic image enhancement methodology to address motion blur in vehicle number plate images. A blurred image of a parked vehicle was captured using a handheld mobile device with unknown camera resolution and pixel characteristics under low-light conditions, replicating common challenges encountered in real-world forensic investigations. The original image was preserved in its native format to maintain evidentiary integrity.

The image was imported into Amped FIVE Professional (Amped SRL, Build 20170302) using standard forensic procedures. An initial examination was conducted to extract and document EXIF metadata, including camera model, aspect ratio, timestamp accuracy, geolocation data, and other device-specific parameters, supporting authenticity verification and chain-of-custody requirements.

A systematic and non-destructive enhancement workflow was then applied. Motion blur caused by hand movement and automatic shutter limitations was addressed using the Deblur filter by estimating the blur direction and magnitude. Denoise filters were applied to suppress noise introduced by low-light capture. Levels adjustment was used to optimize the dynamic range by redistributing shadow, midtone, and highlight values, thereby improving tonal separation of the licence plate characters. Brightness and Contrast adjustments were subsequently applied to further enhance visual clarity.

To improve edge definition and character sharpness without introducing artificial features, the Unsharp Mask filter was applied in a controlled manner. Each enhancement step was performed incrementally, with intermediate results documented to ensure transparency, repeatability, and forensic reliability.

The effectiveness of the enhancement process was evaluated through a comparative analysis of the original and processed images, focusing on improvements in clarity, readability, and interpretability of the licence plate characters. Throughout the process, care was taken to avoid over-enhancement or artifact generation, ensuring that the final output remained a faithful and admissible representation of the original digital evidence.

V. RESULTS AND DISCUSSION

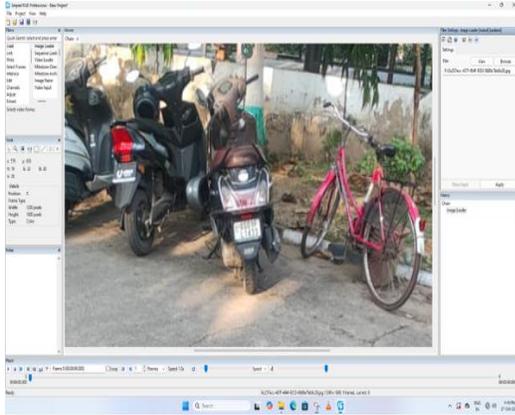FIGURE 1: Obtain the CCTV/DVR footage frame containing the blurred vehicle number plate of vehicle marked as "A".

FIGURE 2: Use the Image Loader tool to import the file (.jpg format)

FIGURE 3: The software reads the file and prepares it for enhancement.

FIGURE 4: MediaInfo of the Image is recorded

FIGURE 5: Exif-Info of the Image is recorded

FIGURE 6: Apply the Nonlinear Deblurring filter to correct blur and noise of the image

FIGURE 7: Apply an Averaging Filter to smooth residual noise or artifacts introduced by previous sharpening steps

FIGURE 8: After all enhancements, the vehicle plate number becomes clearly identifiable. The final readable plate number is: AS01 FL 1433

After performing a sequence of enhancement procedures in Amped FIVE Professional, the blurred vehicle number plate image extracted from the CCTV/DVR footage was successfully processed and clarified. Each applied filter such as Nonlinear Deblurring, Laplacian Sharpening, Unsharp Masking, and Averaging Filter played a vital role in reducing motion blur, enhancing edge definition, and improving the overall visibility of the plate characters. The adjustments in contrast and brightness further optimized the image clarity, allowing for accurate interpretation of the alphanumeric details. As a result of these combined enhancement techniques, the vehicle registration number was distinctly identified as AS01 FL 1433, demonstrating the effectiveness of the adopted image processing workflow for forensic and investigative applications.

VI. CONCLUSION AND FUTURE SCOPE

In this spade work, a blurred vehicle number plate image obtained was successfully processed and enhanced using Amped FIVE Professional software. The workflow systematically applied a series of image enhancement techniques including Nonlinear Deblurring, Laplacian Sharpening, Unsharp Masking, Averaging Filter, and Contrast-Brightness Adjustment to restore image clarity and improve legibility.

The use of the Nonlinear Deblurring algorithm effectively corrected the blur and noise caused as the image was acquired from a distant place, while the Laplacian and Unsharp Masking filters enhanced the edges and details of the number plate. Subsequent smoothing and tonal adjustments improved the overall readability and visual balance of the image.

Through this process, the initially obscured number plate was successfully identified as "AS01 FL 1433", demonstrating the efficiency of the applied techniques in forensic image processing and evidence recovery. The results confirm that systematic digital image enhancement can significantly aid in law enforcement investigations, traffic surveillance, and forensic analysis where visual evidence is critical.

VII. FUTURE IMPLEMENTIONS

Future advancements in forensic video enhancement are moving toward full automation through artificial intelligence and deep learning. By integrating deep learning–based deblurring and super-resolution models, systems can automatically detect, segment, and enhance vehicle license plates from CCTV footage with minimal manual intervention. Such models can learn complex blur patterns, low-light distortions, and compression artifacts, enabling them to restore clarity more effectively than traditional filters. In addition, real-time enhancement capabilities could be deployed to process live CCTV streams, allowing immediate identification of vehicles involved in criminal activities, hit-and-run incidents, or traffic violations.

Another major direction is the integration of advanced enhancement techniques with Automatic Number Plate Recognition (ANPR) systems. Enhanced frames produced through AI-based denoising, deblurring, and contrast correction can significantly increase ANPR accuracy in challenging environments such as night-time scenes, rain, fog, or low-resolution surveillance feeds. By combining forensic-quality image enhancement with robust ANPR algorithms, law enforcement and traffic monitoring agencies can achieve faster, more reliable vehicle identification even under adverse imaging conditions.

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