T.C.

ALTINBAS UNIVERSITY

Institute of Graduate Studies

Civil Engineering

A NEW MODEL FOR CONCRETE COMPRESSIVE STRENGTH ESTIMATION

Liqaa Inam Hadi Al-HAMADANI

Master of Science

Supervisor

Prof. Dr. Tuncer çelik

Istanbul, 2021

A NEW MODEL FOR CONCRETE COMPRESSIVE STRENGTH ESTIMATION

by

Liqaa Inam Hadi Al-HAMADANI

Civil Engineering

Submitted to the Institute of Graduate Studies

in partial fulfillment of the requirements for the degree of

Master of Science

ALTINBAŞ UNIVERSITY

2021

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Liqaa Inam Hadi Al-HAMADANI

DEDICATION

First, I would like to thank Allah Almighty for the power of the mind, health, strength, guidance, knowledge, and skills to complete this study. This thesis is wholeheartedly dedicated to my parents. There are no words to describe what you mean to me; there is nothing that I can repay for what you have done to me. I will continue to do my best to achieve your expectations. Lastly, I dedicated this to the family, relatives, and friends who have been encouraging me during this study.

Liqaa Inam Hadi Al-HAMADANI

ACKNOWLEDGEMENTS

I would like to thank my supervisor Prof. Dr. Tuncer çelik for all support during my study. Its great pleasure to express my deepest gratitude to my friends who have shared with me best moments during my study for the Master degree.

ABSTRACT

A NEW MODEL FOR CONCRETE COMPRESSİVE STRENGTH ESTİMATİON

Al-HAMADANI, Liqaa Inam Hadi

MSc, Civil Engineering, Istanbul Altınbaş University,

Supervisor: Prof. Dr. Tuncer ÇELIK

Date: June, 2021

Pages: 63

Concrete is the utmost chief material in civil engineering. The concrete compressive strength is a highly nonlinear function of age and ingredients. In this thesis, effect of water, gravel, sand, blast furnace slag, plasticizer, and the effects of flay ash on concrete compressive strength was presented by using Long short-term memory (LSTM).

Artificial recurrent neural network (RNN) architecture used in the field of deep learning. Unlike standard feedback neural networks, LSTM has feedback links. The concrete compressive strength is regression problem which several classical artificial intelligence and machine learning techniques applied to solve it. In this study, the model consist from eight input and one output which represented the concrete compressive strength.

Keywords: Concrete Compressive Strength, LSTM, RNN, Deep Learning

ÖZET

Beton Basınç Dayanımı Tahmini için Yeni Bir Model

Al-HAMADANI, Liqaa Inam Hadi

Yüksek Lisans, İnşaat mühendisliği, Altınbaş Üniversitesi,

Danışman: Prof. Dr. Tuncer ÇELIK

Tarih: Haziran, 2021

Sayfa Sayısı: 63

Beton, inşaat mühendisliğinin en önemli malzemesidir. Beton basınç dayanımı, yaşın ve bileşenlerin oldukça doğrusal olmayan bir fonksiyonudur. Bu tezde, Long short-term memory (LSTM) kullanılarak su, çakıl, kum, yüksek fırın cürufu, plastifiyan etkisi ve flay külünün beton basınç dayanımı üzerindeki etkileri sunulmuştur.

Derin öğrenme alanında kullanılan yapay tekrarlayan sinir ağı (RNN) mimarisi. Standart geri beslemeli sinir ağlarının aksine, LSTM'nin geri bildirim bağlantıları vardır. Somut basınç dayanımı, onu çözmek için birkaç klasik yapay zeka ve makine öğrenme tekniğinin uygulandığı regresyon problemidir. Bu çalışmada model, beton basınç dayanımını temsil eden sekiz girdi ve bir çıktıdan oluşmaktadır.

Anahtar Kelimeler: Beton Basınç Dayanımı, LSTM, RNN, Derin Öğrenme

TABLE OF CONTENT

Pages

LIST OF FIGURES

Pages

LIST OF ABBREVIATIONS

SVM	:	Support vector machine
NN	:	Neural Network
KNN	:	K-Nearest Neighbors Algorithm
PSD	:	Power Spectral Density
WT	:	Wavelet Transform
PLS	:	Least Partial Squares
LSA	:	Latent semantic analysis
PCA	:	principal component analysis
ICA	:	Independent Component Analysis
DT	:	Decision Trees
DA	:	Discriminant Analysis

1. INTRODUCTION

The concept of "artificial intelligence" is as old as modern computer science. "Can machines think?" It is Alan Mathison Turing who opened machine intelligence to discussion by posing the problematic. In 1943, II. During World War II, computer science and artificial intelligence concepts were born thanks to the electromechanical devices produced with the requirements of crypto analysis [1].

Alan Turing was one of the most famous mathematicians who tried to crack the encryption algorithm used by the Nazi Enigma machine. The research that started in Bletchley Park in England to decipher Turing's computer prototypes, Heath Robinson, Bombe Computer and Colossus Computers, led to the emergence of the concept of artificial intelligence with data processing algebraic logic based on Boolean data.

These machines and programming logic, which are the ancestors of the modern computer, were actually inspired by human intelligence. However, our modern computers later expanded into application areas and solved the problems of our daily life with programs that we can call expert systems. In the 1970s, companies such as Microsoft, Apple, Xerox, IBM, which were important computer manufacturers, popularized and popularized the personal computer PC and the computer. Artificial intelligence research has been further developed in a small research group [2].

To further this research, a Turing test called Turing is applied to artificial intelligence software in the United States, called the Loebner Awards, and awards are given to the most successful software.

The content of the Turing test is briefly as follows: A group of people who do not know each other discuss a valid time with each other and with the artificial intelligence dialogue system. At the end of this conversation, which takes place without a face-to-face meeting, the subjects are asked questions to determine which is human and which is artificial intelligence. Interestingly, in some tests so far, artificial intelligence has been seen as human and real humans as machine [3].

For centuries, human beings have made great efforts to make their lives easier, to live safer and more comfortably. As a result of these efforts, very important inventions have emerged. The biggest of these inventions is concrete. Today, concrete is the most widely used building material

in construction. The usage area of concrete in construction applications is getting more and more widespread. This situation makes it necessary to know more closely and accurately the properties of the concrete to be used in the production of robust and safe structures. Concrete compressive strength is the indicator of quality concrete production with cement, water, aggregate and concrete mixture calculations that make up the concrete. As an indicator of the usability of a concrete, the compressive strength of the poured concrete on the 7th and 28th days can be given. At the beginning of the works carried out for this purpose, the concrete strength to be used in the building should be known in advance. In addition to the time and high cost spent in determining the concrete compressive strength, experimental errors are also inevitable. Using LSTM and as an alternative approach to determining concrete compressive strengths under laboratory conditions will provide significant gains.

1.1 RESEARCH QUESTIONS

In this thesis, several points were studied and investigated to deal with IDS attacks, these points are described below.

a) How estimate the concrete compressive strength in minimum cost and accurate performance?

b) How to determine the regression technique to estimate concrete compressive strength?

c) How to increase the accuracy by training LSTM?

1.2 THESIS HYPOTHESES

a) Deep learning presented computer programs in a beneficial method to achieve regression method.
b) Effective systems with low cost developed using deep learning techniques in different fields of concrete compressive strength.

1.3 THESIS STRUCTURE

The letter includes five chapters prepared as follows:

a) Chapter I: Introduction: concrete compressive strength, problem statement, thesis goal and finally thesis structure.
b) Chapter II: Literature Review: This chapter provides an overview of the work related to the concrete compressive strength.
c) Chapter 3: Methodology: This chapter outlines the research methodology used in this thesis. Deep learning, LSTM and the proposed method.
d) Chapter 4: details of the implementation of the experiment and the results obtained for all proposed scenarios and comparison of results.
e) Chapter 5: Conclusion and Future Work.

2. RELATED WORKS

2.1 WHATS I S CONCRETE

Concrete building stone, which is composed of materials called "aggregates" such as gravel and sand, combined with a binder and water. The binding agent is also usually cement. For example, in Portland cement concrete, the binder is a mixture of Portland cement and water. Asphalt and other materials are also used as a binder; "asphalt concrete" and "polymer concrete" are obtained. However, when it comes to "concrete", portland cemented concrete comes to mind.

Concrete is a widely used building material. It is used in the construction of roads, buildings, bridges and other structures, as well as in hydraulic works such as dams and canals. It serves both as a support and as a decorative material. It is also preferred in terms of fire resistance, waterproofing and sound insulation. It is also used against nuclear radiation in modern designs. The average annual production of concrete per person in the world is around one tonne. In Turkey, this quantity was around 250 kilograms in 1980 [4].

2.2 HISTORY

Concrete has been used in different ways and generally for 5000 years. Ancient Egyptians used clay mortar in the construction of the pyramids. Mortar was produced by heating limestone (CaCO3) and extracting carbon dioxide gas (CO2). The lime obtained was mixed with aggregate and used as a mortar. It was then converted into the original CaCO3 or limestone, which hardened as CO2. The discovery of water-hardening hydraulic cement dates back to the Romans. The Romans mixed the lime paste into pozzolanic volcanic ash. Composed of this amorphous silica, pozolane hardens to silica gel by chemically reacting with alkali in the presence of water [5].

The word Pozolan came from the Italian town Pozzuoli where the substance was found. The first patent on this subject was given to British James Parker in 1796. In 1824, British mason Joseph Aspdin burned limestone with clay to obtain a binding agent, cement. He named it Portland cement because it resembles the limestone from Portland Island. Today, nearly 100 million Portland cement is used annually in the world.

2.3 CONCRETE MAKING AND PRESSURE RESISTANCE

The most important substance that constitutes concrete is cement, which is the binder. Cement chemically reacts with water and binds aggregate grains. Aggregate makes up approximately 75% of the concrete. It is named as coarse and fine depending on the grain size. Coarse or coarse aggregate can often be obtained from quarries by crushing or can be found naturally. The point to be considered is that it is clean from harmful substances. These harmful substances can be soft grains, clay, soluble salts and organic substances. It can be obtained by sieving naturally fragmented material containing sand or fine aggregate, silica or limestone, or by crushing and grinding from rocks. Another important substance that constitutes concrete is water. The water should not contain harmful substances. Usually potable water is sufficient [6].

Apart from cement, aggregate and water, some additives can also be mixed into concrete. These can be placed before or after the water addition. With additives, it can increase the workability, durability and strength of concrete as well as delay or accelerate the hardening. In addition, heat expansion and permeability can be controlled with concrete additives. There are also additives that create millions of microscopic air bubbles in concrete. The additives that reduce the water requirement of the mixture separate the Portland cement particles by electrically charging them and create a more homogeneous mixture, thereby reducing the need for water [7].

2.4 CONCRETE PRODUCTION

Cement and aggregate required for concrete are prepared in separate industry branches. The last step is the stage of preparing the mixture and using the concrete. Choosing the appropriate mixing ratios; It ensures that features such as economy, workability, strength, durability and appearance are obtained in a balanced way. These vary depending on where they are used. Many mixing ratio calculation methods have been proposed according to the state of the aggregate and the type of cement. The ratio of mixing water to cement amount is the most important factor affecting the strength of concrete. Another important factor is the amount of air in the concrete. This amount is around 0.3-3% in normal concrete. These two effects constitute the two most important factors in the control of concrete quality. It is also important in obtaining the concrete mixture homogeneously [8].

Mixing is carried out on site with concrete mixers. In some special cases, the mixture can also be made with shovels. Generally, the cement bag forming the mixture, aggregate weight (or apparent volume in some cases) and water are also measured in terms of volume. There are also central organizations that prepare the mixture (or sell ready-mixed concrete). In return for the request to be made here, ready-to-use, desired quality mixture, construction is carried out. Mixing can be done in stationary mixers as well as in moving mixers. The benefit of such central concrete plants is that the mixture is made in a controlled manner. Good quality concrete can be easily obtained when suitable sand and gravel is available [9].

After the mixture is obtained homogeneously, the next job is to place it. If the prepared mixture is not close to the casting place, it should be delivered to this place. This process can also be carried out using a cart and bucket or pump. Air bubbles in the mixture placed in the mold can be removed using a vibrator and the concrete can be settled well. In small jobs, bottling can also be applied. Vibration is achieved by rotating an eccentric mass around an axis. This vibration, called vibration, can be done in concrete or can be achieved by the vibration of the mold.

The last step in obtaining concrete is the maintenance and hardening of the poured concrete. Hardening occurs as a result of the hydration of Portland cement, chemical reaction with water. It is important to maintain humid conditions for a certain period of time in the first days. For this, the outer surface of the concrete can be wetted with water or moist covers can be used. Depending on the cement type and temperature, a long maintenance period may be required to achieve full hydration. In most cases, seven days is sufficient. It is generally thought that concrete hardens as a result of the evaporation of its water. Actually, this is not true. Without water there can be neither hydration nor hardening. Water is lost as a result of the hydration of the cement and only excess water can be allowed to evaporate. Chemical reactions in the circuits of concrete are quite complex [10].

Nowadays, the additives produced due to the problems that occur in the concrete produced are used. These additives both increase the strength of the concrete and protect it from the damage of water and also allow the adjustment of the fluid or dullness of the additive according to its consistency.

2.5 CORROSION OF CONCRETE

Today, concrete has an important place as a construction material. One of the most important factors expected in concrete production is durability and the other is cost. Concrete is an artificial stone produced by combining mineral-based granular materials with a binder. The binder is cement, and granular material is called aggregate. The three main qualities required in all concretes are fresh workable, hardened mechanical dispersion and resistance to external conditions.

Concrete additives; They are organic and inorganic chemical substances that are added to concrete in very low amounts except water, aggregate (gravel and sand) and cement. In order to change the properties of cement in a good way and to a certain extent, they improve the properties of fresh and hardened concrete by adding them while concrete is produced or after it is produced.

The water allowed to be used is used in the concrete mix. All kinds of water that does not contain alcohol and sugar can be used in concrete. Acid should not be used in the water and it is forbidden to have high salt in the mixing water [11].

Aggregate is a non-organic, naturally sourced granular material such as sand, pebble crushed stone or artificially sourced such as blast furnace slag, expanded perlite, expanded clay, which are combined with the help of a binder consisting of cement and water in concrete production.

Gravel is a type of aggregate with large grains. Natural ones are generally provided from stream beds. The artificial ones are called stone chips and are obtained from the crushing of stones such as granite limestone.

Sand, on the other hand, is a small aggregate type. It is classified as fine sand and coarse sand. Sand obtained directly from stream beds is natural sand. In addition, granite, limestone, etc. If it is obtained by breaking the material, it is called artificial sand. Sand to be used in concrete must be clean. Sea sand is avoided.

Blast Furnace Slag is waste material from steel production. In fact, although there is not much waste material, one of the main reasons is that it is used as a soil reinforcement material. They provide the same consistency or workability in plasticizer concrete with less water. As the amount of water used in fresh concrete decreases, the strength of concrete increases. It ensures that the concrete produced without reducing the amount of cement that should be used in the production

of plasticizer concrete or compromising strength, is fluid and easily settable. Cement particles tend to combine with each other to form small lumps. Plasticizers combine with water and reduce the surface tension and gravity of the water in the concrete. Fluidizers have a negative electrical charge and tend to move on the water surface. Because of these effects, they prevent agglomeration and at the same time facilitate the sliding of the grains over each other and have a lubricating effect, reducing the internal friction of the concrete and increasing its workability [12].

Fly Ash is a mineral additive. Mineral additives alone do not have binding properties like cement, but when used together, they act similar to cement, thus providing cement economy. Mineral additives are also used in the production of resistant concrete.

3. MATERIAL AND METHODS

3.1 ARTIFICIAL INTELLIGENCE (AI)

Artificial intelligence in general terms; It can be defined as the way of producing intelligence examples or intelligent software with human cognitive features such as problem solving and reconciliation with the self-learning ability produced by humans and loaded on machines. This artificial mind acquires the ability to learn from data, thanks to machine learning, the process of applying related behaviors by imitating human characteristics without explicitly programming it using statistical techniques [13]. Artificial intelligence can perceive and use the data you have to reason, generate hypotheses, predict possible effects and make appropriate judgments and create models. The main goals of the studies in the field of artificial intelligence are to facilitate business life in areas such as perception, object processing, moving, learning and reasoning and planning. In other words, rather than taking the place of the human mind, the purpose is; To help humanity with the features it possesses. Although the business areas that disappeared with the development of technology are daunting, the emerging new professions also increase the number of employment. There will always be a need for people who can train and use the technologies that emerge as a result of these studies. Artificial intelligence; an example of a man-made mind that is loaded into machines and can learn by itself. AI can also be defined as intelligent machines with human qualities such as problem solving and negotiation. The main goals of AI research are learning, thinking, planning, processing and movement of perceptions and objects. [14].

3.2 AI IN CIVIL ENGINEERING

An average of 7 percent of the workforce in the world works in the construction sector, and the expenditures made in this area reach 10 trillion dollars in total annually [15]. From this point of view, the construction industry, which is obviously one of the most important sectors, lags far behind other sectors in investments made on artificial intelligence to increase productivity [16]. Artificial intelligence, whose use continues to spread rapidly in many sectors in the market and stands out with its plus features such as facilitating work and reducing costs, is just beginning in the construction sector, AI projects that are expected to accelerate in the coming years are in demand. With the transition from paper-based business to digital work, it becomes easier to reach the intended smarter, safer and more efficient work [17]. Active use of artificial intelligence in

every sector will soon become a necessity, and at the end of the day, sectors that make progress in the field will be able to keep up with the modern world. Artificial intelligence technology, which we know is used frequently in health studies, video games and industrial areas today, is slowly entering the construction sector, albeit late. It is a matter of curiosity what artificial intelligence can bring to the construction sector, where human intelligence and muscle power are highly needed. Now let's take a look at the work done by the giants in the sector in this direction. a building analysis software company, is also working on the use of artificial intelligence in the construction industry [18]. Oasys, which has made great investments in this regard, aims to use artificial intelligence algorithms in the planning and execution of the construction. With the data loaded on the machine and machine learning, we are working on a system where the most suitable plans can be obtained for the construction to be made. Realizing that the modern world is moving towards artificial intelligence systems, many construction companies are rapidly increasing the work done and the allocated budget in this direction. In the USA alone, the investments made for the use of artificial intelligence in the construction sector have reached 2 billion dollars. We will see together how the machines that process data, gain experience and make applications start to take an active role in the construction field will change the course of the sector [19].

3.1.1 AI Techniques in Civil Engineering

a) Fuzzy Logic: The language of the computer is 0 and 1's, of course, it also dominates artificial intelligence. In classical logic, the object set element that takes the value 1 is not 0, and there is only 1 and 0. However, values that can vary between 0 and 1 in fuzzy logic constitute the membership function and fuzzy logic presents a gray zone. To give an example from everyday life, we don't just call water hot or cold, because the temperature has a certain degree. Uncertainty in the UN is determined by the function assigned to the members representing this situation. If the most severity item has a value of 1, the remainder varies between 0 and 1. The main use advantage in civil engineering applications is the inherent dependence and the ability to introduce a nonlinear behavior of the structure [20].

b) Artificial Neural Networks: Simplified version of the human nervous system model; It is a flexible mathematical modeling method that can learn system behavior using input, output

and data sets. As a result of the generalizations it creates over the existing examples, it can produce unprecedented solutions for any problem in accordance with the input and output. The advantage of studies in civil engineering is that it can easily find the degree of influence of other independent variables related to a variable, providing close and sufficient results to experimental data, as well as generating new values. ANN, whose algorithm is often called the black box, is ideal for solving complex and nonlinear problems. It provides the most accurate estimates by assigning appropriate weights to each element in factors such as the project budget [21].

c) Neural - Fuzzy System (Neuro Fuzzy): A technique that has the technique of creating a fuzzy system from data, learning from examples and improving this system. In short, this technique coexists with the fuzzy system and the neural network theory for the learning algorithm [22].

d) Genetic Algorithms: Based on the principle of natural selection; Numerical improvement method using operators such as selection, crossing, mutation. Individual parameters are encoded into chromosomes. It is possible to reach advantageous calculation results in the optimization of the structures in every sense [23].

3.1.2 AI Applications in Civil Engineering?

a) Preventing Cost Overrun, Planning and implementation: Thanks to artificial neural networks that select the type of work to be done, determine the size of the project, measure the competence of managers and calculate the estimated costs, the project can be planned in the most realistic way. possible. Path. for times and costs [24]. With a system that provides budgets for projects, future problems can be solved without growth through improved training. With a material recognition program, quality management can be made easier by installing a sufficient number of workers and devices according to the project plan and identifying all objects used on job sites via the robot's memory [25].

b) Modeling, Design, optimization: In projects that always seek the best, the desired design can be selected in the most optimized way by evaluating the endless combinations of models and alternatives that can be created for the same project [26]. While it takes seconds to generate meaningful information using machine learning, analyzing and classifying data

from previous years is a long and arduous task for humans. Processes such as analyzing such poorly organized data, ensuring efficiency, evaluating equipment and worker location, determining adequate and insufficient space are gaining more and more importance [27].

c) Occupational safety and productivity: Using facial recognition, cameras and similar technologies, project managers can monitor site operations in real time, assess employee work and performance, and process compliance. [28] The number of industrial accidents in the construction sector and the deaths of workers due to these accidents are five times higher than in other sectors. Through the use of artificial intelligence, the risks that may arise in the construction sector and workers who do not follow safety precautions are minimized, situations that violate safety at work are recognized and warned of certain plans and employees during image analysis. [29] This program facilitates the classification of risks and increases the likelihood of prompt action. In addition, by recording the location of employees with manual sensors, accidents such as the risk of falling can be avoided [30].

d) Risk control: Many disciplines work together in any construction project, so the number of problems that arise is much greater than in one area [31]. Instead of filling out checklist forms with dozens of items to identify the risks these issues may pose and better manage the situation, how about creating a golden artificial intelligence program that predicts risks and prevents potential injury and death [32].

e) Living house, building and city: By combining traditional homes with digital homes and processing them with machine learning, our existing smart homes, buildings and cities can come to life through language processing in the future. The energy efficiency of buildings, ie the energy efficiency of new and existing buildings, can be increased with the useful life and performance of the building [33]. Building efficiency can be improved by providing expected levels of comfort and functionality, such as regular monitoring of heating and cooling systems [34]. In addition, projects can include integrated home software that includes solutions in many areas, from health monitoring to expectation-based control at home [35].

f) Energy saving: By taking a step towards the conscious use of energy and resources through innovative ways such as artificial intelligence applications, energy efficiency can be

increased by reducing energy consumption in many sectors. Sustainability is enhanced if self-sufficient construction vehicles run on solar power without the need for energy such as electricity or gasoline [36].

g) As a result, to keep abreast of fast, easy and straightforward AI applications that can improve efficiency and productivity in many areas such as quality management, design optimization, governance, control, sustainability, risk control, project planning, security. 37]. One of our goals going forward should be to focus on new areas of business that need to be created, allay the profession's fears that AI may kill AI, and conduct four-pronged research. a continuity of comfort is created. We look forward to seeing you as Artificial Intelligence thrives in our industry as we build our present and our future. [38].

3.3 FEATURE EXTRACTION TECHNIQUES

Feature extraction is a compression process that shrinks the original set of raw data into more manageable groups [39]. This large amount of data is characterized by a large number of variables that require processing of a large amount of computing resources. Feature extraction is the name given to how variables are selected or combined into entities to effectively and comprehensively reduce the amount of data to be processed by accurately and completely describing the original dataset [40]. Feature extraction is a compression process has been grouped into easy-to-use groups of the original raw data set. This large amount of data is characterized by a large number of computationally intensive variables. Various feature extraction techniques are presented in this section [41].

3.3.1 Power Spectral Density (PSD)

The time series $\square_{\square\square}(\square)$ of the power spectrum $\square(\square)$ describes the distribution of the frequency components that cause this signal. According to Fourier analysis, any physical signal can decompose into different frequencies or transform into frequency spectra along a continuous sequence. The statistical average of a given signal or any kind of signal (including noise) is analyzed according to the frequency components it contains this called the spectrum [42]. When the energy of the signal is concentrated over a limited time interval, its spectral energy density can be measured, especially if its total energy is limited. Spectral power density (or power spectrum

for short) as it is more commonly used is applied as long as signals exist, or a large amount of Spectral power density (PSD) is related to the spectral energy distribution over a given period of time and can be found in each unit of time. Because the total energy of such a signal is usually Infinite over all time. The sum or integration of the total power of the spectral components (for the physical process) or the difference (for the statistical process) $□^2(□) = □□^2$is equivalent to the value to be obtained, just as Parseval Theory states [43]. The spectrum of a physical process usually carries the necessary information about the nature of. For example, the pitch of a musical instrument (the degree of thickness or fineness of each of the sounds that make up a piece of music) can be determined instantly by spectral analysis. The color of the light source can be determined by the fluctuation of the electric field of electromagnetic waves at extremely high frequency. It is obtained by obtaining spectrum from time series as in Fourier transform and by generalizations based on Fourier analysis. In most cases time values are not used specifically. For example, the light-separating prism is used in spectrography to obtain the spectrum of light, or a sound is used in the auditory perception receptors of the inner ear (one against a certain frequency. But this article focuses on situations where time series are known (least statistical perception) or that can be measured directly (like any computer microfluid). Power spectrum is very important in statistical signal process and statistical study as well as in physics and engineering branches. Typically this process is time dependent, but spatial data divided into spatial frequencies can be discussed. Every signal that can be displayed in amplitude varies with time and has a corresponding frequency spectrum: visible light (perceived as color), musical notes (perceived as pitch), radio / television (determined by their frequencies or sometimes with wavelengths). and it may even be the regular rotation of the Earth. When these signals are examined as frequency spectrum form, they are extracted by certain aspects of the received signals or by the production underlying the process. In some cases the prominent peaks contained in the frequency spectrum may correspond to the sine wave component. In addition, some waves may correspond to the fundamental peaks of harmonic motion. This periodic signal may not be sine curve. frequency ranges mostly have zero power as produced in paddy filter. The mathematical model of the PSD presented as shown in Eq (3.1).

$$□_{□□}(□) = \frac{delta\ (t)^2}{□} \left[\sum_{□=1}^{□} X\ \ □^{□□□□}\right]^2 \quad (3.1)$$

3.3.2 Wavelet Transform (WT)

Wavelet transform is a type of transform used for time-frequency analysis of a signal. Especially the problems experienced during the analysis of seismic data enabled the development of the "Continuous Wavelet Transform". Later, it was seen that wavelet analysis can be applied to a wide variety of signal types. In the studies conducted, wavelet transform has been benefited significantly in the diagnosis of discontinuity in signals (interpretation of heart graphics can be given as an example) and in cleaning noise from the signal As its name suggests, wavelet transformation is performed with the help of wavelets. Similar to the short time Fourier transform (KZFD), a function called the main wavelet takes over the window function in the wavelet transform, but this master wavelet is scaled and shifted during the transformation process. Scaling refers to the expansion and contraction of the wave, and the shift corresponds to the shifting of the wave in the time axis [44]. Since the width of the window function, which remains constant during the transformation in KZFD, is constantly changing in the wavelet transform, the resolution of both the time and the frequency domain increases, which makes the wavelet (wavelet) transform superior to the Fourier transform [45]. Wavelet analysis; Unlike short-time Fourier analysis, it uses the time-scale domain, not the time frequency domain.

$$\square\square_{\square}(\square)(\square,\square) = \langle \square, \square_{\square\square} \rangle = \int \square(\square)\, \square_{\square\square}(\square)\square\square \qquad (3.2)$$

3.3.3 Independent Component Analysis (ICA)

Independent Component Analysis (ICA) is a statistical and computational technique used to identify hidden elements at the root of a measure or set of signals of random variables. The ICA is defining a model for generating multidimensional observable data. It is usually presented as a large sample database. The model assumes that data variables are a linear mixture of unknown and latent variables and that the mixed system is also unknown. Hidden variables are considered independent, not external variables and as independent components of the observed data. The ICA can find these independent components, also called sources or factors. At first glance, the ICA is involved in the analysis of fundamental components and factors. However, ICA is a much more powerful method and can be used to find the underlying factor or source when these traditional methods completely fail [46, 47]. The data analyzed by the ICA can be obtained from a variety of applications,

including digital imagery, documentation databases, economic indicators, and psychometrics. In many cases, measurements are provided as a series of parallel signals or time series. The term blind source propagation is used to describe this problem. Typical examples are simultaneous voice signals recorded by multiple microphones, brain waves recorded by multiple sensors, radio interference signals from cell phones, or parallel time series in industrial processes. The mathematical model presented in Eq (3.3)

$$\text{[illegible]}(\text{[illegible]}) = \frac{1}{\text{[illegible]}} \sum \sum \ln(1 - \tanh(\text{[illegible]})^2) + \text{[illegible]} / \det \text{[illegible]} / \quad (3.3)$$

3.3.4 Isomap

Isomap means isometric view. Isomap is a spectral theory-based method for reducing non-linear dimensions, which requires the acquisition of lower dimensional geodesic distances. Isomap begins building a network of neighbors. Then use the distance from the chart to the approximate geodesic distance between every pair of points. You can find low-dimensional insertions in your dataset by decomposing the eigenvalues of the geodesic distance matrix. For nonlinear variants, the Euclidean distance metric is valid only if the neighborhood structure can be approximated as linear. The Euclidean distance can be very difficult if there are holes nearby [48,49,50]. On the other hand, if you measure the distance between the two points behind the collector, the distance between the two points will be closer. Let's understand this using a very simple 2D example. Suppose your data is in a circular matrix with a two-dimensional structure. The mathematical representation of the Isomap shown in Eq (3.4)

$$\text{[illegible]} = \text{[illegible]} - \frac{1}{\text{[illegible]}} \text{[illegible]} \quad \text{[illegible]} = [1 \ldots \ldots 1] \quad (3.4)$$

3.3.5 Latent Semantic Analysis (LSA)

Latent semantic analysis (LSA) is derived from multidimensional vector representations based on the analysis of large corpora . However, LSA uses a fixed context window (for example at the paragraph level) to perform collaborative whole-body analyzes. Then, the factor analysis method

(singular number decomposition) is applied to the sharing matrix to obtain a reduced series of measures [51]. This reduction in size ensures that words used in the same context have the same vectors, even if they are not used in the same context. For example, "home" and "home" tend to appear with a "roof", but are rarely found together in the language. However, they will have a similar vector representation in the LSA. LSA can summarize individual word vectors to provide a measure of the semantics of a larger text unit. Therefore, the meaning of a paragraph is the sum of the word vectors in that paragraph. This criterion allows you to compare large text units, for example, to compare the meaning of sentences, paragraphs or entire documents [52].

3.3.6 Least Partial Squares (PLS)

The PLS was originally developed in the 1960s using the isometric method, but is now used in many chemical measuring devices. In fact there are two versions of the PLS algorithm (PLS-1 and PLS-2). In an experimental setting, the PLS can be viewed as a simultaneous type of PCA and a type of regression [53]. The advantage of this approach is that the experimenter can create new explanatory variables and send information as the original explanatory variables. Like the polymerase chain reaction, PLS is a widely used spectroscopic technique for multi-dimensional titration. However, this is a one-step process with no PLS regression steps. Instead, PLS analyzes spectrum and concentration data at the same time [54]. For example, the original PCR assay only takes into account the spectra for determining computer parameters. With PLS, the analysis concentration is also contained in the titration sample. The parameters are displayed so that the change in material content can be optimally determined with QP [55].

3.3.7 Principal Component Analysis (PCA)

The origin of principal component analysis (PCA) as we know it today can be found in [56], published in The Psychology of Education. Distribution items show the intended use through factor analysis over time. Since then, it has been used in many other fields, including biology, physics, and engineering [57]. The main goal is to reduce the size of multidimensional datasets and define fewer variables that group large datasets for clearer interpretation. The starting point for PCA is the matrix of correlation coefficients obtained from the original dataset [58]. In practice, the reason for this approach is to obtain correlations of variables measured on a continuous scale. In fact, like key weights, these variables can be fully correlated and separated, as if the variables

were calculated. They should be treated in the same way, and together they can be called a ladder (or ladder). This method is used when the correlation coefficient is not calculated using a scale variable. This analysis is not valid, but it can only provide useful information about the data structure in approximate cases.

3.4 CLASSIFICATION TECHNIQUES

Classification is a central machine learning topic that refers to machine learning to group data based on certain criteria. Classification is the process by which a computer groups data based on certain characteristics. This is known as supervised learning [59]. There is an automatic version of classification called grouping. It has a common feature on all computers that allows you to group data if no category is specified. A typical example of classification is spam detection. To create a spam filtering program, programmers can train machine learning algorithms using a series of email messages that look like spam emails marked as spam [60]. The idea is to create an algorithm that can learn the properties of spam from this tutorial so that you can filter spam when new messages arrive. In this section several classification techniques presented:

3.4.1 Support Vector Machine (SVM)

The goal of the support vector algorithm is to find hyperplanes in N-dimensional space (N hidden surfaces) that uniquely classify data points. You can select as many hyperplanes as possible to separate the data points of both classes. Our goal is to find the level with the highest rank or H. The maximum distance between data points in both classes. There are several enhancements that allow more stable classification of future data points, optimizing edge spacing [61]. Hyperplane is the limit that determines which data point classification can be used. Data points on either side of the hyperplane can be assigned to other classes. The size of the hyperplane depends on the number of functions. A hyperplane has only one line when the number of input functions is two. If there are three input features, the hyperplane will be two-dimensional. It's hard to imagine more than three functions [62].

3.4.2 Decision Trees (DT)

DT is a prediction model that expresses the characteristic space in a recursive partition into subspaces and forms the basis of prediction. DT is a direct root tree. In DT, the nodes with

protruding edges are internal nodes. All other nodes are DT nodes or leaves. DTs are classified according to a hierarchical set of characteristic decisions. The decision made at the internal node is the distribution criterion. In DT, each leaf is assigned to a class or its probabilities. Small deviations in the drive unit lead to different units leading to different DTs. Therefore, the error contribution due to variance is important to DT. Collaborative learning, described in the next section, helps reduce errors due to deviations [63, 64].

3.4.3 Naïve Bayes Classifiers

This is a classification method based on Bayes' theorem and requires independence between the predictors. In short, naive Bayesian classifiers assume that the presence of a particular function in one class is independent of the availability of other functions [65]. For example, a round red fruit about 3 inches in diameter can be considered an apple. Regardless of whether these features are related to each other or depend on the presence of other features, all of these symbols independently influence the likelihood that this fruit is an apple and therefore "naive". Known as Naive Bayesian models are easy to create and are particularly suitable for very large amounts of data. The naive Bayesian method surpasses not only the simplicity, but also very complex classification methods. The mathematical model ofthe Naïve Bayes Classifiers shown in Eq (3.5)

$$\square(\square/\square) = \frac{\square(\square)\,\square\square(\frac{\square}{\square}) \quad \frac{\square}{\square}}{\square(\square)} \tag{3.5}$$

3.4.4 K-Nearest Neighbors (KNN)

KNN is a simple and easy-to-control machine learning algorithm that can solve classification and regression problems. The ANN algorithm assumes that these objects are in the immediate vicinity. In other words, they are close [66, 67]. Look at the picture above. In most cases, similar data points are related. It is based on the assumption that the ANN algorithm is valid enough to make the algorithm useful. The ANN diagram reflects the concept of similarity (also called Proximity Proximity) in some calculations that can be learned as a child in calculating the distance between points. The mathematical model presented in Eq (3.6)

$$\square_{\square}(\square^{\square\square\square\square\square}) \{\square_1 \quad \frac{1}{\square} + \square_2 (\frac{\square}{\square})^{4/\square} \} \{1 + 0(1)\} \tag{3.6}$$

For some constants $\square_1$ and $\square_2$

3.4.5 Random Forests

Let's say you are familiar with creating your own classification tree. Many types of trees grow in random forests. To classify new items using an input vector, place the input vector on every tree in the forest. Each tree is assigned a rating and the tree is called a “vote” for that category. The forest chooses the list with the most votes (among all trees in the forest). To understand and use other parameters, it is useful to know a lot of calculations. Most configurations are based on two data objects generated from a random set. If you use a different sample to remove training indices from the current tree, about a third of the cases will be removed from the sample. This combined data is used to objectively estimate the classification error when trees are added to the forest. It is also used to get an estimate of various values. After each tree is created, all the data in the tree and the computed similarities for each case pair are highlighted. Convergence increases when two events occupy the same endpoint. Once the analysis is complete, it is normalized by dividing by the number of similarity trees. This technique is used to exchange missing data and identify individual values to create a simple and compact representation of the data [68, 69].

3.4.6 Discriminant Analysis (DA)

The proposed discriminant analysis (DA) is often taken from [70]. Compared with other methods of confirming creditworthiness this is a classification approach. The criteria are based on known classes and class predictions that cannot be recognized based on those criteria. DA is parametric or nonparametric. Parametric DA creates a model that assumes a distribution of a specific instance (for example, a normal distribution). However, the model is unbalanced due to an unobservable distribution [71]. Although this parametric DA is rare, it performs poorly in relation to the nonlinear DA problem. On the other hand, there are unlimited claims regarding credit ratings. This approach uses nonparametric structures and methods to investigate the distribution of cases. Classification criteria Consequently, the nonparametric consequences of Alzheimer's disease are strong [72].

3.5 Regression

To start with, the regression systems effort to estimation the charting purpose (f) from the input variables (x) to arithmetical or incessant output variables (y). Now, the production mutable could be a actual rate, which can be an integer or a floating point value. Consequently, the regression expectation glitches are typically amounts or dimensions.

For instance, if you are providing with a dataset near houses, and you are requested to forecast their values, that are a regression job since the value will be a incessant production.

Instances of the mutual regression systems comprise linear regression, Support Vector Regression (SVR), and regression trees [72].

3.5.1 Linear regression(LR)

LR is cast-off to forecast the worth of an consequence mutable *Y* based on one or additional input forecaster variables *X*. The goal is to found a linear association between the forecaster mutable(s) and the reply mutable, so that, we can usage this formulation to approximation the worth of the reply *Y*, when only the forecasters (*X*s) standards are recognized.

The goalmouth of a LR is to model the incessant Y mutable as a mathematical function of one or additional Xvariables, so we can usage this regression modeltoforecast Y when lone Xisrecognized. Thismathematicalequation can bewidespread as shadows:

$$Y = \beta_1 + \beta_2 X + \epsilon \tag{3.7}$$

Where, β1 is the intersection and β2 is the slope. Taken together, they are named regression coefficients. error is the term error, part of the Y regression model powerless to clarify. The Figure 3.1 representedlinearmodelexample.

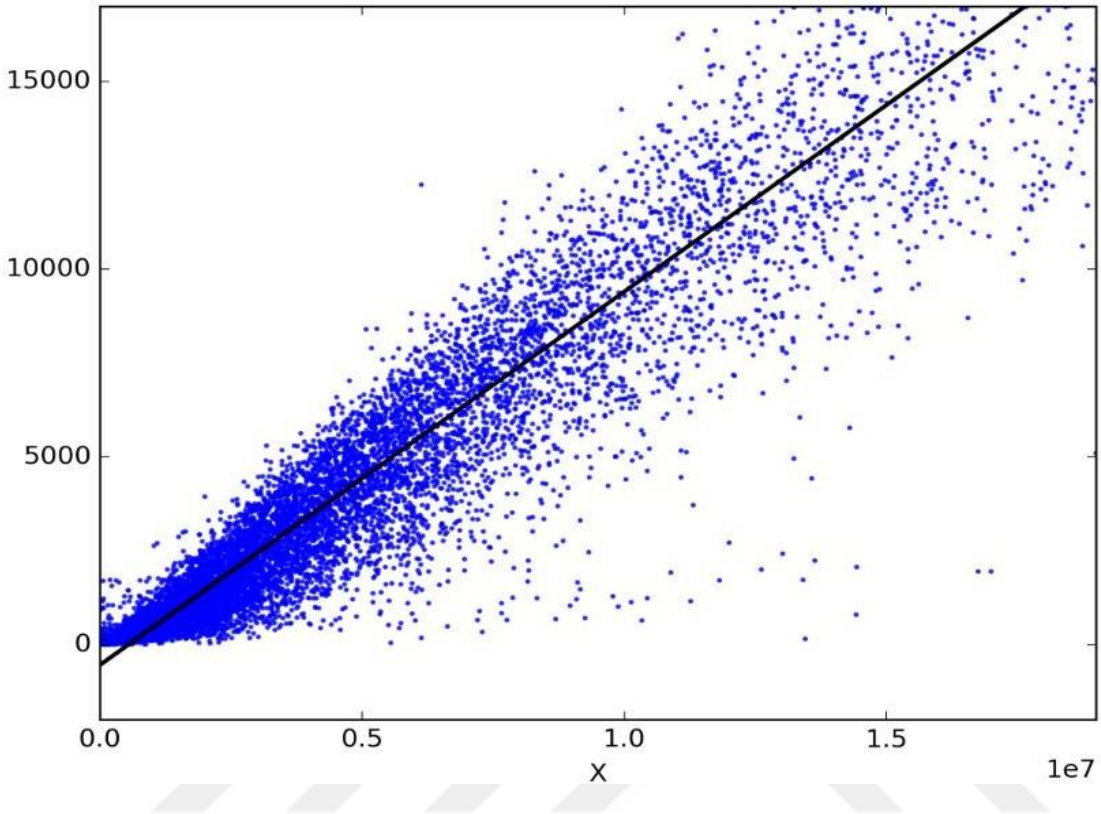

Figure 3.1: Linear Regression Model[73].

3.5.2 Logistic Regression(LR)

LR wasappliedinthebiologicalsciencesininitialtwentiethperiod. It wasthenappliedinseveralsocial sciencerequests. LR isappliedwhentheneedyvariable(target) isdefinite.

Forinstance,

To estimate whether an email is spam (1) or (0)

Whether the tumor is malignant (1) or not (0)

Reflect a situation where they want to categorize whether an email is spam or not. If they custom LR for this problematic, there is an essential for location up a verge depend on which recognition can be complete. Say if the real lesson is evil, foretold incessant value 0.4 and the verge worth is 0.5, the data opinion will be secret as not evil which can principal to thoughtful importance in actual period [74].

From this instance, it can be incidental that LR is not appropriate for organization problematic. LR is limitless, and this transports LR into image. Their worth severely varieties from 0 to 1 see Figure 3.2.

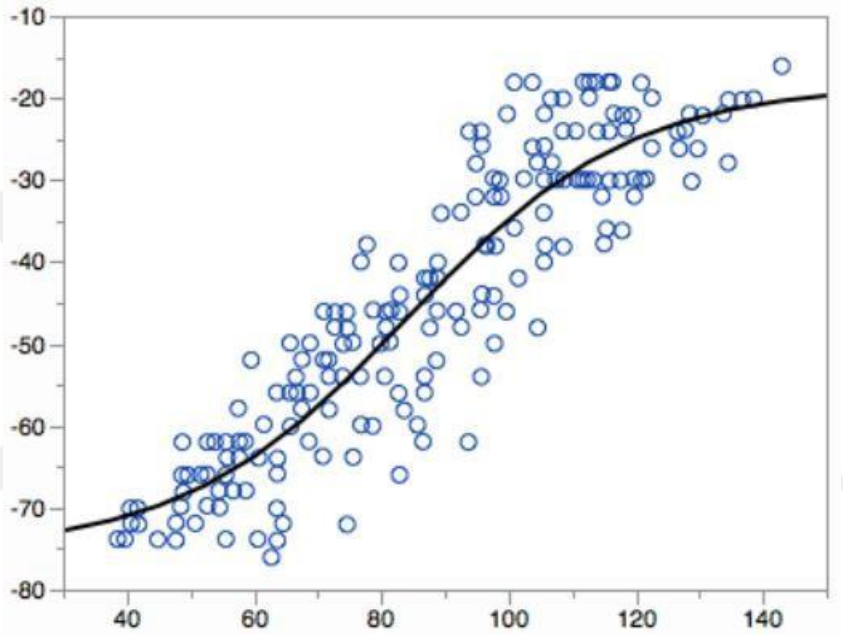

Figure 3.2: Logistic Regression[19].

3.5.3 Polynomial Regression

In statistics, polynomial regression is a regression research technique in which the relationship between the autonomy parameter x and the desired variable y is shown as an n-level polynomial at point x. The hysterical polynomial regression is a nonlinear relationship between the x value and the previous consistent y intensity, denoted by E(y|x). Although polynomial regression applies a nonlinear model to the data, it is linear as a problematic statistical approach because the regression function E(y|x) is linear with respect to the unidentified factors expected from the data. For this purpose, polynomial regression is considered as a special case of multiple linear regressions [75]. See Figure 3.3 as instance.

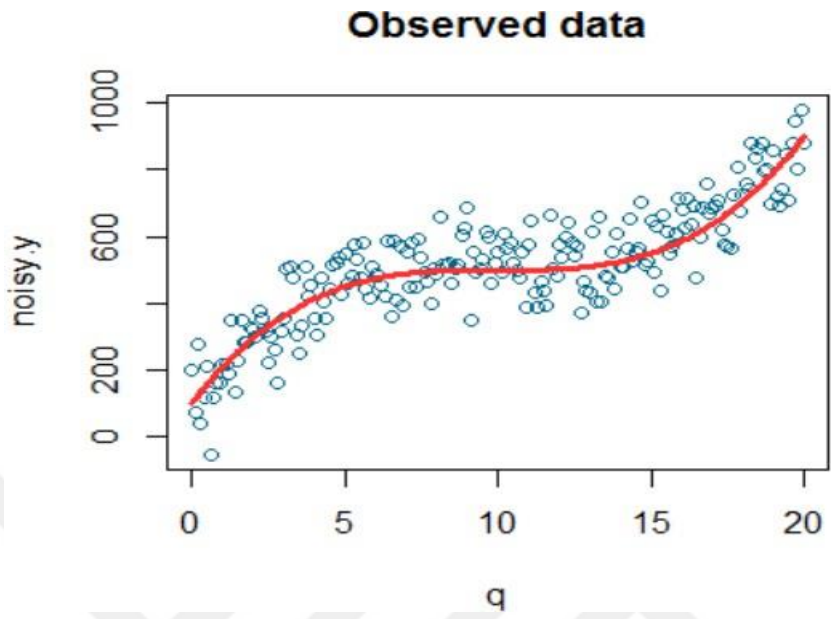

Figure 3.3: Polynomial Regression[76].

3.5.4 Stepwise Regression

Regression analysis is an extensively applied statistical method that pursues to classify relations among variables. The impression is to pond pertinent data to brand better-informed choices and is a shared repetition in the world of capitalizing. Stepwise regression is the step-by-step iterative building of a reversion model that includes involuntary assortment of sovereign variables. The obtainability of statistical software packages brands stepwise regression conceivable, even in replicas with hundreds of variables [77].

The fundamental aim of stepwise regression is, finished a sequence of tests (F-tests, t-tests) to discovery a set of sovereign variables which meaningfully effect the helpless variable. This is complete with computers over iteration, which is the procedure of inward to outcomes or results by successful finished recurrent rounds or series of analysis. Leading tests mechanically with the assistance from arithmetical software letters has the benefit of saving time for the separate [78]. The Figure 3.4 represented the example of Stepwise Regression.

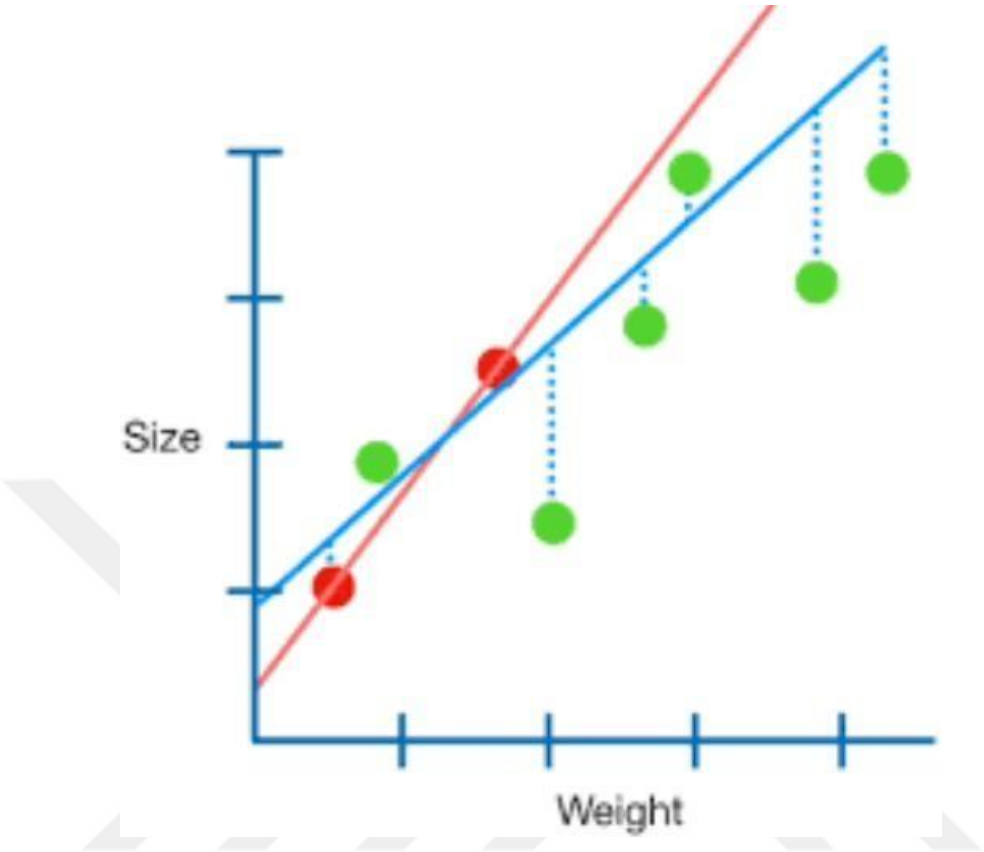

Figure 3.4: Stepwise Regression[79].

3.5.5 Lasso Regression

Lasso regression is a kind of linear regression that applied reduction. Reduction is where information standards are contracted to a dominant point, like the nasty. The lasso process inspires humble, sparse replicas (i.e. models with less parameters) [80]. This specific kind of regression is well-suited for replicas presentation tall stages of multicollinearity or when you poverty to mechanize sure parts of perfect selection, like variable parameter abolition. See Figure 3.5.

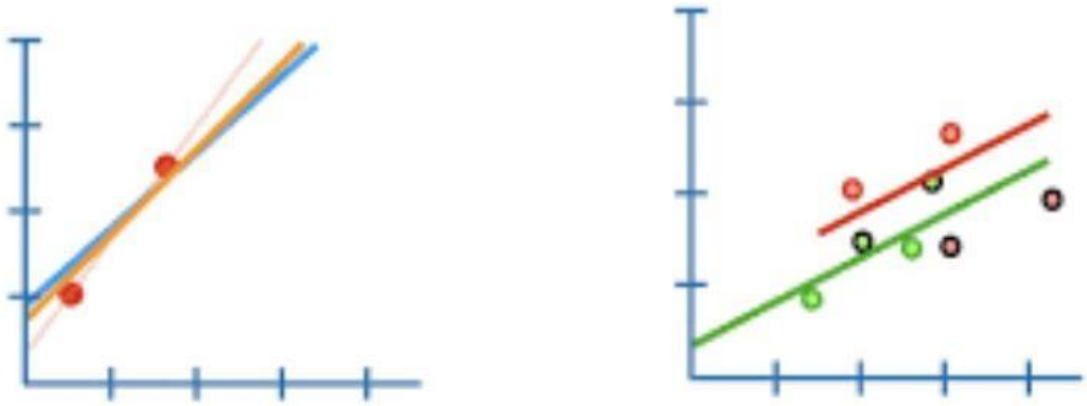

Figure 3.5: Lasso Regression[81].

3.5.5 Recurrent Neural Network(RNN)

Strict feedforward structural enterprise fixes not uphold a short-term reminiscence. Any reminiscence belongings are owing to the method historical inputs are re-presented to the network. A humble RNN has activation feedback which exemplifies short-term memory. A national layer is efficient not lone with the outside input of the network but also with activation after the earlier forward propagation. The feedback is adapted by a group of weights as to allow involuntary version finished learning (e.g. backpropagation) [82].

For humble structure and deterministic activation functions, learning can be attained applying alike gradient descent events to those foremost to the back-propagation technique for feed-forward networks. When the activations are stochastic, pretend hardening methods may be additional suitable [83]. The next will appearance at a insufficient of the greatest significant kinds and features of RNN.

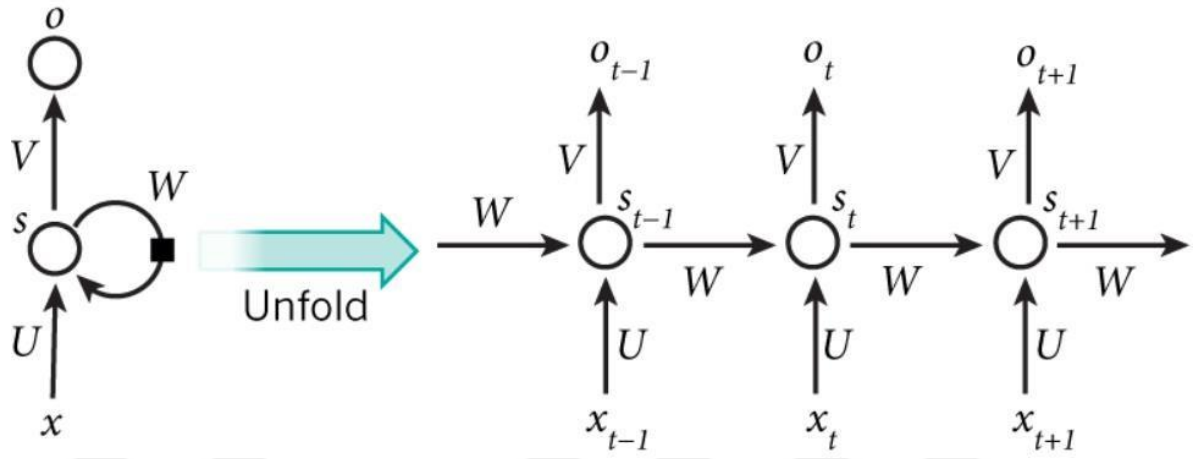

Figure 3.6: RNN Structure [84].

3.5.6 Long Short Term Memory Networks(LSTM)

An LSTM has an alike switch movement as a RNN. It procedures data at transitory oninfo as it broadcasts forward. The changes are the processes inside the LSTM's cells [85].

The essential idea of LSTM's are the cell national, and its numerous entrances. The cell state performance as a conveyance thoroughfare that transfers comparative information all the way depressed the order cable. Gates comprises sigmoid function. A sigmoid function is alike to the tanh function. In its place of squeezing standards between -1 and 1, its quelches standards between 0 and 1.

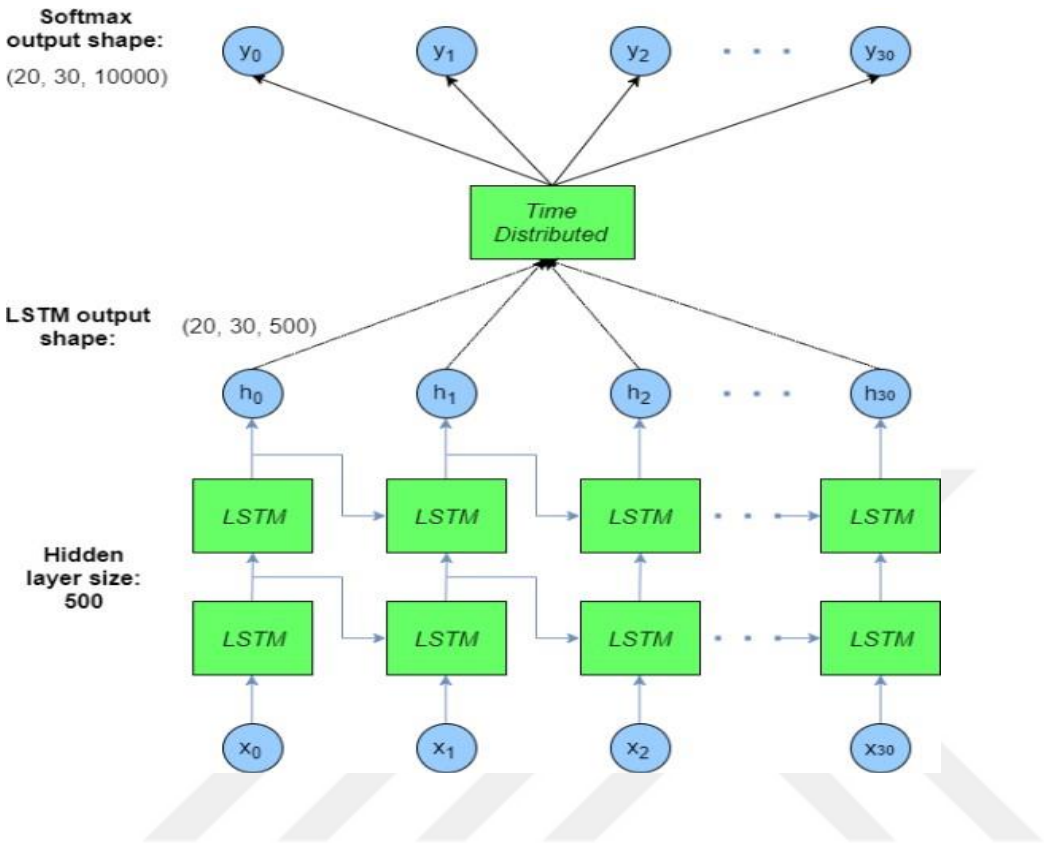

Figure 3.7: LSTMbased SoftMax.

Furthermore, structureof LSTMalsopresentedinthe Figure 3.8.

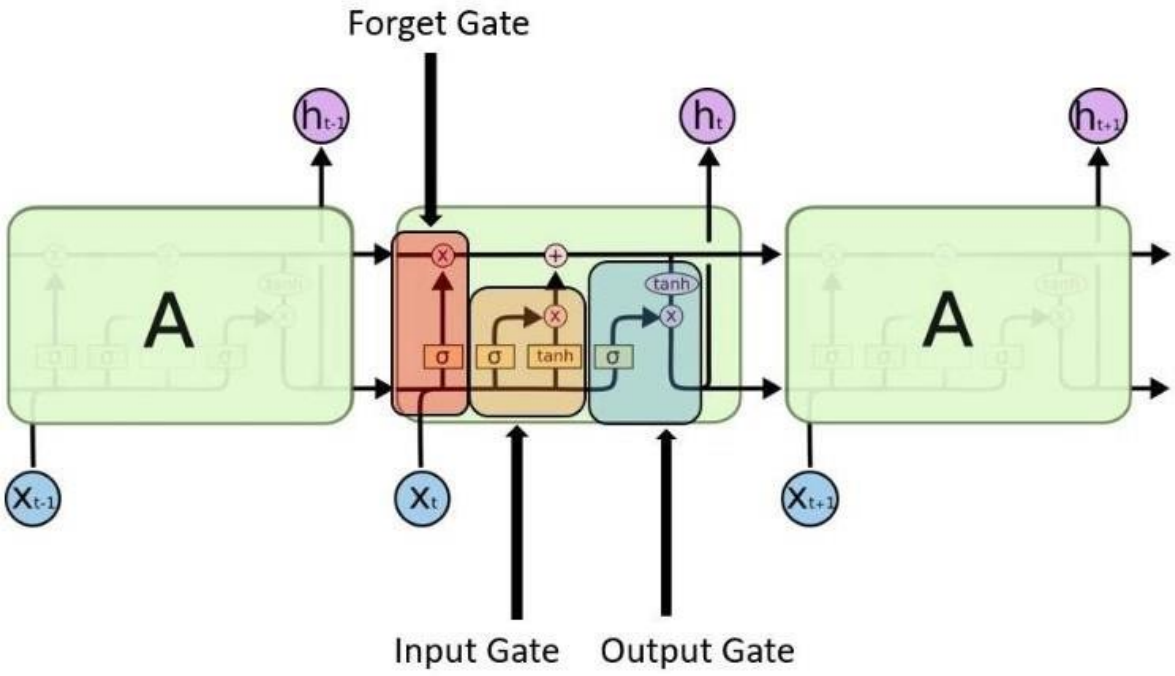

Figure 3.8: LSTMStructure.

3.6 A NEW MODEL FOR CONCRETE COMPRESSIVE STRENGTH PREDICATION

In this section, we presented LSTM as new predication model which the model receive the properties of the concrete as an input and after analysing the input features the model predicate the Concrete Compressive Strength. The compressive strength is the capability of solid or construction to carry the loads on its surface deprived of any blow or ricochet. A physical under compression tends to decrease the size, while in tension, size elongates. Compressive strength formulation for any solid is the load applied at the point of disappointment to the cross-section part of the expression on which load was applied.

$$h = \text{load} / \text{area} - \text{compressive strength}$$

The data obtained which the dataset consist from 1030 example and our model used 988 examples to train the model. Furthermore, the remain examples used to test the model. The presented model developed using MATLAB. The presented application read the data from excel sheets as shown in Figure 3.9.

```
XTrain = xlsread('Train.xlsx',1,'A1:H7904');
```

Figure 3.9: read train data from excel

Furthermore, the test data read by using the same command to test the model as shown in the Figure 3.10.

```
YTest= xlsread('Test.xlsx',1,'I1:I45');
```

Figure 3.10: read test data from excel

The input size of the parameters are 8 parameters in each case. The output is regression type because the parameters are not discrete but continuous. The number of hidden units are represented in num. hidden. The layers of the RNN developed in this section which consist from LSTM and fully connected layers. The properties of the network presented in the Figure 3.11.

```
inputsize=8;

numberofoutput=1;

numhidden=10;

Layers=[sequenceInputLayer(inputsize)
    lstmLayer(numhidden)
    fullyConnectedLayer(numberofoutput)
    regressionLayer
    ];

options = trainingOptions('sgdm', ...
    'MaxEpochs', 1000,...
    'InitialLearnRate', 0.0001);
net=trainNetwork(XTrain,YTrain,Layers,options);
YPred= predict(net,XTest);
```

Figure 3.11: Network properties

4. EXPERIMENTS AND DISSCUSION

MATLAB (matrix laboratory) is a multi-paradigm digital computer software and a fourth generation programming language. MATLAB is a proprietary programming language developed by MathWorks. MATLAB allows the user to manipulate an array, create functions and data, implement algorithms, create user interfaces, and connect to programs written in other languages such as C, C ++ , Java and Fortran. Although MATLAB is primarily designed for digital manipulation, it uses the MuPAD symbol engine, which can also perform symbolic calculations. The additional package includes Simulink, multipoint graphical modeling, and model-based design for integrated and dynamic systems [86]. In 2004, MATLAB had approximately one million academic and industrial users. MATLAB users come from a variety of backgrounds including engineering, science, and business. MATLAB is widely used in academic and research institutions, as well as in industrial enterprises. Clive Moler was the head of the computer science department at the University of New Mexico and began developing MATLAB in the late 1970s. Cleve Mohler developed LINPACK and EISPACK to train their students and teach them the programming language Fortran. Applied mathematics has recently been well received by a large audience at other universities and in the community. Moler met Jack Little while studying at Stanford University in 1983. Steve Bungert saw the potential of the company and joined them. They rewrote MATLAB in C and founded MathWorks in 1984 to continue development. Rewritten libraries are called JACKPAC. In 2000, MATLAB was rewritten to create new libraries to manipulate LAPACK arrays [87]. MATLAB was first adopted by researchers and management experts. It is still used in education, especially in the teaching of linear algebra, numerical analysis, and among image scientists. Several tests were performed under different conditions, the tests and results were measured with different capacities, the results of many tests were compared and the results were highlighted in color [89].

4.1 DATASET

Concrete is the utmost significant physical in civil engineering. The concrete compressive strength is an extremely nonlinear function of stage and fixings. Assumed are the mutable name, variable type, the measurement unit and a brief description. The concrete compressive strength is the regression problem. The order of this listing corresponds to the order of numerals along the rows

of the database. Then, the description of the dataset presented in the Figure 4.1. The dataset obtained from https://archive.ics.uci.edu/ml/datasets/Concrete+Compressive+Strength.

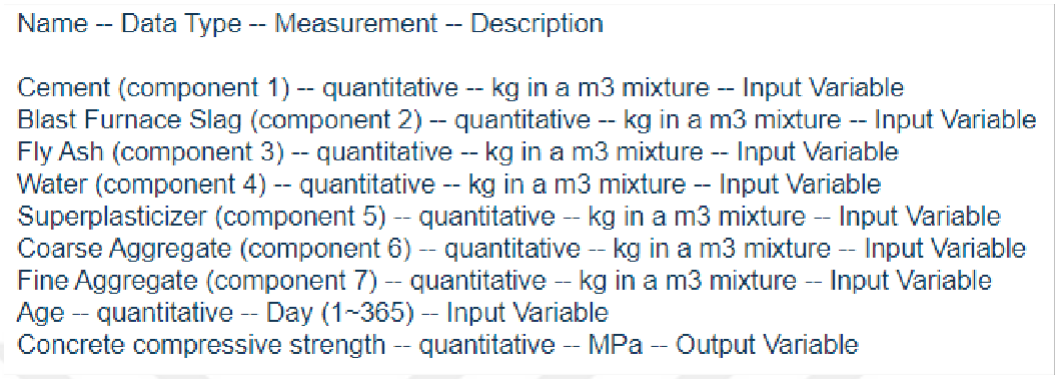

Figure 4.1: Dataset

4.2 EVALUATION PARAMETERS

4.2.1 Mean Error

Mean error is the average error between predicted values predicted by a machine learning model and actual values. Error in this context is the uncertainty in a measurement or the difference between the estimated value and the actual value.

4.2.2 Mean Percentage Error

It is the average percentage of the difference between the values predicted by a machine learning model and their actual values. MPE is mostly used for comparing predictive models. Positive and negative predictive errors can balance each other, as the actual values of the prediction errors rather than their absolute values are used when calculating the MPE value. Consequently, MPE can be used as a measure of bias in estimates. A disadvantage of this criterion is that if a single true value is zero, it is not defined [90].

4.2.3 Mean Absolute Error

Average absolute error is the measure of the difference between two continuous variables. MAE is the average vertical distance between each actual value and the line that best matches the data. MAE is also the average horizontal distance between each data point and the optimal line. The MAE is easy to interpret and is widely used for time series and regression problems. MAE is a

linear estimate that measures the mean size of the errors in a series of estimates in any direction, and all individual errors are averaged and weighted equally. The MAE range is 0. Negative scores or lower predictors perform better [91].

4.2.4 Mean Squared Error

Simply, mean square error tells you how close a regression curve is to a set of points. MSE measures the performance of ML models that are forecasters, while forecasters that are always positive and have an MSE value close to zero may achieve better [92].

4.2.5 Root Mean Square Error

It is a quadratic metric that measures the size of the error and is often used to determine the distance between the predicted value of a predictor and the actual value of a machine learning model. Standard deviation of RMSE residuals. In other words, the residual is a measure of the distance between the regression line and the data points. The RMSE is a measure of the level of this residue. That is, it gives the data density around the row that best matches the data. The range of RMSE values is 0 to. Negative scores, ie H. Predictors with lower values do better. Zero RMSE means the model is correct. The advantage of RMSE is that you are more likely to be penalized for serious misconduct and can adapt better to a particular situation. RMSE avoids using unnecessary absolute values in many mathematical calculations [93].

4.2.6 Mean Absolute Percentage Error

Regression and time series models often use the mean absolute error of a ratio to measure the accuracy of their predictions. If there are zeros below the actual value, MAPE cannot be calculated because it is division by zero. For very low forecasts the error percentage cannot exceed 100%, but there is no limit for a very high forecast error percentage. When using MAPE to compare the precision of the predictions, MAPE is biased as the methods that are too weak to predict are chosen in order. This small but serious problem can be solved by using precision criteria to find the relationship between the predicted and actual values. This method results in an estimate that can be interpreted as a geometric mean [94].

4.2.7 Mean Absolute Percentage Error

Symmetric Mean Absolute Percent Error (SMAPE) is the Average Absolute Percent Error (MAPE) alternative when there is zero or near zero demand for items. SMAPE limits itself to an error rate of 200%, reducing the impact of these low volume items. Low volume items are problematic otherwise they can have infinitely high error rates that skew the overall error rate [95].

4.2.8 Mean Absolute Scaled Error

In statistics, the mean absolute scale error (MASE) is a measure of the accuracy of estimates. In 2005, it was proposed by statistician Rob J. Hyndman and Professor of Quarantine Sciences Anne B. Koehler to describe "the smooth predictive accuracy seen in other measurements as a generally applicable measure". The mean absolute scale error has favorable properties compared to other methods used to calculate prediction errors such as root mean square deviation and is therefore recommended for determining the comparative accuracy of predictions [96,97].

4.3 RESULTS

The Compressive Strength of Concrete determines the quality of the concrete. This is usually determined by standard compression tests on concrete cylinders. To do this, engineers must make small concrete cylinders using a combination of different raw materials and test the cylinders for changes in strength as each raw material changes. The recommended wait time for the balloon test is 28 days to ensure accurate results. It takes time and effort to prepare and test different prototypes. This method is also prone to human error and can introduce significant delays due to small errors.

One way to reduce the latency and the number of combinations tested is to use a digital simulation which can tell the computer what we know and the computer will estimate the compression rate to test other combinations. This reduces the number of combinations that can be physically tested and the time it takes to experiment. However, in order to develop this software, we need to know the relationships between all commodities and how they affect resistance. It is possible to derive mathematical equations and simulate these equations, but the relationships in the real world cannot be the same. Additionally, these tests have been run multiple times and have enough real world data to be used for predictive modeling. Our model was trained on the mean squared error (MSE) to reduce the size of the model error for better results. The MSE of our model is shown in Figure 4.2.

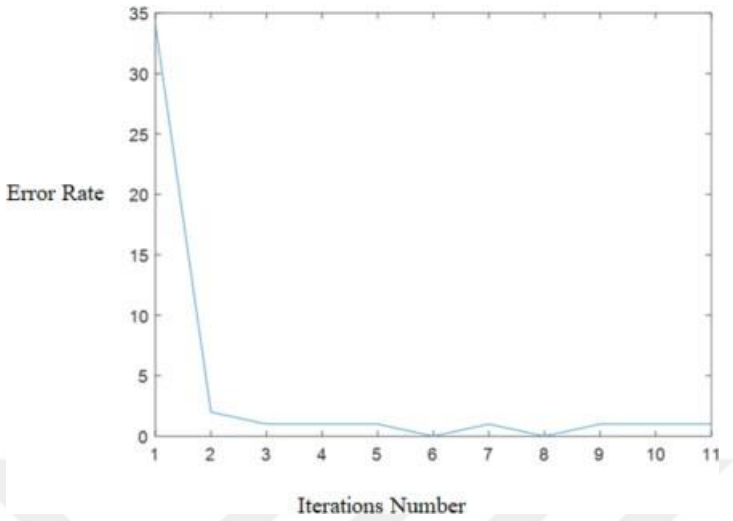

Figure 4.2: MSE of our model

Then, our model results presented and compared with SVM and DT and the obtained results presented in Figure 4.3.

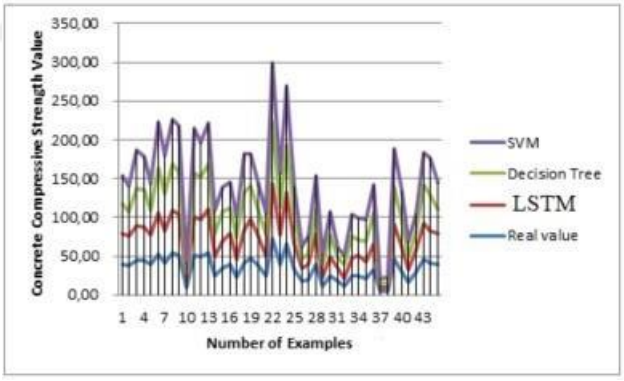

Figure 4.3: Predication results

The MSE of the predicated values of all 45 elements are calculated to compare the obtained MSE. The minimum MSE is best for any model which mean that the error rate is little than others.

Furthermore, several techniques compared such as SVM, DT, and LSTM and the MSE calculated for all these techniques and the results show that the LSTM is best.

Table 4.1: Comparisons between previous studies

Techniques	MSE
SVM	3.243
Decision tree	4.74
LSTM	0.547

5. CONCLUSIONS

The aim of this work was to study computer intelligence. Three machine learning and artificial intelligence methods were used, namely random forests, support vector machines and artificial neural networks, and the results were compared to our LSTM method. Visualization and pretreatment techniques were also used to improve results. These can be models for a particular problem, when it is believed that there is a validation gap, or when a particular methodology is not available. In order to predict the properties of concrete with high reliability, traditional and innovative models can be replaced by models with artificial intelligence instead of expensive experimental research. As this study shows, Computational Intelligence models can be used successfully, Computational Intelligence models can be used successfully. The prediction of the average billing agreement for this maximum degree of pressure agreement is evaluated experimentally on the concrete samples used.

5.1 FUTURE WORKS

After analyzing the results that are obtained in this study, the author can presented number of notes that can assist the researchers in the future studies. We advise the researcher to apply other new deep learning techniques to predicate the concrete compressive strength. Furthermore, feature extraction techniques also advised to apply to this problem which an effect features will removed. We advise also, to applied the presented model to the other concrete compressive strength datasets to evaluate and prove the obtained results.

5.2 LIMITATION OF THE STUDY

This study include number of limitations such as the applying deep learning technique to estimate the concrete compressive strength which deep learning techniques need high number of features and number of examples which are not offered in dataset that applied in this study. On the other hand, the presented framework effective with numerical datasets only which the framework can’t deal with non-numerical datasets.

REFERENCES

[1] Farfan, J.; Fasihi, M.; Breyer, C. Trends in the global cement industry and opportunities for long-term sustainable CCU potential for Power-to-X. J. Clean. Prod. 2019, 217, 821–835.

[2] van Oss, H.G. Mineral Commodity Summaries: Cement; U.S. Geological Survey: Reston, VA, USA, 2000.

[3] van Oss, H.G. Mineral Commodity Summaries: Cement; U.S. Geological Survey: Reston, VA, USA, 2018.

[4] McGrath, T.E.; Kwasny, J.; Aiken, T.; Cox, S.; Soutsos, M.; Chen, J.F.; Mariotti, J.; Sha, W.; Correia, R. Demonstration of using low carbon precast concrete products for an energy efficient built environment. Sustain. Constr. Mater. Technol. 2019.

[5] Meesala, C.R.; Verma, N.K.; Kumar, S. Critical review on fly-ash based geopolymer concrete. Struct. Concr. 2020, 21, 1013–1028.

[6] Vafaei, M.; Allahverdi, A. High strength geopolymer binder based on waste-glass powder. Adv. Powder Technol. 2017, 28, 215–222.

[7] Detphan, S.; Chindaprasirt, P. Preparation of fly ash and rice husk ash geopolymer. Int. J. Miner. Metall. Mater. 2009, 16, 720–726.

[8] Guru Jawahar, J.; Lavanya, D.; Sashidhar, C. Performance of fly ash and ggbs based geopolymer concrete in acid environment. Int. J. Res. Sci. Innov. 2016, 3, 101–104.

[9] Al Bakri, A.M.M.; Kamarudin, H.; Bnhussain, M.; Rafiza, A.R.; Zarina, Y. Effect of Na2SiO3 /NaOH Ratios and NaOH Molarities on Compressive Strength of Fly-Ash-Based Geopolymer. ACI Mater. J. 2012, 109, 503–508.

[10] Joseph, B.; Mathew, G. Influence of aggregate content on the behavior of fly ash based geopolymer concrete. Sci. Iran. 2012, 19, 1188–1194.

[11] Farhan, N.A.; Sheikh, M.N.; Hadi, M.N. Investigation of engineering properties of normal and high strength fly ash based geopolymer and alkali-activated slag concrete compared to ordinary Portland cement concrete. Constr. Build. Mater. 2019, 196, 26–42.

[12] Tempest, B.; Sanusi, O.; Gergely, J.; Ogunro, V.; Weggel, D. Compressive strength and embodied energy optimization of fly ash based geopolymer concrete. In Proceedings of the 3rd World Coal Ash, WOCA Conference, Lexington, KY, USA, 4–7 May 2009.

[13] Y. Siboopimpa, T. Chaipranitan, S. Chiewchanwattana and K. Sunat, "“I am in ASEAN”: A learning media application on Android operating system," 2014 Third ICT International Student Project Conference (ICT-ISPC), Nakhon Pathom, 2014, pp. 9-12, doi: 10.1109/ICT-ISPC.2014.6923206.

[14] H. Peng, C. Gates, B. Sarma, N. Li, Y. Qi, R. Potharaju, C. Nita-Rotaru, I. Molloy, "Using probabilistic generative models for ranking risks of android apps", (CCS 2012) ACM Conference on Computer and Communications Security, New York, USA, 241–252, October 16-18, 2012.

[15] Y. Zhao et al., "An Experimental Study on Software Aging in Android Operating System," 2015 2nd International Symposium on Dependable Computing and Internet of Things (DCIT), Wuhan, 2015, pp. 148-150, doi: 10.1109/DCIT.2015.19.

[16] A. Sarkar, A. Goyal, D. Hicks, D. Sarkar and S. Hazra, "Android Application Development: A Brief Overview of Android Platforms and Evolution of Security Systems," 2019 Third International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), Palladam, India, 2019, pp. 73-79, doi: 10.1109/I-SMAC47947.2019.9032440.

[17] Jaiswal, Y. Malik and F. Jaafar, "Android gaming malware detection using system call analysis," 2018 6th International Symposium on Digital Forensic and Security (ISDFS), Antalya, 2018, pp. 1-5, doi: 10.1109/ISDFS.2018.8355360.

[18] Sung Wook Moon, Young Jin Kim, Ho Jun Myeong, Chang Soo Kim, Nam Ju Cha and Dong Hwan Kim, "Implementation of smartphone environment remote control and monitoring system for Android operating system-based robot platform," 2011 8th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), Incheon, 2011, pp. 211-214, doi: 10.1109/URAI.2011.6145963.

[19] O. Sohail and T. Naqash, "Anti-theft cloud application for android operating system (Nougats)," 2018 IEEE International Conference on Applied System Invention (ICASI), Chiba, 2018, pp. 321-324, doi: 10.1109/ICASI.2018.8394598.

[20] Bezobrazov, A. Sachenko, M. Komar and V. Rubanau, "Artificial immune system for Android OS," 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS), Warsaw, 2015, pp. 403-407, doi: 10.1109/IDAACS.2015.7340767.

[21] Rajalakshmi and N. Anusha, "Sensor based application for malware detection in android OS(Operating System) devices," 2017 International Conference on Information Communication and Embedded Systems (ICICES), Chennai, 2017, pp. 1-6, doi: 10.1109/ICICES.2017.8070722.

[22] Ayyasamy, "Survey on Android application advancement and security," 2015 Seventh International Conference on Advanced Computing (ICoAC), Chennai, 2015, pp. 1-4, doi: 10.1109/ICoAC.2015.7562799.

[23] A. Utku and İ. A. Doğru, "Malware detection system based on machine learning methods for Android operating systems," 2017 25th Signal Processing and Communications Applications Conference (SIU), Antalya, 2017, pp. 1-4, doi: 10.1109/SIU.2017.7960231.

[24] P. G. A. A. Putra, E. Sediyono and A. Setiawan, "E-land design of mobile application for land information system using Android-based Google Maps API V2," 2017 International Conference on Innovative and Creative Information Technology (ICITech), Salatiga, 2017, pp. 1-5, doi: 10.1109/INNOCIT.2017.8319145.

[25] Ho Jun Myeong, Yeo Hun Yoon, Nam Ju Cha, W. Y. Du and Dong Hwan Kim, "User tracking of an educational robot with android operating system based robot platform," 2012 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), Daejeon, 2012, pp. 132-135, doi: 10.1109/URAI.2012.6462951.

[26] M. Kovacev, K. Lazic, N. Jovanovic, A. Stefanovic and I. Petrovic, "Implementation of Disaster recovery agent within Android based set-top box," 2013 IEEE Third International

Conference on Consumer Electronics ¿ Berlin (ICCE-Berlin), Berlin, 2013, pp. 1-3, doi: 10.1109/ICCE-Berlin.2013.6697996.

[27] N. T. Cam, T. Nguyen, K. Nguyen, T. Nguyen and V. Pham, "Detect Malware in Android Firmware Based on Distributed Network Environment," 2019 IEEE 19th International Conference on Communication Technology (ICCT), Xi'an, China, 2019, pp. 1566-1570, doi: 10.1109/ICCT46805.2019.8947099.

[28] M. Dinić, A. Rikalo, A. Marković and P. Jovanović, "TLB maintenance optimization in android emulator for mips platform," 2016 24th Telecommunications Forum (TELFOR), Belgrade, 2016, pp. 1-4, doi: 10.1109/TELFOR.2016.78188.

[29] K. Wang, Y. Hou and Y. Xu, "Design and Implementation of Remote Control System between Android Platform," 2016 International Conference on Information System and Artificial Intelligence (ISAI), Hong Kong, 2016, pp. 143-147, doi: 10.1109/ISAI.2016.0039.

[30] A. Heryana, E. Nugraheni, B. Kusumo, A. F. Rojie and B. Setiadi, "Applying agile methods in designing an earthquake and landslide early warning system application for Android," 2017 International Conference on Computer, Control, Informatics and its Applications (IC3INA), Jakarta, 2017, pp. 80-84, doi: 10.1109/IC3INA.2017.8251744.

[31] O. C. Novac, M. Novac, C. Gordan, T. Berczes and G. Bujdosó, "Comparative study of Google Android, Apple iOS and Microsoft Windows Phone mobile operating systems," 2017 14th International Conference on Engineering of Modern Electric Systems (EMES), Oradea, 2017, pp. 154-159, doi: 10.1109/EMES.2017.7980403.

[32] C. Yuan, Y. Yue, X. Li and L. Feng, "Performance analysis and optimization of inter process communication in Android," 2016 6th International Conference on Electronics Information and Emergency Communication (ICEIEC), Beijing, 2016, pp. 297-300, doi: 10.1109/ICEIEC.2016.7589742.

[33] Arshad, M. A. Shah, A. Wahid, A. Mehmood, H. Song and H. Yu, "SAMADroid: A Novel 3-Level Hybrid Malware Detection Model for Android Operating System," in IEEE Access, vol. 6, pp. 4321-4339, 2018, doi: 10.1109/ACCESS.2018.2792941.

[34] E. Türk and S. Arslan, "Boot time optimization for Android-based embedded systems," 2017 International Conference on Computer Science and Engineering (UBMK), Antalya, 2017, pp. 1004-1008, doi: 10.1109/UBMK.2017.8093416.

[35] A. Yao, P. Sun, S. Yang and D. Li, "Evolution of Function-Call Network Reliability in Android Operating System," in IEEE Transactions on Circuits and Systems I: Regular Papers, vol. 67, no. 4, pp. 1264-1275, April 2020, doi: 10.1109/TCSI.2020.2972995.

[36] Z. D. Patel, "Malware Detection in Android Operating System," 2018 International Conference on Advances in Computing, Communication Control and Networking (ICACCCN), Greater Noida (UP), India, 2018, pp. 366-370, doi: 10.1109/ICACCCN.2018.8748512.

[37] M. Cajic, B. Brkic and M. Veinovic, "System of assessment security for Android operating system," 2012 20th Telecommunications Forum (TELFOR), Belgrade, 2012, pp. 1448-1451, doi: 10.1109/TELFOR.2012.6419491.

[38] M. A. Dar, S. Nisar Bukhari and U. I. Khan, "Evaluation of Security and Privacy of Smartphone Users," 2018 Fourth International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB), Chennai, 2018, pp. 1-4, doi: 10.1109/AEEICB.2018.8480914.

[39] F. Heriniaina, "CoSINcheck to protect users from installing potentially harmful Android applications," 2017 Third International Conference on Mobile and Secure Services (MobiSecServ), Miami Beach, FL, 2017, pp. 1-5, doi: 10.1109/MOBISECSERV.2017.7886564.

[41] R. Manoharan and S. Chandrakala, "Android OpenCV based effective driver fatigue and distraction monitoring system," 2015 International Conference on Computing and Communications Technologies (ICCCT), Chennai, 2015, pp. 262-266, doi: 10.1109/ICCCT2.2015.7292757.

[40] M. Kovacevic, B. Kovacevic, B. Pavlovic and N. Bandic, "Visualization of interactive digital television services content in Android operating system," 2012 20th Telecommunications Forum (TELFOR), Belgrade, 2012, pp. 1357-1360, doi: 10.1109/TELFOR.2012.6419469.

[42] R. Hunt, "Security testing in Android networks - A practical case study," 2013 19th IEEE International Conference on Networks (ICON), Singapore, 2013, pp. 1-6, doi: 10.1109/ICON.2013.6781950.

[43] O. C. Novac, I. Mureşan, M. C. Novac, M. P. Ursu, M. Oproescu and C. M. Dindelegan, "Development of a Weather Mobile Application in Android Operating System," 2019 11th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), Pitesti, Romania, 2019, pp. 1-5, doi: 10.1109/ECAI46879.2019.9042040.

[44] S. Agarwal and N. Agarwal, "Interfacing of robot with android app for to and fro communication," 2016 Second International Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH), Ghaziabad, 2016, pp. 222-226, doi: 10.1109/CIPECH.2016.7918771.

[45] Guha, S., Yau, S. S., & Buduru, A. B. (2016, August). Attack detection in cloud infrastructures using artificial neural network with genetic feature selection. In Dependable, Autonomic and Secure Computing, 14th Intl Conf on Pervasive Intelligence and Computing, 2nd Intl Conf on Big Data Intelligence and Computing and Cyber Science and Technology Congress (DASC/PiCom/DataCom/CyberSciTech), 2016 IEEE 14th Intl C (pp. 414-419). IEEE.

[46] Nguyen, K. K., Hoang, D. T., Niyato, D., Wang, P., Nguyen, D., & Dutkiewicz, E. (2018, April). Cyberattack detection in mobile cloud computing: A deep learning approach. In Wireless Communications and Networking Conference (WCNC), 2018 IEEE (pp. 1-6). IEEE.

[47] F. Gao, L. Leng and X. Fu, "Palmprint Verification System with Dual-Line-Single-Point Assistance on Android Mobile Devices," 2018 4th Annual International Conference on Network and Information Systems for Computers (ICNISC), Wuhan, China, 2018, pp. 437-441, doi: 10.1109/ICNISC.2018.00095.

[48] K. Nagata, Y. Nakamura, S. Nomura and S. Yamaguchi, "Measuring and Improving Application Launching Performance on Android Devices," 2013 First International Symposium on Computing and Networking, Matsuyama, 2013, pp. 636-638, doi: 10.1109/CANDAR.2013.116.

[49] E. G. d. Oliveira, M. S. F. d. Oliveira, N. R. Neto, F. d. P. Soldati and T. L. C. Nassur, "Development and evaluation of a mobile educational application to support teaching of management of process in Operating Systems," 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia, 2020, pp. 19-21, doi: 10.1109/ICALT49669.2020.00012.

[50] S. N. Verzynov, I. V. Bochkarev and V. R. Khramshin, "Development of Line Locator Software Component for Mobile Operating Systems," 2020 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), Sochi, Russia, 2020, pp. 1-5, doi: 10.1109/ICIEAM48468.2020.9112019.

[51] Nemet, S. Radovanović, R. Simikić, I. Papp and T. Novković, "Adaptive TR-069 system service for Android-based consumer electronic devices," 2013 IEEE Third International Conference on Consumer Electronics ¿ Berlin (ICCE-Berlin), Berlin, 2013, pp. 258-260, doi: 10.1109/ICCE-Berlin.2013.6697980.

[52] Mu, Z. Tan and G. Zhu, "Android-Based Order Recommender System," 2018 International Conference on Robots & Intelligent System (ICRIS), Changsha, 2018, pp. 258-261, doi: 10.1109/ICRIS.2018.00073.

[53] V. Bjelić, N. Lukić, S. Kovačević and M. Vucelja, "Improving teletext support for set top box based on Android operating system," 2013 21st Telecommunications Forum Telfor (TELFOR), Belgrade, 2013, pp. 995-998, doi: 10.1109/TELFOR.2013.6716399.

[54] Kumar and R. M., "Location Based Parental Control-Child Tracking App Using Android Mobile Operating System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), Greater Noida, India, 2018, pp. 1-4, doi: 10.1109/CCAA.2018.8777612.

[55] H. Shang, Q. Zhang, M. Jin, W. Wang, J. Zhu and Q. Kong, "A portable pulse signal acquiring and monitoring system based on Android platform," 2013 IEEE International Conference on Bioinformatics and Biomedicine, Shanghai, 2013, pp. 226-227, doi: 10.1109/BIBM.2013.6732679.

[56] E. Zhang, S. Peng and Y. Zhai, "Design and Application Development of the Camps Navigation System Based on ArcGIS Runtime SDK for Android : ——Taking the Yunnan Normal University as an example," 2019 IEEE 4th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), Chengdu, China, 2019, pp. 1262-1266, doi: 10.1109/IAEAC47372.2019.8997730.

[57] Y. Zhao, Z. Yang, C. Song and D. Xiong, "Vehicle dynamic model-based integrated navigation system for land vehicles," 2018 25th Saint Petersburg International Conference on Integrated Navigation Systems (ICINS), St. Petersburg, 2018, pp. 1-4, doi: 10.23919/ICINS.2018.8405846.

[58] M. Ivankovic and I. Basicevic, "Additional Multimedial Screen for Control of a Hbbtv Application with the use of Android Operating System," 2018 26th Telecommunications Forum (TELFOR), Belgrade, 2018, pp. 420-425, doi: 10.1109/TELFOR.2018.8611871.

[59] S. Iqbal, A. Yasin and T. Naqash, "Android (Nougats) security issues and solutions," 2018 IEEE International Conference on Applied System Invention (ICASI), Chiba, 2018, pp. 1152-1155, doi: 10.1109/ICASI.2018.8394488.

[60] D. Hongyu, L. Lizong, Q. Dixin and O. Baibing, "Design of College Canteen Ordering System Based on Cortex-A9 and Android," 2020 International Workshop on Electronic Communication and Artificial Intelligence (IWECAI), Shanghai, China, 2020, pp. 179-183, doi: 10.1109/IWECAI50956.2020.00043.

[61] A. H. Sabani and R. Jailani, "Android based control and monitoring system for leg orthosis," 2015 IEEE 11th International Colloquium on Signal Processing & Its Applications (CSPA), Kuala Lumpur, 2015, pp. 40-45, doi: 10.1109/CSPA.2015.7225615.

[62] Xu, Ning Su, Rujing Wang and Liangtu Song, "A novel variable rate fertilization system based on the Android platform," 2015 IEEE International Conference on Progress in Informatics and Computing (PIC), Nanjing, 2015, pp. 395-398, doi: 10.1109/PIC.2015.7489876.

[63] M. Kovacevic, B. Kovacevic, B. Pavlovic and N. Bandic, "Visualization of interactive digital television services content in Android operating system," 2012 20th Telecommunications Forum (TELFOR), Belgrade, 2012, pp. 1357-1360, doi: 10.1109/TELFOR.2012.6419469.

[64] R. Hunt, "Security testing in Android networks - A practical case study," 2013 19th IEEE International Conference on Networks (ICON), Singapore, 2013, pp. 1-6, doi: 10.1109/ICON.2013.6781950.

[65] O. C. Novac, I. Mureşan, M. C. Novac, M. P. Ursu, M. Oproescu and C. M. Dindelegan, "Development of a Weather Mobile Application in Android Operating System," 2019 11th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), Pitesti, Romania, 2019, pp. 1-5, doi: 10.1109/ECAI46879.2019.9042040.

[66] S. Agarwal and N. Agarwal, "Interfacing of robot with android app for to and fro communication," 2016 Second International Innovative Applications of Computational Intelligence on Power, Energy and Controls with their Impact on Humanity (CIPECH), Ghaziabad, 2016, pp. 222-226, doi: 10.1109/CIPECH.2016.7918771.

[67] F. Gao, L. Leng and X. Fu, "Palmprint Verification System with Dual-Line-Single-Point Assistance on Android Mobile Devices," 2018 4th Annual International Conference on Network and Information Systems for Computers (ICNISC), Wuhan, China, 2018, pp. 437-441, doi: 10.1109/ICNISC.2018.00095.

[68] K. Nagata, Y. Nakamura, S. Nomura and S. Yamaguchi, "Measuring and Improving Application Launching Performance on Android Devices," 2013 First International Symposium on Computing and Networking, Matsuyama, 2013, pp. 636-638, doi: 10.1109/CANDAR.2013.116.

[69] E. G. d. Oliveira, M. S. F. d. Oliveira, N. R. Neto, F. d. P. Soldati and T. L. C. Nassur, "Development and evaluation of a mobile educational application to support teaching of management of process in Operating Systems," 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia, 2020, pp. 19-21, doi: 10.1109/ICALT49669.2020.00012.

[70] Karim, A. M., Güzel, M. S., Tolun, M. R., Kaya, H., & Çelebi, F. V. (2019). A new framework using deep auto-encoder and energy spectral density for medical waveform data classification and processing. Biocybernetics and Biomedical Engineering, 39(1), 148-159. doi:10.1016/j.bbe.2018.11.004.

[71] Karim, A., KARAL, Ö. and ÇELEBİ, F. (2019). A deep learning approach to EEG based epilepsy seizure determination. [online] Available at: https://www.researchgate.net/publication/304405331_A_deep_learning_approach_to_EEG_based_epilepsy_seizure_determination [Accessed 30 Sep. 2019].

[72] S. N. Verzynov, I. V. Bochkarev and V. R. Khramshin, "Development of Line Locator Software Component for Mobile Operating Systems," 2020 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM), Sochi, Russia, 2020, pp. 1-5, doi: 10.1109/ICIEAM48468.2020.9112019.

[73] N.Nemet, S. Radovanović, R. Simikić, I. Papp and T. Novković, "Adaptive TR-069 system service for Android-based consumer electronic devices," 2013 IEEE Third International Conference on Consumer Electronics ¿ Berlin (ICCE-Berlin), Berlin, 2013, pp. 258-260, doi: 10.1109/ICCE-Berlin.2013.6697980.

[74] V. Bjelić, N. Lukić, S. Kovačević and M. Vucelja, "Improving teletext support for set top box based on Android operating system," 2013 21st Telecommunications Forum Telfor (TELFOR), Belgrade, 2013, pp. 995-998, doi: 10.1109/TELFOR.2013.6716399.

[75] P.Kumar and R. M., "Location Based Parental Control-Child Tracking App Using Android Mobile Operating System," 2018 4th International Conference on Computing Communication and Automation (ICCCA), Greater Noida, India, 2018, pp. 1-4, doi: 10.1109/CCAA.2018.8777612.

[76] H. Shang, Q. Zhang, M. Jin, W. Wang, J. Zhu and Q. Kong, "A portable pulse signal acquiring and monitoring system based on Android platform," 2013 IEEE International Conference on Bioinformatics and Biomedicine, Shanghai, 2013, pp. 226-227, doi: 10.1109/BIBM.2013.6732679.

[77] E. Zhang, S. Peng and Y. Zhai, "Design and Application Development of the Camps Navigation System Based on ArcGIS Runtime SDK for Android : ——Taking the Yunnan Normal University as an example," 2019 IEEE 4th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC), Chengdu, China, 2019, pp. 1262-1266, doi: 10.1109/IAEAC47372.2019.8997730.

[78] A. Lazić, M. Z. Bjelica, D. Nad and B. M. Todorović, "Google Assistant Integration in TV Application for Android OS," 2018 26th Telecommunications Forum (TELFOR), Belgrade, 2018, pp. 420-425, doi: 10.1109/TELFOR.2018.8612143.

[79] M. Ivankovic and I. Basicevic, "Additional Multimedial Screen for Control of a Hbbtv Application with the use of Android Operating System," 2018 26th Telecommunications Forum (TELFOR), Belgrade, 2018, pp. 420-425, doi: 10.1109/TELFOR.2018.8611871.

[80] A. M. Karim, F. V. Çelebi and A. S. Mohammed, "Software Development for Blood Disease Expert System", Lect. Notes Softw. Eng, vol. 4, no. 3, pp. 179-183, 2016.

[81] D. Hongyu, L. Lizong, Q. Dixin and O. Baibing, "Design of College Canteen Ordering System Based on Cortex-A9 and Android," 2020 International Workshop on Electronic Communication and Artificial Intelligence (IWECAI), Shanghai, China, 2020, pp. 179-183, doi: 10.1109/IWECAI50956.2020.00043.

[82] Karim, A.M.; Kaya, H.; Güzel, M.S.; Tolun, M.R.; Çelebi, F.V.; Mishra, A. A Novel Framework Using Deep Auto-Encoders Based Linear Model for Data Classification. Sensors 2020, 20, 6378.

[83] P. A. Shinde, Y. B. Mane and P. H. Tarange, "Real time vehicle monitoring and tracking system based on embedded Linux board and android application," 2015 International Conference on Circuits, Power and Computing Technologies [ICCPCT-2015], Nagercoil, 2015, pp. 1-7, doi: 10.1109/ICCPCT.2015.7159414.

[84] J. Park, H. Chun and S. Jung, "API and permission-based classification system for Android malware analysis," 2018 International Conference on Information Networking (ICOIN), Chiang Mai, 2018, pp. 930-935, doi: 10.1109/ICOIN.2018.8343260.

[85] G. Paul and J. Irvine, "Achieving Optional Android Permissions without Operating System Modifications," 2015 IEEE 81st Vehicular Technology Conference (VTC Spring), Glasgow, 2015, pp. 1-5, doi: 10.1109/VTCSpring.2015.7145666.

[86] Karim, A.M.; Kaya, H.; Güzel, M.S.; Tolun, M.R.; Çelebi, F.V.; Mishra, A. A Novel Framework Using Deep Auto-Encoders Based Linear Model for Data Classification. Sensors 2020, 20, 6378.

[87] N. Moustafa and J. Slay, "UNSW-NB15: A comprehensive data set for network intrusion detection systems (UNSW-NB15 network data set)," in Proceedings of the Military Communications and Information Systems Conference, pp. 1–6, 2015.

[88] L. Ye, H. Qiuyun, M. Xiaofeng, Z. Peng, F. Yanhong and J. Jingsai, "Design and implementation of Android-based speech storage system," 2016 IEEE Information Technology, Networking, Electronic and Automation Control Conference, Chongqing, 2016, pp. 178-181, doi: 10.1109/ITNEC.2016.7560344.

[89] C. Khammassi and S. Krichen, "A GA-LR wrapper approach for feature selection in network intrusion detection," Computers & Security, vol. 70, pp. 255–277, 2017.

[90] Karim, A. M., Güzel, M. S., Tolun, M. R., Kaya, H., and Çelebi, F. V., "A New Generalized Deep Learning Framework Combining Sparse Auto-encoder and Taguchi Method for Novel Data Classification and Processing," pp. 1–22.

[91] M. Kostić, N. Vranić and N. Nikolić, "One solution for safe playback of multimedia content on Android-based systems," 2017 25th Telecommunication Forum (TELFOR), Belgrade, 2017, pp. 1-4, doi: 10.1109/TELFOR.2017.8249449.

[92] Usukhbayar Baldangombo, Nyamjav Jambaljav, and Shi-Jinn Horng "A STATIC MALWARE DETECTION SYSTEM USINGDATA MINING METHODS", International Journal of Artificial Intelligence & Applications (IJAIA), Vol. 4, No. 4, July 2013, 10.5121/ijaia.2013.4411.

[93] Zhang, Y. Yang, X. Wang, A novel android malware detection approach based on convolutional neural network, in: Proceedings of the 2nd International Con- ference on

Cryptography, Security and Privacy, ICCSP 2018, Guiyang, China, March 16–19, 2018, 2018, pp. 144–149, doi: 10.1145/3199478.3199492.

[94] K. Xu, Y. Li, R.H. Deng, K. Chen, Deeprefiner: Multi-layer android malware de- tection system applying deep neural networks, in: 2018 IEEE European Sym- posium on Security and Privacy, EuroS&P 2018, London, United Kingdom, April 24–26, 2018, 2018, pp. 473–487, doi: 10.1109/EuroSP.2018.0 0 040.

[95] T.H. Huang, H. Kao, R2-D2: color-inspired convolutional neural network (cnn)- based android malware detections, in: IEEE International Conference on Big Data, Big Data 2018, Seattle, WA , USA , December 10–13, 2018, 2018, pp. 2633–2642, doi: 10.1109/BigData.2018.8622324.

[96] C. Hasegawa , H. Iyatomi , One-dimensional convolutional neural networks for android malware detection, in: 2018 IEEE 14th International Colloquium on Signal Processing & Its Applications (CSPA), IEEE, 2018, pp. 99–102.

[97] Y. Jiang, K. F. Zheng, Y. X. Yang, S. S. Luo and J. P. Zhao, "Evaluation Model for DoS Attack Effect in Softswitch Network," 2010 International Conference on Communications and Intelligence Information Security, Nanning, 2010, pp. 88-91, doi: 10.1109/ICCIIS.2010.30.