

## Development of an Automotive Glare Suppression and Night Vision System and Vision Based Driver Assistance

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### Abstract:

This paper Automotive Glare Suppression and Night Vision Assistance system is designed to improve driver safety and visibility during nighttime driving. Glare from oncoming vehicle headlights often causes temporary vision impairment, leading to accidents. The system uses a Raspberry Pi 3 Model B+ as the central unit, connected to a Pi Camera that captures real-time road images. These images are processed to detect high intensity light from approaching vehicles. When glare is identified, adaptive filtering techniques reduce brightness and enhance image clarity. Additionally, night vision enhancement improves visibility in low-light conditions, and the output is displayed on a 7-inch HDMI LCD screen. The system also includes automatic headlight control, which switches between high and low beams based on detected glare. Automatic indicator control using tilt sensors improves turning signals. An accident detection mechanism is incorporated to send emergency alerts via a GSM module.

**KEY WORDS:** Glare reduction, Night vision, Driver assistance system, Raspberry Pi, Image processing.

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### I. Introduction

The project focuses on Road safety during night-time driving is a major concern due to reduced visibility, glare from oncoming vehicle headlights, improper signaling during turns, and delayed emergency response after accidents.[1]High-beam headlights from approaching vehicles can cause temporary blindness, increasing the risk of collisions. In addition, drivers may forget to operate indicators correctly, and in the event of an accident, immediate communication with emergency services is often not available.

To address these issues, the project Automotive Glare Suppression and Night Vision Assistance presents an intelligent driver assistance system using embedded vision and automation technologies. The system employs a Raspberry Pi 3 B+ as the central controller, interfaced with a Pi Camera to capture real-time road images. Image processing techniques are applied to detect headlight glare and enhance visibility in low-light conditions. [2]The processed video output is displayed on a 7-inch HDMI LCD screen, providing

the driver with improved situational awareness during night driving. The system also includes automatic headlight beam control, which switches between high and low beams based on detected glare conditions, thereby reducing discomfort to both the driver and oncoming vehicles. Automatic indicator control is implemented using tilting switches mounted on the steering mechanism to ensure proper signaling during turns.[3]For emergency situations, a manual accident alert push button is provided; when pressed, it activates a GSM module to send alert messages to the nearest police station and hospital, enabling faster rescue and medical assistance. Overall, this project integrates vision-based assistance, vehicle automation, and emergency communication into a single cost-effective system.[17]

## II. Literature Review

Several research efforts have been made to improve night-time driving safety and reduce glare effects. Traditional solutions include automatic headlight dimming systems, which switch between high and low beam based on light intensity.[18] However, these systems rely on simple sensors and lack precise control. Recent developments in computer vision have introduced advanced techniques for glare detection and image enhancement.[10] Methods such as histogram equalization, adaptive filtering, and contrast enhancement have been widely used to improve visibility in low-light conditions. These approaches provide better performance compared to traditional sensor-based systems. Some researchers have explored deep learning techniques for object detection and scene understanding in automotive applications.[4] Although these methods provide high accuracy, they require significant computational resources and are not always suitable for low-cost embedded systems.[16] In the area of accident detection, many systems use accelerometers or vibration sensors to detect collisions. However, these methods may produce false alerts due to sudden braking or road conditions.[5] The proposed system addresses this limitation by using an **airbag deployment-based detection mechanism**, ensuring that alerts are generated only during severe accidents. Overall, existing systems focus on individual functionalities such as glare reduction or accident detection. The proposed system integrates multiple features into a single platform, providing a more efficient and reliable solution

## III. Methodology

The proposed system follows a **vision-based embedded processing approach** to detect and suppress glare while enhancing night-time visibility and integrating additional safety features.[6] The methodology is divided into multiple stages to ensure modularity, scalability, and real-time performance.

### 3.1 System Overview

The system continuously captures real-time video using a camera module mounted on the vehicle. Each frame is processed to identify glare regions, enhance visibility, and control vehicle lighting and safety mechanisms.[11]

### 3.2 Image Acquisition

A camera captures continuous frames of the road ahead. Frames are processed at a suitable frame rate to maintain real-time operation. The captured data serves as input for glare detection and enhancement

algorithms.

### 3.3 Preprocessing

Preprocessing is essential to improve image quality and reduce computational complexity.[1]

Steps involved:

- Resize frames to a fixed resolution
- Convert images to grayscale or HSV color space
- Apply noise reduction (Gaussian filtering)
- Normalize pixel intensity values
- This ensures uniform input for further processing.

### 3.4 Glare Detection

Glare is identified by analyzing high-intensity pixel regions.[12]

Process:

- Apply thresholding to detect bright regions
- Identify regions exceeding intensity threshold
- Use contour detection or region masking to isolate glare areas
- These regions correspond to headlight beams from oncoming vehicles.

### 3.5 Glare Suppression

Once glare regions are detected:

- Adaptive filtering is applied to reduce brightness
- Intensity scaling is used to normalize bright regions
- Local smoothing techniques prevent loss of surrounding details

This ensures glare reduction without affecting overall image clarity.

### 3.6 Night Vision Enhancement

To improve visibility in dark areas:

- Apply **CLAHE (Contrast Limited Adaptive Histogram Equalization)**
- Enhance local contrast in low-light regions
- Preserve edges and important features

This step significantly improves driver visibility in poorly lit environments.[7]

### 3.7 Automatic Headlight Dimming

- System analyzes glare intensity level
- If glare exceeds threshold → switch to **low beam**
- Otherwise → maintain **high beam**

This reduces discomfort for oncoming drivers and improves safety.[13]

### 3.8 Indicator Control Mechanism

- Vehicle direction is detected using tilt

- or steering input
- When tilt/turn is detected:
  - Corresponding indicator is activated
- Ensures automatic signaling during turns

### 3.9 Accident Detection and Alert System

- Airbag deployment signal is monitored
- Airbag trigger indicates severe collision
- System sends emergency alert via GSM module [8]

Message includes:

- Predefined alert text

### 3.10 System Integration

All modules are integrated into a single embedded system:

- Image processing module
- Control module
- Communication module

This ensures seamless and synchronized operation.

## IV. Implementation

The The implementation of the proposed system is carried out using a **hardware-software co-design approach** to ensure real-time operation and reliability.

### 4.1 Hardware Setup

The system consists of the following components:

- **Raspberry Pi 3 Model B+** – central processing unit
- **Pi Camera Module** – captures real-time video
- **HDMI Display** – displays processed output
- **GSM Module** – sends accident alerts
- **LED Indicators** – simulate vehicle signals
- **Tilt Sensor / Input Mechanism** –

detects turning

- **Power Supply (5V, 3A)** – powers the system All components are interconnected using GPIO pins, CSI interface, and communication ports.[14]

### 4.2 Software Implementation

The system is developed using:

- **Python programming language**
- **OpenCV** for image processing
- **NumPy** for matrix operations

### 4.3 Algorithm Implementation

#### 4.3.1 Glare Detection Algorithm

- Capture frame
- Convert to grayscale
- Apply intensity threshold

- Identify bright regions
- #### 4.3.2 Glare Suppression Algorithm
- Mask detected regions
  - Reduce intensity using scaling
  - Apply smoothing filter
- #### 4.3.3 Enhancement Algorithm
- Apply CLAHE
  - Improve contrast in dark regions

### 4.4 Control System Implementation

- GPIO pins control headlights and indicators
- Logic conditions determine ON/OFF states
- Real-time control ensures immediate response

### 4.5 Accident Alert Implementation

- GSM module interfaced via UART
- AT commands used to send SMS
- Triggered only when airbag signal is detected

### 4.6 System Workflow

1. Capture video frame
2. Process glare detection
3. Apply suppression and enhancement
4. Update display output
5. Control headlights and indicators
6. Monitor accident signal
7. Send alert if required

## V. Results

The system was tested under various real-time conditions to evaluate its performance.

### 5.1 Glare Suppression Performance

- High-intensity headlight glare was successfully reduced
- Bright regions were normalized without affecting surrounding areas
- Reduced visual discomfort for drivers



Fig 5.1: Before glare suppression



Fig 5.2: After glare suppression

## 5.2 Overall System Performance

- Bright regions were normalized without affecting surrounding areas
- Reduced visual discomfort for drivers
- Dark regions were significantly improved
- Road objects became more visible
- Contrast enhancement improved overall clarity
- Automatic switching between high and low beam worked effectively
- Response time was minimal
- Reduced glare impact on opposite vehicles
- Indicators activated correctly during directional movement
- Reliable operation with tilt-based input
- Alert triggered only during airbag deployment
- Successfully sent SMS using GSM module
- Low-cost implementation
- Stable operation under different lighting conditions

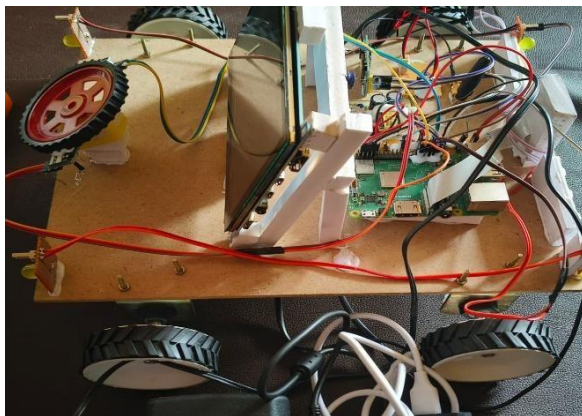


Fig 5.3: Final project kit

## VI. Conclusion

The proposed automotive glare suppression and night vision assistance system successfully addresses the challenges associated with night-time driving. By combining image processing techniques

with embedded system design, the system effectively reduces glare and enhances visibility, improving overall driver safety.

The integration of additional features such as automatic headlight dimming, indicator control, and airbag-based accident alert system makes the solution more comprehensive and practical. Unlike traditional systems, the proposed approach uses real-time visual data, resulting in better accuracy and adaptability.

Experimental results demonstrate that the system performs reliably under different lighting conditions and provides a clear improvement in visibility compared to conventional methods. The use of low-cost components ensures that the system is economically feasible for real-world implementation.

Overall, this project presents a scalable, efficient, and intelligent driver assistance system that can be further developed into advanced automotive safety technologies

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