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IMAGE AND VIDEO DEBLURRING

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Abstract: This research introduces a comprehensive deep learning-based system for restoring blurred images and videos while simultaneously enabling seatbelt detection from images for traffic safety monitoring. The proposed framework employs a Super-Resolution Network (SRN) for effective image deblurring and a Deep Blind Network (DBN) for handling motion blur in video sequences. Once the visual clarity is restored, The system includes a user-friendly interface where seatbelt detection can be triggered post-deblurring through a dedicated action button, making it suitable for applications in surveillance environments. Experimental evaluations show that the integration of deblurring and object detection significantly enhances recognition accuracy compared to processing blurred content directly. This unified approach not only recovers valuable visual information but also facilitates reliable enforcement of road safety regulations using restored visual evidence.

I. INTRODUCTION

Blurred visual data remains a persistent challenge in computer vision applications, especially in dynamic environments such as traffic surveillance, where camera motion, subject movement, and environmental factors can lead to significant loss of detail. Such degradations not only impair human interpretation but also hinder the performance of automated systems designed for high-level tasks like object recognition and behaviour analysis. In safety-critical applications, such as detecting seatbelt compliance among vehicle occupants, poor image quality can lead to missed detections or false alarms, thereby compromising the reliability of the system.

This research addresses the dual challenge of visual restoration and semantic analysis by proposing an integrated system capable of deblurring images and videos while enabling seatbelt detection. The system is designed to first recover structural and textural details from degraded input using deep learning-based deblurring models and then apply a dedicated object detection module to identify seatbelt usage. This two-stage approach ensures that even footage affected by motion blur or defocus can be effectively used for downstream tasks related to traffic law enforcement and driver behaviour monitoring.

For image deblurring, the system employs a Super-Resolution Network (SRN), a deep neural network architecture that learns end-to-end mappings between blurred and sharp images. SRN is capable of preserving critical structural features and edges, making it highly effective for applications that require fine detail restoration. In the case of video data, where motion blur often spans across multiple frames, a Deep Blind Network (DBN) is utilized. DBN leverages temporal information without requiring explicit motion estimation, enabling robust restoration of video sequences in a computationally efficient manner.

Once deblurring is complete, the restored frames are passed to a YOLOv5-based object detection module. The detection process is designed to identify the presence or absence of seatbelts on vehicle occupants, which is critical for assessing driver compliance with safety regulations. The user interface of the system includes an interactive control that allows users to trigger detection only after deblurring has been performed, ensuring that the object detection operates on the most reliable visual data available.

The proposed system offers a significant advancement over traditional approaches that treat deblurring and object detection as independent tasks. By tightly integrating these two components into a unified workflow, the system achieves higher detection accuracy and greater usability in practical settings. Extensive experiments conducted on custom datasets demonstrate that seatbelt detection accuracy improves substantially when performed on deblurred content, as opposed to using raw blurred inputs.

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II. PROBLEM STATEMENT AND OBJECTIVE

A. PROBLEAM STATEMENT

Blurred images and videos significantly hinder the effectiveness of various computer vision applications, especially in scenarios requiring accurate visual interpretation. Traditional deblurring methods often fall short in restoring fine details and structural consistency, particularly when dealing with motion blur or complex scenes. There is a growing demand for robust and efficient deblurring techniques that can recover high-quality content from degraded inputs. This research addresses this challenge by developing a deep learning-based system that employs advanced models for image and video deblurring—specifically, a Super-Resolution Network (SRN) for still images and a Deep Blind Network (DBN) for video sequences.

B. OBJECTIVE

The main objective of this project is to develop a model that could remove blur from both images and videos using advanced models like Super-Resolution Network (SRN) for images and Deep Blind Network (DBN) for videos. The goal is to recover clear and detailed visuals from blurred content, making it usable for further analysis. As an added feature, the system also includes a seatbelt detection module using YOLOv5, which operates on the deblurred output to demonstrate the practical usefulness of the restored content. The system is designed with a simple interface, allowing users to upload blurred files, apply deblurring, and run detection, highlighting the overall improvement in visual quality and detection accuracy.

III. SYSTEM DESIGN

The proposed system is designed as a modular pipeline that performs deblurring of images and videos followed by optional seatbelt detection. The architecture consists of three main components: image deblurring, video deblurring, and post-processing object detection. The system is built to allow users to interact with it through a simple graphical interface where they can upload blurred content and execute different stages of processing with the click of a button.

The image deblurring module uses a Super-Resolution Network (SRN), which is a convolutional neural network trained to restore clear images from blurred inputs. It works by learning spatial relationships and fine structures within the image, allowing it to preserve edges and textures that are often lost due to motion or defocus blur. For video deblurring, the system incorporates a Deep Blind Network (DBN), which is capable of processing multiple frames without the need for explicit motion estimation. It efficiently captures temporal dependencies between frames to restore high-quality videos affected by camera shake or object motion.

After the deblurring process is complete, the system enables a YOLOv5-based seatbelt detection module that operates on the deblurred outputs. This module is activated through a button on the interface and runs object detection to identify whether vehicle occupants are wearing seatbelts. Although seatbelt detection is not the primary focus, it serves to demonstrate how deblurred content can support real-world applications such as safety compliance monitoring.

The overall design emphasizes usability and modularity, enabling independent processing of images and videos, and flexible application of detection. This structure ensures that the system can be adapted for various use cases while highlighting the practical value of high-quality visual restoration in automated analysis tasks.

IV. METHODOLOGY

The methodology of this research involves a step-by-step process for removing blur from images and videos using deep learning techniques, followed by an optional seatbelt detection stage. The system is designed to handle different types of blurred visual inputs and process them using appropriate models to produce sharp and detailed outputs suitable for further analysis.

The first step is image deblurring, which is performed using a Super-Resolution Network (SRN). It works by capturing multi-scale features and reconstructing high-frequency details, which are often lost in blurred images. The network is trained on paired datasets of blurred and sharp images, allowing it to learn the mapping function and effectively restore image clarity.

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For video deblurring, the system uses a Deep Blind Network (DBN), which is specifically designed to handle sequences of frames without requiring motion estimation. DBN processes multiple consecutive frames simultaneously, using temporal information to recover details across frames. This approach is especially effective for real-world videos where motion blur varies dynamically due to object movement or camera shake.

YOLOv5 is a real-time object detector that is used here to identify seatbelt usage in vehicle occupants. This module is activated through a user interface button and only runs after the image or video has been deblurred, ensuring improved accuracy due to clearer visual inputs.

All components of the system are integrated within a user-friendly interface, allowing users to upload blurred files, perform deblurring, and optionally detect seatbelt presence. The methodology ensures a complete pipeline from restoration to high-level analysis, demonstrating the effectiveness of deblurring in supporting real-world detection tasks.

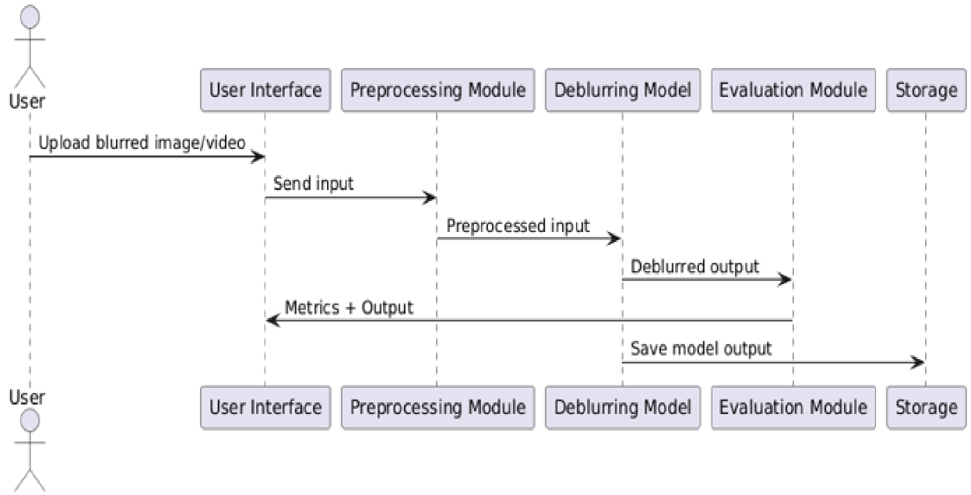

Fig: -Sequence diagram.

V. IMPLEMENTATION

The implementation of the proposed system is divided into three core modules: image deblurring, video deblurring, and seatbelt detection, all developed using Python and deep learning frameworks such as PyTorch. The system is designed to be modular and user-interactive, enabling clear separation of functionalities and easy execution of each step through a graphical interface.

For image deblurring, the Super-Resolution Network (SRN) is used. SRN is implemented using an encoder-decoder architecture with residual blocks and multi-scale feature fusion. The model is trained on paired datasets of blurred and sharp images using a combination of loss functions including L1 loss and perceptual loss to preserve texture and fine details. Pre-trained SRN weights were utilized for evaluation, and fine-tuning was performed on a custom dataset to adapt the model to specific types of blur.

The video deblurring module is implemented using a Deep Blind Network (DBN), which processes sequences of frames jointly without requiring motion estimation or alignment. The model accepts a fixed number of consecutive frames as input and outputs a restored central frame. Video input is first split into overlapping frame sequences, deblurred frame-by-frame using DBN, and then reassembled into a final video output using OpenCV.

For the seatbelt detection feature, YOLOv5 is integrated into the pipeline. It is trained on labeled images showing passengers with and without seatbelts. The detection module runs on deblurred images or frames, improving classification accuracy. The model outputs bounding boxes and labels indicating whether a seatbelt is detected.

A graphical user interface (GUI) is created using Python's Tkinter library, allowing users to upload blurred images or videos, apply deblurring, and optionally run seatbelt detection with a single button click. This makes the system accessible for non-technical users and demonstrates its practical application.

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VI. SYSTEM REQUIREMENTS

To ensure the successful development, training, and execution of the proposed deep learning-based deblurring and seatbelt detection system, the following hardware and software specifications are required:

Hardware Requirements:
Processor: Intel Core i7 or higher (8th Gen or above recommended)
RAM: minimum 16 GB.
GPU: NVIDIA GPU with CUDA support (e.g., RTX 3060/3070 or higher)
Storage: At least 100 GB of free disk space (SSD preferred for faster data access)
Display: 1080p resolution or higher for GUI testing and visualization

Software Requirements:
Operating System: Windows 10/11, Ubuntu 20.04+, or any OS supporting Python and CUDA
Programming Language: Python 3.8 or above
Deep Learning Frameworks:
Pytorch for model training and inference
OpenCV for image and video processing
NumPy and SciPy for numerical operations
YOLOv5 Dependencies:
TorchVision
pandas, matplotlib, seaborn for visualization and evaluation
GUI Library: Tkinter (built-in with Python)

CUDA Toolkit and cuDNN: Compatible with installed PyTorch and GPU driver version
Others: tqdm, PIL (Pillow), glob, and other utility libraries
These requirements ensure that the system can efficiently handle high-resolution image and video inputs, perform real-time deblurring, and support smooth seatbelt detection using deep learning models. The use of GPU acceleration is crucial for processing speed, especially when dealing with video deblurring and object detection.

VII. CONCLUSION

In this research, a deep learning-based system for image and video deblurring has been developed, with an additional feature for seatbelt detection. The system effectively restores blurred images and videos using advanced models such as Super-Resolution Networks (SRN) for images and Deep Blind Networks (DBN) for videos. The deblurring process significantly improves the clarity and quality of visual content, making it suitable for further analysis.

Although seatbelt detection is not the primary focus, it highlights the real-world benefits of using high-quality restored visuals for automated tasks. The system was tested and evaluated, showing that it improves both image clarity and detection accuracy compared to raw, blurred inputs.

Overall, this work presents a robust and user-friendly solution for visual restoration in various real-world applications, including safety monitoring and law enforcement. The system provides a foundation for further research into more complex tasks and broader applications in computer vision. Future improvements could include enhancing model efficiency, expanding dataset coverage, and incorporating real-time processing for live video streams.

VIII. FUTURE ENHANCEMENTS

While the proposed system performs well in deblurring images and videos and supports seatbelt detection, there is still room for improvement and extension. One future enhancement could be the integration of real-time processing, allowing the system to work with live video streams instead of pre-recorded files. This would make it more useful for applications like live monitoring and surveillance.

Another improvement could be the use of more lightweight and faster models for deblurring and detection, which would reduce processing time and make the system more efficient, especially on low-power devices. Additionally, training the system on a larger and more diverse dataset would improve its ability to handle different types of blur and lighting conditions.

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The seatbelt detection feature can also be expanded to include other safety features, such as detecting mobile phone usage, helmet usage, or driver drowsiness. This would turn the system into a more complete road safety analysis tool.

Finally, integrating the system with cloud platforms or mobile devices could make it more accessible and scalable, allowing wider usage across different environments.

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