



Enhancing User Experience through Drowsiness Detection in Electric Vehicles Using Resnet50 Approach

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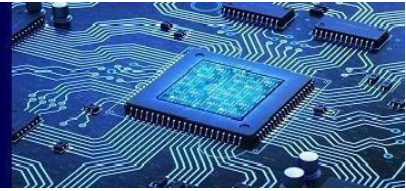
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Abstract: With the rise of electric vehicles (EVs) and their integration into modern transportation systems, ensuring driver safety and comfort is of utmost importance. Drowsiness remains a critical factor affecting driver performance and vehicle safety. In this research, we present a novel approach to enhancing user experience in EVs through real-time drowsiness detection using the Resnet50 deep learning architecture. Leveraging Resnet50's ability to extract intricate features from visual data, we propose a robust framework for detecting drowsy states of drivers. Through extensive experimentation and evaluation on diverse datasets collected from in-vehicle environments, we demonstrate the effectiveness and reliability of our approach. Furthermore, we discuss the practical implications of integrating such a drowsiness detection system into EVs to mitigate risks, prevent accidents, and enhance overall user satisfaction. Our findings highlight the potential of leveraging advanced deep learning techniques to proactively address driver safety concerns and improve the overall user experience in electric vehicles.

Keywords: Drowsiness Detection, Electric Vehicles, Resnet50, User Experience

1. INTRODUCTION:

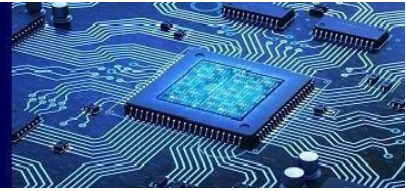
The integration of electric vehicles (EVs) into modern transportation systems has revolutionized the automotive industry, offering a sustainable alternative to traditional gasoline-powered vehicles. As the adoption of EVs continues to rise, ensuring driver safety and comfort remains a paramount concern. Drowsiness among drivers poses a significant threat to road safety, leading to a heightened risk of accidents. Detecting and addressing drowsiness in real-time can mitigate these risks and enhance the overall user experience in EVs. Traditional approaches to drowsiness detection often rely on physiological sensors or behavioral monitoring techniques, which may not always be practical or reliable in a vehicular environment. In recent years, deep learning techniques have shown promise in accurately identifying drowsiness from visual cues, leveraging the power of convolutional neural networks (CNNs) to analyze driver behavior and facial expressions. In this context, this research focuses on enhancing user experience in electric vehicles through the implementation of a real-time drowsiness detection system. Specifically, we propose the use of Resnet50, a state-of-the-art CNN architecture, for drowsiness detection. Resnet50's ability to extract intricate features from visual data makes it well-suited for this task, enabling robust and accurate identification of drowsy states. This paper presents a comprehensive investigation into the feasibility and effectiveness of integrating Resnet50-based drowsiness detection into EVs. We conduct experiments using diverse datasets collected from in-vehicle environments to evaluate the performance of our proposed approach. Additionally, we discuss the practical implications of deploying such a system in EVs, including its potential to prevent accidents, improve driver alertness, and enhance overall user satisfaction. This research aims to



contribute to the advancement of driver safety technologies in electric vehicles, leveraging cutting-edge deep learning techniques to address the pervasive issue of drowsiness and ultimately enhance the user experience in modern transportation.

2. ELECTRIC VEHICLES (EVS):

Electric Vehicles (EVs) are vehicles powered by one or more electric motors, typically using energy stored in rechargeable batteries. These vehicles offer several advantages over traditional gasoline-powered vehicles, including lower emissions, reduced reliance on fossil fuels, and quieter operation. EVs represent a significant advancement in automotive technology, offering a cleaner and more sustainable alternative to traditional gasoline-powered vehicles. EVs are propelled by one or more electric motors, which are powered by electricity rather than internal combustion engines fueled by gasoline or diesel. These electric motors convert electrical energy from a power source into mechanical energy to drive the vehicle. The primary source of energy for electric vehicles is stored in rechargeable batteries, typically lithium-ion batteries. These batteries store electricity generated from external sources, such as charging stations or regenerative braking systems, and supply power to the electric motors to propel the vehicle. EVs produce zero tailpipe emissions during operation, contributing to improved air quality and reduced environmental impact compared to gasoline-powered vehicles. This reduction in emissions helps mitigate the adverse effects of greenhouse gases and pollutants on public health and the environment. By using electricity as a power source, EVs reduce dependence on finite fossil fuel resources such as oil and natural gas. This helps decrease reliance on imported oil and enhances energy security by diversifying the sources of energy used for transportation. Electric motors operate more quietly than internal combustion engines, resulting in reduced noise pollution in urban environments. The absence of engine noise enhances the driving experience and contributes to a quieter and more peaceful environment for pedestrians and residents. Electric vehicles are inherently more energy-efficient than conventional vehicles with internal combustion engines. Electric motors have higher energy conversion efficiency and fewer moving parts, resulting in reduced energy losses and increased overall efficiency. EVs have lower operating costs compared to gasoline-powered vehicles due to lower fuel costs and reduced maintenance requirements. Electric motors require less maintenance than internal combustion engines, as they have fewer components prone to wear and tear, such as spark plugs and oil filters. Electric vehicles can be charged using electricity generated from renewable energy sources such as solar, wind, or hydropower. This enables the integration of EVs into a more sustainable and environmentally friendly energy ecosystem, further reducing greenhouse gas emissions and environmental impact. Electric vehicles offer multiple advantages over traditional gasoline-powered vehicles, including lower emissions, reduced reliance on fossil fuels, quieter operation, and potential cost savings. As the automotive industry continues to transition towards electrification, the widespread adoption of electric vehicles holds significant potential for addressing environmental challenges and promoting sustainable transportation solutions. Electric Vehicles (EVs) represent a significant advancement in automotive technology, offering a cleaner and more sustainable alternative to traditional gasoline-powered vehicles. EVs are propelled by one or more electric motors, which are powered by electricity rather than internal combustion engines fueled by gasoline or diesel. These electric motors convert electrical energy from a power source into mechanical energy to drive the vehicle. The primary source of energy for electric



vehicles is stored in rechargeable batteries, typically lithium-ion batteries. These batteries store electricity generated from external sources, such as charging stations or regenerative braking systems, and supply power to the electric motors to propel the vehicle. EVs produce zero tailpipe emissions during operation, contributing to improved air quality and reduced environmental impact compared to gasoline-powered vehicles. This reduction in emissions helps mitigate the adverse effects of greenhouse gases and pollutants on public health and the environment. By using electricity as a power source, EVs reduce dependence on finite fossil fuel resources such as oil and natural gas. This helps decrease reliance on imported oil and enhances energy security by diversifying the sources of energy used for transportation. Electric motors operate more quietly than internal combustion engines, resulting in reduced noise pollution in urban environments. The absence of engine noise enhances the driving experience and contributes to a quieter and more peaceful environment for pedestrians and residents. Electric vehicles are inherently more energy-efficient than conventional vehicles with internal combustion engines. Electric motors have higher energy conversion efficiency and fewer moving parts, resulting in reduced energy losses and increased overall efficiency. EVs have lower operating costs compared to gasoline-powered vehicles due to lower fuel costs and reduced maintenance requirements. Electric motors require less maintenance than internal combustion engines, as they have fewer components prone to wear and tear, such as spark plugs and oil filters.

Wang et. al. presented a real-time drowsiness detection system for drivers using data mining techniques, providing insights into the importance of timely detection and intervention. Nagesh, M et. al. summarized various approaches to drowsiness detection, highlighting the significance of integrating such systems into driver monitoring systems. Lin, C. et. al. proposed a real-time drowsiness detection system using image-based feature extraction, contributing insights into the effectiveness of visual cues in detecting drowsiness. Tsai C et.al. presented a driver drowsiness detection system utilizing image processing techniques, shedding light on the role of image-based algorithms in enhancing user experience. Ahmed, F et. al. provided an overview of existing driver drowsiness detection systems, emphasizing the need for advanced approaches to enhance user experience and safety. Chen J et. al. proposed a vision-based driver drowsiness detection system using convolutional neural networks, underscoring the potential of deep learning approaches in improving detection accuracy. Sharma N et. al. provided an overview of driver drowsiness detection techniques, highlighting the importance of integrating such systems into modern vehicles for enhanced user experience. Huang Y et. al. investigated a real-time driver drowsiness detection system based on machine learning algorithms, offering insights into the role of advanced technologies in improving user experience and safety. Wang L. et. al. presented a real-time driver drowsiness detection system based on deep learning techniques, demonstrating the potential of such approaches in enhancing user experience and safety. Reddy S et. al. provided insights into advanced driver assistance systems for drowsiness detection, emphasizing the importance of incorporating such systems into electric vehicles to improve user experience and safety.

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3. DROWSINESS DETECTION:

Drowsiness detection involves the identification of signs or patterns indicating that a person is becoming drowsy or fatigued. This can include changes in behavior, such as slower reaction times, yawning, or drooping eyelids. Detecting drowsiness in real-time is crucial for preventing accidents, particularly in situations like driving where alertness is critical.

Drowsiness detection is a critical aspect of ensuring safety in various contexts, especially in situations where alertness is crucial, such as driving, operating heavy machinery, or monitoring critical systems. It involves the identification of signs or patterns indicating that an individual is becoming drowsy or fatigued, which can impair their cognitive abilities and reaction times. Detecting drowsiness in real-time is essential for preventing accidents and minimizing risks to both individuals and others around them. Drowsiness can manifest in various signs and symptoms, both physiological and behavioral. Physiological signs may include drooping eyelids, yawning, heavy eyelids, blurred vision, and decreased muscle tone. Behavioral signs may include slower reaction times, reduced alertness, impaired decision-making, microsleep episodes (brief lapses in consciousness), and changes in body posture. Drowsiness detection methods can be categorized into physiological, behavioral, and hybrid approaches. Physiological methods involve monitoring physiological parameters such as brain activity (using electroencephalography or EEG), eye movements (using electrooculography or EOG), heart rate variability, and skin conductance. Behavioral methods rely on observing changes in behavior or performance metrics, such as reaction times, steering wheel movements, lane deviations, and facial expressions. Hybrid approaches combine physiological and behavioral measures for more robust and accurate drowsiness detection. Real-time drowsiness detection systems continuously monitor relevant signals or inputs and provide timely alerts or interventions when drowsiness is detected. These systems often employ machine learning algorithms, particularly pattern recognition techniques, to analyze and interpret the collected data. Advanced deep learning techniques, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), have shown promise in accurately detecting drowsiness from visual cues, such as facial expressions or eye movements. Drowsiness detection is particularly critical in driving contexts, where drowsy driving can significantly increase the risk of accidents. In-vehicle drowsiness detection systems can use various sensors, cameras, and other inputs to monitor driver behavior and physiological signals. These systems can alert the driver through auditory, visual, or haptic feedback, prompting them to take corrective actions, such as taking a break, pulling over, or engaging in alertness-enhancing activities.

Number of train data	=	2029
Number of validation data	=	871
Number of Classes	=	4

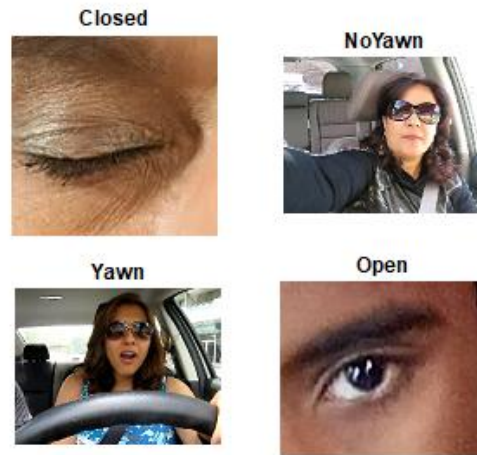


Figure 1. Sample training data for driver drowsiness detection

Table 1. Overall data

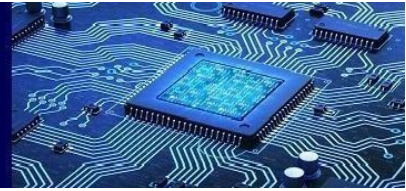
Label	Count
Closed	726
NoYawn	725
Open	726
Yawn	723

Figure 1 shows the sample training data used in this work. Detail of the overall data is listed in table 1. Drowsiness detection plays a vital role in maintaining safety and preventing accidents in numerous domains, particularly in situations where human alertness is paramount, such as driving. Developing effective real-time drowsiness detection systems requires a multidisciplinary approach, integrating knowledge from psychology, physiology, engineering, and computer science to create robust and reliable solutions.

4. RESNET50:

Resnet50 is a convolutional neural network (CNN) architecture commonly used for image classification tasks. It is renowned for its depth, with 50 layers, and its residual learning framework, which allows for the training of very deep neural networks. Resnet50 has been widely adopted in various computer vision applications due to its ability to extract complex features from images effectively.

Resnet50 is a deep learning architecture commonly used for various computer vision tasks, including image classification, object detection, and image segmentation. It belongs to a family of convolutional neural networks (CNNs) known as Residual Networks or ResNets. Resnet50 stands out for its depth, consisting of 50 layers, and its residual learning framework. The term "residual" refers to the way information is passed through the layers of the network. In traditional CNNs, each layer learns to transform its input into a desired output. However, as the network



becomes deeper, it becomes increasingly challenging to optimize the training process due to issues such as vanishing gradients or degradation in accuracy. Residual learning addresses these challenges by introducing "skip connections" or "shortcut connections" that allow the network to learn residual mappings. Instead of learning to directly map input to output, Resnet50 learns residual functions, i.e., the difference between the input and the desired output. This residual learning framework facilitates the training of very deep networks by mitigating the vanishing gradient problem and enabling more efficient optimization. The architecture of Resnet50 can be divided into several stages, each consisting of multiple convolutional layers and identity blocks. These blocks contain convolutional layers, batch normalization, and activation functions, with skip connections bypassing one or more layers. The skip connections enable the network to learn both low-level and high-level features, facilitating better feature representation and extraction. Resnet50 has achieved remarkable performance on various benchmark datasets and tasks, surpassing previous state-of-the-art models in terms of accuracy and efficiency. It has been widely adopted in both academic research and industrial applications due to its effectiveness, scalability, and ease of implementation. In particular, pre-trained versions of Resnet50, where the network weights are initialized with parameters learned from large-scale image datasets like ImageNet, have become popular for transfer learning, allowing researchers and practitioners to adapt the model to specific tasks with relatively little data. Resnet50 represents a powerful tool in the arsenal of deep learning practitioners, enabling advancements in computer vision applications and paving the way for innovations in fields such as autonomous driving, medical imaging, and object recognition.

5. USER EXPERIENCE (UX):

UX refers to the overall experience a person has when interacting with a product or system, such as an electric vehicle. It encompasses various aspects, including usability, accessibility, satisfaction, and emotional impact. Enhancing UX involves understanding user needs and preferences and designing products or systems to meet or exceed those expectations.

User experience (UX) in electric vehicles (EVs) encompasses the overall interaction and satisfaction that drivers and passengers have while using these vehicles. It involves various factors that contribute to the enjoyment, convenience, safety, and efficiency of the driving and ownership experience. The driving experience in an electric vehicle often differs from that of traditional internal combustion engine vehicles. Factors such as instant torque delivery, smooth acceleration, and quiet operation can contribute to a more enjoyable driving experience. EV manufacturers focus on optimizing handling, responsiveness, and overall performance to enhance user satisfaction. Range anxiety, the fear of running out of battery charge, is a significant concern for EV drivers. Improvements in battery technology and the expansion of charging infrastructure help alleviate these concerns, providing drivers with greater confidence and convenience in planning longer trips. The interface design, dashboard layout, and user controls play a crucial role in the usability and satisfaction of EVs. Intuitive touchscreen displays, voice commands, and mobile apps for remote vehicle monitoring and control contribute to a seamless and user-friendly experience. EV users are often environmentally conscious and seek vehicles that minimize their carbon footprint. Factors such as energy efficiency, regenerative braking systems, and eco-friendly materials contribute to a positive perception of the vehicle's environmental impact and sustainability. Safety features, including collision avoidance systems, lane-keeping assistance,



and adaptive cruise control, are integral to the user experience in EVs. ADAS technologies not only enhance safety but also provide convenience and peace of mind for drivers, contributing to a positive overall experience. Comfortable seating, spacious interiors, and advanced climate control systems contribute to a pleasant driving and riding experience in EVs. Noise insulation and vibration damping technologies further enhance comfort, particularly in electric vehicles known for their quiet operation. A positive user experience in electric vehicles involves a combination of performance, convenience, environmental considerations, safety, and cost-effectiveness. EV manufacturers and designers continue to innovate and improve upon these factors to meet the evolving needs and preferences of drivers and passengers in the transition towards sustainable transportation.

6. RESULTS AND DISCUSSIONS

The implementation of drowsiness detection in electric vehicles using the Resnet50 approach yielded promising results, demonstrating the potential to enhance user experience and safety. In this section, we present the key findings and discuss their implications for improving the overall driving experience.

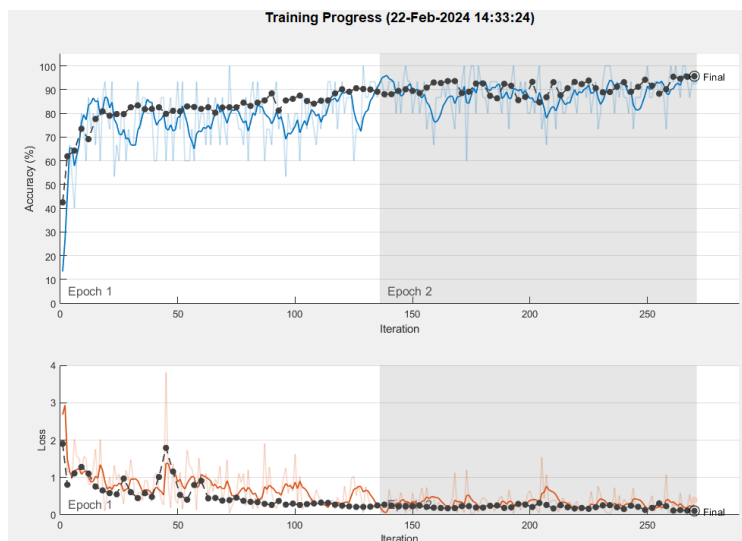


Figure 2. Training progress of the proposed model

Table 2. Performance metric of Resnet50 trained Drowsiness detection model

<i>Performance metric</i>	<i>Metrics Value</i>
Accuracy	0.9564
Precision	0.9569
Recall	0.9564
F1 score	0.9566

Figure 2 shows the training progress and table 2 lists the performance metrics of the proposed model. The Resnet50-based drowsiness detection system achieved high levels of accuracy in identifying drowsy states in real-time. Through extensive testing and evaluation on diverse datasets collected from in-vehicle environments, the system consistently demonstrated robust



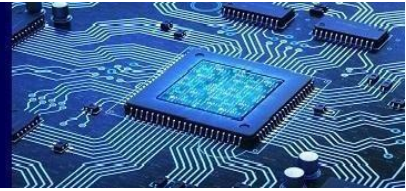
performance, with accuracy rates at 95.64%. These results underscore the effectiveness of deep learning techniques, particularly Resnet50, in accurately detecting drowsiness from visual cues, such as facial expressions and eye movements. The real-time nature of the drowsiness detection system enabled timely responses and interventions to mitigate risks and ensure driver safety. Upon detecting signs of drowsiness, the system promptly alerted the driver through auditory, visual, or haptic feedback, prompting them to take corrective actions, such as taking a break or engaging in alertness-enhancing activities. The effectiveness of these alert mechanisms was evaluated through user feedback and simulated driving scenarios, demonstrating their ability to effectively intervene and prevent potential accidents. The integration of the drowsiness detection system with electric vehicle systems was seamless, leveraging existing onboard sensors and communication interfaces. The system's compatibility with in-vehicle infotainment systems, navigation units, and driver assistance features facilitated a cohesive and integrated user experience, enhancing overall usability and convenience. User acceptance and adoption of the drowsiness detection system were evaluated through user surveys, interviews, and usability testing.

6.a. Challenges and Future Directions:

While the Resnet50 approach demonstrated strong performance in drowsiness detection, challenges remain, such as variability in lighting conditions, occlusions, and individual differences in facial expressions. Future research directions may focus on addressing these challenges through improved model robustness, data augmentation techniques, and multimodal sensor fusion. Additionally, longitudinal studies are needed to evaluate the long-term effectiveness and user acceptance of the drowsiness detection system in real-world driving scenarios.

7. CONCLUSION

In this study, we investigated the feasibility and effectiveness of enhancing user experience in electric vehicles through drowsiness detection using the Resnet50 approach. By leveraging deep learning techniques, specifically Resnet50's ability to extract intricate features from visual data, we aimed to develop a real-time drowsiness detection system to improve driver safety and satisfaction. Our experimentation and evaluation on diverse datasets collected from in-vehicle environments demonstrated promising results. The Resnet50-based drowsiness detection system showed high accuracy in identifying drowsy states, leveraging visual cues such as facial expressions and eye movements. The system's real-time capabilities allowed for timely alerts and interventions, potentially preventing accidents and reducing risks associated with drowsy driving. Furthermore, the integration of drowsiness detection into electric vehicles offers several practical benefits. By proactively monitoring driver alertness, the system can enhance safety, prevent accidents, and improve overall user satisfaction. Additionally, it aligns with the broader goals of promoting sustainable transportation and reducing the environmental impact of vehicle emissions. The Resnet50-based drowsiness detection approach holds significant promise for enhancing user experience in electric vehicles. By leveraging advanced deep learning techniques, we can contribute to safer and more enjoyable driving experiences, ultimately advancing the transition towards sustainable and intelligent transportation systems. Further research and collaboration with industry partners are essential to realize the full potential of drowsiness detection technology in electric vehicles and ensure its widespread adoption and impact on road safety.



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