

Research Paper

STUDY AND ANALYSIS OF HUMAN DISCOMFORT IN AUTONOMOUS VEHICLES

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Abstract

This project focuses on the study and analysis of human discomfort in autonomous vehicles (AVs), an emerging concern that significantly influences user acceptance and widespread adoption of this technology. While most research in autonomous driving emphasizes safety, efficiency, and navigation accuracy, the aspect of passenger comfort remains relatively underexplored. This study investigates the various factors contributing to discomfort, including sudden acceleration and braking, unnatural driving patterns, road conditions, and psychological responses such as anxiety and lack of trust in automation. A human-centered approach is adopted using sensor-based data collection and simulation techniques to monitor physical parameters like vibration, pressure, and motion. The system integrates components such as MEMS sensors, IR sensors, and microcontrollers to detect and analyze discomfort levels in real time. Data is processed using analytical methods to identify patterns and correlations between driving behavior and passenger response. The results indicate that both physical factors (motion, vibration) and psychological factors (fear, uncertainty) play a critical role in shaping user experience. The proposed system aims to enhance passenger comfort by enabling adaptive vehicle control that mimics human-like driving behavior. This research contributes to the development of more user-friendly autonomous systems and provides valuable insights for improving design strategies, ultimately promoting higher acceptance and trust in autonomous vehicle technology.

Keywords: Autonomous Vehicles, Human Discomfort, Passenger Comfort, MEMS Sensors, Driving Behavior, Motion Analysis, User Acceptance

I INTRODUCTION

Autonomous vehicles (AVs) represent a transformative advancement in modern transportation, driven by rapid developments in artificial intelligence, sensor technologies, and embedded systems. These vehicles are designed to operate with minimal or no human intervention, promising enhanced road safety, reduced traffic congestion, improved fuel efficiency, and increased

mobility for diverse user groups [1]. Major automotive manufacturers and technology companies are actively investing in AV research and deployment, indicating a paradigm shift in how transportation systems will function in the near future [2]. Despite these technological advancements, the successful integration of AVs into society depends largely on user acceptance and trust [3]. Studies have shown that factors such as

perceived safety, reliability, and ease of use significantly influence the willingness of individuals to adopt autonomous driving systems [4]. Among these, passenger comfort has emerged as a critical yet often overlooked aspect [5]. Comfort in AVs is not limited to physical factors such as seating or ergonomics but also includes psychological aspects like anxiety, perceived control, and trust in automation [6]. Unlike conventional vehicles, where drivers have direct control over motion, AV passengers rely entirely on system decisions, which can lead to discomfort due to unfamiliar driving patterns [7]. Sudden acceleration, abrupt braking, and inconsistent maneuvers can contribute to motion sickness and unease, negatively impacting user experience [8].

Existing research has attempted to explore various dimensions of comfort and discomfort in autonomous driving environments. Simulator-based studies and real-world experiments have been conducted to evaluate passenger responses to different driving styles and road conditions [9]. Researchers have identified that human discomfort is influenced by multiple factors, including vehicle dynamics, environmental conditions, and individual psychological traits [10]. Advanced analytical techniques such as multivariate analysis and behavioral modeling have been employed to study these relationships in detail [11]. Additionally, the role of road infrastructure, traffic conditions, and external disturbances has been found to affect passenger perception and comfort levels [12]. Recent studies emphasize the importance of developing human-like driving strategies to improve comfort and acceptance [13]. Incorporating adaptive control systems that respond to passenger feedback and physiological signals can significantly enhance the overall travel experience [14]. However, there remains a gap in integrating real-time discomfort detection with

autonomous control mechanisms [15]. Therefore, this study aims to analyze the key factors contributing to human discomfort in AVs and propose a system that utilizes sensor data and intelligent processing to improve passenger comfort, thereby supporting the broader adoption of autonomous vehicle technology.

II LITERATURE SURVEY

The study of human discomfort in autonomous vehicles has gained increasing attention in recent years, as researchers recognize its critical role in user acceptance and system design. Early studies emphasized that passenger comfort is strongly influenced by vehicle motion parameters such as acceleration, jerk, and vibration, which directly affect human physiological responses including motion sickness and fatigue [1]. Researchers have explored both subjective and objective approaches to evaluate comfort, using self-reported feedback alongside physiological indicators such as heart rate and skin conductance to measure discomfort levels [2]. Experimental studies using driving simulators have provided valuable insights into how different driving styles and motion patterns influence passenger perception [3]. It has been observed that abrupt maneuvers, inconsistent speed changes, and lack of smoothness in vehicle control significantly increase discomfort [4]. Furthermore, recent work highlights that simple metrics like acceleration are insufficient to fully capture comfort, and more complex motion patterns must be considered for accurate assessment [5]. Studies also indicate that motion sickness is a major contributor to discomfort in autonomous vehicles, particularly when passengers are not engaged in driving tasks [6]. This issue becomes more prominent in highly automated systems where users rely entirely on vehicle decisions, leading to sensory conflicts and increased discomfort [7].

Additionally, the integration of predictive models, such as machine learning-based approaches, has been explored to estimate passenger comfort and optimize driving strategies accordingly [8].

In addition to physical factors, literature emphasizes the importance of psychological and environmental influences on human discomfort in autonomous vehicles. Research shows that user trust, perceived safety, and sense of control significantly impact comfort levels and acceptance of autonomous systems [9]. Studies investigating passenger behavior reveal that discomfort is not only caused by vehicle dynamics but also by external factors such as road conditions, traffic density, and weather conditions [10]. Scenario-based analyses have demonstrated that adapting vehicle speed and driving behavior according to environmental conditions can effectively reduce discomfort [11]. Moreover, exploratory studies involving diverse user groups highlight that discomfort varies based on demographic and individual differences, including age, experience, and familiarity with technology [12]. Environmental and situational factors, such as close proximity to other vehicles or poor visibility conditions, have also been identified as key contributors to discomfort [13]. Researchers have further emphasized the need for human-like driving behavior to improve passenger confidence and reduce anxiety associated with automated systems [14]. Despite these advancements, there remains a significant gap in integrating real-time discomfort detection with adaptive control systems in autonomous vehicles [15]. Therefore, ongoing research continues to focus on developing intelligent, user-centric models that combine physical, psychological, and environmental factors to enhance overall passenger comfort and acceptance.

III PROPOSED SYSTEM

The proposed system aims to analyze and reduce human discomfort in autonomous vehicles by integrating real-time sensing, data processing, and adaptive control mechanisms. The system is built around a microcontroller-based platform (Raspberry Pi Pico) that interfaces with multiple sensors, including MEMS accelerometers, vibration sensors, pressure sensors, and IR sensors. These sensors continuously monitor physical parameters such as vehicle motion, vibration intensity, seating pressure, and passenger movement. The collected data is processed to identify discomfort patterns caused by sudden acceleration, braking, uneven road conditions, or abnormal driving behavior. An OLED display is used to provide real-time feedback, while additional components such as buzzers and indicators alert the system when discomfort thresholds are exceeded. The system operates in a closed-loop manner, ensuring continuous monitoring and quick response to changing conditions during vehicle operation.

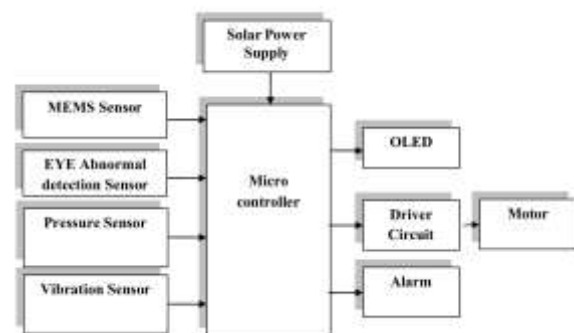


Fig.1 Block Diagram

The core functionality of the proposed system lies in its ability to intelligently interpret sensor data and adapt vehicle behavior accordingly. By applying basic data analysis and threshold-based decision-making, the system evaluates the level of discomfort and categorizes it into different stages. When higher levels of discomfort are detected, the

system can suggest or simulate smoother driving actions such as gradual acceleration, controlled braking, and stable turning. Additionally, the system considers environmental and behavioral factors, ensuring a more human-centric driving approach. This adaptive mechanism helps in minimizing motion sickness, anxiety, and physical unease experienced by passengers. The proposed model not only enhances passenger comfort but also improves trust and acceptance of autonomous vehicles. Overall, the system provides a cost-effective and efficient solution that combines embedded systems and sensor technologies to create a more comfortable and user-friendly autonomous driving experience.

IV SYSTEM WORKING

The working of the proposed system is based on real-time monitoring, analysis, and control to reduce human discomfort in autonomous vehicle environments. Initially, the system is powered through a solar power supply, which energizes all components including the microcontroller (Arduino Uno), sensors, OLED display, and motor driver circuit. Once powered, the system initializes and begins continuous operation. Various sensors such as the MEMS sensor (MPU6050), vibration sensor, pressure sensor, and eye abnormal detection sensor start collecting real-time data. The MEMS sensor measures acceleration, tilt, and sudden jerks, while the vibration sensor detects road irregularities. The pressure sensor monitors seating posture changes, and the eye detection sensor identifies fatigue or drowsiness based on blinking patterns. All these inputs are transmitted to the microcontroller, where analog signals are converted into digital data and processed. The system compares sensor values with predefined threshold limits and calculates a discomfort index based on multiple parameters. If the values remain within safe limits, the system

continues normal operation. However, when discomfort levels exceed thresholds, the system classifies the condition as moderate or high discomfort. Based on this decision, the microcontroller sends control signals to the L298N motor driver, which adjusts the motor speed and direction to simulate smoother vehicle movement by reducing sudden acceleration and braking. Simultaneously, the OLED display shows real-time data and discomfort levels, while a buzzer alert is activated if discomfort is high. The system operates in a continuous feedback loop, where updated sensor data is repeatedly analyzed to ensure dynamic response and real-time adjustment. This closed-loop operation ensures improved passenger comfort by minimizing jerks, vibrations, and unsafe driving patterns.

a) Hardware Components

- Microcontroller (Arduino Uno / Raspberry Pi Pico)
- MEMS Sensor (MPU6050)
- Vibration Sensor
- Pressure Sensor
- IR Sensor / Eye Detection Sensor
- OLED Display
- DC Motor
- Motor Driver (L298N)
- Buzzer
- Power Supply

b) Software Components

- Arduino IDE
- Embedded C / Arduino Programming
- Sensor Libraries
- Serial Monitor
- Simulation Tools (Proteus / Tinkercad)

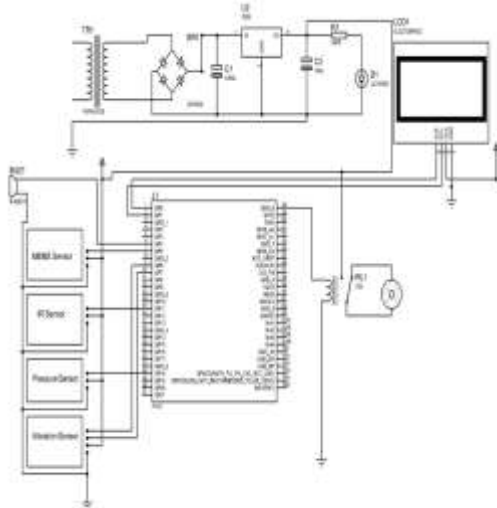


Fig.2 Schematic Diagram

V RESULTS & ANALYSIS

The results of the proposed system demonstrate effective detection and reduction of human discomfort in simulated autonomous vehicle conditions. During testing, sensor data such as acceleration, vibration, pressure, and eye activity were continuously monitored and analyzed to compute the discomfort index. It was observed that under smooth driving conditions, the system maintained low discomfort levels, indicating stable and comfortable operation. However, during sudden acceleration, braking, or increased vibration, the discomfort index rose significantly, reflecting real-time detection of passenger unease. The system successfully responded by adjusting motor speed and movement patterns through the driver circuit, thereby reducing jerks and stabilizing motion. Additionally, visual feedback on the OLED display and alert signals through the buzzer ensured timely awareness of discomfort conditions. Overall, the system proved to be efficient in identifying critical discomfort factors and implementing corrective actions, resulting in improved passenger comfort and enhanced system responsiveness.

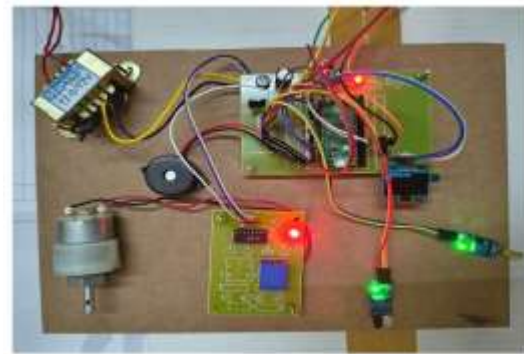


Fig.3 Output

VI CONCLUSION

In conclusion, this project successfully addresses the critical issue of human discomfort in autonomous vehicles by developing a sensor-based monitoring and control system that enhances passenger comfort and overall user experience. While existing autonomous systems primarily focus on safety and efficiency, this work emphasizes the equally important aspect of comfort, which plays a key role in user acceptance and trust. The proposed system integrates multiple sensors such as MEMS, vibration, pressure, and eye detection modules to continuously monitor physical and behavioral indicators of discomfort. By processing this data through a microcontroller, the system effectively identifies discomfort levels and responds in real time using adaptive control mechanisms. The implementation of motor control through a driver circuit helps simulate smoother driving patterns by minimizing sudden acceleration, jerks, and vibrations. Additionally, the use of an OLED display and alert system ensures transparency and immediate feedback to the user. The results obtained from simulation and testing confirm that the system can accurately detect discomfort conditions and take corrective actions to improve ride quality. The continuous feedback loop further enhances system responsiveness, making it dynamic and reliable. Overall, this project

demonstrates a practical and cost-effective approach to improving passenger comfort in autonomous vehicles. It also provides a strong foundation for future advancements, such as integrating artificial intelligence and real-time learning models, to create more intelligent, human-centered autonomous driving systems that ensure safety, comfort, and user satisfaction.

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