A MACHINE LEARNING MODEL FOR PREDICTING THE OCCURRENCE OF FIRE OUTBREAK

BY

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A PROJECT WRITTEN AND SUBMITTED TO THE DEPARTMENT OF COMPUTER SCIENCE, COLLEGE OF PURE AND APPLIED SCIENCES (COPAS), IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN COMPUTER SCIENCE OF CALEB UNIVERSITY, LAGOS.

JULY 2022

DECLARATION

This is to declare that Oduwole Halima Ayomipo with matriculation number 18/4283 hereby declare that this project titled, “A Machine Learning Model for Predicting the Occurrence of Fire Outbreak” is my work and has not been submitted by me or any other person for any course or qualification at this or any other tertiary institution. I also declare that all cited works have been acknowledged and referenced.

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Student Name/ Matric Number Signature

CERTIFICATION

This is to certify that this research work was carried out by ODUWOLE Halima Ayomipo in the Department of Computer Science, College of Pure and Applied Sciences, Caleb University, Lagos. The research work is considered adequate in partial fulfillment of the requirements for the award of Bachelor of Science in Computer Science.

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DEDICATION

This project is dedicated to Almighty Allah for his wisdom, protection and guidance throughout my course of study. It is also dedicated to my supervisor; Professor Zacchaeus Oni Omogbadegun and my co-supervisor; Dr. Emmanuel Ajulo. Finally, to my parents; who has encouraged and supported me financially all the way from start to finish

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ABSTRACT

The harmful effects of fire outbreaks cannot be over-emphasized. Danger to lives and properties, air and water pollution, deforestation, habitat degradation, and other issues are only a few of them.

Fire outbreaks are catastrophic events by which its occurrence can most likely be prevented if predicted. The school's cafeteria has been a victim of incessant fire outbreaks. What if there was a mechanism put in place that could seamlessly predict if the fire outbreak will occur or not? Well, using Machine Learning, it is very possible.

The ML model that will be developed will provide an-easy-to-implement but precise approach to predicting the occurrence of fire outbreak. The Machine Learning Model will be tuned to a level of high degree of accuracy and precision in order to prevent a scenario of false prediction and creating unnecessary panic in the lives of the residents and occupants in the environment.

This method solely relies on values obtained from three parameters as its input dataset. These parameters are: Relative Humidity, Environmental Temperature and the Relative humidity. Furthermore, the training of the ML model will be done using python programming language and its output will be displayed on a website whose layout and style will be designed using html and css.

This research model can be of various advantages in generating financial revenue in the market sector. The model can be further extended into a proper working system as it scalable. The proposed system can further be integrated into various organizations, offices, schools, airports and even hotels and reservation centers. Similarly, the software model can be further transformed into a stand-alone working system which can aid the services provided by the Federal Fire Service (FFS) in Nigeria.

Keywords

Fire-Outbreak prediction, Artificial Neural Network, Density, Humidity, Temperature, Machine learning model,Federal Fire Service (FSS).

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CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Mankind has harnessed the use of fire since the beginning of civilization. It has been utilized in agriculture for land reclamation, generating electricity and, warmth through coal, a method of communication (signaling), metalworking, casting, garbage incineration, as a weapon or means of destruction and a lot more.

Fire ignites when a highly flammable or combustible matter, in conjunction with a significant amount of oxygen gas or another oxygen-rich compound, is exposed to a heat source or a high amount of temperature exceeding the matter's flash point - The flash point of a substance (i.e., liquid) is the minimum temperature at which that substance fails to release smoke hence generating a highly flammable combination in the air near its own surface. The lower the flash point of materials, the easier the material is to ignite (Johnson, 2008). Hence, these components, in the appropriate proportions, are requisite for fire to start burning. For instance, a matter (substance) will only begin to burn if the proportions of fuel and oxygen are adequate. In simple terms, fire needs three elements to ignite: fuel, oxygen, and heat.

Many variables contribute to fire outbreaks and disasters, some of which may be attributed to human mistakes while others are beyond our control. An inferno can be generated by a huge fire outbreak. Inferno is a massive, untamed fire that has the potential to cause bodily harm and catastrophe.

According to Obong'oOballa (2019), fire can in no time spread quickly, destroying lives, properties, and environments, as well as leaving devastating memories in the lives of human. Fires outbreaks are caused in numerous ways and its fueling agents (i.e., flammable substances) are in abundance everywhere in the environment, especially in our homes. As a result, in the event of a fire outbreak, most buildings (e.g., offices, houses, workstations, and companies) are extremely hazardous.

1.2 Statement of Problem

In modern days, there are so many occurrences of fire outbreaks. Some outbreaks can even last as long as days, weeks, or even months. More than 1,000 large fires have burned since January 2021 across the rainforest *(*Jones, 2021).

Moving ahead, we can all tell how catastrophic these events can be if they are not handled with great caution. Regardless of age, financial background, political status, social standing, or other factors, anybody, anywhere can become a victim of a fire accidents.The key concern is that, in most cases, there are no mechanism implemented to predict these outbreaks early enough to save businesses, properties and in worst scenarios, lives. Hence, calls for aid from employees, students, or passers-by after (or during) the fire epidemic has begun are mostly relied on (Agaji, 2016).

Manual method is not as accurate as using a machine learning model for predicting a fire outbreak because it involves physical observance like smell and smoke. Most of the time, the fire would have already started before the fire service department is being notified. The automated

approach for predicting fire outbreaks using a machine learning model is particularly effective at eliminating the fundamental flaw of the manual method, which is basically not proffering an accurate and reliable solution. For various organizations, residences, schools, institutions, and even the fire service department in metropolitan countries, predicting the occurrence of fire breakouts has been a big challenge. Hence the research work is of great importance to the society at large.

1.3 Aims and Objective of the Study

Using Machine Learning, this research work focuses on solving a real-life problem of predicting the possibilities of a fire outbreak. The Objectives of the projects are:

i. building a machine learning model that predicts the likelihood of fire occurring in an environment;
ii. training the model in (i);
iii. deploying the model on a website designed using HTML and CSS; and
iv. testing and evaluating the developed system.

1.4 Significance of Study

The prediction system is a machine learning model that will allow users (residents, organizations, fire departments, etc.) to implement an automated way of predicting fire outbreak occurrence, thereby preventing disasters from happening. Presently, urban fire remains to be a persistent disastrous event, especially with the expansion of highly occupied urban settlements, which is why the research work aims to provide a solution to this obstacle.

Predicting fire occurrences has mostly been regarded as something “obscure” by people. What if there is an automated way of predicting the occurrence of fire outbreaks? Yes, it is possible through the use of Machine learning, a subset of AI. This model will provide an easy to use but precise way of predicting the occurrence of fire outbreaks with a very high degree of accuracy.

1.5 Research Scope

The main focus of this initiative is to accurately predict the occurrence of fire outbreak with the help of a machine learning model that will be designed using python programming language. The research work considers just the atmospheric condition that leads to fire outbreak.

1.6 Justification for the new System

Strengthening the prediction of fire outbreak occurrence system in institutions, residential apartments, offices and buildings is very critical and essential. Hence, this system will include a centralized database to store the login ID of the personnel stationed to make effective use of this system and also used to store the input dataset used for the system. Furthermore, this system is significant because it eradicates all of the drawbacks of the existing system. It is also a very user-friendly and easy to use and implement.

1.7 Structure of the Project

The project structure is presented is Five (5) chapters;

i. **Chapter 1**: This chapter provides the whole project with the introduction of the research study and it is also concerned with statement of the problem, aims and objective of the

study, significance of the study, research scope and the definition of terms used in this research.

ii. **Chapter 2**: The literature review and a detailed summary of previous library works, paper and documentation on the prediction of the occurrence of a fire outbreak is discussed in this chapter.

iii. **Chapter 3:** The chapter covers the analysis of the methodologies adopted in this research work. It also includes an overview of the dataset used in training the machine learning model. A performance indices based on the probability of fire outbreak occurring will also be reviewed.

iv. **Chapter 4:** The Forth Chapter deals with the implementation and results of the machine learning model developed. The system implementation, requirements, prototype display, and program documentation are all included in this chapter.

v. **Chapter 5:** This is the final chapter. It outlines the overview and the conclusion of this research work with relevant and critical recommendation.

Reverences and appendices are included in the concluding part of this documentation.

1.8 Definition of Terms

The following technical terms are used in this work:

1.8.1 Prediction

Prediction can be referred to statement of what someone or a group of people thinks might happen in the future. Usually based on scientific research or observations, study of past and historical data or sometimes guesses. For instance, study explains that whenever environmental temperature begins to rise, the body temperature starts to rise equally. Hence, with this

knowledge, we can make a simple prediction that says “if the weather goes above 36˚C, an individual is likely to feel very hot”.

1.8.2 Regression

Regression is a mathematical approach to find the relationship between the two or more variables in question. It is widely used in AI to make prediction of a variable based on values derived from another variable. For instance, given the popular linear equation y=mx + c, the value of y can be predicted based on the values gotten from m, x and c which are the variables y depends on.

1.8.3 Machine Learning

Machine Learning is a subfield of Artificial intelligence. It focuses on the use of data and algorithm to identify patterns and make decisions with little or no human intervention. More on machine learning will be explained in the subsequent chapter.

1.8.4 Machine Learning Algorithm

Machine Learning Algorithm are the various step by step procedure involved in developing a data set into a machine learning model which can eventually be used to make prediction and decision without being explicitly instructed by humans. There are three main types of machine learning algorithms which are: Supervised Learning, Unsupervised Learning and Reinforced Learning Algorithm.

1.8.5 Machine Learning Model

Machine learning models are the various algorithms, files, procedures that have been trained over time to identify certain types of patterns in order to make complex decisions and predictions. In order to build the perfect machine learning model, the machine learning algorithm has to be trained properly and then fed into the ML model.

1.8.6 Artificial Intelligence (AI)

Artificial Intelligence (AI) is a theory that studies the development of computer systems that can act and perform tasks that normally require human intervention/ intelligence. Facial Detection and Recognition system, Text editors and auto-correct, Recommendation and search algorithms are all features of human intelligence that are being implemented in Artificial Intelligence.

1.8.7 Artificial Neural Networks (ANNs)

Artificial neural network (ANN) is a form of Deep Learning. ANN is a tool required for the intelligence of a machine. Hence, it uses processes similar to the way the brain operates to develop algorithms that can be used to model complex patterns and find solutions to prediction problems.

1.8.8 Automation

Automation is simply the procedure or technique that involves the use of machines and technology to make some certain tasks and process perform on their own (i.e., automatically) without little or no manual labor. Examples of devices that uses automation are: Electric Appliances, Self driving car, Data cleaning and clearing scripts etc.

1.8.9 Federal Fire Service (FSS):

The Federal Fire Service (FSS) in Nigeria, established in 1901 is a body that is exclusively responsible for fire mitigation, fire prevention, firefighting and providing paramedical assistance to victims of fire accidents through regulation, training and reinforcements (Federal Fire Service, 2022).

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter presents a representation on a logical review of relevant literature as regards predicting the occurrence of fire outbreak and its importance. It also discusses the major scopes and concept that are pertaining to this research work. It further describes Nigeria's perspective on the proposed system and a brief history of The Federal Fire Service in Nigeria. The software development model used for the development of the application in this research work and the reason for optimizing that such model will also be reviewed in this chapter.

2.2 A Brief History of Federal Fire Service in Nigeria

According to fedfire.gov.ng, the Nigerian fire service was constituted in 1901. The British administration did in fact, established the Nigerian fire service agency. Back then, the Federal Fire Service was not what it is now. It began as a simple branch of the Lagos Police Department, known as the Fire Brigade.

The Federal Fire service main functions include:

i. Fire Fighting,
ii. Rescue Service,
iii. Fire Prevention,
iv. Paramedical and information services,
v. Assistance to the less privileged,
vi. Establishment of fire service training schools,
vii. As well as other fire-related services.

The administrative headquarters of the Federal Fire Service of Nigeria is located at Garki Area 10, Garki Abuja, Nigeria. The current head of this body is Ibrahim AlhajiLiman. The Federal Fire Service is basically a firefighting organization, with the sole mission of preventing, detecting, and extinguishing fires, as well as other associated activities (Tersoo, 2019).

Figure 2.1 The Federal Fire Service, Nigeria Logo (fedfire.gov.ng, 2020)

The Federal Fire Service of Nigeria now has nine zonal commands. The goal of establishing these zones is to increase the quality of work done by these agencies, such as increasing emergency response times and providing quality firefighting services to the nation, to highlight a few. "Our impact was restricted to Abuja, Lagos, and the six geopolitical zones when I began my tenure." The Chairman of the Federal Fire Service, Ibrahim AlhajiLiman, stated, "We know that with the additional zones, it would broaden our reach and strengthen us to accomplish more." This comment led to the establishment of these zonal commands (Tersoo, 2019).

2.3 Nigerian View on Fire Outbreak Prediction

Thousands of buildings, stores, residential apartments, and other structures have been destroyed by fire on a regular basis throughout the last few decades. In the process, people's lives and property are being destroyed.

On January 1, 2022, VANGUARD news documented the most recent fire outbreak (as of today - 19th January 2022). In Surulere, Lagos, a three-story building was destroyed by fire. According to reports, the source of the outbreak was electrical equipment exploding immediately after electricity was restored to the building. They further stated that the Federal Fire Service and Lagos State Fire Service workers were unable to extinguish the fire because the equipment they brought to the scene stopped functioning (Idowu, 2022).

Figure 2.2 Diagram of a 3 storey Building on Fire at Surulere, Lagos (Vanguard, January 2022)

It is evident that there was no system in place to effectively avoid this disastrous catastrophe. What if the occupants of this building had access to a Fire Outbreak Prediction System? Is there a Prediction System that warns them that their house could burn down in the next several minutes? Without a shadow of a doubt, if that system had been in place, this tragic disaster, plus lots of others, would have been avoided.

The fire service in Nigeria is largely undeveloped. The evolution of efficient and functioning automated fire forecasting technology has stalled. Fire outbreaks are still one of the most deadly and traumatic events that may occur to a person, but they are treated with less severity due to a lack of suitable technology and the carelessness exhibited by the agencies responsible for fire outbreak regulation. In Nigeria, there are clearly insufficient fire prediction systems and technologies; hence, this research contributes to the reduction of inefficiencies in this area.

2.4 Concepts and terminologies

A Fire outbreak prediction system serves as a basic utilization of prediction and regression algorithm in the field of artificial intelligence that is; it is a crucial problem that AI can help solve. The terminology and topics of this research effort are discussed in the following subsection.

2.4.1 Overview of Fire Outbreaks

The spread of an uncontrolled fire is referred to as a fire outbreak. Uncontrolled fire may spread quickly, inflicting irreparable damage to the home, building, valuables, and other nearby properties, as well as putting people's lives in jeopardy.

2.4.1.1 Fire Triangle

According to an article published Rachel Engel (2020), the fire triangle, also known as the combustion triangle, is made up of the three essential components (or substances) needed to ignite a fire. The first and possibly most crucial and vital ingredient in a fire triangle is heat (or Ignition Temperature). A considerable and sufficient quantity of heat is required to sustain a fire. Which is why, in most scenarios, a cooling agent, such as water, is the first thing used to put out a fire. Oxygen and fuel are the other two elements of a fire triangle. In order to ignite, fire requires a source of fuel. Any combustible element can be used as a fuel source (i.e., Fiberboard, wood, foil, paper).

The fire combustion process is delayed when the oxygen content in the air is reduced. Fire requires a lot of oxygen to function properly. For a fire to keep burning or ignite, it requires enormous amount of oxygen. In a large-scale fire (i.e., an inferno) where fire fighters are desperately needed, removing oxygen from the fire triangle is typically not practicable since there is no efficient way to do it in such a large area, hence alternative methods of extinguishing the fire must be adopted.

As long as these three components are viable, fire will continue to burn. The flame, on the other hand, is formed when the burning heats the surrounding material while also releasing more fuel and gases. As a result, fire will keep spreading as long as the flame burns the current gases and fuels.

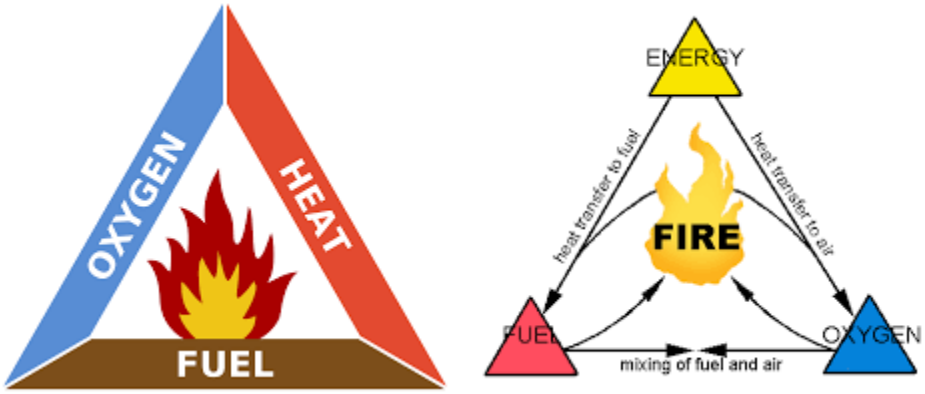

Figure 2.3 Diagram of A fire Triangle (Source: Wikipedia, Fire Triangle 2020)

The fire triangle must be disrupted in order to eradicate fire breakouts. At the very least, one of the components must be removed. No matter how intense the fire is, removing one of the components will quench it. Similarly, in order to avoid a fire, these three components must be separated as far away as possible (Eve, 2020).

2.4.1.2 Fire Tetrahedron

The addition of the fourth element, Chemical Exothermic Reaction, is the most significant distinction between the Fire Triangle and Fire Tetrahedron. Chemical exothermic reactions are chemical processes (the conversion of one or more compounds to one or more distinct compounds) that release energy into their surroundings, often in the form of heat or light.

In the Fire Triangle Model, the Fire Tetrahedron adds additional element (Chemical Reaction).

The Fire Tetrahedron is just a Fire Pyramid with Four Planes.

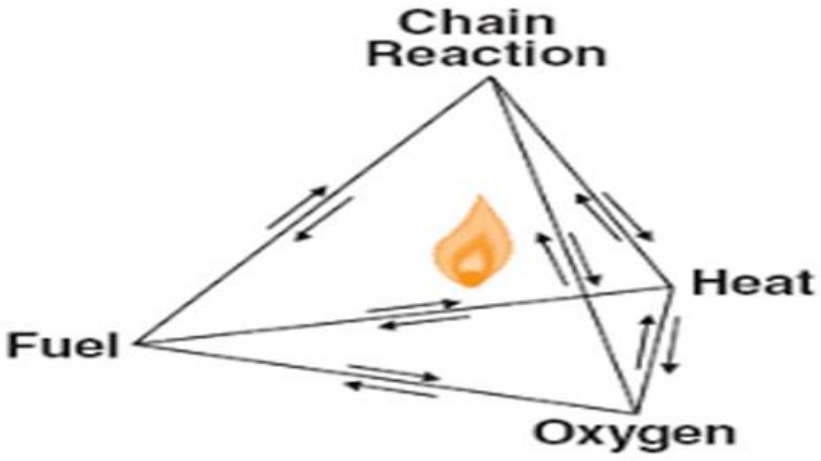

Figure 2.4 Diagram of a Fire Tetrahedron Pyramid (Source: Business Watch, January 29, 2020)

2.4.1.3 Classes of Fire and Fire Extinguishers

Depending on the substance being burned, a fire is categorized into one of several classifications. This fire classification notifies us about the strategy to take and the sort of fire extinguisher that should be used to put out the fire. This is the fundamental explanation for the idea that water does not put out any form of fire, and in some cases, it may even make the fire worse. We must note that not all fuels are the same, and that using the incorrect type of fire extinguisher on the wrong type of fuel might result in an even more dangerous situation. As a result, the proper type of fire extinguisher must be used to put out the blaze (Engel, 2020).

Figure 2.5 ABCs and Ks Fire Extinguisher

2.4.1.4 Causes of Fire Outbreak

In seconds, a fire may start and spread uncontrollably, destroying a building and its valuables in minutes. A fire outbreak can put residents' lives in jeopardy and inflict massive damage in a short amount of time. As a result, it is safer to grasp the reasons of this catastrophe. That is, it is far preferable to have a strategy in place for preventing the conditions that lead to a fire in the first place. Fires can emerge in a variety of ways, but they all fall into one of three categories:

- Human Errors,
- Arson,
- Lightning.

Human Errors cause fire outbreaks when the fire is not treated properly by the person in control. Human recklessness and negligence can be the primary cause of a traumatic incident that results in the loss of life and property. The following are some examples of reckless behaviors exhibited by human that has the potential of leading to a fire outbreak:

- Use of candles and other open fires without caution
- Smoking
- Irresponsible handling of chemical substances in the laboratory and residential areas
- Cooking Equipment; if not properly monitored, overheated cooking equipment (i.e., pots, pans, and other cooking utensils) can induce a fire.
- Combustible Liquids: Residents and homeowners often take these liquids (such as kerosene, gasoline, diesel, and so on) into their apartments and garages for use. If not handled carefully, these substances can cause a fire to break out.
- Fireworks; The festive season is meant to be celebrated. The careless usage of fireworks might result in a deadly fire outbreak. Fireworks should only be used under the supervision of an adult and in the proper manner (i.e., aiming them at the sky and not another direction).

On a worldwide and national basis, **arson** continues to be a concern. Arson causes a lot of property damage, injuries, and deaths. It is the intentional burring of one's or another's property. During riots, social or political upheaval, these properties (houses, land, cars, etc.) might be set on fire. Arson is sometimes used to destroy a crime scene or evidence at the site, or even to commit murder. The majority of the time, fires are caused by arson are outside the housekeeper's control. It has even resulted in the fire spreading to nearby houses and properties. Arson should be avoided at all costs in order to completely avoid the consequences of fire outbreaks.

Lightning is another crucial facet that contributes to fire outbreaks. The number of buildings and properties burned by lighting is nearly equivalent to the number of fire breakouts caused by humans. Although lightning cannot directly ignite fires in houses and buildings, it can cause

damage to electrical equipment, roof shingles, and other items in the residence, resulting in the start of a fire outbreak.

Various strategies can be used to avoid lightning as a source of fire outbreak. It includes the following:

i. Installation of lighting isolators
ii. Installation of smoke detectors
iii. Before leaving the room, make sure all electrical plugs and switches are turned off.
iv. Constantly inspecting the electrical wiring and loose wiring.

(Obong'oOballa, 2019).

2.4.1.5 Smoke and Fire Detectors

Devices that can detect a fire are known as fire detectors. As soon as the fire starts, these devices send signals to the alarm circuit they are connected to. Smokes, flames, heat, or a combination of these variables can stimulate fire detectors. `

A smoke detector is electronic fire-protection equipment that detects the presence of smoke, which is a major indicator of a fire break out. The Photoelectric (Optical) and Ionization (Physical Process) smoke detectors are the two most common varieties. Installation of a combination of these two types of smoke detector (Dual Sensor Smoke Detector) is required for if optimum protection from both quick and slow spread fire (Arthimn.d).

Figure 2.7 Smoke and Heat Detectors(Good Housekeeping, 2019)

2.4.2 Artificial Intelligence

Artificial intelligence is a field in which computers are taught to "think" and be "intelligent." Artificial intelligence is the imitation of human cognitive acts and processes in machines (most notably computer systems). From virtual assistants (such as Apple's Siri, Amazon's Alexa, Google Assistant, and Microsoft's Cortana) to Computer Vision, Auto Correct Scripts and Programs, Movie and Music Recommendation Systems, Natural Language Processing Systems (such as Google Translate), Robotics, and Speech Recognition, there is a lot to learn. It is evident how AI concepts may be applied to a wide range of applications.

2.4.3 Machine Learning

Machine learning is a fascinating and intriguing field of study. Machine Learning is a branch of Artificial Intelligence that enables computers to learn without being explicitly programmed. Machine Learning focuses on the development of computer programs and algorithms to make them more comparable to 'humans' using outcomes based on historical data and observation. Machine Learning is built on the foundation of how humans learn, reason, and makes decisions.

Machine Learning's main goal is to teach computer algorithms and systems to learn on their own. In this research work, machine learning was implemented as the methodology for predicting the occurrence of fire outbreaks because it takes much more lesser time to train and training is done on the CPU and not on the GPU as in deep learning. Also, lesser amount of dataset is required to train a machine learning model (Team Expert AI, 2020).

2.4.4 Machine Learning Algorithms

Machine learning algorithms are the step-by-step processes required in turning a dataset into a Machine Learning Model. Machine learning algorithms can be adopted in predicting the occurrence of fire outbreak in a variety of techniques. There are three main learning algorithms;

i. **Supervised Learning:** The dataset used to train the model is divided into labels in supervised learning. The machine learning system uses these labels to generate correct decisions, analyses, and predictions.
ii. **Unsupervised Learning:** In this case, the computer does not have any labels with which to learn. Rather, the data is organized into groups or clusters. Based on the categorization supplied, the algorithm makes judgments and determines the dataset pattern and structure on its own in this way.
iii. **Reinforced and Semi-supervised Learning:** Semi-supervised learning is a type of learning that lies between supervised and unsupervised learning. The algorithm is trained using a lesser amount of labeled data and a larger amount of unlabeled input in semi-supervised learning. In the medical field, semi-supervised learning is commonly employed in CT scans and MRIs.

Reinforced learning involves using a reward system to train an algorithm (Trial and Error). If the algorithm completes a job successfully, it is rewarded; otherwise, it is not. Video games a perfect example of reinforced learning, complete a level then earn more rewards and, in most cases, move to the next level. A reinforced algorithm's overarching goal is to forecast the best next step to take in order to optimize the final reward (Tsymbal Oleksii, 2020).

Machine learning algorithms are the procedures used to train a set of data. Whereas,**Machine Learning Models** are well-defined outputs that are as a result of these machine learning algorithms. It takes some set of values as inputs then produces a set of values as outputs.

Machine Learning Model == Model Dataset + Prediction Algorithm

In this reaserch, the type of machine learning that will be adopted in the supervised learning. numerous data set will be labeled into three; Temperature, oxygen and Realtive humidity. This datasets are what the machine learning model will be trained with.

The training dataset will be in the form of an excel sheet (i.e. rows and colums) and Python Programming Language and some of its libraries will be used to train the model. Precision, Accuracy and Efficiency reamins the overall aim of the model that will be designed.

2.4.5 Deep Learning

A subset of machine learning is deep learning. Machine learning has progressed since it now requires a larger dataset to learn and solve problems. The use of machine learning may be seen in Amazon's Alexa and Apple's Siri. DeepMind from Google, on the other hand, is a deep learning implementation. Although it takes longer to train Deep Learning algorithms than Machine Learning algorithms, the former is more accurate. In addition, unlike Machine Learning, Deep Learning does not need a substantial domain knowledge base to get desired outcomes.

2.4.6 Neural Network

Neural network is a field inspired by the human brain. Neural Network is widely used in extracting and processing complex information from a wide data set, using different tools and algorithm to achieve these tasks. Neural Networks are sets of layers consisting of highly interconnected elements know as neurons. Logically, deep earning utilizes these neural networks to mimic the brain activities to solve complex problems. When input is given to the Neural Network, it is processed through the layers of perceptron until the output is produced.

A Neural Network consists of basically three layers, which are;

i. Input layers
ii. Hidden layers
iii. Output layers

The Input Layer analyzes the data that is fed into the Neural Network system for further pre-processing by the artificial neurons in the subsequent layers.

The Hidden Layers are all the layers that exist between the Input Layer and the Output Layer. The neurons in these Hidden Layers employ weighted inputs and biases to generate an output using activation functions.

The Output Layer is the last layer of neurons that gives us the results of the given program (Jahnavi. 2017).

2.5 Software Development Models

Software development models are frameworks, techniques, and procedures for planning and executing projects based on the project's goals and objectives. Software can be developed using a range of different models. There are many developments model that can be used to achieve different stated objectives. Some of which are explained below:

i. Waterfall Model

The waterfall model is the oldest type of software development models. It is also the most basic of the Software Development Model. The development processes in a waterfall model are structured in a linear sequence. The first phase's output becomes the second phase's input. Before moving on to the next step, each phase must be completed. As a result, there are no overlaps or inconsistencies in the procedure. The Waterfall Model is divided into phases that include requirements analysis, system design, implementation, testing, deployment, and maintenance.

ii. Iterative Model

Iteration basically means repetition. In an iterative model, the process begins with a small fraction of the software needs being implemented at a low cost, followed by an examination and evaluation for more requirements. This process is done until a model that is satisfactory is generated. This Software Development Model emphasizes the value of repetition. Although results are obtained early and frequently under an iterative model, it is not suitable for small projects.

iii. Spiral Model

The spiral model combines both the technique of waterfall model and iterative model, which makes it the most adaptable Software Development models. The spiral model has four phases; Identification/ Planning, Design, Construction and Evaluation (Risk Assessments and Testing). The software projects iterate through these phases as it passes through them. Both the management and the entire process is very complex and the end result of the project might not be revealed early enough.

iv. Software Prototype Model

The software prototype model as the name implies refers to building an application prototype which is developed based on current requirements. The method gives the users the 'actual feel' of the system. Prototyping is actual used in large and complicated systems. A prototype is simply a working model of an entire system. It is not the actual system and it usually built for demonstration and illustration purposes.

v. Agile Model

In Agile Software Development Model, the software project is broken down into smaller and incremental blocks. It separates the project into cycles and each cycle are completed within a

brief period of time. These cycles are provided on iterations. Each iteration process last for about one to three weeks depending on how large and tasking the project is. According to Robert Half, the downside of this model is that an overemphasis on customer interaction can occasionally lead to the project going in the wrong direction.

(Tutorials Point, 2021)

Overall, The Waterfall Development Model will be used in this project work as it is very simple to use and understand, perfect for mid-sized project where requirements are clear, easy to classify and prioritize tasks. Also, project developed with the Waterfall methodology is very easy to manage as a result of the rigidity of the model.

2.6 Review of Related Literature

The significance of implementing an automated and well-organized Fire Outbreak Prediction System has been recognized. Several methodologies have been deployed in the past for the prediction of fire outbreaks using several machine learning algorithms. In this chapter, the conclusion as well as a study that has been proposed by various researchers, with a theoretical discussion of previous works will be emphasized.

Sharma et al (2019) conducted research on "Sensory Network Based Forest Fire Detection and Early Warning System". This research suggests a general, easily deployable forest fire detection and management system that is based on Sensor Networks (SN). In dangerous and sensitive places, sensor networks are being used for monitoring as well as for gathering and analyzing important environmental data. A wireless sensor network that has been set up for the forest

region under study and equipped with sensors that can identify environmental changes based on by an event, in this case "fire initiation," serves as the methodology for this research. The drawback of such systems is that they are still in the research and development stage and are limited by the capabilities of wireless sensor networks, power sources, and network connections.

Dasig, Jr. (2015) conducted research on the design and prototype implementation of a fire detection and intelligent alarm system. The goal of this study was to design a fire detection and intelligent alarm system for educational establishments that were classified by the bureau of fire protection. The approaches outlined in this research mainly rely on web science interaction with embedded systems. The problem with our research is that it does not offer a trustworthy method of spotting the fire before it emerges. It was only concerned with finding the fire once it had begun.

AgajiandShangbum (2016) conducted a study titled A Neural Based Experimental Fire-Outbreak Detection System for Urban Centers. In order to detect the occurrence of urban fires, this research implements Artificial Neural Networks (ANN) with the back propagation approach. The method takes as inputs the concentration of cooking gas, room temperature, and smoke density. Java programming was used to train the artificial neural network. After training, the suggested system uses real-time data to identify fire in urban buildings. The system's flaw is that not enough dataset was used during the training of the TLPNN using the back propagation approach, which reduced the accuracy of the system. Additionally, because the methodology of the study only considers residential fires in different homes and restaurants, scaling and extensibility are not very feasible.

Chen et al. (2021) conducted research and designed a distributed fire alarm system for the indoor internet of things based on LoRa. In this paper, a distributed indoor LoRa-based IoT fire alarm system is proposed. The system makes use of LoRa communication technology to install scattered nodes and gateways in a star network layout. The node gathers environmental data and instantly synchronizes it with a remote monitoring system. The node monitoring system has the ability to immediately sound an alarm in the case of a fire. The sensor filtering and weighted fusion algorithm can properly detect whether a fire has occurred, and the remote user monitoring system can monitor the system status of each node in real time. The system has the features of easy deployment and extended service life. The node also features routine data transmission, low power sleep, and energy-saving modes to help devices be used for extended periods of time. The downside of the research work is that the entire operation of the system depends solely on the IoT. Once the IoT fails, the entire project fails.

Sowah et al. (2019) carried out a research titled Hardware Module Design and Software Implementation of Multisensory Fire Detection and Notification System Using Fuzzy Logic and Convolutional Neural Networks (CNNs). The study describes the design and implementation of a web-based warning system with trained convolution neural networks for proximity and wide-area fire detection, as well as a fuzzy logic-based multimodal fire detection system. As a result of their ability to carry out feature extraction and classification in the same architecture, convolutional neural networks are widely used deep learning techniques. By utilizing a variety of fire signatures, including flames, smoke, and heat, the system is intended to enable early fire detection in residential, commercial, and industrial environments. A major gap of this work is that the final experimental and performance evaluation results revealed that the accuracy rate of

CNN was 94% and that of the fuzzy logic unit was 90%. Incorporating neuro-fuzzy to significantly increase the detection rate and adding more images to train the network for greater accuracy are two potential enhancements to the developed system.

Youssef et al. (2013) revealed a method for using artificial neural networks to forecast forest fires in the real world. The neural network utilized for this application is a multilayer perception whose architectural parameters, i.e., the number of hidden layers and the number of neurons per layer, were heuristically selected. Using the back propagation learning algorithm and a significant amount of actual data pertinent to the investigated issue, the synaptic weights of this design were modified. The application is a Linux-based object-oriented program written in the C++ language. It is classified into two different sections: the learning process using a training dataset and the back propagation technique, and the test of the trained topology using unseen new data.

Marin-Perianu et al. presented a distributed fuzzy inference engine called DFLER (Distributed Fuzzy Logic Engine for Rule-Based) In order to detect events via wireless sensor networks (WSN). Using smoke and temperature sensors, they thought of fire as an event. Using a distributed fuzzy logic engine, D-FLER combines local observation with individual sensor inputs. Utilizing ambient Node 2.0 platforms, their work's prototype was put into action. The fact that the researchers only used temperature and smoke sensors to base the fire detection on puts the validity of this research in question and increases the likelihood that the system would record false alarms as a result.

Khule et al. (2017) carried out a research titled design and implementation of a fire detection and control system for automobiles using fuzzy logic. This research work presents a fire detection system to monitor and detect fire in automobile system using various sensors such as Flame, Temperature and Smoke sensors. Also, the included that fuzzy logic is more popular since it uses engineering experience from years of testing rather than mathematical models when optimizing a variety of complicated control systems with different parameters.

The two main components of the car fire detection and control system are:

i. Fire detection subsystem (network of sensors) and
ii. Fire control subsystem (carbon dioxide distribution network)

A gap in this research work is that it only focuses on automobiles alone. The scope of study for the research work was limited.

Udak et al. (2017) researched on a project titled support vector machine-based fire outbreak detection system. Based on data from the Fire Outbreak Data Capture Device, Support Vector Machine (SVM) was used in this work to classify and predict fire outbreaks. The values of the environmental factors utilized in this investigation were captured by the fire outbreak data capture device (FODCD) that was employed. The FODCD gadget included an

i. ESP8266 Wi-Fi module,
ii. LM393 flame sensor,
iii. DHT11 temperature sensor,

iv. MQ-2 smoke sensor,

v. Arduino mini v3.0 board.

The FODCD device was used to collect 700 data points, of which 60% were used for training and the remaining 20% for testing and validation, respectively.The True Positive Rate (TPR), False Positive Rate (FPR), Accuracy, Error Rate (ER), Precision, and Recall performance measures were used to evaluate the SVM model. The performance results demonstrate that the SVM algorithm has a minimum error rate of 0.2 percent and an accuracy of 80% in predicting the occurrence of fires. With greater precision, our technology was able to forecast the occurrence of fires.

Vigneshwara et al. carried out a research titled Fire Detection using Support Vector Machine (SVM). An intelligent fire detection and mitigation system is reviewed in this paper. The study suggested a fire detection approach based on an adaptive fusion of three sensors: flame, temperature, and gas. As a source of the input data, an Arduino Uno with a flame sensor, temperature sensor, and gas sensor is used. The Arduino IDE was utilized for system implementation. Because the system took into account the input from several sensors while determining the real fire event, the actual fire might occasionally be mistaken for the false fire.

The next chapter discussed the method used in this research.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter focuses on the design and construction of the machine learning model architecture and design. The Machine learning architecture is a framework (or a flowchart) that depicts the fundamental building blocks that makes up the machine learning model. The chapter will go further into explaining in details these building blocks. Some of these phases includes; Datasets, Data retrieval, Data preparation, Testing and training datasets, the learning algorithm used, et al. Finally, an evaluation and description of the newly developed system, the programming languages used and the installation requirements of the machine learning model, will be reviewed.

3.2 Machine Learning Architecture

The concept of machine learning architecture is viewed as a domain that helps in transforming the conception of arbitrariness (i.e. datasets) to a proof of reality (i.e. a prediction system). In other words, the machine learning architecture designed is a representation that outlines the different layers (phases) that is involved in the development of the final prediction system. It includes the major processes that transform raw (and unprocessed) dataset into the final machine learning model that can be deployed and implemented.

One might begin to wonder the difference between a machine learning architecture and a machine learning model. Well, these two concepts are very dististinct but the differences are not farfetched. Machine learning model is just a phase in the machine learning architecture. The

machine learning architecture covers the entire processes in the development of the machine learning system itself which is capable of carrying out prediction.

The illustration below is a diagrammatic representation of the machine learning architecture that was designed for this project.

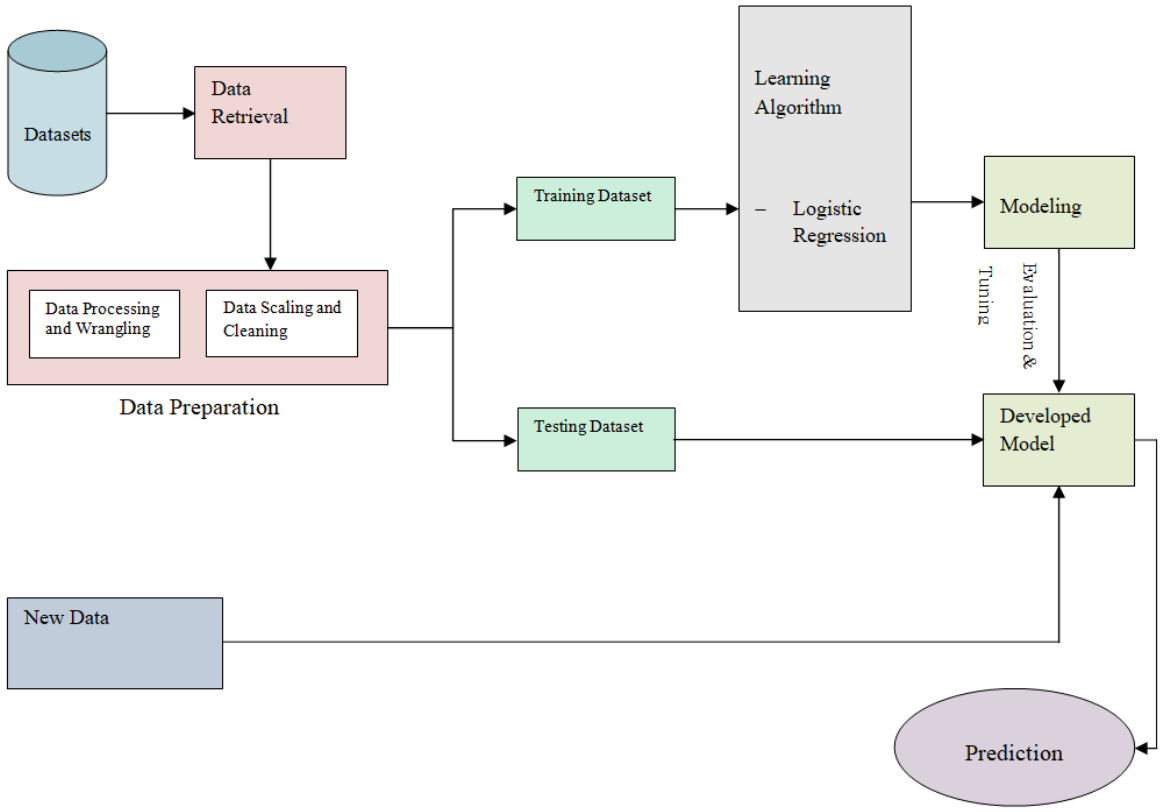

Figure 3.1: Machine Learning Architecture

A detailed understanding of these various layer represented in the illustration above is done in the subsection below.

3.2.1 Datasets

In machine learning, datasets contain many different bits of data but it may be used to train an algorithm with the purpose of identifying predictable patterns within the dataset as a whole. There are three types of data sets Numerical data (such as house price, temperature, stock price), Categorical data (Yes/No, Blue/Green, Dark/Bright etc.), Ordinal data (These data are comparable to categorical data, but they may be compared and quantified).Understanding what dataset that is to be used for any project is the first phase in the Machine learning architecture as its importance cannot be overemphasized.

A sample of the dataset used in this study is properly documented in Appendix II.

This project focuses on using the environmental humidity, temperature, and oxygen measurements to predict the occurrence of fire outbreak, that is, the dataset is continuous and numerical. These quantities are the environmental factors which when their corresponding values are being measured and analyzed by a machine learning model, the result can be used to drive the forecast of a fire outbreak. The values gotten from these measurements (which will be discussed consequently) will serve as the data set that will be used to train the model.

Before a fire outbreak can occur, there are three parameters that must be put into consideration: The Relative Humidity, Temperature and Lastly, the environmental oxygenation.

i. The Relative Humidity

The quantity of moisture in the atmosphere is usually expressed as Relative Humidity. It is the proportion of existing water vapor in the atmosphere to the quantity that would saturate the atmosphere at that temperature. A hygrometer is often used to calculate the humidity of a given

environment. There is no specific SI unit for the measurement of relative humidity (but in most cases we use percentage, %).

The lesser the relative humidity, the faster it is to initiate and sustain a fire; the more rapidly it burns, and vice versa. This is mathematically expressed in equation (i);

$$R.H \propto 1/\text{ Fire Intensity} \qquad \text{(i)}$$

According to Science Direct (Karl F. Tiefenbacher, 2019), the range of relative humidity is usually given as a percentage from 0% to 100%.

i. 0% RH means absolutely dry air, zero moisture content,
ii. 100% RH means that the saturation with moisture, the dew point is reached.

ii. Environmental Temperature

Environmental Temperature simply refers to how hot or cold the air of the environment is. I would say that the air temperature is the important factor influencing a fire behavior. Air Temperature has direct impact on fire behavior. The air temperature and the momentum for fire are directly proportional (i.e., the intensity of the fire increases as the temperature rises, and vice versa). This is mathematically expressed in equation (ii);

$$\text{Temperature} \propto \text{Fire Intensity} \qquad \text{(ii)}$$

There are three units for the temperature of an environment: Kelvin (K), Fahrenheit (°F), and Celsius (°C). The temperature of an environment can be measured using a thermometer.

iii. Environmental Oxygenation

The environmental oxygenation is just the amount of oxygen content in the environment. Most flames require at low as 16% concentration to ignite, whereas air contains roughly 21% oxygen. Definitely, considering this factor, fire can burn easily in any ventilated environment. When fuel burns, it combines with oxygen in the air around it, producing heat and combustion products (gases, smoke, embers, etc.). Oxidation is the name for this process.

In an environment, oxygen and the momentum for fire are directly proportional. A small increase in the oxygen in the air results the fire starting to ignite more easily, which will then burn hotter and more intense than normal. This is mathematically expressed in equation (iii);

$$\text{Oxygen} \propto \text{Fire Intensity} \qquad \text{(iii)}$$

Lastly, not all datasets call for numerical values. For instance, dataset required for a pattern recognition system may take the form of texts, numbers, photos, or videos.

A dataset with 210 entries was used for this project. However, the dataset increases as the project's scope expands. Similar to this, the accuracy of the model increases with the size of the dataset.

3.2.2 Building the dataset

Building the dataset is the next process after knowing the type of data and amount required for the modeling. Raw data is a great place to start when creating a proper dataset for a machine learning project. It is the freshly acquired dataset that hasn't been cleaned or altered in any way.

It is evident that one cannot just feed the raw data set into the learning algorithm and expect the algorithm to produce insightful results.

A lot of data is needed to work on machine learning projects since machine learning models can't be trained without data. The most important aspects of building a machine learning project is retrieving and preparing the dataset.

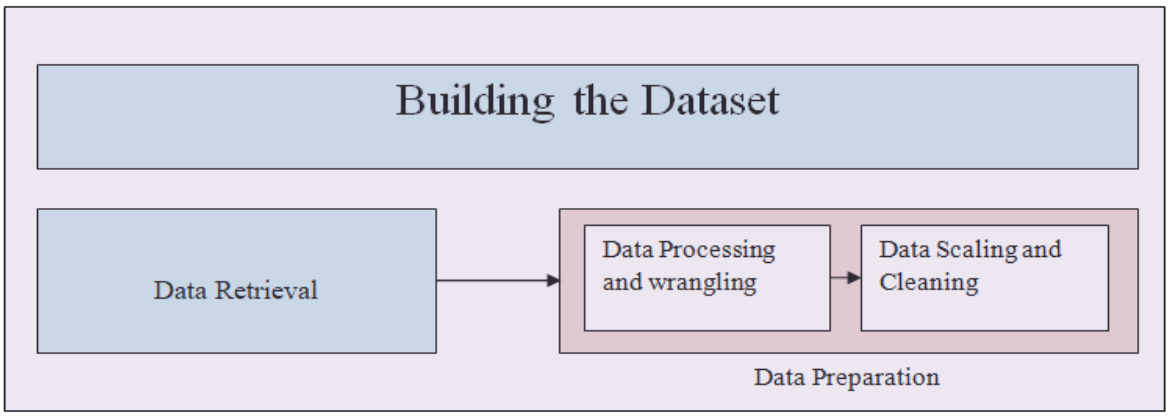

Figure 3.2 Building the Machine Learning Dataset

3.2.3 Data Retrieval and Preparation

Once the concept of the dataset of the project has been clearly analyzed, data retrieval and preparation phase is next. In data retrieval, what we aim to achieve is to obtain these dataset in question. Many new dataset repositories, catalogs, and portals have emerged in the scientific and AI fields. Regardless, the challenge of how to retrieve datasets that meet the nature of the problem after a large number of datasets are published on such data portals still emerge.

For this research work, the dataset used were obtained from a GitHub repository. These data has been retrieved from a fire service department and has been utilized before. The data retrieved was stored in the form of a CSV (comma separated value) file.

In some other cases, real-time data retrieval may require the ML engineer to go out into the field to collate these data needed. This process could take weeks or even months to finish this process before it is fully complied. There are different website where datasets used for machine learning and AI projects can be retrieved from. Popular sources for Machine Learning datasets include; Kaggle datasets, UCI Machine Learning Repository, Datasets via AWS, computer vision datasets, government datasets, GitHub, Microsoft, Scikit learn etc.

Data preparation commences once all the dataset needed for modeling has been acquired. Every data set is inaccurate. We must perform some data preparation at this stage of the model creation because it is crucial to the machine learning process. Data preparation basically entails making your data set more appropriate for machine learning. The majority of the time spent on machine learning projects is spent on preparation of the data.

The process of altering raw data so that data scientists and analysts may use machine learning algorithms to find insights or make predictions is known as "data preparation" (sometimes referred to as "data preprocessing"). In an ML project, data preparation is different. Depending on the complexity and scope of the project, some projects go through more processes than others to prepare the datasets.

The data preparation phase was broken down into two different categories;

i. Data Processing and Data wrangling

ii. Data scaling and Data cleaning

Since the dataset retrieved from the GitHub repository has been utilized in a project before, not much data preparation analyses was carried out on the dataset. Hence, at this stage, the dataset is ready to be trained.

3.2.4 Training and Testing Datasets

Once the data has been prepared and ready to be used, the next step is the data slicing. Data slicing in machine learning is simply separating the dataset into two parts during the development of a machine learning model; training data and testing data. The initial dataset you use to train a machine learning program to identify patterns or meet your criteria are called training data, whereas the testing datasets are used to evaluate the accuracy of the machine learning model.

In this project, the testing data set was 0.3 of the entire dataset and 0.7% of the entire data se was used for the training dataset. In every ML project, the training dataset must be far greater than the testing data set.

```
19
20  X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=0)
21
```

Figure 3.3: Image showing the line of code that was used to split the dataset

After the dataset has been split into its appropriate category, the training dataset is fed to the learning algorithm while the testing dataset goes directly into the developed model.

3.2.5 Learning Algorithm

In supervised learning algorithm, the model to be developed are trained using a well-labeled training data and then predicts the output based on that input data. The labeled data indicates that some of the input data has already been tagged with the appropriate output. Here, the training data provided to the machines behaves as a supervisor, instructing the machines on how to correctly predict the output. It uses the same notion as when a student learns under the guidance of a teacher. The process of giving input data as well as precise output data to the machine learning model is known as supervised learning. The concept of supervised learning can be utilized in the real world for applications like: Stock Price Prediction, Face detection, Signature recognition, spam detection, customer discovery et al.

The following highlighted below are the steps that will be followed in using supervised learning to predict the occurrence of fire outbreak:

i. First, an analysis of the type of dataset to be used will be done,
ii. Then, these datasets will be retrieved and prepared i.e., the labeled dataset will be obtained
iii. The dataset obtained in (ii) will be split according to their appropriate proportions i.e. into training dataset and test dataset.
iv. A suitable supervised machine learning algorithm will be determined. Some of which include; support vector machine, decision tree, linear regression, etc.

v. The algorithm obtained in (v) above will be executed on the training dataset in (iii)

vi. Finally, the accuracy of the model will be evaluated by providing the test dataset. if the machine learning model developed predicts the correct output, then a conclusion that the model is accurate is made.

Regression algorithm is quite suitable for predicting the occurrence of fire outbreak because this a forecast that depends on dynamic quantities (including; Temperature, oxygen and humidity) which are continuous in nature.Under regression algorithm, there a lot of algorithms that can be implemented in this research work. After thorough comparison and review, it has been finalized that logistic regression will be used.

Logistic Regression as a type of supervised machine learning algorithm is used in this research because it is used to predict the chance of a binary (yes/ no) event occurring. An instance of logistic regression aside predicting the probability of fire occurrence is applying machine learning to determine if a person is likely to be infected with covid-19 or not. Logistic regression is used in that instance because there are just two possible outcome – Yes, the person is infected or no, the person is not (this is further referred to as binary classification).

```
21
22    log_reg = LogisticRegression()
23    log_reg.fit(X_train, y_train)
24    print("Accuracy of Logistic Regression: ", log_reg.score(X_test, y_test))
25
```

Figure 3.4: Image showing the line of code that represented our machine learning algorithm

```
C:\Users\DELL\AppData\Local\Programs\Python\Python39\python.exe "C:/Users/DELL/Desktop/FIREOPS1/_FIREOPS MODEL/fireops.py"
Accuracy of Logistic Regression:  0.8095238095238095

Process finished with exit code 0
```

Figure 3.5: Image showing the result of the accuracy of the logistic regression

3.2.6 Modeling

A machine learning model is a small scale representation of the entire machine learning system. A software that can draw conclusions from a dataset that has never been seen before is known as a machine learning model. For instance, in this project the built machine learning model can now receive inputs (relative humidity, temperature and oxygen) and the correctly weight this input to produce accurate results.

Machine learning algorithm and machine learning model are quite distinct. Depending on the task, the machine learning algorithm is modified during training to identify particular patterns or outputs from the dataset. Once the machine learning algorithm is perfect, trained with the training dataset, it becomes a machine learning model.

Pickle library in python programming language was used to store the results of the machine learning algorithm (ML model) in to a .pkl file. The essence of this process is to prevent the algorithm from reloading each time the system is to be made use of. Rather, the system just loads the machine learning model from the .pkl file. This approach also improves the speed and efficiency of the entire pr4ediction system.

```
32
33    pickle.dump(log_reg,open('model.pkl','wb'))
34    model=pickle.load(open('model.pkl','rb'))
35
```

Figure 3.6: Image illustrating the pickle library

3.2.7 Developed Model

In simple terms, a machine learning model becomes a developed model once it has undergone the stages of Tuning and Evaluation. Model tuning enables you to tweak your models so they produce the most accurate results and offer you extremely important insights into your data, allowing you to optimize strategic decisions. Whereas, In model evaluation our aim is just to confirm that the model actually carry out the task it was designed for. This is done by feeding the developed model the testing dataset. The testing dataset helps us validate the efficiency and the accuracy of the developed model. Therefore, the developed model is just advancement on the originally developed model.

Gridsearchcv, a module in Scikit learn was used to carry out hyper parameter for the model.

```
c_space = np.logspace(40, 8, 15)
param_grid = {'C': c_space}

log_reg = LogisticRegression()

log_reg = GridSearchCV(log_reg, param_grid, cv = 5)

log_reg.fit(X_train, y_train)
print("Accuracy of Logistic Regression: ", log_reg.score(X_test,y_test))
print("Tuned Logistic Regression Parameters: {}".format(log_reg.best_params_))
```

Figure 3.7: Code illustrating the tuning using gridsearchcv.

3.2.8 Prediction

Prediction refers to the output of an algorithm that has been trained on past data and applied to new data. This phase is the last phase in the machine learning model architecture. After the model has been developed, tuned, evaluated and tested, then we can conclude that the model is ready to make prediction. In order for the system to make prediction, it is fed with new, unseen real time data.

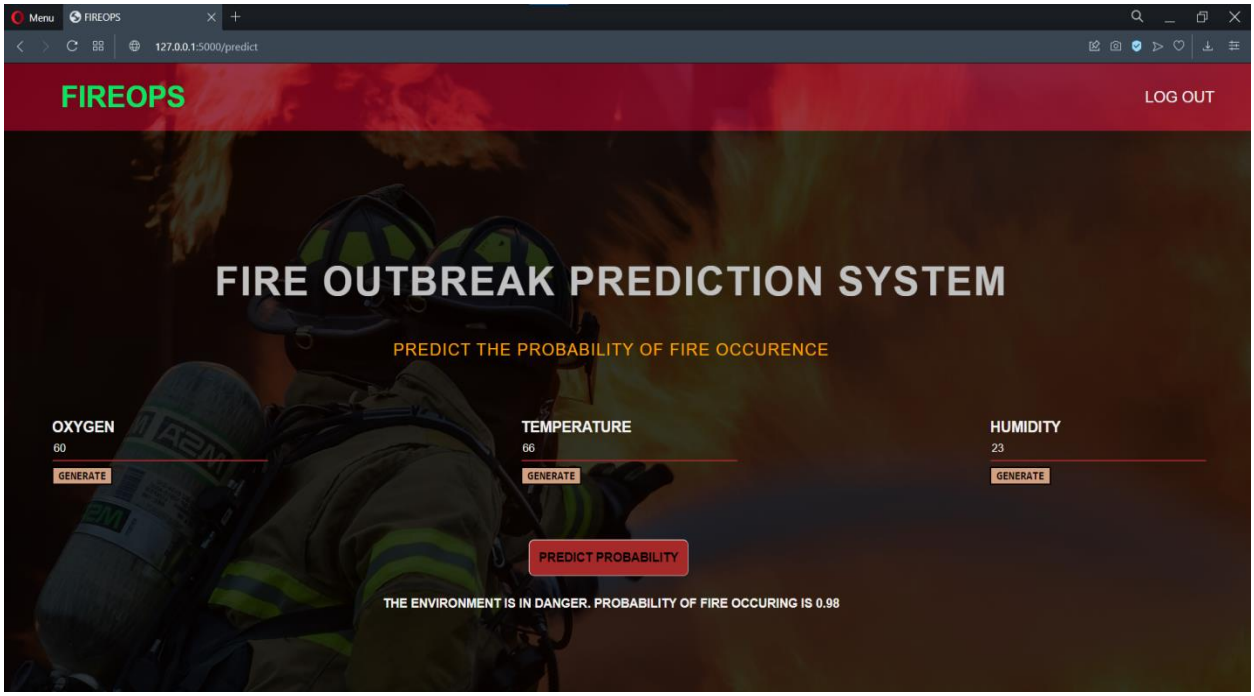

Figure 3.8: Illustration of the Machine Learning system making a successful prediction

3.3 Deployment and Integration of the Machine Learning Model

Once the system can predict the occurrence of fire outbreak accurately giving the measurement of the three environmental quantities, the model is ready to be deployed and integrated. The process of integrating a machine learning model into an operating production environment in order to use data to make decisions is known as deployment.

The prediction system was deployed using flask API integrated with python programming language. The essence of deploying the model is to ensure a suitable user interface and also prevent the users from accessing the python code directly.

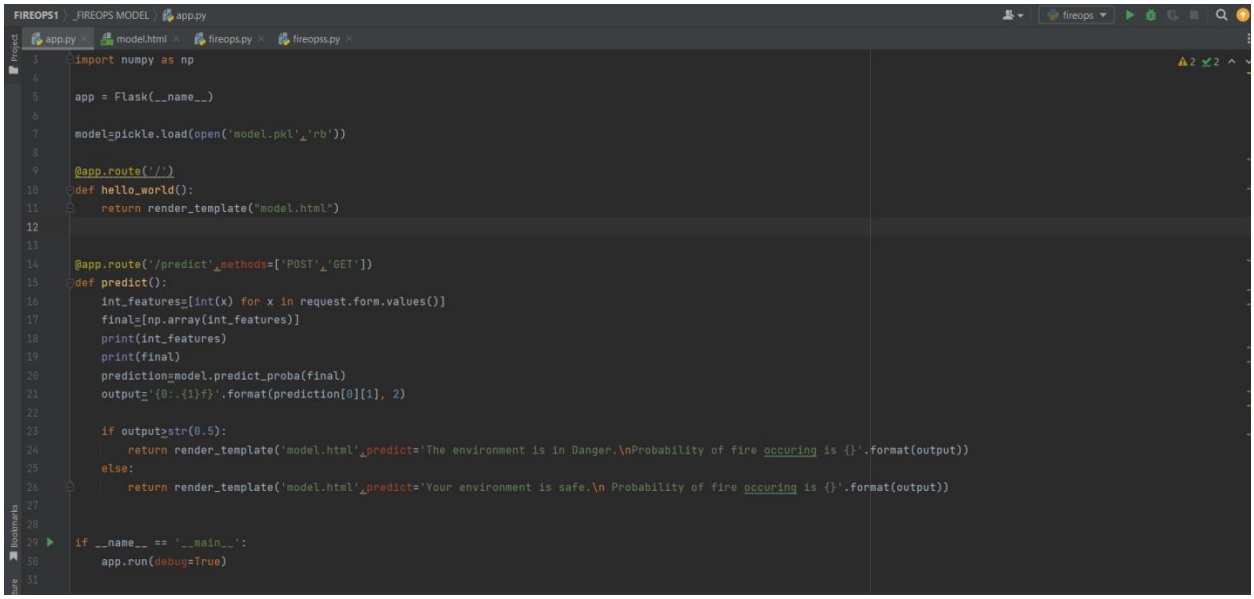

Figure 3.9: Flask code used to deploy the machine learning system

3.4 System Analysis

In this section, the application program's software requirements, hardware requirements and development model will be discussed. An analysis of the existing system used in the prediction of fire outbreak and specification of the new system will be evaluated.

3.4.1 Analysis of the existing System

The existing system of predicting the occurrence of fire outbreak is the manual system. In this manual system, a human trained observer will be positioned in areas of high concentration of valuables and human. A human trained observer could be just anybody, a housekeeper, a janitor, a staff or even the house owner. These trained personnel just need to make use of his eyes and nose as the parameter for the prediction. The personnel use his/her/their eyes to take note of any visible smoke in the premises and uses his/her/their nose to perceive any gas leakage that could act as a fuel and lead to a fire outbreak.

Critical analysis and study of this manual method revels that it is prone to tons of errors and most of the time, the prediction is not made early enough, other times the prediction might be a false prediction making it very inaccurate.

Listed below are some of the drawbacks faced in the existing system

i. Delay in the prediction as there might not be visible signs before the fire emerges
ii. Requires too much man power and concentration which can be quite tasking
iii. Lack of good user interface
iv. This method is not reliable and independent.

3.4.2 Description of the Proposed System

The operations of predicting the occurrence of fire outbreak are automated in the new system. This proposed system is without any doubt better than the manual system in terms of speed, efficiency, scalability and a lot more other feature etc. The need for this new system is to proffer solutions to the limitation discovered in the previously existing system.

The personnel in charge will have complete control over the fire prediction system, which includes:

i. Logging in to the system
ii. inputting the numerical values obtained from the measurements of the input parameters,
iii. reading the results generated from the system
iv. contacting the closest fire department in case of positive situation

v. executing the results obtained

Registered Personnel are in charge of utilizing the system. They input these measurements periodically and confirm the environment is safe and free from any advent of fire breakout. However, this is only possible when they have been granted authorization following a successful login.

In terms of security, the system is backed up by a very sophisticated login page. Only after inputting a registered login credentials before one can be granted permission into the system.

3.4.3 A Use Case Diagram

In this research work, a use case diagram was designed in order to have a better understanding and pictorial view of the fire prediction system's capabilities. It will also help to identify the various use cases and the different system's users, hence interpreting the user's possible interaction with the proposed system. Registered and unregistered personnel are the two instances of users that are available for utilizing the system.

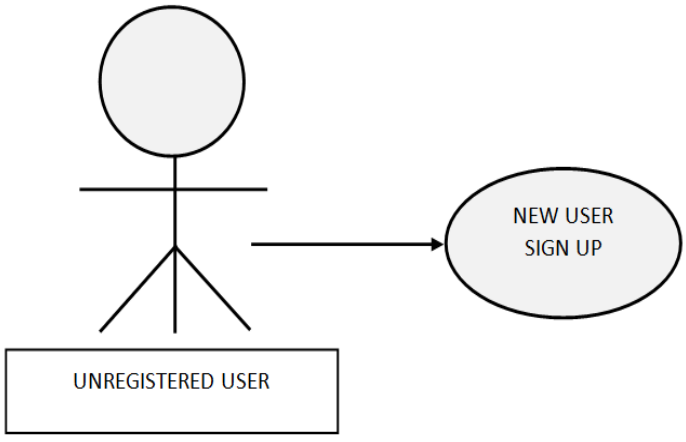

Figure 3.10 Unregistered user's use case diagram

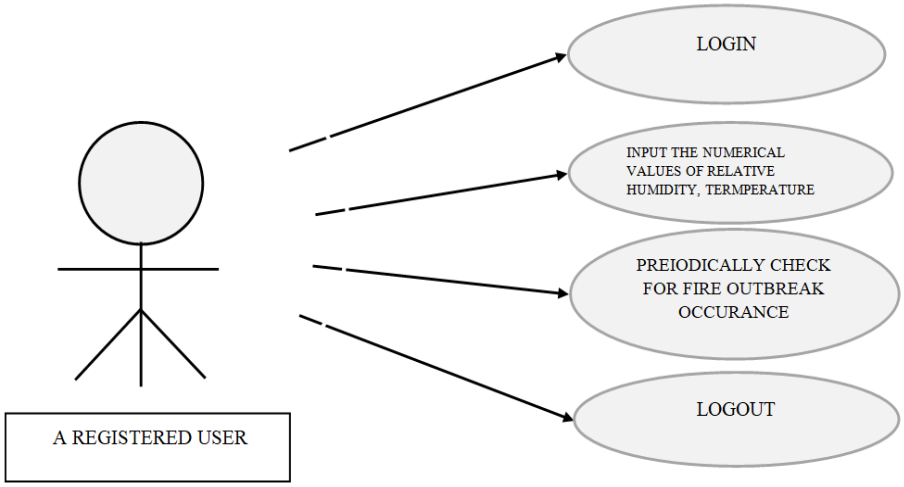

Figure 3.11 Registered user's use case diagram

3.4.4 Requirements Analysis

Requirement analysis simply clarifies the conditions that must be met for the proposed model to function. It also referred to as requirement engineering gives a broad view of the software, hardware, and the development model requirements of the proposed model. Failure to meet up with these requirements can impose installation issues and also hinder the deployment processes. The models failure or success critically depends on its requirement analysis. In the early phase of implementing the system into the working environment, it has to be ascertained on whether the user's requirements were satisfied or not. The new model also has to be tested concurrently to be affirmed that its activities are performed as proposed.

3.4.5 Analysis of the Proposed Model

The system will be a web-based system, an online application. Here, the registered personnel logs in to the system then inputs the numerical values obtain from the measurement of the three parameters: Relative humidity, Temperature and oxygen concentration. A device that can

accurately measure these values must be on standby. Afterwards, the personnel will proceed to instruct the system to deduce the probability value of the prediction (this can be achieved by the mere clicking of a button) then the model predicts whether the environment is safe or not.

This proposed method collects input and the machine learning model prediction are more accurate and reliable. The interface of this system is also very user-friendly, i.e., there is no form of complexity at all.

3.5 Coding

In this subsection, the programming language adopted and their functions in the development of the system will be discussed. Python programming language was used in the development and the training of the machine learning model adopted. HTML was used for the website layout and structure and CSS was implemented to create a user-friendly and an engaging interface website design. An extract of the code written is documented in Appendix I

3.5.1 Python Programming Language

Python Programming Language is an open source interpreted high-level programming language. Python can be adopted in web development, data science, machine learning software prototype design, and a lot more fields. Our main concern in this project is the application of data science in Machine Learning. As it the main programming language that will be used throughout the course this project. There are several libraries and frameworks embedded in this programming language that can be used for machine learning such as: Scikit-learn, Matplotlib, Pandas, NumPy, Pickle et al. All these powerful libraries and framework will be employed in this project to develop the machine learning model.

3.5.2 Flask

Flask is a popular python framework that aids swift development of secure and well-structured website. Flask was used for the database design of this research. The database simply stores the use login credentials for the registered personnel. Flask was chosen because it fixes the hurdle of web development, it enables programmers to concentrate more on the development of the application rather than reinventing the wheel as lots of templates has been made provided. Flask is also very suitable for midsized project.

3.5.3 Hypertext Markup Language (HTML)

The frontend interface of the fire prediction application was designed using HTML. The most common language used in web development is HTML. It serves as the fundamental programming language for websites. HTML specifies how a web page should be structured, such as what titles, graphics, and text should display on the page. It also specifies the sequence in which those features should be shown in the browser. HTML is one of the most extensively used programming languages on the internet.

3.5.4 Cascading Style Sheet (CSS)

CSS, Cascading Style Sheet is used with HTML in web development. They can be used to specify text styles, table sizes, and other characteristics of Web pages that were previously defined in the HTML code of the page. CSS enables Web designers to establish a consistent look across several pages of a website. In this research CSS was used to design the style of the HTML script written. There are three types of CSS styling: The inline styling, the internal styling and

the external styling. For the development of this website, the inline styling and the external styling will be used.

3.6 Installation Requirements

The minimum criteria that a software design must meet in order to make use of specific hardware or software is referred to as the system requirements. Some requirements has to be finalized before this system can function adequately. The subsection below is the hardware and software prerequisites needed for the automated system operation.

3.6.1 Hardware Requirements

The hardware requirements that will be required for the proposed system to function adequately are highlighted below:

i. System Processor: Intel Pentium N5000 CPU @ 1.10GHz
ii. Installed Memory (RAM): 4.00GB as minimum
iii. Storage: 500GB (HDD or SSD) ROM as minimum
iv. Compatible Mouse and Keyboard.

3.6.2 Software Requirements

The table below is an evaluation of the various software needed and their requirements.

Table 3.5 Software Requirements

REQUIREMENTS	**SOFTWARE**
Programming Language	Python Programming Language, HTML and CSSs
Integrated development environment	Atom, Pycharm
Web servers	Flask
Operating System	Windows 10 Operating OS, 64 bits (Minimum)
Internet Browser	Chrome **B**rowser, Google Chrome, Mozilla Firefox, Brave Browser, etc.

CHAPTER FOUR

SYSTEM IMPLEMENTATION AND RESULTS

4.1 Introduction

In this phase, the project testing and implementation is carried out. This phase is of importance in order to note if some certain parameters and requirements are in place and also to note if any error occurred that needs to be attended to. The program documentation, design prototype and also the installation requirements will be evaluated.

4.2 System Implementation

Notification of users, user training, hardware and software requirements, system integration on the proposed system are all part of the system implementation processes. System implementation can be referred to as the process of integrating a plan, technique, or any notion, idea, model, policy, or standard into operation. Hence, system implementation is a phase that must proceed after all the preplanning procedures for a software to function effectively.

4.3 Design Prototype

Design prototype is a preliminary reflection of a working model. The design prototype of a system is usually used by system analyst and end users to assess a new design in order to improve precision of the system requirements. In this research work, the design prototype is adopted in order to preview an early release of the fire outbreak system developed.

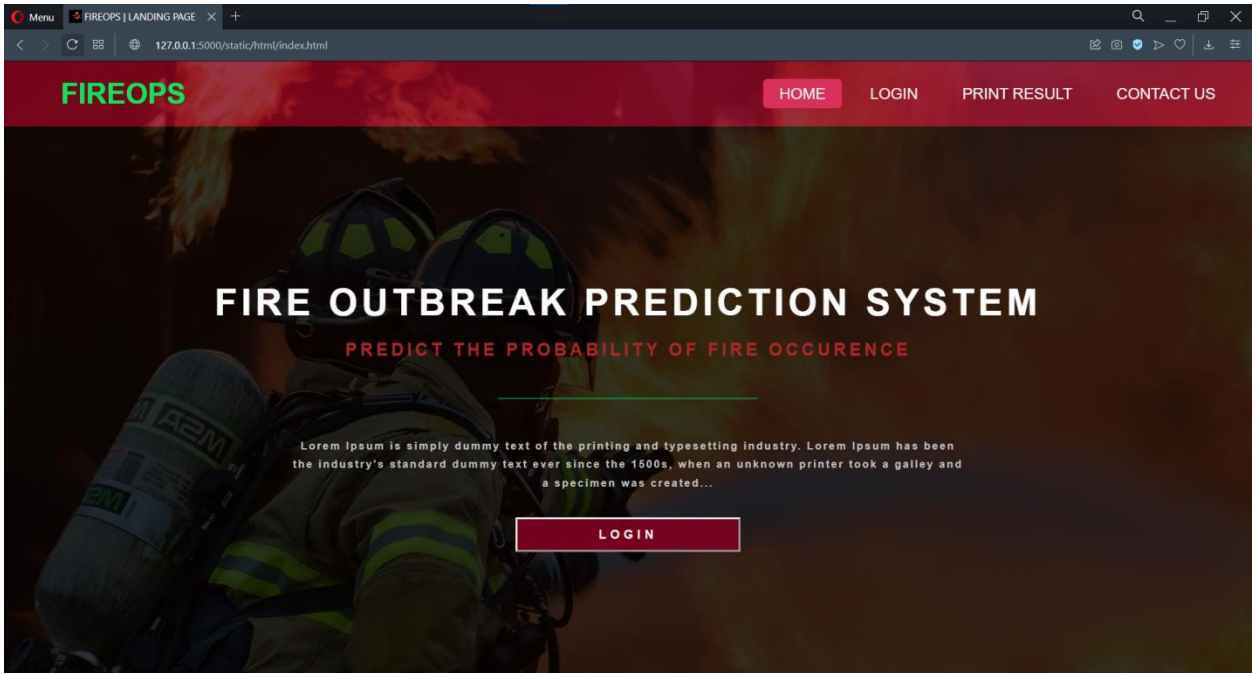

Figure 4.1 Illustration of a Working Sample

4.3.1 How to Install

The application has already been deployed on a website hosting site. Hence, it does not require any prior installation on a local workstation. In order to lunch this website, all the user needs to do is to enter the url on any web browser.

4.4 Program Documentation

Every system must produce an output. Hence, this section will cover several pictorial illustration and brief description of the Frontend development of the website i.e., the user interface of the program. This online application is 100% responsive and can be viewed in any browser.

4.4.1 Home Page

The home page is the user's landing page. It includes the login button, a menu bar above which houses the contact page, the login page and the print result page. This is shown in Figure 4.2.

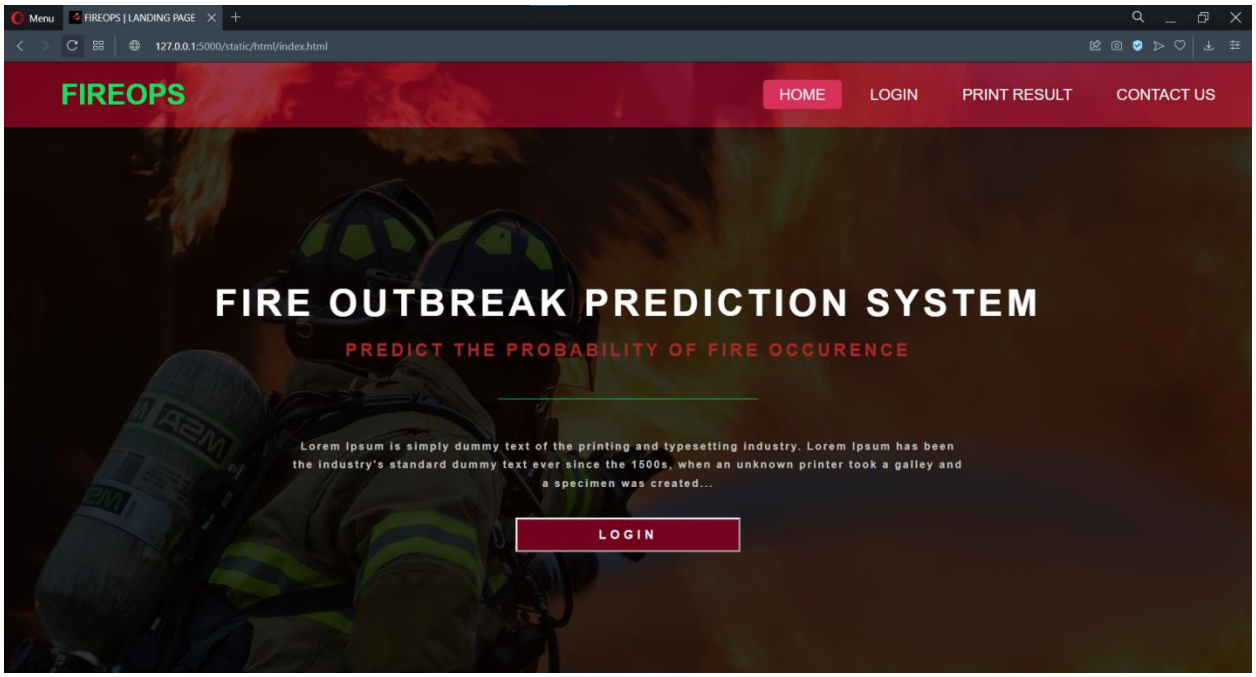

Figure 4.2 Illustration of the system Homepage

NB: if a user who is not currently logged in attempts to print result, an error message illustrated below will be displayed. The error message will instruct the user to return to home page and log in.

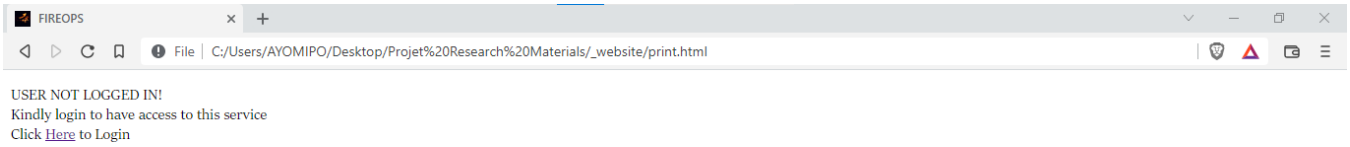

Figure 4.3 Illustration of the error message generated from trying to print result without a successful login.

4.4.2 Login Page

The login page is thenext page after the home page. It includes a welcome message, an instruction that tells the user to enter their login details to proceed and a login form where user input their login credentials; a login button and a menu bar above which houses the contact page, the login page and the print result page. The signup button is also on this page.

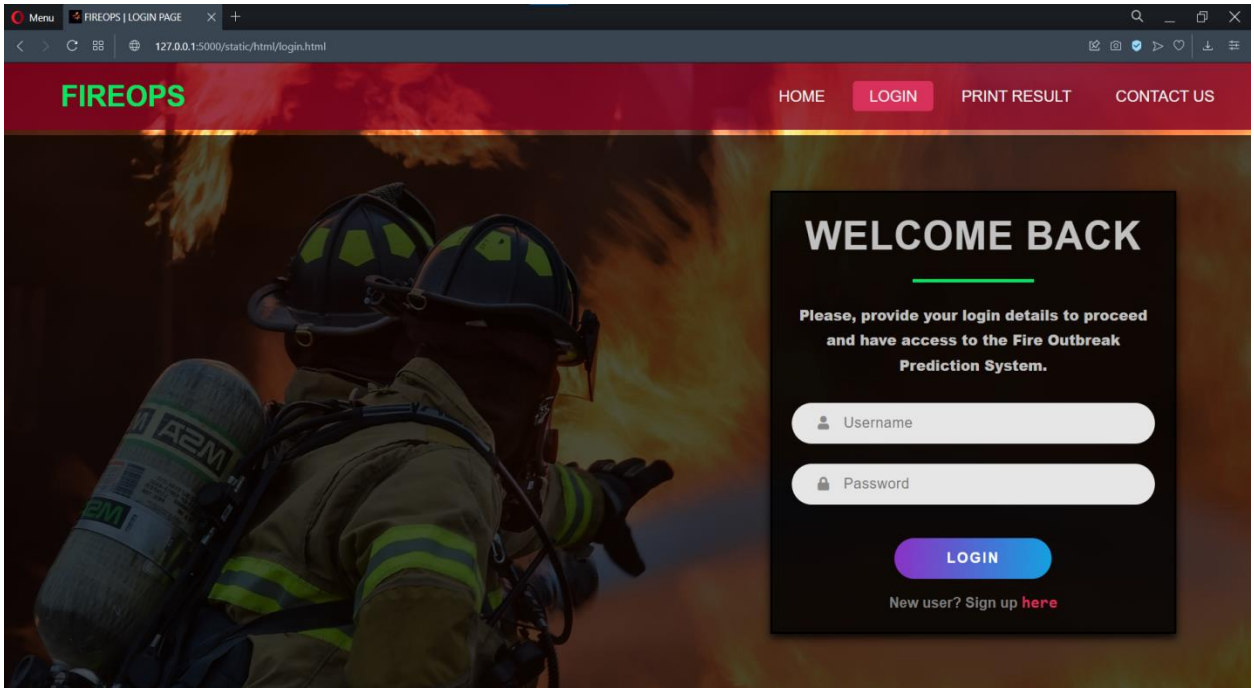

Figure 4.4 Illustration of the system Login page

4.4.3 Sign up Page

FIREOPS (which stands for Fire outbreak prediction system) is a much classified system. If it falls into the wrong hands, there is possibilities of it leading to a false alarm and can even be used as threat to the neighborhood and place of use. Hence, to closely and efficiently monitor the registered user of this system, the sign up and the registering of a new personnel can only be done by administrative; either the developer or the organization.

An attempt to sign up via the sign-up button in the home page will prompt a message instructing the user to contact the developer or the organization.

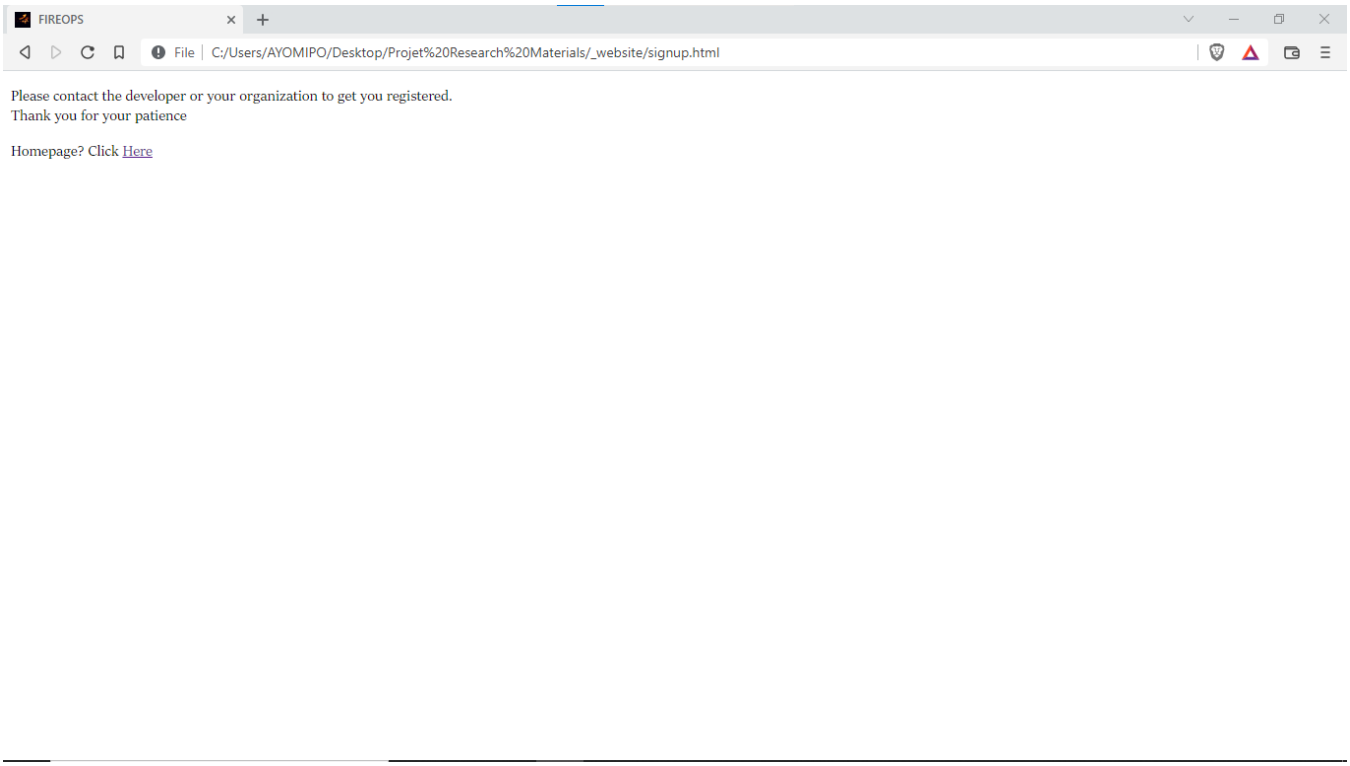

Figure 4.5 Illustration of the sign-up message.

4.4.4 Contact Page

The contact page can be easily accessed from the menu bar located at the top of the website. This page contains an instruction telling users to reach out to the organization on the developer in terms of any contribution or any recommendation. It also includes a contact form, phone number, the email address of FIREOPS, an address and submit button.

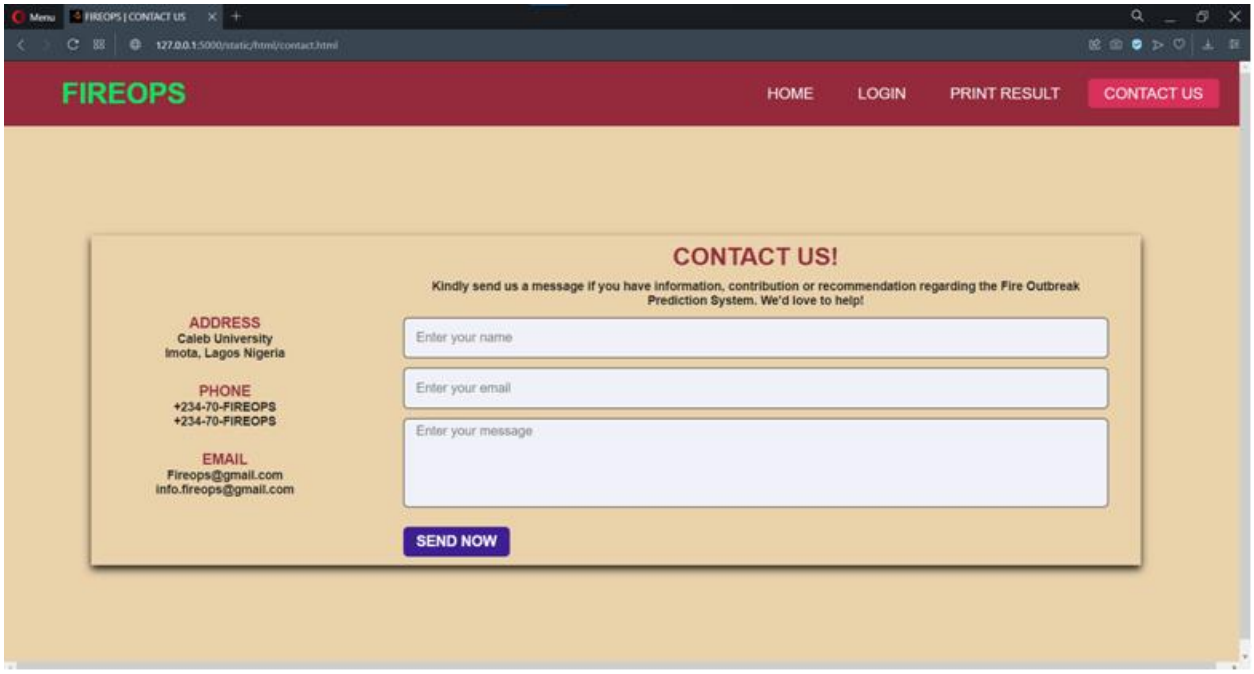

Figure 4.6 Illustration of the contact us page

4.4.5 Input Page

This page consists of an input field where the user can proceed to input the value obtain from the measurement of the three parameters: (temperature, oxygen and the humidity). Once the input is completed, the user can proceed to predict the probability of a fire outbreak occurring. The result of the probability is also displayed on in the screenshot above.

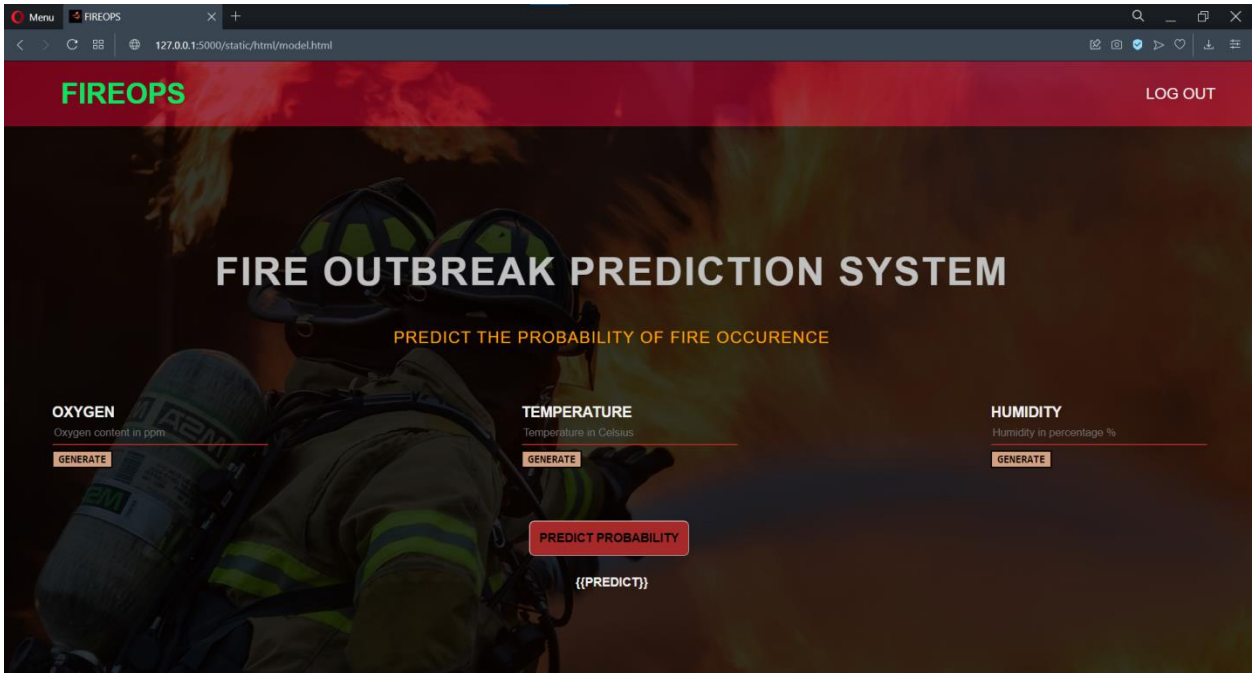

Figure 4.7 Illustration of the Input page

4.4.6 Result Page

Scenario one: Here, when the input is cold weather (14 degrees), low oxygen content and a very high humidity. There is a very low probability of a fire emerging. Hence, the fire is predicted to be safe.

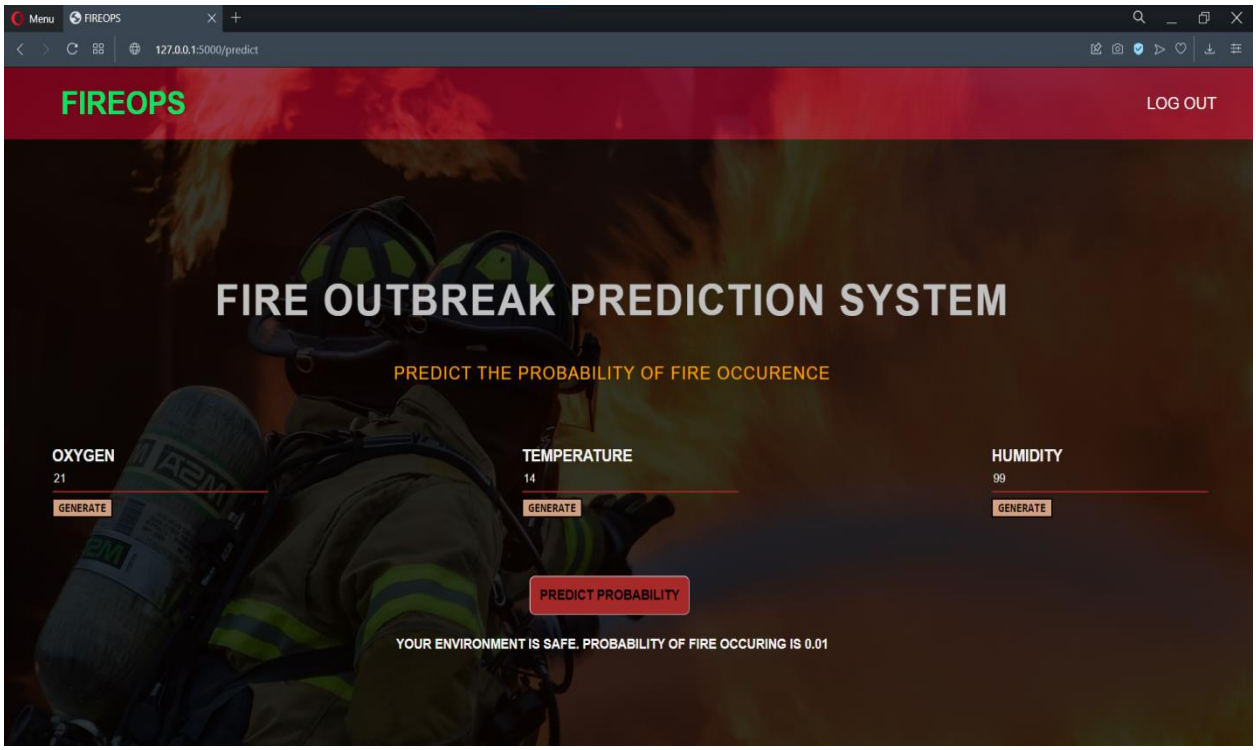

Figure 4.8 Scenario One

Scenario Two: Here, when the input is hot weather (66 degrees), high oxygen content and a very low humidity. There is a very high probability of a fire emerging. Hence, the environment is in danger of fire.

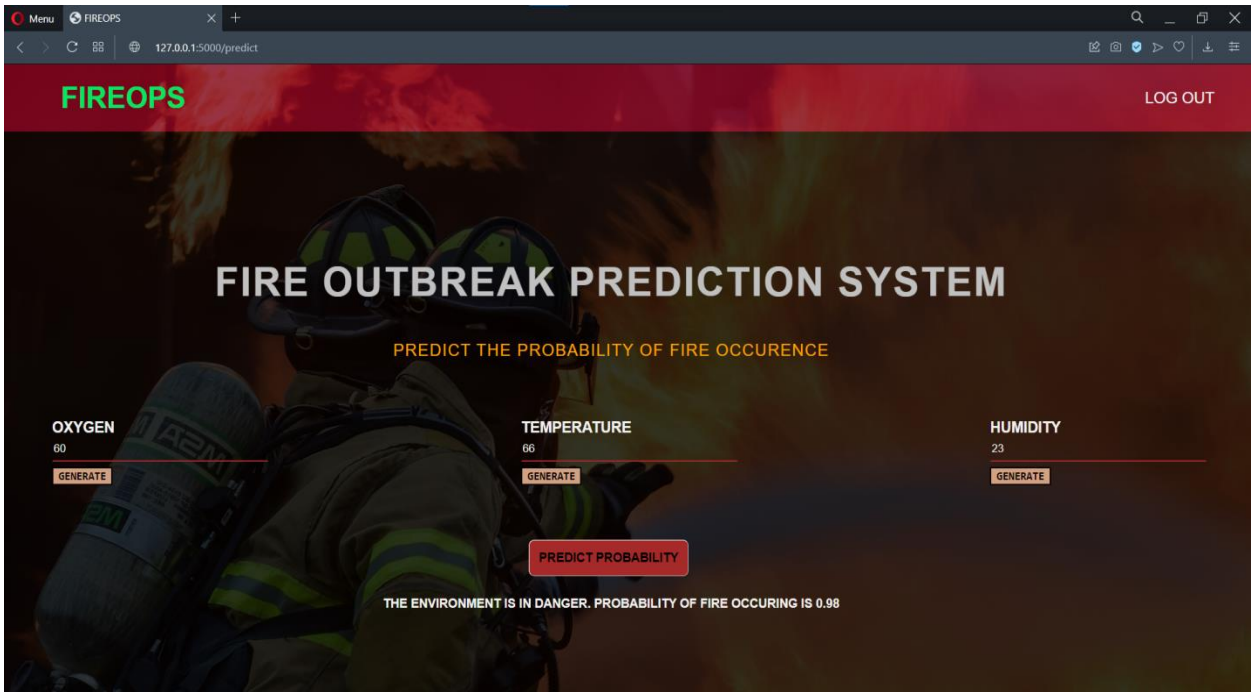

Figure 4.9 Scenario Two

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

The results of the research's work and experiments were summarized in this chapter. Research conclusion, contributions and also recommendation for further studies were assessed. This research focuses on the use of Machine Learning and its algorithm to predict the outcome of a fire outbreak.

5.2 Summary of Research Findings

A precise and concise account of the research work discussed the online automated system of predicting fire outbreak occurrence. It also focuses on operations concerning the challenges, the new system's goals, the various specifications and finally execution of the program. Related studies of different researcher's work were reviewed as well as Fire outbreak as a concept.

This system is a web-based application that was developed in an HTML and CSS environment using python programming language (a user-friendly programming language) for deployment and machine learning model training. The system was tested and improved based on user requirements and specification.

Although, this research works has loopholes, the advantages and its importance in immeasurable. It has improved the technique of predicting fire outbreak in terms of accuracy, preciseness, processing speed, efficiency and optimization.

5.3 Research Conclusion

Overall,the aim of this project was to create a web-based software that classifies two possibilities; whether a fire outbreak will occur or whether a fire outbreak will not occur, based on measurements of temperature, relative humidity and density as the input parameters which is gotten from the environment using machine learning and its algorithm.

Fire department, Fire fighters, house owners, and personnel regardless of the position in the society should be able to make use of this system to predict the traumatic occurrence of these fire disasters in a much faster and more accurate manner.

On a large scale, the program may also be extended as a stand-alone system with its own microprocessor and I/O device which can be a support system for fire service department in the nation and across the globe.

5.4 Recommendations for Further Study

Researcher and institutions should focus embrace endeavoring on improving the Fire Prediction and detection system on a very broad sense by employing artificial intelligence. It would be quite fascinating to explore the features, behavior\ and outputs of the different types of neural network such as; Artificial Neural Network (ANN), Convolution Neural Network (CNN), Probabilistic Neural Network (PNN), Deep Neural Network (DNN), and basic neural networks, by adopting a vast number of data sets.

Schools' administrative departments, offices, shopping malls, markets, museums and all other public and private spaces should endeavor to adopt and promote this system so it may be utilized and prevent these catastrophic aftermaths of fire outbreaks.

5.5 Limitations of Study

In this research work, a major limitation is concerning the fact that the scope of the research focuses majorly on just environmental conditions to predict the probability of fire outbreak. In the case of explosion or combustion, the machine learning model developed will fail. Also, the method of new data collection to the developed model was not extensive reviewed due to the time factor constraints.

The new data needed by the developed model can be gotten from the society through either;

i. A wireless sensor network or
ii. A hardware device; where the personnel can read the measurements of the humidity, temperature and oxygen level of the environment at intervals (five minutes in this case). The measurement hence can be used to drive the developed model.

5.6 Contributions to knowledge

This research has made the following contributions to academic knowledge:

i. Accurate and reliable method of predicting the occurrence of fire outbreak. Using powerful libraries in Python Programming language like Numpy, Scikit learn, and Matplotlid, this project's accuracy was up to 80%.

ii. There is an increased speed in the rate at which the model predicts the occurrence of fire outbreak. Once the input data is fed into the developed model, in less than a second the machine learning model produces the output.

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APPENDIX

Appendix I

HTML code for illustrating the index page

model.html — static\html | index.html | model.html — templates

```
21      <input type="checkbox" id="toggle"></label>
22        <label class="logo">FIREOPS</label>
23        <ul>
24          <li><a class="active" href="index.html">Home</a></li>
25          <li><a href="login.html">login</a></li>
26          <li><a href="print.html">Print Result</a></li>
27          <li><a href="contact.html">Contact Us</a></li>
28        </ul>
29      </nav>
30
31      <section>
32        <div class="container">
33          <div class="Heading">
34            <h1>Fire Outbreak Prediction System</h1>
35          </div>
36          <div class="Motto">
37            <h2>Predict The Probability of Fire Occurence</h2>
38          </div>
39          <div class="separator"></div>
40         <div class="Intro">
41            <h3>Lorem Ipsum is simply dummy text of the printing and typesetting
42                industry. Lorem Ipsum has been the industry's
43                standard dummy text ever since the 1500s, when an unknown printer took a
44                galley and a specimen was created... </h3>
45        </div>
46          <div class="Login">
47            <h3> <a href="login.html">Login</a> </h3>
48          </div>
49       </div>
50      </section>
51
52    </body>
53  </html>
54
```

HTML code for illustrating the model page

model.html — static\html | model.html — templates

```
<!DOCTYPE html>
<!-- Designined by Oduwole Ayomipo -->
<html lang="en" dir="ltr">
  <head>
      <meta charset="UTF-8">
      <meta name="viewport" content="width=device-width, initial-scale=1.0">
      <meta http-equiv="X-UA-Compatible" content="ie-edge">
      <!-- Fontawesome CDN Link -->
      <link rel="stylesheet" href="https://cdnjs.cloudflare.com/ajax/libs/font-awesome/5.15.1/css/all.min.css">
      <link rel="stylesheet" href="../css/model.css">
      <script src="https://kit.fontawesome.com/a076d05399.js" charset="utf-8"></script>

      <link href="https://fonts.googleapis.com/css2?family=Montserrat&display=swap" rel="stylesheet">
      <link rel="shortcut icon" type="image/jpg" href="../img/favicon.jpg">
      <title> FIREOPS </title>
   </head>

  <body>
    <nav>
      <label for="toggle" id="menuBTN">Menu</label>
      <input type="checkbox" id="toggle"></label>
        <label class="logo">FIREOPS</label>
         <ul>
          <li><a href="index.html">log out</a></li>
        </ul>
     </nav>

     <section>
       <div class="container">
         <div class="Heading">
           <h1>Fire Outbreak Prediction System</h1>
         </div>
          <div class="Motto">
            <p>Predict The Probability of Fire Occurence</p>
```

HTML code for illustrating the login page

model.html — static\html | index.html | login.html | model.html — templates

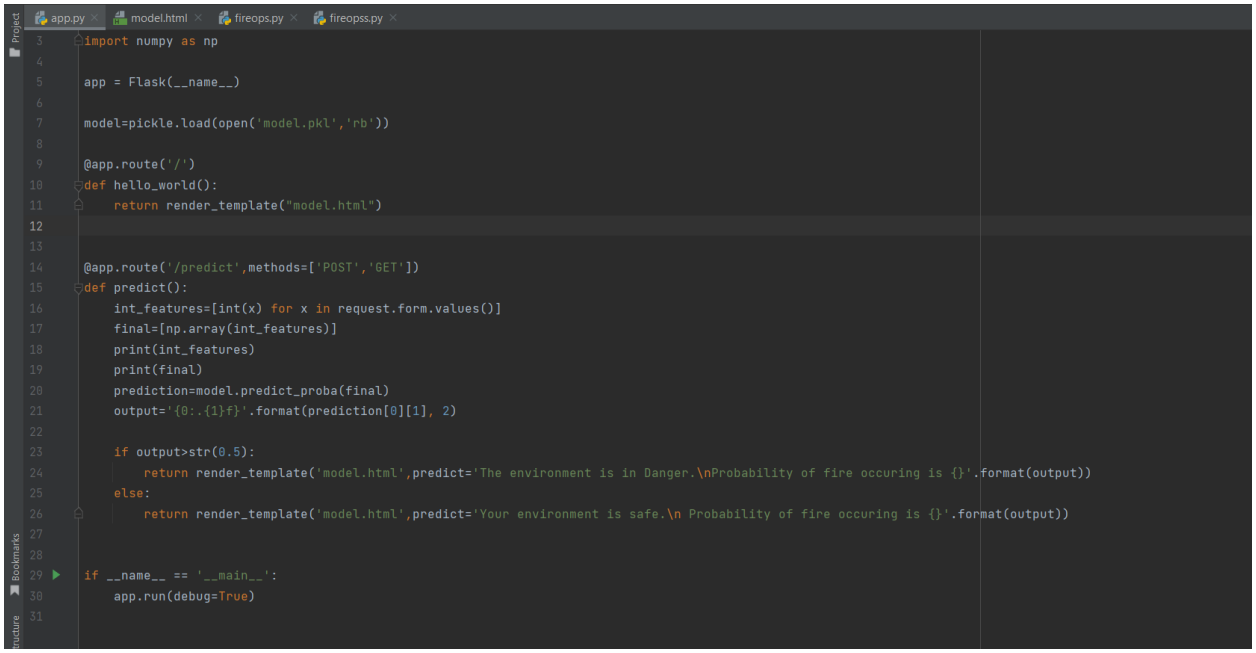
```
      <label class="logo">FIREOPS</label>
      <ul>
        <li><a href="index.html">Home</a></li>
        <li><a class="active" href="login.html">login</a></li>
        <li><a href="print.html">Print Result</a></li>
        <li><a href="contact.html">Contact Us</a></li>
      </ul>
   </nav>


  <section class="main">
      <div class="login-container">
          <p class="title">Welcome Back</p>
          <div class="separator"></div>
          <p class="welcome-message">Please, provide your login details to proceed and have access to the Fire Outbreak Prediction System.</p>

          <form class="login-form">
              <div class="form-control">
                  <input type="text" placeholder="Username">
                  <i class="fas fa-user"></i>
              </div>
              <div class="form-control">
                  <input type="password" placeholder="Password">
                  <i class="fas fa-lock"></i>
              </div>
              <a class="submit" href="model.html"> Login </a>

          </form>
          <div>
            <p class="sign-up"> New user? Sign up <a href="signup.html" class="signup-link"> here</a> </p>
          </div >
      </div>
  </section>

```

HTML code for illustrating the contact us page

project_ds.csv × contact.html ×

```
40
41          <div class="phone details">
42            <div class="topic">Phone</div>
43            <div class="text-one">+234-70-FIREOPS</div>
44            <div class="text-two">+234-70-FIREOPS</div>
45          </div>
46          <div class="email details">
47            <div class="topic">Email</div>
48            <div class="text-one">Fireops@gmail.com</div>
49            <div class="text-two">info.fireops@gmail.com</div>
50          </div>
51        </div>
52        <div class="right-side">
53          <div class="topic-text">Contact Us!</div>
54          <p class="contact-message"> Kindly send us a message if you have information, contribution or recommendation regarding the Fire Outbreak
            Prediction System. We'd love to help! </p>
56        <form action="#">
57          <div class="input-box">
58            <input type="text" placeholder="Enter your name">
59          </div>
60          <div class="input-box">
61            <input type="email" placeholder="Enter your email">
62          </div>
63          <div class="input-box message-box">
64            <textarea placeholder="Enter your message"></textarea>
65          </div>
66          <div class="button">
67            <input type="button" value="Send Now" >
68          </div>
69        </form>
70      </div>
71      </div>
72    </div>
```

Flask API code



Dataset used for the modeling

	A	B	C	D	E	F
1		OXYGEN	TEMPERATURE	HUMIDITY	FIRE OCCURANCE	
2	a	25	45	41	1	
3	b	2	37	60	0	
4	c	31	57	96	1	
5	d	44	56	49	1	
6	e	9	41	8	1	
7	f	27	51	98	1	
8	g	59	54	26	1	
9	h	22	22	88	0	
10	i	2	84	79	0	
11	j	6	25	67	0	
12	k	56	48	12	1	
13	l	98	11	6	1	
14	m	55	18	25	1	
15	n	16	81	12	1	
16	o	82	80	3	1	
17	p	2	79	28	1	
18	q	56	5	37	0	
19	r	53	35	7	1	
20	s	4	71	91	0	
21	t	80	72	19	1	
22	u	1	22	12	0	
23	v	44	66	86	1	
24	w	26	100	43	1	
25	x	14	40	41	0	
26	y	14	21	3	0	
27	z	62	60	54	1	
28	aa	77	51	94	1	
29	ab	17	14	78	0	
30	ac	12	36	80	0	
31	ad	28	21	79	0	

	A	B	C	D	E
32	ae	24	63	97	0
33	af	15	7	10	0
34	ag	1	76	96	0
35	ah	97	75	65	1
36	ai	35	6	46	0
37	aj	54	60	9	1
38	ak	37	57	87	1
39	al	87	76	87	1
40	am	100	54	39	1
41	an	20	96	7	1
42	ao	61	72	47	1
43	ap	39	81	25	1
44	aq	71	57	23	1
45	ar	13	91	47	0
46	as	21	94	99	0
47	at	62	83	33	1
48	au	98	36	40	1
49	av	5	72	8	1
50	aw	22	65	59	0
51	ax	18	100	18	1
52	ay	64	84	90	1
53	az	40	30	100	1
54	ba	78	21	18	1
55	bb	25	70	9	1
56	bc	5	57	78	0
57	bd	7	9	89	0
58	be	62	88	2	1
59	bf	83	98	79	1
60	bg	1	62	96	0
61	bh	70	37	29	1
62	bi	32	67	27	1

	A	B	C	D	E	F
63	bj	98	57	45	1	
64	bk	33	80	27	1	
65	bl	89	46	42	1	
66	bm	62	2	94	0	
67	bn	94	14	67	0	
68	bo	34	10	17	1	
69	bp	11	2	43	0	
70	bq	95	2	44	0	
71	br	4	12	18	0	
72	bs	46	59	18	1	
73	bt	44	2	84	0	
74	bu	77	10	46	0	
75	bv	10	69	51	0	
76	bw	61	25	10	1	
77	bx	5	63	69	1	
78	by	5	12	13	0	
79	bz	81	71	91	1	
80	ca	26	1	67	0	
81	cb	82	26	20	1	
82	cc	85	54	91	1	
83	cd	25	16	64	0	
84	ce	30	30	89	1	
85	cf	3	52	88	0	
86	cg	74	4	95	0	
87	ch	66	35	7	1	
88	ci	3	48	69	0	
89	cj	50	1	71	0	
90	ck	1	21	47	0	
91	cl	64	25	81	1	
92	cm	61	75	19	1	
93	cn	17	10	41	0	

	A	B	C	D	E
94	co	64	33	61	1
95	cp	36	47	8	1
96	cq	67	61	92	1
97	cr	53	38	45	1
98	cs	23	18	63	0
99	ct	76	94	25	1
100	cu	13	73	48	0
101	cv	53	33	30	1
102	cw	2	60	10	1
103	cx	30	71	84	1
104	cy	100	80	42	1
105	cz	9	30	3	1
106	da	51	5	67	0
107	db	82	20	93	0
108	dc	99	88	53	1
109	dd	12	4	9	0
110	de	61	95	9	1
111	df	29	70	93	0
112	dg	1	62	5	1
113	dh	60	22	35	0
114	di	80	2	67	0
115	dj	55	8	82	0
116	dk	71	28	17	1
117	dl	59	16	79	0
118	dm	77	87	20	1
119	dn	97	15	76	0
120	do	60	14	87	0
121	dp	49	17	58	0
122	dq	95	85	62	1
123	dr	67	21	32	0
124	ds	67	24	6	0

	A	B	C	D	E	F
125	dt	98	17	45	0	
126	du	40	8	83	0	
127	dv	34	22	53	0	
128	dw	53	41	72	1	
129	dx	46	90	56	1	
130	dy	55	64	51	1	
131	dz	91	12	65	0	
132	ea	8	48	32	1	
133	eb	53	55	46	1	
134	ec	27	54	52	1	
135	ed	2	9	47	0	
136	ee	30	61	13	1	
137	ef	92	58	64	1	
138	eg	10	58	22	1	
139	eh	50	26	93	1	
140	ei	67	31	72	1	
141	ej	10	18	98	0	
142	ek	28	15	21	0	
143	el	94	27	66	1	
144	em	12	6	91	0	
145	en	73	28	7	1	
146	eo	35	24	38	1	
147	ep	1	97	6	1	
148	eq	86	26	98	1	
149	er	50	53	72	1	
150	es	47	15	92	0	
151	et	1	60	100	0	
152	eu	22	42	23	1	
153	ev	96	15	55	0	
154	ew	34	33	43	1	
155	ex	44	1	52	0	

	A	B	C	D	E
156	ey	6	28	26	1
157	ez	69	68	8	1
158	fa	81	83	11	1
159	fb	95	56	58	1
160	fc	12	57	69	0
161	fd	36	20	20	1
162	fe	62	93	51	1
163	ff	53	16	11	1
164	fg	36	15	61	0
165	fh	4	75	17	1
166	fi	53	45	9	1
167	fj	86	77	49	1
168	fk	12	77	11	1
169	fl	98	58	80	1
170	fm	77	37	24	1
171	fn	46	33	66	1
172	fo	37	52	82	1
173	fp	23	52	57	0
174	fq	38	19	61	0
175	fr	27	21	8	1
176	fs	16	54	47	0
177	ft	84	16	52	0
178	fu	7	31	54	0
179	fv	50	59	12	1
180	fw	17	43	71	0
181	fx	80	19	73	0
182	fy	92	42	100	1
183	fz	27	66	26	1
184	ga	44	6	84	0
185	gb	26	98	24	1
186	gc	35	60	61	1

	A	B	C	D	E	F
187	gd	87	7	29	1	
188	ge	59	22	29	1	
189	gf	18	4	13	0	
190	gg	20	18	20	0	
191	gh	93	52	88	1	
192	gi	90	15	29	1	
193	gj	100	44	95	1	
194	gk	60	67	88	1	
195	gl	13	64	19	1	
196	gm	41	66	73	1	
197	gn	86	84	78	1	
198	go	89	8	71	0	
199	gp	34	95	61	1	
200	gq	2	82	58	0	
201	gr	44	97	35	1	
202	gs	98	93	86	1	
203	gt	41	81	84	1	
204	gu	25	14	20	0	
205	gv	40	10	53	0	
206	gw	25	44	23	1	
207	gx	10	81	55	0	
208	gy	35	88	47	1	
209	gz	8	74	46	0	
210	ha	18	49	78	0	
211	hb	20	56	100	0	