Internet of Things (IoT) – based Intelligent Direct Current (DC) Automobile Speed Control and Measurement System

M. S. Faathima Fayaza, S. Aysha Asra and A.R.F.S. Fanoon

Abstract Accidents have become one of the primary sources of man-killers in this fast-moving modern society. Many groups, including government authorities around the globe, are making countless efforts to bring this number of deaths under control, however, they are not successful. Most of these accidents occur due to exceeding the speed limits imposed by the government or authorities. It is necessary to carefully control the speed of a Direct Current (DC) motor to an exact Revolutions per Minute (RPM) in electric vehicles or automated systems. To address this, the study developed an intelligent Internet of Things (IoT)-based system that monitors and controls motor speed in real time. The system, simulated within the TinkerCAD virtual environment, enables accurate RPM adjustments, data monitoring, and remote control. The proposed solution ensures efficient speed regulation, which can enhance safety and reduce accidents.

***Index Terms* — Internet of Things (IoT), Arduino, speed control, sensor**

I. Introduction

IN this modern world, road networks are rapidly expanding and enriching the standard of living of human beings. The rapid development of roads is also being undertaken to match and accommodate the rising number of vehicle usage in day-to-day life. Unfortunately, this increasing number of vehicle usage and over-speed driving has become a significant reason for countless accidents and deaths.

According to the World Health Organization (WHO), nearly 1.35 million people die yearly, and between 20 and 50 million people suffer non-fatal injuries from road accidents [1]. Further road accidents cause economic losses for individuals, families, and the country. According to WHO, road accidents cost 3% of the gross domestic product in most countries [1]. Around 60% of the world's vehicles are used in second and third-world countries, and in these countries, 93% of deaths occur because of road accidents [1].

Conferring to studies, the two primary reasons for accidents are alcohol and over-speeding [2]. To reduce the accidents caused by the alcoholic effect, a few technical devices were fixed in automobiles to measure the alcohol level in the driver's body [3]. According to the studies, a 1% increase in speed causes a 4% increase in the fatal crash risk and a 3% increase in the severe crash risk [1]. There are various technologies related to the over-speeding issue. However, most of them lack efficiency and effectiveness in their functionality since vehicles with those technologies are expensive, and all cannot afford them. The traffic police continuously make many efforts to reduce this number by fining it as a penalty to the proven guilty drivers. However, the steps do not down the number of offenders and the casualties caused by them.

There are two kinds of electricity that can be used in electric cars. Alternating Current (AC) and Direct Current (DC) power. While batteries store DC electricity, many electric motors in vehicles utilize AC power, requiring an inverter to convert DC from the battery into AC. A DC motor, on the other hand, operates using direct current and relies on magnetic forces generated by currents in the motor's coils to produce mechanical force. In traditional internal combustion engine (ICE) vehicles, alternators generate AC power, which is then converted to DC by a rectifier to charge the battery and power electrical components like lights, wipers, and radios. However, in electric vehicles (EVs), DC power is supplied directly by the battery, eliminating the need for an alternator.

Available automobiles DC motor speed control systems lack in intelligent and adaptability. Therefore, this study aims to demonstrate the smart control system for DC motor speed regulation using IoT technologies. This study proposes a cost-effective module to continuously monitor the speed of a DC motor. Speed control is achieved using Pulse Width Modulation (PWM), with the duty cycle varied from minimum to maximum. The system monitors and records the motor's real RPM and applied voltage, establishing a correlation between the duty cycle, voltage, and RPM. Observations are tabulated to evaluate motor performance under varying conditions.

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ISSN: 2961-5992

measures[2]. This necessitates a comprehensive understanding of the latest machine learning techniques and their applicability to the dynamic landscape of payment card fraud, considering both their strengths and limitations in addressing the unique challenges posed.

This research aims to explore emerging trends and potential future directions in leveraging machine learning for more robust and adaptive fraud detection systems. This exploration will consider advancements in areas such as deep learning, ensemble methods, and explainable AI, highlighting their potential to enhance fraud prevention strategies. A key focus will be on explainable AI's (XAI) role in increasing transparency and trust in fraud detection models.

Furthermore, this research will analyze the strengths and limitations of various machine learning approaches in addressing the unique challenges associated with payment card fraud. These challenges include imbalanced datasets, real-time detection requirements, model interpretability, and the ability to adapt to evolving fraud patterns. The objective is to offer a clear understanding of the most appropriate machine learning methods for specific fraud detection scenarios.

Finally, this research study will provide a comprehensive review of the existing machine learning techniques that have been utilized for the purpose of identifying fraudulent transactions within the payment card industry. The survey will encompass both conventional and novel approaches, covering supervised, unsupervised, and hybrid learning methodologies. This review will serve as a foundation for understanding the current state of the art and identifying areas for future research and development.

A systematic literature search was conducted, searching for relevant studies in prominent academic databases such as IEEE Xplore, Scopus, and PubMed. The keywords used in the search included terms related to credit card fraud detection, machine learning algorithms, payment card fraud, fraudulent transactions, and anomaly detection. The search was limited to English-language studies published between 2010 and 2024. Initial screening based on title/abstract review was followed by full-text assessment. Studies outside finance or lacking empirical findings were excluded. Of the initial 500 studies, 450 remained after duplicate removal. Abstract screening yielded 150 relevant studies, with 49 meeting the final inclusion criteria. Most of the selected articles were published within the last five years.

II. Literature Review

A. Overview of Payment Card Fraud

Payment card fraud, a pervasive issue within the financial landscape, encompasses any unauthorized use of a payment card, including credit, debit, and prepaid cards, to illicitly obtain funds or goods[3][10]. The exponential expansion of e-commerce and digital payment transactions has been accompanied by a concomitant rise in fraudulent activities directed towards this payment modality[4][7]. Fraudsters employ various tactics, ranging from basic scams like counterfeit cards to more sophisticated schemes involving stolen card data and online account takeovers[7].

The ramifications of payment card fraud are extensive, affecting financial institutions, individual consumers, and merchants alike. Financial losses, eroded trust in payment systems, and the escalating costs of fraud prevention measures represent significant challenges for all stakeholders involved [2][5].

Several factors contribute to the vulnerability of payment cards to fraudulent activities. The rise of e-commerce and card-not-present transactions has created more opportunities for fraudsters, as physical card possession is no longer necessary. This shift to online transactions makes it easier for criminals to operate remotely and target a wider range of victims[3][4].

Large-scale data breaches expose sensitive cardholder information, making it easier for criminals to create counterfeit cards or conduct unauthorized transactions. These breaches can compromise millions of card details at once, providing a wealth of information for fraudsters to exploit[7][8].

Additionally, fraudsters continuously adapt their methods, employing techniques like phishing, malware, and social engineering to compromise card details and exploit system vulnerabilities. The increasing sophistication of these techniques makes it more challenging for individuals and institutions to protect themselves from fraud [3][4][11].

The dynamic landscape of payment card fraud necessitates a proactive and adaptable approach to detection and prevention. Traditional rule-based systems frequently struggle to keep up with emerging fraud patterns, underscoring the need for more advanced solutions like machine learning.

B. Traditional Fraud Detection Models

Conventional fraud detection approaches predominantly leverage rule-based systems and manual review processes. These methods frequently incorporate expert systems, where rules are established based on subject matter experts' knowledge of recognized fraud patterns and anomalies. Transactions flagged by these rules are then investigated further. Statistical analysis, such as anomaly detection techniques, is also used to identify transactions that deviate significantly from expected patterns. Finally, suspicious transactions are reviewed manually by fraud analysts, who make decisions based on their experience and intuition[3][4].

While these traditional methods have been employed for some time, they often prove inadequate in addressing the evolving landscape of payment card fraud. They are often static and inflexible; rule-based systems face difficulties in adapting to emerging fraud patterns, necessitating frequent updates that can be both time-consuming and resource-intensive. Traditional methods are also prone to high false positives, leading to unnecessary investigations and customer inconvenience[2][3][4]. Furthermore, the sheer volume of transactions in today's digital age overwhelms manual review processes and limits the effectiveness of traditional methods. The shortcomings of conventional fraud detection methods underscore the necessity for more advanced and flexible approaches, thereby paving the way for the integration of machine learning techniques within this domain[4][5].

ISSN: 2961-5992

III. Related Work

Sundar and Joseph invented a speed control system using Radio Frequency (RF) [4]. In this study, once the speed limit is achieved, a fuel cut takes place, in which, to continue driving, the driver needs to reduce the speed below the set speed limit. Reddy et al. created a speed control system using wireless communication [5]. This project targeted heavy traffic zone speed control using wireless communication. In this approach, once the vehicle enters the smart zone (school, hospital, and courts), wireless radio frequency identifies the area and sends the signal to the microcontroller to reduce speed. Mokel et al. used Smart Display Controller to control the vehicle speed [6]. Smart Display Controller has two major components, a transmitter and a receiver, which can fit into the dashboard to identify the zone.

Kim and Park presented two intelligent control systems to cut off the engine speed variations at idle: 1. an evolutionary computing control based on genetic algorithms and 2. a stochastic control based on the Alopex algorithm [7]. Puleston et al. introduced an adaptive control framework for speed control [8]. Balluchi et al. formalised the crankshaft speed within a given range [9].

Currently, there are speed controllers in Audi, Mercedes - Benz, and BMW cars at 155mph assigned by with the green party to prevent the enormous amount of carbon dioxide emitted into the atmosphere from damaging the greener environment. This is not aimed at accidents due to the high speeding of vehicles. These speed controllers are developed and implemented by the vehicle manufacturer himself. Therefore, this speed controller comes built-in, and it is only available for that specific manufacturer's vehicle. In contrast, this product will enable the authorities to implement it in any vehicle they want regardless of the model if it fulfils the system requirements [10].

The Navig8r M35 with SpeedAlertTM device is mainly a Global Positioning System (GPS) device that knows places and their speed limits. Therefore, this would only indicate to the driver that he is going over or violating the speed limits in some particular area. This does not do anything to control that speed to keep him bound to the speed limit recommended by the authorities [11].

IV. Methodology

This study aims to minimise the casualties of high-speed crashes by limiting the vehicle's speed as required. This is possible by controlling the acceleration with a programmed device. In order to determine the motor speed at various applied voltages, the applied voltage to the motor is also measured. The observation table for pulse width (duty cycle), applied voltage, and motor speed in RPM is meticulously constructed once all the values have been noted. The required components are stated below in Table 1. Fig .1 outlines the architecture of the system

A. Arduino UNO

Arduino UNO is a programmable open-source microcontroller board that is low-cost and flexible. It can be integrated with other electronic components to design and develop electronic circuits. Arduino UNO features six analogue pins and 14 digital input/output pins [12]. Compared to other microcontrollers available, Arduino UNO consumes less power and is easy to program. It is an open-source device that can easily be interfaced with analogue circuits [13].

Table I
Component List

Name	Quantity	Component
U2	1	Arduino UNO
R1	1	Potentiometer 10k
U3	1	LCD 16 x 2
R2	1	180 Ω Resistor
M1	1	2737 DC Motor with encoder
P1	1	5 , 5 Power Supply
Rpot1	1	10 kΩ Potentiometer
T1	1	NPN Transistor (BJT)
U1	1	741 Operational Amplifier
U4	1	1 ms Oscilloscope
R3	1	1 kΩ Resistor

B. Liquid Crystal Display

A 16X2 Liquid Crystal Display (LCD) is used in the circuit as it is low cost, easily programmable, and has no limitations to display custom characters. It has 16 columns and two rows. The LCD has a parallel interface in which the microcontroller needs to manipulate several interface pins at the same time to control the display [14].

C. Potentiometer

In cars, potentiometers are used in various electronic systems to adjust the resistance and control the behavior of different components. In this system researchers suggest connecting the potentiometer with an engine accelerator.

D. NPN Transistor

To drive a DC motor, you need a larger amount of current than Arduino board can give. For that reason, you must use a transistor. Transistors have limits and maximum specs; just be sure those values are enough for your use.

E. Oscilloscope

An oscilloscope's trigger function synchronizes the horizontal sweep at the correct point of the signal. This is essential for clear signal characterization. Trigger controls allow you to stabilize repetitive waveforms and capture single-shot waveforms.

ISSN: 2961-5992

F. DC Motor with Encoder

DC motor encoders are used for speed control feedback in DC motors. The DC motor encoder provides a mechanism to measure the speed of the rotor and provides closed-loop feedback to the driver for precise speed control.

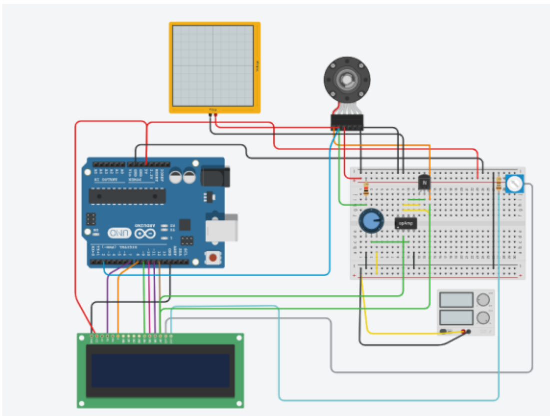

Fig.1 System Architecture

The circuit is constructed with an Arduino UNO development board, a Potentiometer, a 16x2 LCD, an NPN transistor, and 1 ms Oscilloscope, as seen in Figure 1. Additionally, resistors, 2737 DC motor with encoder, power supply unit, operational amplifier were used in the required place. Arduino UNO is used as a microcontroller. Arduino UNO connected with other components such as breadboard, LCD, DC motor with encoder as well. Fig. 2 shows the sample code of the system.

Through the current limiting resistor R1, the Arduino board's 5V supply is used to apply forward bias to the internal LED. Resistor R3 pulls up the internal photo transistor. The Arduino or digital pin 7 are linked to the transistor's collector output. · Digital pins 5, 4, 3, and 2 of the Arduino are linked to LCD data pins D4 to D7, while digital pins 12 and 11 are connected to control pins Rs and En. The RW pin is linked to the ground. The Arduino board's 5V supply is linked to the VCC and LED+ pins, while the Arduino board's ground is connected to the VSS and LED-pins. A single pot is linked to a vee pin to adjust the LCD's contrast.

V. Results and Discussion

The motor is first powered by an external power supply at 12 V. Subsequently, the Arduino board, LCD, and sensor receive power via USB from a PC or laptop. At first, the LCD displays various parameters such as DC motor speed. Potentiometers are used in various electronic systems to adjust the resistance and control the behavior of different components. The engine accelerator connected with potentiometer. When the engine accelerator rotates or performs fast (speed of the car) the potentiometer climbs high accordingly. Potentiometer connected with operational amplifier and NPN transistor. Both operational amplifiers and NPN transistors connected with DC motor encoder.

When potentiometer goes high (speed increases), the DC motor encoder will rotate high. At first, the LCD displays various parameters such as DC motor speed. The motor will then begin rotating at its maximum speed when the Arduino applies PWM to it with the maximum pulse width. A certain amount of time is paused to enable the motor to reach its maximum speed. The change in motor speed that is shown on the LCD as speed in RPM is visible to user as shown below.

An oscilloscope is connected in parallel with the DC motor. Either raising the pulse frequency or widening the pulse width will increase the motor's revolutions per minute (rpm).

Normally we are engaged at km per hour when using the car speed. In here we are using rpm. Actually, to calculate the RPM, we have to divide the speed in meters per minute by the product of Pi and the diameter of the rotating object. The speed limit in Sri Lanka is 40km/h in the city and urban areas for motorcycles and heavy vehicles and 60km/h for cars and light vehicles. So, we can conclude with 60 km/h is the average speed of the car, particularly in our country. So approximately 800 rpm has the average speed of the car. When reaching or over passing the speed limit of 800 rpm, the LCD display shows the high-speed alerts. Basically, it blinks the screen to get the driver's attention. Fig. 3 shows the increased and decreased motor speed. Fig. 4 shows the high-speed detection in LCD.

The driving environment is sensed by the Smart Vehicle Over Speeding Detector to achieve high detection accuracy. In order to prevent frequent accidents, the proposed system is utilized in particular to detect over speeding vehicles.

```
#include <LiquidCrystal.h>
volatile int count = 0;
int interruptPin = 2;
float speedRPM = 0;
LiquidCrystal lcd(7, 8, 9, 10, 11, 12);

void encoderPulse()
{
  count++;
}
void setup() {
  lcd.begin(16, 2);
  lcd.print("DC Motor Speed:");
  lcd.setCursor(13, 1);
  lcd.print("RPM");
  pinMode(interruptPin, INPUT_PULLUP);
  attachInterrupt(digitalPinToInterrupt(interruptPin), encoderPuls
}
void loop() {

  lcd.setCursor(0, 1);
  count = 0;
  delay(200);

  speedRPM = count * 6.25;
  lcd.print(speedRPM);
}
```

Fig.2 Code of the System

VI. Conclusion

The main objective of this system is to design an electronic device that could prevent the vehicle from exceeding a given speed limit. In electric cars, the motor is controlled by a controller that regulates power from the battery pack. The controller controls the flow of power from the battery to the motor. This system proposes the use of an Arduino Uno microcontroller, a 16x2

ISSN: 2961-5992

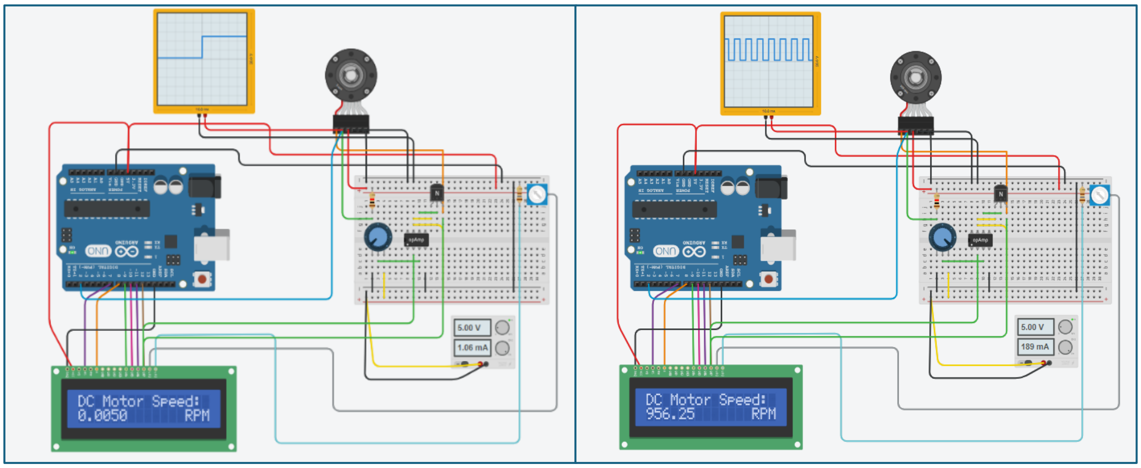

Fig.3 Increased and Decreased DC Motor Speed

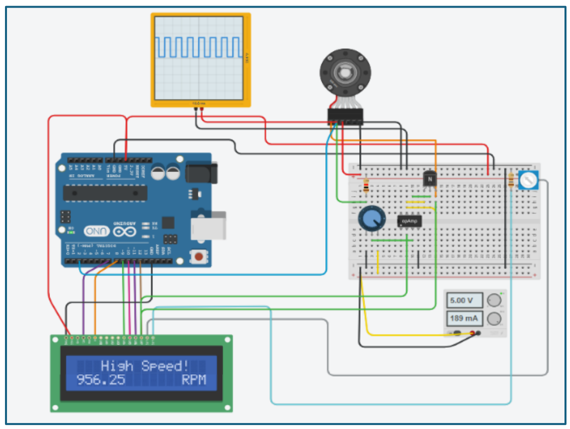

Fig.4 High speed detection in LCD

Liquid Crystal Display (LCD), a potentiometer, an NPN transistor, a 1 ms oscilloscope, and basic electronic components to implement cost-effective and efficient speed control. The Arduino UNO regulates the motor's speed by generating Pulse Width Modulation (PWM) signals based on input from the potentiometer, which simulates the throttle's behavior. The LCD displays real-time speed data, while the oscilloscope ensures accurate signal monitoring. Unlike other expensive systems, this solution is cost-effective and can be easily implemented. It is also energy-efficient, enabling continuous operation of the motor while maintaining speed control. By adhering to speed limits, this system can help reduce accidents caused by speeding, promoting safer driving practices. It is particularly useful for vehicle owners to maintain control over speed and comply with regulations, contributing to road safety and accident prevention.

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ISSN: 2961-5992