A Case Study on Coronary Heart Disease using Machine Learning Techniques

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ABSTRACT

Background/Purpose: *We have seen an increase in coronary heart disease and heart attack risk in recent years. This is a case study on Sri Jayadeva Institute of Cardiovascular Sciences and Research, Bengaluru to get a better understanding of the heart related ailments and their related symptoms. The hospital specializes in cardiology, cardiothoracic surgery and paediatric cardiology. Based on the symptoms various ailments are diagnosed and treated with different treatments like angioplasty, placement of stent, lifestyle changes and medicines. As part of the research, various health parameters will be collected and analyzed for diagnosing heart related ailments using Machine Learning methods. Determining the appropriate Machine Learning technique to achieve maximum accuracy is the key to achieve a better treatment and prevention of mortality.*

Design/Methodology/Approach: *This study was undertaken using secondary sources, such as website of Sri Jayadeva Institute of Cardiovascular Science and Research, journals, conference articles, the internet and scholarly articles. The SWOT framework is used to analyse, and present, the information acquired from web articles, scholarly papers and other sources.*

Findings/Results: *Heart ailments can be predicted using a few key parameters which can help in avoiding mortality. For this purpose machine learning algorthims, Neural Networks, Particle Swarm algorithm and many more can be applied on those medicial parameters.*

Originality/Value: *This paper reports an exhaustive and comprehensive overview of Coronary Heart Diseases and the treatment provided by Jayadeva Cardiology Hospital on different data collected.*

Paper Type: *Case study-based Research Analysis*

Keywords: Coronary heart disease, Cardiology, Symptoms, Diagnosis, Machine Learning, Treatment, SWOT Analysis.

1. INTRODUCTION :

Early in the fourth millennium BCE, people began to believe that some of their gods could heal. People who went to the shrines of Saturn and, later, the shrines of Asclepius in Asia Minor knew that they were places where they could get better. Historical records show that Brahmanic hospitals were set up in Sri Lanka as early as 431 BCE. In 230 BCE, King Ashoka set up a network of hospitals in Hindustan. Around 100 BCE, the Romans started building hospitals so that their sick and hurt soldiers could get medical care. The Latin word "Hospile," which means "hospital," is where this phrase comes from. The main job of a hospital is to take care of people who are sick, either physically or mentally. All hospitals are supposed to offer spiritual care to the people who stay there. Based on the services they offer, hospitals can be put into categories like specialty hospitals, central government hospitals, government hospitals, government hospitals, private hospitals, public hospitals, corporate hospitals, isolation hospitals, and so on. As with general hospitals in cities, the main goal of rural taluk hospitals, rural primary health centres, and other similar facilities is to provide basic medical care to the general public by treating common diseases and minor symptoms. In specialised hospitals, treatment will be based on a field that focuses on a certain disease or a system's condition, such as ENT, cancer, heart disease,

tuberculosis, and so on. Isolation hospitals are mostly used to treat infections and other diseases that spread easily. When diseases like epidemics and pandemics happen, people have to be kept away from the rest of the world. This paper will aim at understanding the heart related problems and the safety measures taken to analysis with the help of machine learning algorithms. The Sri Jayadeva Institute of Cardiovascular Sciences and Research is an autonomous institute that is run by the government and is dedicated solely to the treatment of cardiac conditions. It is one of the largest single centres in South East Asia that specialises in heart care. People from all different socioeconomic situations can take advantage of this organisation, which operates only on donations, to receive cutting-edge cardiac care at a price that is affordable to them [11].

2. RELATED RESEARCH WORKS :

There has been a lot of research in the field of the prediction of heart related ailments. There have been many papers published based on this research. Each paper uses specific algorithm to predict heart related ailments and every algorithm uses a specific data set for analysis. The prediction accuracy differs based on the data set used and the algorithm used.

The following table summarizes relevant research on specific keywords Coronary heart disease, Artificial Intelligence, Machine learning algorithms from Google Scholar. The listed articles have been published between 2012 – 2021.

Table 1: Scholarly literature on Coronary Heart disease, Artificial Intelligence, Machine Learning Algorithms

S. No	Field of Research	Focus	Outcome	Reference
1	Patient Records	SympGraph: A Framework for Mining Clinical Notes through Symptom Relation Graphs	The experimental results suggest that enlarged symptoms can improve AUC for disease diagnosis prediction, supporting work's therapeutic usefulness.	Sondhi et al., (2012). [1]
2	Mental Health	Psychiatric disorders and cardiac anxiety in exercising and sedentary coronary artery disease patients: a case-control study	CAD patients who participated in a medically supervised exercise programme had decreased PD, anxiety, and sadness.	Braz et al., (2012). [2]
3	Health Behaviors	Direction of Association Between Depressive Symptoms and Lifestyle Behaviors in Patients with Coronary Heart Disease: the Heart and Soul Study	CHD patients with depressive symptoms were more likely to engage in less physical activity, take their medications less consistently, and have poorer quality sleep.	Nancy et al., (2016). [3]
4	Heart disease prediction	Prediction of Heart Disease using Data Mining Techniques	Research shows that Random Forest is more effective than both the decision tree and the Naive Bayes methods.	Fredrick et al., (2018). [4]
5	Cardio vascular diseases	Comparative Analysis of various Techniques for	Possibilities of Datamining techniques to be used in the	Goel et al., (2019). [5]

		Heart Disease Prediction	analysis of Heart Disease. Mentioned the advantages of Analysis model.	
6	Health Care	HeartCare: IoT based heart disease prediction system	Risk assessment for cardiovascular disease using a trained model.	Gupta et al., (2019). [6]
7	Decision Support Sytem	Genetic Algorithm Based Fuzzy Decision Support System for the Diagnosis of Heart Disease	Predicting cardiovascular disease risk using a genetic algorithm-based fuzzy decision support system.	Paul et al., (2016). [7]
8	Heart – Focused Anxiety	Association between heart-focused anxiety, depressive symptoms, health behaviors and healthcare utilization in patients with coronary heart disease	Secondary prevention and increased outpatient care for people with CHD may be hampered by the presence of anxiety and depression.	Katharina et al., (2020). [8]
9	Deep Learning	A Smart Healthcare Monitoring System for Heart Disease Prediction Based On Ensemble Deep Learning and Feature Fusion	With the use of ensemble deep learning and feature fusion, a cutting-edge healthcare system can accurately foretell the onset of cardiac disease.	Ali et al., (2020). [9]
10	Medical Diagnosis	Fuzzy-based Decision for Coronary Heart Disease Diagnosis	A review of the research on how fuzzy-based decisions can be used to diagnose CHD.	Dianirani et al., (2021). [10]

3. RESEARCH GAP :

A few medical signs can give a good idea of a person's chance of getting coronary artery disease (CAD). Blood tests can tell a lot about triglycerides, cholesterol, haemoglobin A1c, fasting glucose, insulin, and heart rate, among other things. The heart rate of a person has a big effect on how well the heart works and how much oxygen is in the body. Several things, like the partial pressure of oxygen (PO2) and the partial pressure of carbon dioxide, affect the heart rate (PCO2). Up until now, not much research has been done on how PO2 and PCO2 affect coronary heart disease and how to predict it. In this study, PO2 and PCO2 will be looked at to see if they can be used to predict heart disease.

4. RESEARCH AGENDA :

(1) Understand the various medical parameters which play a major role in identification of coronary heart disease in a person.
(2) Understand the effect of PO2 and PCO2 on coronary heart disease and prediction model.
(3) Build a hybrid Machine Learning algorithm which can refine the input dataset and improve the prediction accuracy of coronary heart disease in a person based on the high risk parameters in the refined dataset.

5. OBJECTIVES OF THE CASE STUDY :

The objectives of the case study are:
(1) To study about Jayadeva Cardiology Hospital and heart related treatments available.

(2) To understand the functioning of the heart.
(3) To understand about the mal functions of the heart and heart related ailments.
(4) To study the machine learning applications related to heart ailments.
(5) To analyze the various algorithms related to heart disease prediction.
(6) Conduct a SWOT analysis to understand the various algorithm.

6. METHODOLOGY :

Explanatory study is carried out to understand the various heart related ailments and the treatments provided to treat them. Also the various medical parameters related to the heart ailments were collected for analysis. The numerous machine learning techniques and algorithms for predicting the occurrence of heart disease in a person were investigated. For this case study, journals, research papers, and websites were used to obtain information and content.

7. JAYADEVA CARDIOVASCULAR HOSPITAL – AN OVERVIEW :

As an autonomous institute of the Karnataka government, the Sri Jayadeva Institute of Cardiovascular Sciences and Research (SJICR) is located in Bengaluru, Mysuru, and Kalaburagi. As one of Asia's largest heart hospitals, the Bengaluru campus's current 1150 in-patient beds for cardiovascular medicine and surgery as well as paediatric cardiology are housed in two twin eight-story towers.

8. FUNCTIONING OF HEART, CORONARY HEART DISEASES AND THEIR TREATMENTS :

Heart failure is a disorder that arises when the heart is unable to pump enough blood to meet the demands of the body. This can lead to a variety of health problems. This condition is also referred to as coronary heart malfunction [13]. This is called heart failure. Heart disease risk factors include heart attack, smoking, obesity and alcohol misuse, high blood pressure, vitamin deficiency, environmental pollutants, being inactive, sleep apnea, and eating a diet high in animal fats and salt [14, 15, 16].

People who don't get enough oxygen-rich blood have a heart attack when the heart muscle gets hurt or even killed. These arteries bring blood to the heart, like the heart sends oxygen and additional nutrients to other parts of the human body with its own blood. Oxygen isn't getting to the heart muscle because one or more coronary arteries are blocked or narrowed. Cardiac cells that don't get enough oxygen for a long time are permanently damaged or killed. It's medically known as a "myocardial infarction" when someone has a heart attack. As long as the heart has four major arteries, it can move blood all over the body. The body's largest artery, the aorta, pumps blood all over the body after it leaves the heart. The pulmonary artery is the part of the body that brings blood to the lungs. A lot of the heart's blood comes from both the right and left coronary arteries [11].

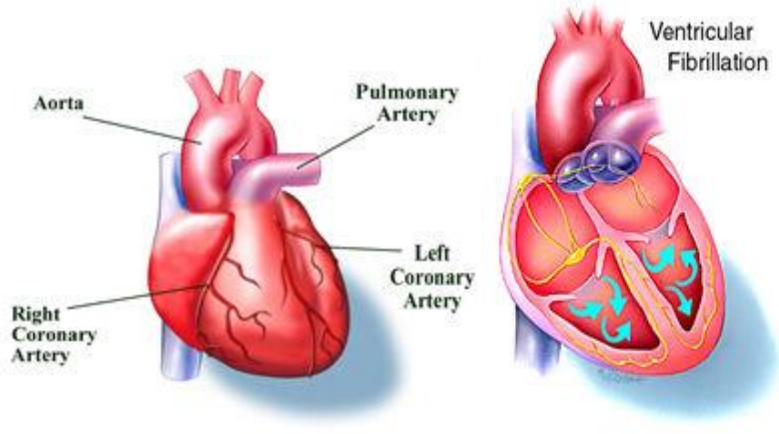

Fig. 1: Image Source: www.jayadevacardiology.com

Types of Heart Diseases

Peripheral arterial Disease: Peripheral arterial disease refers to a constriction or blockage of the arteries that supply blood to the legs from the heart. Atherosclerosis is brought on by the accumulation of fatty plaque in the arteries.

Congenital Heart Disease: Congenital refers to a birth defect. Congenital heart disease can affect the flow of blood through the heart. Several congenital heart disorders affect the heart's natural function.
Rheumatic Heart Disease: Rheumatic fever causes rheumatic heart disease, an inflammatory condition that can affect the heart, joints, skin, or brain. Inflammation and damage to the heart valves are possible. This might result in heart valve constriction or leakage, making regular heart function difficult. Over time, this can result in heart failure.
Aortic Aneurysm: An aortic aneurysm is a bulging or enlargement of the aortic wall. An aneurysm occurs anywhere in the vascular tree.
Angina: Angina is pain in the chest that happens when blood can't get to a part of the heart. It can make the chest feel tight, like a person having a heart attack. It's also known as angina pectoris. It occurs when anything blocks or restricts the arteries that carry oxygen-rich blood to the heart [11].

Heart Failure

Signs and Symptoms

Although the signs and symptoms of a heart attack vary by individual, they are rarely as evident and severe as people imagine. Many heart attacks begin slowly, with chest pain or discomfort that lasts more than a few minutes or that disappears and reappears. A heart attack typically results in pain lasting longer than 30 minutes and can continue several hours. The higher the duration of pain, the greater the chance of muscle injury. Angina is chest pain caused by a reduction in the heart's blood flow. This may be a trigger to a heart attack [11].

Diagnostic Tests

Because the heart's electrical system is so complicated, heart arrhythmias can only be found with special testing skills and tools. To figure out what's wrong, a doctor will do a physical exam and get a medical history. The doctor will next order particular tests based on many factors, including symptom patterns. Several diagnostics exist to diagnose coronary heart disease:

Electrocardiogram (ECG/EKG)

By attaching ten electrodes to various parts of the body, a specific recording device takes a picture of the electrical signals that are responsible for heartbeat patterns.

Echocardiogram

A microphone-like imaging device can film the four chambers of the heart, the valves, and their movements.

Holter Monitoring

In order to identify any abnormal heart beats, patients must wear a recording box the size of a Walkman linked to their chest by five sticky electrode patches for a time duration of 24-48 hours [11].

Event Recorder

Patients carry a small event recording box the size of a pager so that they can record their heart rhythm for one to two minutes when they are experiencing symptoms, rather than waiting until the next day. This is beneficial for people who have symptoms that occur only infrequently and for a short period of time.

Tilt Table Test

This test determines syncope causes. While lying on an exam table, a patient's heart rate and blood pressure can be tracked. Patient is positioned at a 70° to 80° angle for 30–45 minutes.

Electrophysiology Study (EPS)

Electrode catheters are threaded into the heart through the groin or neck in a sterile environment. Heart electrical conduction will be monitored and electrical impulses are often used to produce and study a fast heart rate. The results of this examination can reveal potentially fatally low or high heart rates.

Radionuclide Ventriculography

In radionuclide ventriculography, the heart's pumping ability is measured using multiple-gated acquisition scanning (MUGA).

Cardiac Catheterization

A catheter is a thin, hollow tube that is passed through a blood vessel and into the heart during a cardiac catheterization. The catheter can take samples of damaged heart muscle, assess heart pressure, and identify blood vessel or heart valve dysfunction [11].

Treatments for Coronary Heart ailments

For every heart condition or disease, a range of treatments can be considered.

Balloon angioplasty, stent installation, atherectomy (removal of plaque), pacemaker implantation, and other procedures are all performed in the Cardiac Catheterization Laboratory.
Lifestyle adjustments, medications, device implantation, and surgery may be advised by the Heart and Lung Treatment and Transplant Center. Medicines boost cardiac function and make exercise easier, according to studies [11].

Various facilities available at Jayadeva Hospital

Stress ECG : An exercise stress ECG helps the doctor evaluate if the heart gets adequate oxygen and blood flow when it needs it most, like during exercise.

- Myocardial Perfusion Scan:Myocardial Perfusion Scan reveals how effectively blood flows through the heart muscle and is painless. It reveals damaged cardiac muscle and also known as the Nuclear stress test, that demonstrates how well the heart pumps.
    - Cardiac Catheterization : Cardiac catheterization is a test to see how well the heart is working. A catheter is put into one of the main blood vessels that go to the heart. A cardiac catheterization is used to find out if the heart muscle, the heart valves, or the coronary arteries are damaged.
    - Coronary Angiogram : Coronary angiogram uses a particular dye and x-rays to see how blood flows through the heart's arteries. The procedure is commonly done with cardiac catheterization. This procedure measures heart chamber pressures.
    - Angioplasty : Angioplasty is a way to open up coronary arteries that are blocked. So, there won't be any open-heart surgery. Angioplasty can be done in a situation of emergency, like a heart attack.
    - Stenting : A stent is a small tube that can help treat heart problems. A stent can keep a blocked passage open. Helps to restore blood flow or other fluid flow.
    - Valvuloplasty : Valvuloplasty can fix a stiff heart valve. In valvuloplasty, a thin, hollow tube is inserted into the heart through a groin artery. The doctor inflates a balloon at the catheter's end to open the stiff valve. Doctor deflates balloon and removes catheter after opening the valve.
    - Pacemaker : Usually, Pacemakers are small devices that can be implanted in the body through surgery. They help the heart's electrical system work better. They can stabilise irregular heart rhythms and keep a person from having problems that could harm or disrupt the life.
- RF Ablation : Radiofrequency ablation (RFA) is a way to get the heart back in the right rhythm. A thin wire sends heat to fix parts of the heart that don't work properly. To put the heart back into a normal rhythm, medicines can also be used.
- EP Studies : An electrophysiological study (EP study) is a test that looks at the heart's electrical system and looks for heart rhythms that don't seem right. Natural electrical impulses from within the body coordinate the contractions of the different components of the heart. When this is done, the blood flow improves.
- 64 slice cardiac - C.T. Scan : The 64-slice multidetector CT scanner allows doctors to see previously invisible coronary artery diseases and blockages. CT collects many pictures, allowing for more diagnostic information in less time. A CT scan takes narrow x-ray scans from numerous directions, unlike typical 2-D imaging.
- M.R.I Scan : Magnetic resonance imaging (MRI) combines magnets and radio waves to take photographs inside the body. As a result, the doctor can see the patient's bones as well as any soft tissue that may be present. However, the focus of a heart or cardiac MRI is limited to the cardiac organ and its surrounding blood arteries.

Statistical Report of Patients and Procedures in Jayadeva Hospital

Now a days there is an increase in the number of people getting affected by Coronary heart diseases. The awareness about diseases, their symptoms and their related treatments have increased among people. Hence people visit hospitals at the earliest and Jayadeva Hospital is a pioneer in treating Coronary heart diseases. As depicted in graphs below in Fig 2, Fig 3, Fig4 and Fig 5, number of outpatients, number of in patients, number of cardiac path procedures performed, number of stenting procedures performed are increasing year by year [12].

Fig. 2: Shows Substantial increase in heart disease treatment at jayadeva hospital [12]

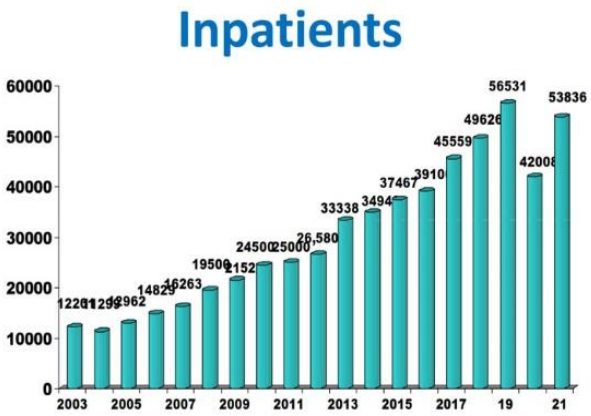

Fig. 3: Substantial increase in inpatients treatment for heart disease at jayadeva hospital [12]

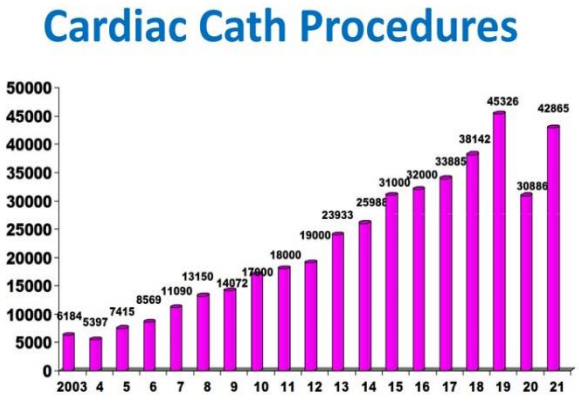

Fig. 4: Number of Cardiac path procedure done in Jayadeva hospital from 2003 to till date [12]

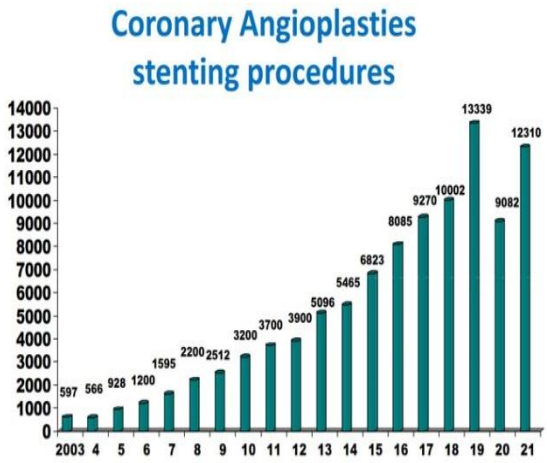

Fig. 5: number of Coronary Angioplasties stenting procedures done in Jayadeva hospital from 2003 to till date [12]

9. ROLE OF MACHINE LEARNING IN HEART DISEASE PREDICTION :

Machine Learning

In recent years, Artificial Intelligence (AI) has become a main topic of discussion not only inside the scientific community but also outside of it. There have been a significant number of scholarly articles published on the topics of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL). Even though the phrases are the same, we can't switch between them. AI is a field that focuses on making machines do intellectual tasks that humans have always done. The goal of artificial intelligence can be reached through machine learning and deep learning [23].

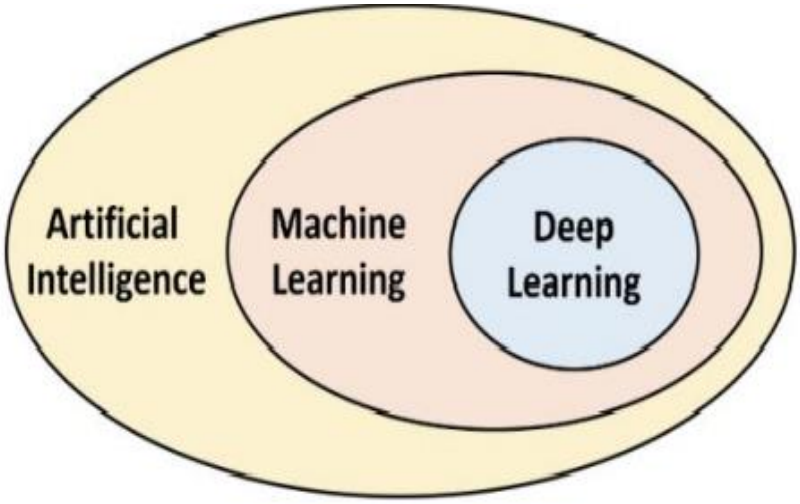

Fig. 6 : Artificial Intelligence, Machine Learning and Deep Learning Paradigm

ML is an area of AI that develops algorithms to appropriately represent data. Classical programming uses well-known algorithm properties. An algorithm is derived based on machine learning prinicples and is applied on subsets of data that may include innovative or various combinations of attributes [17].

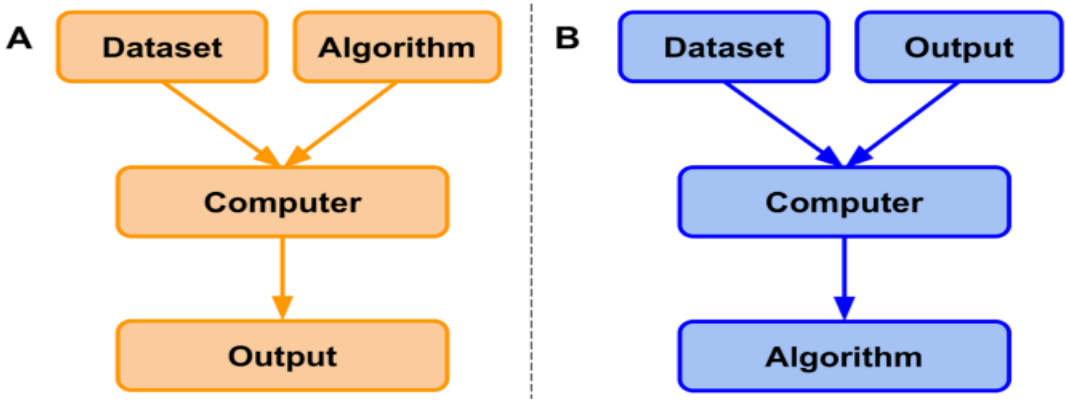

Fig 7: Classical Programming versus Machine Learning
(A) Classical Programming (B) Machine Learning

Machine learning technology includes multidisciplinary theoretical knowledge, such as statistics and algorithm complexity, which boosts AI's functional qualities [18].

The goal of ML is to derive new facts from existing data. Many studies have been conducted to regulate how to programme computers to learn on their own. The demand for ML is increasing as a result of the size of data that is available. Machine learning is used in a variety of applications, from medical to the military, to extract vital information [19].

Working of Machine Learning

There are 3 main steps in Machine Learning:

A Decision Process: Machine learning algorithms make a prediction or categorization. Based on labelled or unlabeled input data, the algorithm assumes a data pattern.

An Error Function: The accuracy of the model's predictions is measured by an error function. If there are examples that are already known, an error function can be used to compare them and figure it out how accurate the model is.

Model Optimization Process: When the model matches the training set data better, the weights are modified to decrease the difference between the actual example and the estimated value. After evaluating and optimising, the algorithm will update weights until a particular level of accuracy is reached.

Learning Methods

ML uses three learning methods for solving different tasks:

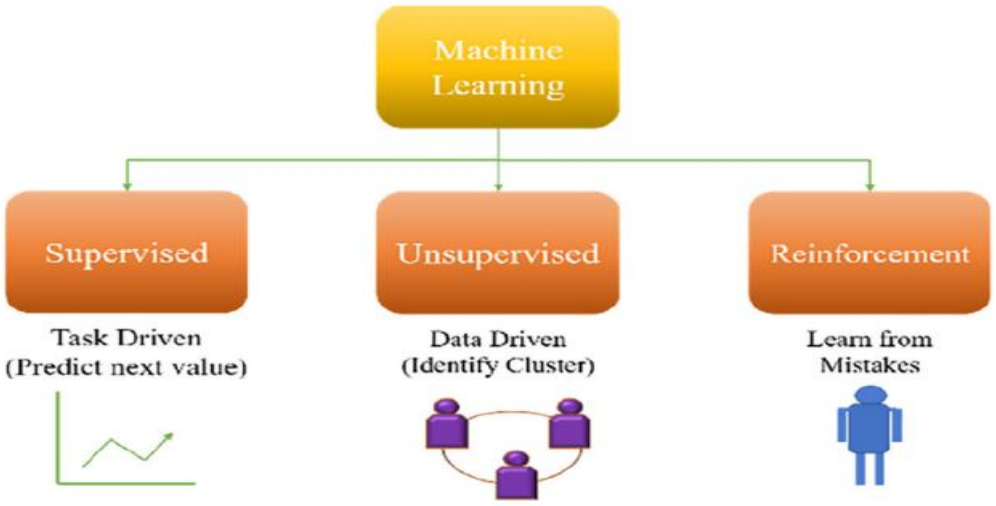

Fig. 8: Learning methods of Machine Learning

Supervised Learning

External support is required for Supervised Learning because it is based on an algorithm. The provided input database has been divided into two groups: training datasets and testing datasets. In the training database, the output variable is predicted or categorized. When learning from a database, algorithms attempt to learn particular forms and then apply these patterns to a testing database, which produces results in the form of estimation [20].

Unsupervised Learning

Only a few number of data features are extracted by unsupervised learning methods. When new data is introduced, the system determines the type of data by using previously learnt features. It is primarily used in clustering and feature reduction techniques [19].

Semisupervised Learning

Semisupervised learning methods combine the advantages of supervised and unsupervised learning into a single algorithm. In disciplines such as machine learning and data mining, when unlabeled data is already present and acquiring labelled data is a time-consuming process, this technique can be useful [19].

Reinforcement Learning

Action-based decision concept learning is reinforcement learning. So that the outcomes are of more value at the output or desired favourable situation, measurements are made based on the decision taken. But the learner lacks past data. In supervised learning, the correct answer is instructed to the model by providing the training data that includes the answer key. In reinforcement learning, there is no right answer. Instead, the agent that gives reinforcement decides what to do. It is forced to learn from its own mistakes since it lacks access to a training dataset [20].

10. MACHINE LEARNING ALGORITHMS :

The following are the commonly used algorithms for Machine Learning:

Decision Tree Algorithm

The decision tree algorithm is included in the category of classic algorithms. A decision tree is a structure for inductively learning the relationships between categories of data. It's a method of machine learning that uses simple decision-making steps to break down massive volumes of data into more digestible bits. If a group is successfully subdivided, its constituent parts become progressively more like one another at the end of the process [21]. When processing data, it starts at the root node of the collection instance and moves forward until it gets to the place where all the nodes come together to make a full collection instance. There are scientific categories for practical examples. The decision-making process will separate the branches to make data analysis easier and trim the branches to improve data quality [18].

Random Forest Algorithm

A technique for group classification is called a "random forest algorithm" is widely used in the fields of machine learning and data science for a wide range of tasks, such as recognising images. "Parallel ensembling" is used, which involves fitting numerous decision tree classifiers at once to distinct subsamples of various data sets and letting the conclusion or final outcome be selected by majority vote or averages. As a result, the problem of "over-fitting" is kept to a minimum, while the accuracy of predictions and control are both improved. Random Forest learning models with several decision trees are often more accurate [22].

Artificial Neural Network Algorithm

In data processing, to mimic the performance of real neural networks in the brain, engineers have developed artificial neural networks. Brain-inspired artificial neural networks are built around neurons (process components). An input neuron has five main functions: weights (coefficient), summation function, activation function, and output [21].

To simulate the process of human information transfer, artificial neural networks are used to classify distinct data into one neuron and connect the data neurons together with the help of the network in order to achieve complicated memory functions [18].

SVM Algorithm

In 1995, Cortes and Rapnik created a supervised classification technique called support vector machines (SVM), which is still widely used today. It is a subfield of machine learning that can make inferences about unlabeled data [21].

The algorithm in this specific application process is heavily reliant on the vector machine approach to perform the well-known data analysis work. The SVM algorithm will make advantage of the automatic help provided by the SVM to examine the data information that will be processed in order to improve the data information [18].

Boosting and Bagging Algorithms

This is a new type of ML algorithm. The primary benefit of its application is that it may finish the processing of data information with a higher degree of precision, hence increasing the precision of the processing result that is ultimately produced. In actual practise, the system for function prediction will be constructed using the Boosting algorithm, and the content of the system will be uninterruptedly optimised using the reinforcement learning mode, which will result in a faster processing of data. The Bagging algorithm is fairly similar to other algorithms in terms of how it processes data. The Bagging method uses a random selection process to select the training set. Additionally, during the process of calculating the function model, the Bagging algorithm does not perform an analysis of the weight content. Because of this, we need to continuously optimise the data model with the assistance of training in order to improve the accuracy of the results of the data analysis [18].

About Dataset

In ML, a dataset is a group of pieces of data that a computer can think of as a single unit for the purposes of analysis and prediction. To put it another way, the data collected should be rendered standard and understandable for a machine, which does not see data in the same way people do.

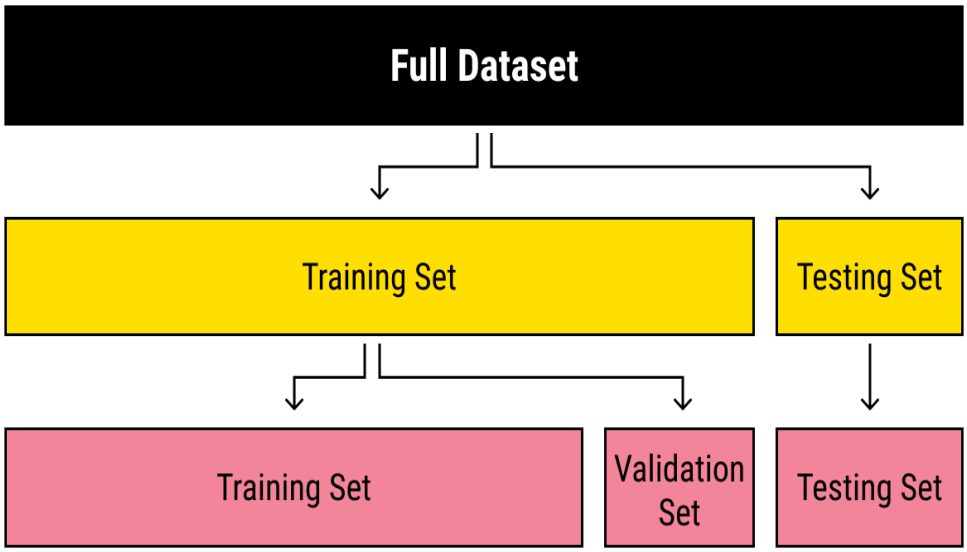

Fig. 9: Splitting dataset into training, testing, and validation datasets

Sample Dataset table with parameters

Table 2: Sample dataset with medicial parameters for heart ailment prediction [27]

	Age	Sex	ChestPain	RestingBP	Cholesterc	FastingBS	RestingECG	MaxHR	ExerciseAr	Oldpeak	ST_Slop	HeartDisease
2	40	M	ATA	140	289	0	Normal	172	N	0	Up	0
3	49	F	NAP	160	180	0	Normal	156	N	1	Flat	1
4	37	M	ATA	130	283	0	ST	98	N	0	Up	0
5	48	F	ASY	138	214	0	Normal	108	Y	1.5	Flat	1
6	54	M	NAP	150	195	0	Normal	122	N	0	Up	0
7	39	M	NAP	120	339	0	Normal	170	N	0	Up	0
8	45	F	ATA	130	237	0	Normal	170	N	0	Up	0
9	54	M	ATA	110	208	0	Normal	142	N	0	Up	0
10	37	M	ASY	140	207	0	Normal	130	Y	1.5	Flat	1
11	48	F	ATA	120	284	0	Normal	120	N	0	Up	0
12	37	F	NAP	130	211	0	Normal	142	N	0	Up	0
13	58	M	ATA	136	164	0	ST	99	Y	2	Flat	1
14	39	M	ATA	120	204	0	Normal	145	N	0	Up	0
15	49	M	ASY	140	234	0	Normal	140	Y	1	Flat	1
16	42	F	NAP	115	211	0	ST	137	N	0	Up	0
17	54	F	ATA	120	273	0	Normal	150	N	1.5	Flat	0
18	38	M	ASY	110	196	0	Normal	166	N	0	Flat	1
19	43	F	ATA	120	201	0	Normal	165	N	0	Up	0
20	60	M	ASY	100	248	0	Normal	125	N	1	Flat	1
21	36	M	ATA	120	267	0	Normal	160	N	3	Flat	1
22	43	F	TA	100	223	0	Normal	142	N	0	Up	0
23	44	M	ATA	120	184	0	Normal	142	N	1	Flat	0
24	49	F	ATA	124	201	0	Normal	164	N	0	Up	0
25	44	M	ATA	150	288	0	Normal	150	Y	3	Flat	1
26	40	M	NAP	130	215	0	Normal	138	N	0	Up	0
27	36	M	NAP	130	209	0	Normal	178	N	0	Up	0

Sample Parameter Descriptions for Heart Disease Prediction

Resting BP : In adults, hypertension is not a concern if the systolic pressure is less than 120 mm Hg and the diastolic pressure is less than 80 mm Hg. When the systolic pressure is between 120 and 129 mm Hg and the diastolic pressure is less than 80 mm Hg, a person has high blood pressure [27, 28].

Cholesterol Level: Heart disease is more likely to happen if the cholesterol level is high. Total cholesterol should be less than 200 mg/dL (milligrammes) or 5.2 mmol/L (millimoles). LDL cholesterol, or low-density lipoprotein cholesterol [29].

Fasting BS: Normal fasting blood glucose is 70-100 mg/dL. A fasting blood glucose of 100 to 125 mg/dL requires lifestyle changes and glycemia monitoring [30].

Resting ECG: Resting ECG measures cardiac electrical activity. The sinus node pumps blood through rhythmic contractions triggered by electric impulses [31].

11. SWOT ANALYSIS :

SWOT analysis stands for "strengths, weaknesses, opportunities, and threats." It is a structured process that looks at a project or business from four different angles. A SWOT analysis can be done on a business, a product, a place, an industry, or a person [24].
The introduction of AI techniques in healthcare represents a qualitative and quantitative leap in the interpretation of clinical imaging data and the processing of enormous volumes of data for imaging research. Currently, AI approaches in healthcare have a diverse range of well-established applications that can be considered [26]. SWOT analysis of Machine Learning and Artificial Intelligence includes the various strengths, weaknesses and also opportunities and threats of this methodology in heart disease prediction.

11.1 Strengths:

- It has been common in the medical field for a long time to use science and technology to help prevent, control, diagnose, and treat diseases [25]. AI and ML are crucial in predicting the occurrence of any disease in a person.
- In the definition of EBM (Evidence-Based Medicine), it is "the careful, explicit, and judicious application of current best evidence in making decisions regarding the care of individual patients." Data-based medicine is defined as "the integration of human clinical competence with the best available external clinical evidence derived from systematic research" [25].
- Because of developments in data storage, analytics tools, processing power, and its methods, EBM will become more practical and effective as data volume, diversity, and accessibility continue to rise [25].

- The availability of an Electronic Health Record facilitates data analysis and prediction of heart disease at an early stage through the application of various machine learning algorithms.
- The proliferation of mobile devices (such as wearable fitness trackers) and mobile apps is largely attributable to advancements in areas such as the Internet, mobile telecommunication networks, global positioning systems (GPS), and cloud computing, all of which are having significant impact on healthcare and our daily lives [25].

11.2 Weaknesses:

- When it comes to acute and chronic illnesses, modern medicine excels at alleviating symptoms but falls short when it comes to disease prevention and treatment. This is because diseases are complicated and have many underlying clinical, behavioural, and socioeconomic factors [25].

Measureable and non-measurable elements that influence health and healthcare can be identified. In the case of natural or measurable factors, ML and AI may be successful tools, but they must rely on human intellect and decision in the case of cultural or immeasurable aspects [25].

11.3 Opportunities:

- The fields of computer science and information technology have advanced at a remarkable pace over the past decade. At the junction of the Internet of Things (IoT), cloud computing, mobile computing, ML, AI, and other technologies, there has emerged a multitude of tools, approaches, and tools for performing massive data analyses [25].
- The application of AI is focused on the refinement of existing ML algorithms and the development of new ones to allow a more resourceful and accurate diagnosis while eliminating the need for human interaction [26].
- Caffe, Tensorflow, Apache MXNet, and Torch are just a few of the deep learning frameworks that are now accessible for free and open source: As a result of these frameworks, which enable efficient multithread implementations of common operations in ML and new projects are being developed [26].
- Applications of Deep Learning
    - **Health Sector**: At the moment, the medical industry is producing tremendous amounts of data. This data can be used to improve patient outcomes in a variety of ways, if it is analysed quickly and accurately. A variety of fields, including medical research, imaging analytics, disease prevention, guided medication development, and natural language processing which can be particularly useful for filling out free text clinical notes in electronic health records—have embraced DL algorithms in recent years (EHRs).
    - **Public Sector**: Government agencies can use DL to increase automation and efficiency as more departments, systems, and procedures are digitised. Image detection and categorization can assist police in locating suspects in public places. Algorithms can be used to automate aspects of the visa and immigration processes. DL is being used by airports to automate queue management and increase security. DL algorithms can assist in predicting traffic conditions, which can help to reduce traffic congestion [26].

11.4 Threats:

- Reality is unknown. Data are approximations of the real properties of an object, and they can be collected by people or by sensors. It is impossible to avoid the biases of the people who make the tools for measuring and collecting data. Analytics results are skewed by data that is incomplete, wrong, or missing [25].
- Even while big data analytics have the potential to enhance the quality and efficiency of healthcare, we must not take cyberattacks and data breaches lightly. Patient confidentiality and healthcare providers' bottom lines are both jeopardised by cyberattacks on healthcare IT systems [25].
- The general public and the medical profession have the impression that algorithms and computers are unable to deliver a more accurate diagnosis than medical specialists [26].
- It is difficult and time-consuming to validate various ML potential applications by administrations, which is one of the main barriers to ML adoption in clinical practise Professionals must approve or reject almost every clinical output of ML algorithms [26].

- The lack of industry-wide integrated solutions that incorporate ML into workstations limits its widespread clinical application. The use of ML approaches will be postponed until both environments are merged [26].

12. FINDINGS AND SUGGESTIONS :

Despite significant efforts and enthusiasm, ML has not yet fulfilled its promise, especially in cardiology. Even while the number of articles published on ML has increased rapidly in recent years, prospective trials demonstrating therapeutic benefit, especially in cardiovascular medicine, are still uncommon. To present, very few ML project outcomes have been incorporated into cardiology clinical guidelines, which clinicians utilise routinely when treating patients.

The doctor-patient interaction adds another level of intricacy. When dealing with acute or chronic illness, patients often consult with their doctors for advice on the best course of therapy. When doctors struggle to implement the findings of machine learning-based clinical research into patient care, the process becomes incredibly difficult. The therapeutic relationship between the doctor and patient suffers as a result, and the patient may feel overburdened by the weight of responsibility for their care.

Carefully constructed tools should be built to adequately express output of ML risk models during patient encounters, perhaps through the use of interactive dashboards, and the incorporation of ML principles into modern medical school curriculam should begin immediately. Building a foundation of trust between clinicians and patients for the outcomes of ML algorithms is crucial to the future of ML's widespread use in healthcare and Cardiology in specific.

13. CONCLUSION :

“Prediction and diagnosis of any kind of ailment in the body at an early stage will help treat the ailment in a better way and cure the same.” Science and Technology has grown rapidly today to make the above statement possible. Machine Learning is a division of Data Science which can help in the field of Medicine to diagonise and treat numerous ailments in a better way. One of the major ailments which have become prevelant today is heart related ailments. Mortality due to heart related ailments and heart attack can be prevented by using the appropriate Machine Learning Algorithm and making precise prediction on a particular data set of the health related parameters. Arriving at the appropriate algorithm to make accurate prediction is the key to achieve this goal. This case study gives a wide knowledge on this key factor.

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