**Extreme Road Incident Detection in Autonomous Vehicles using deep learning**

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**ABSTRACT**

Driverless vehicles or Autonomous vehicles (AVs) are described as the future of transportation systems due to their limited need or absence of a human driver. Furthermore, AVs introduces several potential inherent advantages such as road decongestion, reduction in human and automobile accident rates, lower carbon emissions, and optimized road usage. While many research papers have focused on AVs routing efficiency, lane changing, congestion avoidance routing, route reservation algorithms, and localization, this research paper proposes a real-time deep learning-based decision-making system for an AV during extreme sudden and catastrophic path obstructing traffic incidences. The case study of raging bush/road fires and flash floods is used in this paper. This paper reviewed several works of literature of research works to address these challenges. The deep learning algorithm of the Convolutional neural network (CNN) is used based on its excellent performance in image recognition, computer vision, and classification of unstructured data. Regular fire and flood image datasets obtained from a secondary data source are used in training the model which enables the Autonomous vehicle to detect cases of raging road fires and flash floods in other to avoid such scenarios when it occurs in real-time. The result of the model is compared with the results from existing works of literature. Metrics such as accuracy and confusion matrix and F1-score are used to measure the performance of the convolutional neural network (CNN) model developed in this research work

**CHAPTER 1**

**INTRODUCTION**

# Background of the study

The 21st century marks the most dramatic transformation in the automotive industry since the first one was created more than 120 years ago. Autonomous driving systems are developing at a rate that is equal to that of electric car development. Electric vehicles are thus replacing cars with combustion engines, while both combustion and electric-driven vehicles are becoming more autonomous. Automobiles continue to enhance consumer expectations, from collision avoidance technologies to parking aid systems. Without ground-breaking breakthroughs in processor design, machine learning, data science, and other fields, these advancements would not have been conceivable. Data is based on facts and gives you real insights into how to reach your goals with a high degree of certainty in a very short length of time, it is used by every industry to optimize performance quickly. Data are only the operation's fuel at this point. Deep learning, machine learning, and artificial intelligence technologies are the driving forces behind this unparalleled advancement[1].

John McCarthy, a computer scientist and cognitive scientist from the United States, coined the term "artificial intelligence" (AI) in 1955.

AI is described as a computer program's or machine's capacity for thought, learning, and decision-making [2].

A computer software that mimics natural human intelligence is referred to as artificial intelligence. Industrial systems, computer programs, and robots are starting to imitate human behavior in many sectors, surpassing human skills, thanks to the development of AI. In order to make rational judgments in real time and in the smallest amount of time possible, machines executing these algorithms process, analyze, and store massive amounts of data. Neural networks, robotics, computer vision, deep learning, and machine learning are some of the subgroups of AI.

Machine learning refers to a variety of techniques that allow systems or computer programs to automatically develop and design data-driven models using discernible statistically significant patterns [3]. Through the use of machine learning techniques and algorithms, machines or systems can continually learn from previous data processing experiences and then apply what they've learned to brand-new data sets produced by novel scenarios. Therefore, machine learning is the act of giving machines the capacity to learn and improve over time without being restricted to a rigid human mathematical model or explicit programming. Three (3) further categories—Supervised Learning, Unsupervised Learning, and Reinforcement Learning—are also divided up [4]. A completely new situation arises when machine learning is used to apply AI to the transportation sector. Every automobile operator is aware of the difficulties of the road. Some of the difficult elements for human drivers to overcome include predicting the movements of other vehicles, the state of the road, route selection, and fatigue-related mistakes. Additionally, due to the lack of real-time information, unexpected road maintenance may cause you to delay or change your route. The necessity for autonomous vehicles is raised by this.

In order to make driving decisions without the assistance of a driver, an autonomous vehicle (AV) or driverless vehicle uses software structures of Planning, Perception, and Control through the sensors and actuator hardware [5].

Fully automated driving is used by AVs operating at level 5 autonomy (Full Automation) to enable the vehicle to react to road circumstances that human drivers would encounter. As a result, AVs can execute safe driving maneuvers with great accuracy, repeatability, and few errors. The World Health Organization estimates that 1.35 million people die in traffic accidents every year, and 20 to 50 million people suffer non-fatal injuries, some of which leave them disabled. Such a waste of a valuable human life, and all because of a careless human mistake [6]. Given that machines nearly never exhibit randomness, driverless cars are better suited to address this issue. Road accidents will become much less likely as a result of driverless cars. Long drives often cause physical and mental stress, which cuts into the time we have for leisure or other critical duties. By boosting productivity and increasing human efficiency, driverless cars would be helpful in this aspect.

Machine learning technologies have advanced to the point where they can now comprehend all potential factors significantly more easily than a typical human could. System learning methods that train a machine using different datasets are crucial in this situation. The machine evolves such that it may use the knowledge gleaned from the sample sets in new, complex contexts. As a result, unlike humans, there is no possibility of a random error. In the simplest terms, it can be described as a vehicle that senses, analyzes, and goes safely from one location to another with little to no human involvement. These vehicles are therefore outfitted with a range of sensors, including radar, LIDAR (Light Detection and Ranging), GPS, Sonar, Odometry, and inertial measurement units, to enable all of this movement without the need for human labor. From Level 0 (completely manual) to Level 5 (totally autonomous), the Society of Automotive Engineers (SAE) has currently defined 6 levels of driving automation [7].

Due to its numerous uses in industries as diverse as smart surveillance and monitoring, health and medicine, sports and recreation, robots, drones, and self-driving automobiles, computer vision has grown in importance and effectiveness over the past several years. The fundamental components of many of these applications and recent advancements in Convolutional Neural Networks (CNNs) have produced remarkable performance in these cutting-edge visual recognition tasks and systems, including picture categorization, localization, and detection [8]. CNNs are mainly employed for image classification tasks, such as inspecting and categorizing images. Researchers have developed a range of object detection algorithms as a result of recent developments in self-driving cars. However, this research will attempt to narrow down the object detection in AVs to raging fire and flood, the detector and classification on sample fire and flood data sets will be individually trained using a fast Convolutional neural network deep learning method. The detector model will be used to detect fire and flood while the classification model will be used to classify the severity level of the detected scenario

# 1.2 Statement of Problem

Driverless cars use several analytical Algorithms and machine learning algorithms for object detection and tracking, sensor data-based mapping, and planning/decision making.

Current fully autonomous systems utilize perception localization, mission planning, motion planning, and trajectory tracking to navigate road networks. However, in a dynamic urban setting, the classification of an unpredictable and rare event has not been specifically addressed. Unpredictable urban driving scenarios such as the breakout of/approaching bush wildfires, approaching flash floods, road accident inferno, sudden road obstruction, etc. requiring the vehicle to reverse from the potentially dangerous event and re-route are rare but probable in occurrence. The decision of the classification model is expected to determine the response of the AV to these occurrences, as, without the classification model, existing localization algorithms, detection, and perception systems may leave a fully autonomous vehicle stuck without the ability to differentiate between a little erosion by the roadside to a large flash flood scenario or a big inferno to trash been burnt by the road. Without a dedicated extreme event (EE) detection subroutine in the overall planning algorithm, the AV may wait to take needless decisions like reversing due to a small erosion or burning a little trash in a nearby house. This paper is to design the subroutine which enables the AV to identify the scenario and differentiate it from a traffic gridlock with a high degree of accuracy within a safe time frame.

# 1.3 Aim and Objectives

The aim and objectives of this research work is shown in 1.3.1 and 1.3.2 respectively

## 1.3.1 Aim

This research aims to develop a deep learning model for the detection and classification of Extreme events in Autonomous vehicles. The objectives are listed below.

## 1.3.2 Objectives

The specific objectives of this research include the following:

ii. Generate data required for developing a detection and classification system.

iii. Preprocess and extract relevant features of the data.

iv. Use Convolutional Neural Networks to detect the cases of fire and flood

iv. Analyze and classify the severity of the fire and flood scenario.

v. Train the models and simulate for accuracy.

# 1.4 Methodology

The process followed to achieve the methodology is in Figure 1.1

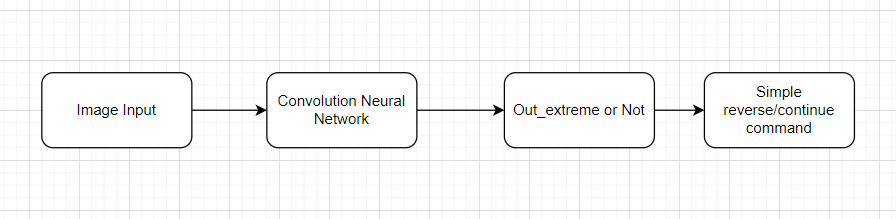


Figure 1.1: Approach to building detection and classification system

To achieve the objectives in section 1.3.2, the methods to be used are highlighted below

1. Obtain image of regular fire and flood
2. Obtain camera image of regular autonomous car images
3. Preprocess the images
4. process the images and extract relevant features
5. build CNN model
6. train and test the model
7. report performance
8. simple function to show reverse message on classification as extreme

# 1.5 Significance of Research

Fully Autonomous vehicle technology is currently in the developmental and testing phases. With the advancement in AI algorithms, autonomous vehicle development is accelerating at a remarkable pace. This research is a contribution to the Decision-making algorithm of Autonomous vehicles with a focus on path obstructing incidences on urban roads.

Significant research in the areas of routing, lane changing and object detection has been conducted and implemented in AVs but when an AV encounters a raging bush or road fires and flash floods or is faced with scenarios that require unconventional withdrawal, the current AVs can get stuck. This project is to develop an algorithm that enables an AV to detect and classify a raging bush or road fires and flash floods scene which will enable it to determine whether to re-route its path or move the vehicle in the opposite direction for the aim of arriving at the preplanned destination safely. Therefore, the significance of this project is to enable an AV to decide how to utilize Vehicle to Infrastructure (V2I) data, machine vision, and mapping to assess incident scenes and then make a quick decision on how to reach the planned destination.

# 1.6 Scope of Research

The goal of this research is to use a convolutional neural network to develop a detection model for detecting fire and flood for an Autonomous Vehicle, the research will also implement a classification model for classifying the severity of the flood and fire scenarios to help the AV make quality decisions on how to get to its desired destination. The result of the model will be compared with that of existing works of literature and metrics such as accuracy, confusion matrix, and F1-score will be used to calculate the performance of the model used.

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