COVID-19 MONITORING WITH IoT DEVICES

Ambika Nagaraj

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COVID 19 – Monitoring with IoT Devices

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FOREWORD I

Till December 2022, more than six hundred fifty-one million confirmed cases of COVID-19, whereas more than six million deaths were reported to WHO from all over the world. The SARS-CoV-2 virus and its variants spread mainly if there is close contact between people. In confined and enclosed places, short-range aerosol, airborne, droplet transmission happens at a conversational distance. It is recommended to avoid poor ventilation, and crowded indoor settings, and touching eyes, nose, or mouth after touching surfaces or objects. Anyone asymptomatic or pre-symptomatic carrying the virus can spread it. Singing, and breathing during the exercise can cause the virus to spread. Well-fitted three-layered masks, alcohol-based hand rubs, one-meter distance, cleaning hands, avoiding touching surfaces, and getting vaccinated can avoid SARS-COV-2 virus infection.

Monitoring public places, and hospitals, and understanding the overall situation in a country and the world is important to reduce the adverse impacts of Covid-19. Monitoring the situation, and venues without direct touch is possible through the Internet of Things (IoT) based solutions. The sensors, actuators, RFIDs, Near Field Communications, Unmanned Aerial Vehicles (UAVs) connected through the Wireless Sensor Network, and the Internet are the crucial elements in the monitoring of the COVID-19 situation.

Smart thermometers, Telehealth Consultations, wearables, robot assistance, and remote monitoring through the GPS-based ArogyaSetu are a few examples of IoT-enabled devices useful in COVID-19 monitoring. In particular, electronic sensors in the form of epidermal tattoos biomarkers cortisol, contact lenses for intraocular pressure, textiles face masks observe breathing patterns, airborne pathogens, inflammation markers, skin temperature, and metabolism monitoring, wristbands for the heartbeat and O_2 monitoring, and microneedle patches can help collect previously inaccessible physical and biochemical signals. Professor Steve Lindsay from Durham University developed the organic semiconducting (OSC) sensors that can detect fingerprints from body odor samples.

Author Dr. Ambika has good experience in the research field of WSN and academic experience. The content of the book is interesting and timely. Alone an IoT cannot bring insights and decisions based on the data collection, hence the author has elaborated machine learning techniques for the necessary actions based on the predictions. The predictions can help the government, social bodies, and individuals prepare themselves to handle the difficult situation of the pandemic. The content is highly relevant to extend the research in the health domain and to support the preparation of the policies in the governance of the country.

The pandemic created emotional and psychological impressions of low mood, tiredness, pessimism, poor sleep, and appetite, and feeling helpless, guilty, and hopeless, with a gradual reduction in work output. The IoT System monitoring the behavioral and allied patterns is equally important as that of social monitoring. The individual suffering from the infections needs to be monitored and counselled through the technological aspect. This will be an important input for all who would like to contribute and like to work in this direction.

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FOREWORD II

Covid sickness (COVID-19) is an irresistible illness brought about by the SARS-CoV-2 infection. The vast majority contaminated with the infection will encounter gentle to severe respiratory ailment and recuperate without requiring urgent treatment. In any case, some will turn out to be genuinely sick and require clinical consideration. More weak individuals and those with basic ailments like cardiovascular infection, diabetes, acute respiratory sickness, or disease are bound to foster difficult diseases. Anybody can get infected with COVID-19 and become genuinely sick or pass on at whatever stage in life. Observing and overseeing expected contaminated patients of COVID-19 is yet difficult with the most recent advancements. As a preventive measure, legitimate group checking, and the board frameworks are expected to be introduced in the open spots to restrict unexpected out brakes and confer further developed medical care. The quantity of new contaminations can be essentially diminished by taking on social distancing. In such scenarios, these smart IoT gadgets can become a very significant and important tool. The book introduces 5 chapters that discuss many interesting ideas that show how IoT devices are helping to tackle situations in the manufacturing and operational ecosystem of COVID-19.

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PREFACE

In patients with severe COVID-19, SARS-CoV-2 can cause not only antiviral immune responses to be activated but also uncontrolled inflammatory responses characterized by the significant release of pro-inflammatory cytokines. It can result in lymphopenia, lymphocyte dysfunction, and abnormalities in granulocytes and monocytes. Septic shock, severe multiple organ dysfunction, and infections by microorganisms may result from these immune abnormalities brought on by SARS-CoV-2. There is growing evidence that patients with viruses have resistant patterns closely linked to their disease progression. These patients exhibit lymphopenia, activation, and dysfunction of lymphocytes. They also have abnormalities in granulocytes and monocytes. They show elevated cytokines and increased immunoglobulin G (IgG) antibodies.

The well-defined scheme known as the Internet of Things (IoT) comprises digital, mechanical, and interconnected computing techniques. These devices can transmit data over a defined network without any human involvement. It is the network-compliant system of connected devices and operations, including; software, hardware, the network's connectivity, and any other necessary computer or electronic device that ultimately makes them responsive by supporting data altercation and collection. Utilizing an interconnected web made it possible for the healthcare system to be helpful for the proper monitoring of COVID-19 patients. The hospital readmission rate is reduced, and this technology improves patient satisfaction. The book is a description of how these devices aid in helping humanity.

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CHAPTER 1

COVID -19

Abstract: Corona is a single-stranded RNA virus that has been around since the late 1960s when it was first discovered. The Nidovirales order includes the Corona viridae family of viruses. The crown-shaped spikes on the virus structure's outer surface inspire the name Corona. The virus has affected chickens and pigs, but there hasn't been a significant human-to-human transmission. The virus's mode of communication and other related information are continually updated every few weeks, increasing uncertainty. A Chinese study suggests that the COVID-19 pandemic had a significant psychological impact on more than half of the participants. One more ongoing review from Denmark revealed mental prosperity as adversely impacted. According to the American Psychiatric Association's survey, nearly half of Americans were anxious. The chapter details the disease, its symptoms and measures taken.

Keywords: Covid-19, SARS-CoV-2.

1.1. INTRODUCTION

The most recent infectious disease to rapidly spread across the globe is coronavirus disease 2019, also known as COVID-19 [1, 2]. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [3] is the etiologic agent of COVID-19. The World Health Organization and the Public Health Emergency of International Concern declared the 2019–2020 pandemic due to the discovery of SARS-CoV-2 for the first time in Wuhan, China, in 2019. The disease began in Asia, but it has rapidly spread worldwide. It is the first coronavirus-related pandemic, according to the World Health Organization. Italy has risen to a prominent position in the international picture of infected patients due to the impressive growth in reported cases over time. Fig. (**1**) depicts the transmission of the disease. Fig. (**2**) represents SARS-CoV-2 virus depicting spike protein and mRNA core. Figs. (**3**-**5**) represent Integrative post-COVID symptoms model in non-hospitalized patients.

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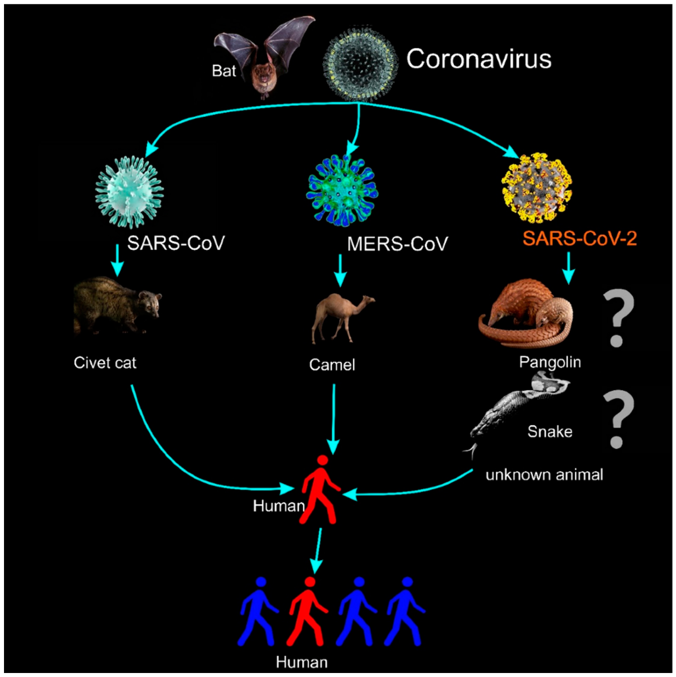

Fig. (1). Illustration for the transmission of coronaviruses [3].

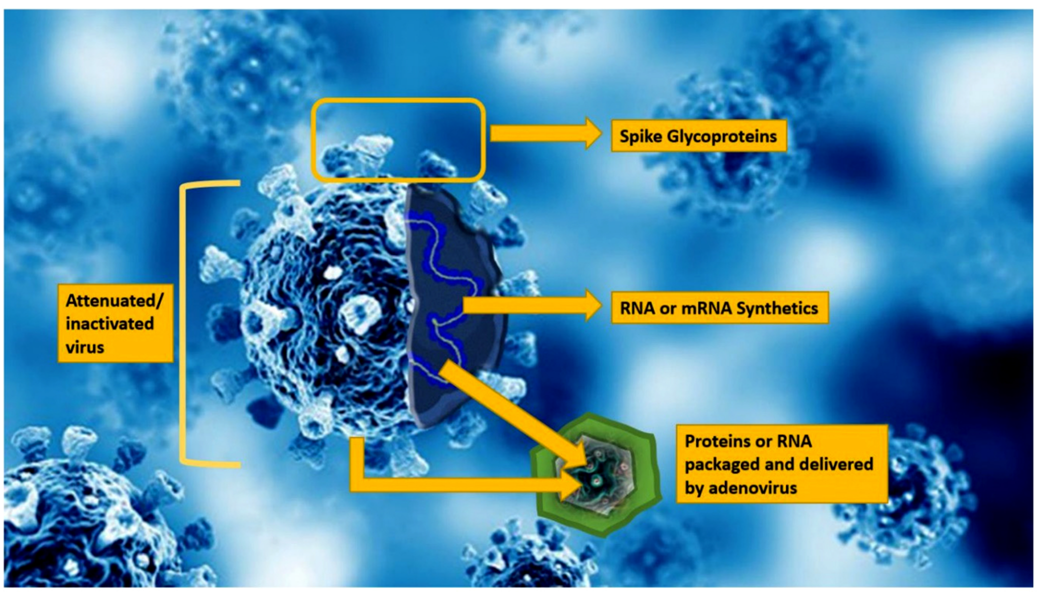

Fig. (2). Artist sketch of SARS-CoV-2 virus depicting spike protein and mRNA core [4].

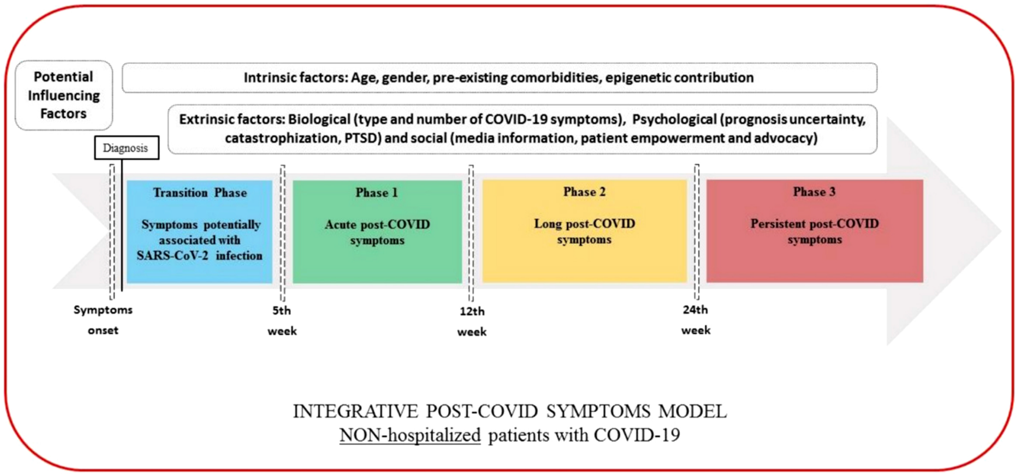

Fig. (3). Integrative post-COVID symptoms model in non-hospitalized patients showing transition phase (blue), and phases 1 (green), 2 (yellow), and 3 (red) of post-COVID symptoms. PTSD: post-traumatic stress disorder [5].

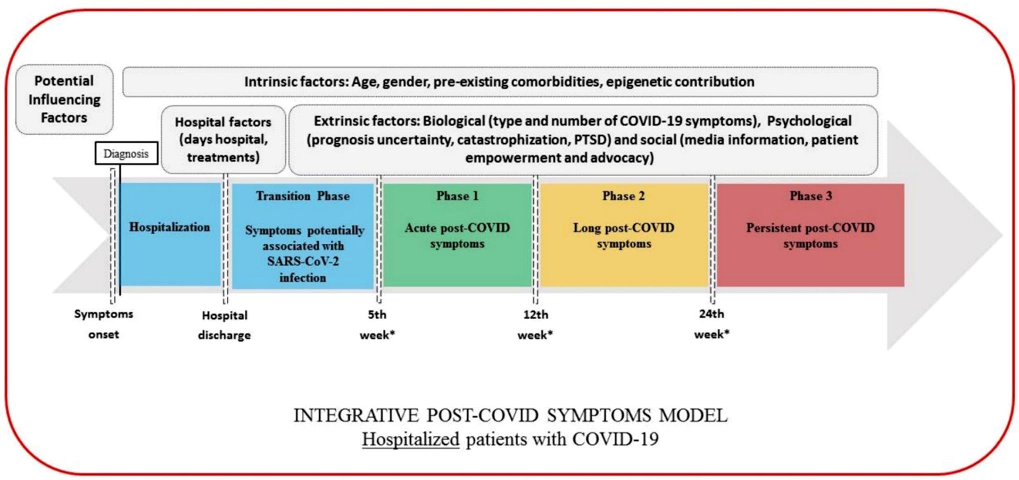

Fig. (4). Integrative post-COVID symptoms model in hospitalized patients showing transition phase (blue), and phases 1 (green), 2 (yellow), and 3 (red) of post-COVID symptoms. PTSD: post-traumatic stress disorder [5].

CHAPTER 2

Supervised Learning Algorithms

Abstract: Numerous domains now employ learning algorithms. It has distinct performance metrics appropriate for them.. Based on a predetermined set of paired input-output training samples, a machine learning paradigm known as “Supervised Learning” is used to gather information about a system's input-output relationship. An input-output training sample is also known as supervised or labeled training data because the output is regarded as the input data or supervision label. Supervised learning aims to build an artificial system that can learn the mapping between input and output and predict the system's output, given new information. The learned mapping results in the classification of the input data if the output takes a limited set of discrete values representing the input's class labels. Regression of the information occurs if the output takes continuous values. The chapter details the various algorithms, technologies used and their applications.

Keywords: Known Label, Regression, Supervised Algorithms.

2.1. INTRODUCTION

Numerous supervised learning methods [2] have found applications in processing multimedia content and supervised learning accounts for a significant amount of machine learning research. In supervised learning, a mapping between a set of input variables X and an output variable Y is learned and used to predict outputs for data that has not been seen. The availability of annotated training data is the defining characteristic of supervised learning. The name evoked the concept of a “supervisor” who directs the learning system regarding the labels to associate with training examples. In classification problems, these labels are typically class labels. From these training data, supervised learning algorithms generate models that can be used to classify other unlabeled data. Fig. (**1**) represents contrastive learning pipeline for self-supervised training.

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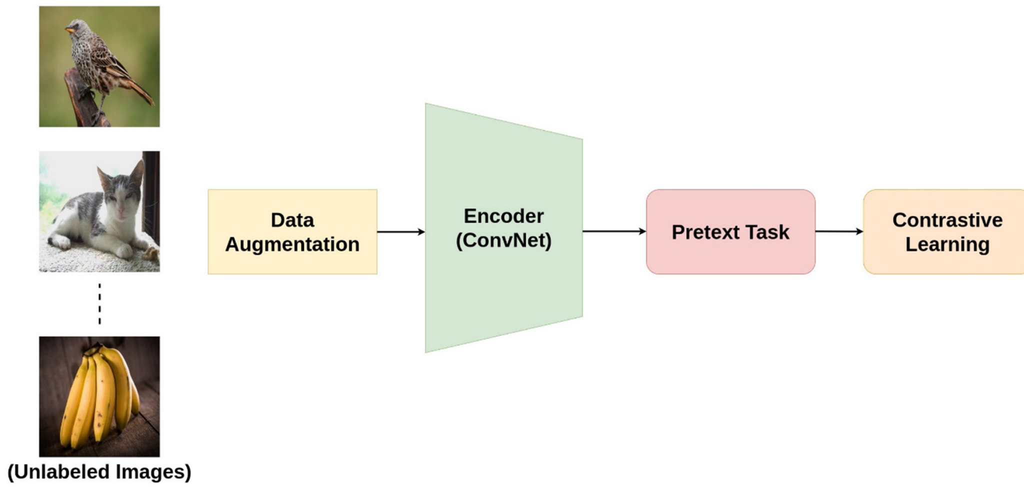

Fig. (1). Contrastive learning pipeline for self-supervised training [1].

The five main components of the proposed system model [3] are as follows: pre-processing, balancing, feature extraction, classification, and validation of the data are all included. The three-sigma rule, normalization, and interpolation of missing values are used to pre-process electricity data. The next model uses the pre-processed data for data balancing. The data are balanced using the Adasyn algorithm. Thirdly, the essential features are extracted from time series data using a VGG-16, and fourthly, the critical parts are given to FA-XGBoost for classification. A high-resolution accurate, intelligent meter data set provided by China's State Grid Corporation serves as the basis for testing the proposed system. 1032 are the input dimensions or features. The collection of data lasted for three years. Forty-two thousand three hundred seventy-two customers' electricity consumption data are included. The recently released data reveals the undisputed fact that 9% of all customers are victims of electricity theft. Fig. (**2**) depicts the same.

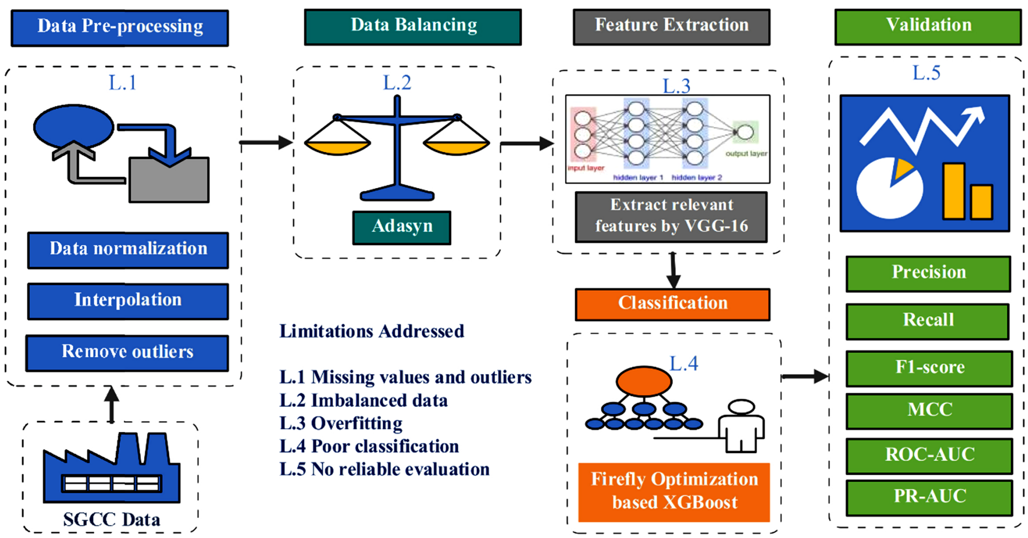

Fig. (2). Proposed model [3].

2.2. SUPERVISED LEARNING ALGORITHMS

2.2.1. Support Vector Machine

A computer algorithm known as a support vector machine (SVM) uses examples to teach itself how to label objects. By looking at many scanned images of handwritten zeroes, ones, and other digits, SVM can learn to recognize them. Additionally, SVMs have been successfully utilized in many biological applications. The automatic classification of microarray gene expression profiles is a common biomedical application for support vector machines. It can determine a diagnosis or prognosis by analyzing the gene expression profile derived from a tumor sample or peripheral fluid.

The speech recognition process [4] is improved by utilizing a hybrid Support Vector Machine (SVM) and Dynamic Time Warping (DTW) algorithm to contribute to the proposed framework. It is a smartphone-dependent system for speech recognition to execute a single command based on matching against the user command and the recorded speech templates. The proposed solution is a machine learning-based system for controlling smart devices through speech commands with an accuracy of 97 percent. To train the system to recognize these commands using the smartphone's microphone and voice command matching, each user should record these commands for various home appliances. Then, only a smartphone is used to send orders. A machine learning model is used to match

CHAPTER 3

Semi-Supervised Algorithms

Abstract: Semi-supervised learning, or SSL, falls somewhere between supervised and unsupervised learning. The algorithm is provided with some supervision data in addition to unlabeled data. There are two primary learning paradigms in it. Transductive education aims to use the trained classifier on unlabeled instances observed during training. This kind of algorithm is mainly used for node embedding on graphs, like random walks, where the goal is to label the graph's unlabeled nodes at the training time. Inductive learning aims to develop a classifier that can generalize unobserved situations during a test. This chapter details different semi-supervised algorithms in healthcare.

Keywords: Semi-supervised algorithms, Logistic regression, Unlabeled data, Linear regression.

3.1. INTRODUCTION

The subfield of machine learning, known as semi-supervised learning, uses both labeled and unlabeled data for specific learning tasks. In semi-administered learning research, an extra presumption frequently included is group suspicion. The information addresses similar classes. The primary objective of semi-supervised learning is to use unlabeled data to improve learning methods. The relative performance of various machine learning algorithms is influenced by numerous decisions when evaluating and comparing them. Additional factors play a role in semi-supervised learning. First, it must decide which to label data points and which should remain unlabeled in many benchmarking scenarios. Second, one can evaluate the learner's performance on a test set that is entirely disjointed or on the unlabeled data used for training, which is, by definition, the case in transductive learning. In addition, it is essential to establish high-quality supervised baselines to evaluate the unlabeled data's added value accurately. Fig. (**1**) portrays the same.

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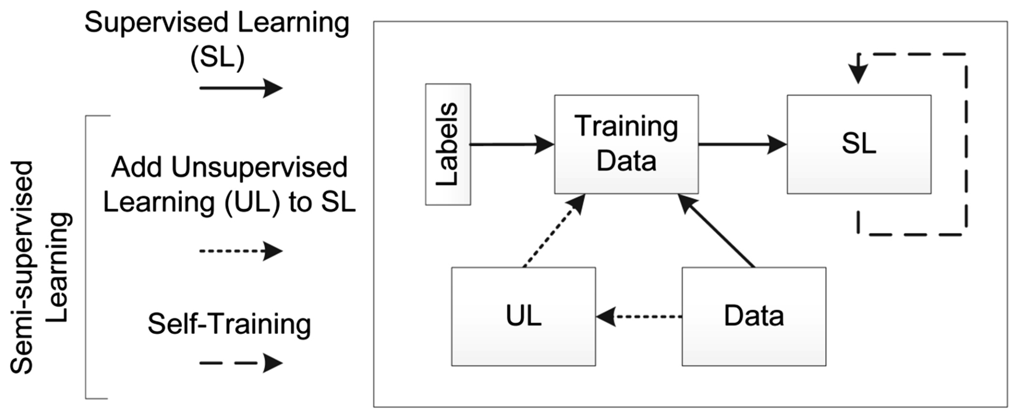

Fig. (1). Relation of semi-supervised learning (SSL) approaches to standard supervised learning [1].

3.2. SEMI-SUPERVISED ALGORITHMS IN HEALTHCARE

A type of Machine Learning (ML) technique is called semi-supervised learning (SSL). It is somewhere between administered and solo learning, *i.e*., the dataset is somewhat named. It eliminates the disadvantages of supervised and unsupervised learning. Compared to unlabeled data, the labeled data should be shorter. The idea behind semi-supervised learning is that performance significantly shifts when labeled and unlabeled data are used together. The training set that is being used is more temporary. Usually, it is used to find outliers. Various information has materialized in medical care, including clinical information, sensor information, Omics information, *etc*. This kind of data requires multiple algorithms to be trained to make better predictions, and various mining techniques are used to find the most relevant features. Fig. (**2**) represents the Conceptual schematic for artificial intelligence in cardiovascular genetics.

The study [3] is a brand-new semi-supervised model for medical image classification. It uses an improved version of focal loss at the supervision loss to reduce sample misclassification. It incorporates a self-attention mechanism into the backbone network to learn more meaningful features for image classification tasks. It contains samples of intrinsic relationship characteristics. The mechanisms have student and teacher models. The model can spontaneously extract richer inherent information from representatives of unlabeled data and capture more crucial features of the current classification task. Finally, the improved focus loss is incorporated into the supervision loss, resulting in misjudged samples dominating the model's minimization goal and consequently improving the model's performance. For single-label classification, the ISIC 2018 dataset is utilized. It contains 10,015 examination images of seven common skin lesions labeled as instances. Fig. (**3**) represents the same.

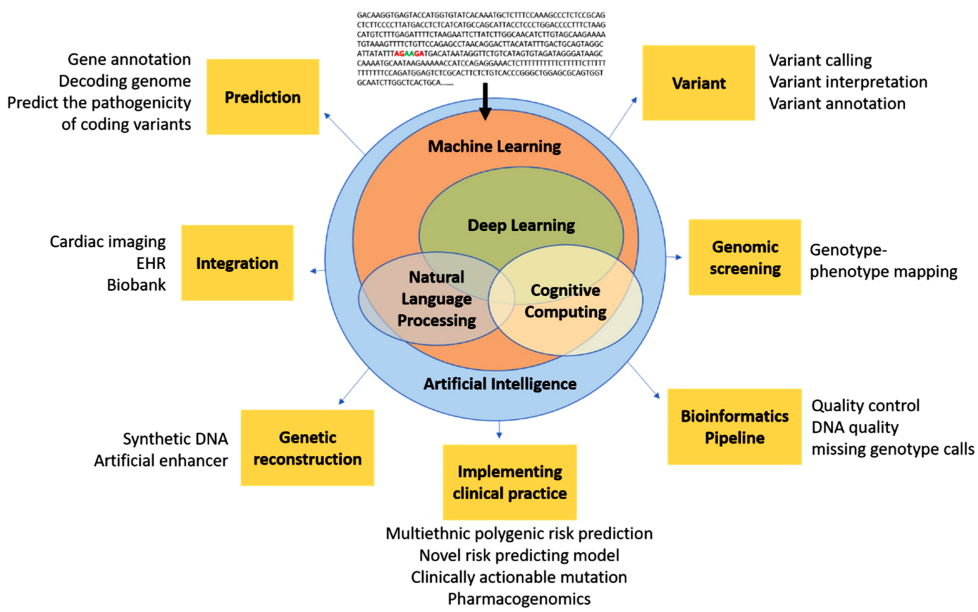

Fig. (2). Conceptual schematic for artificial intelligence in cardiovascular genetics [2].

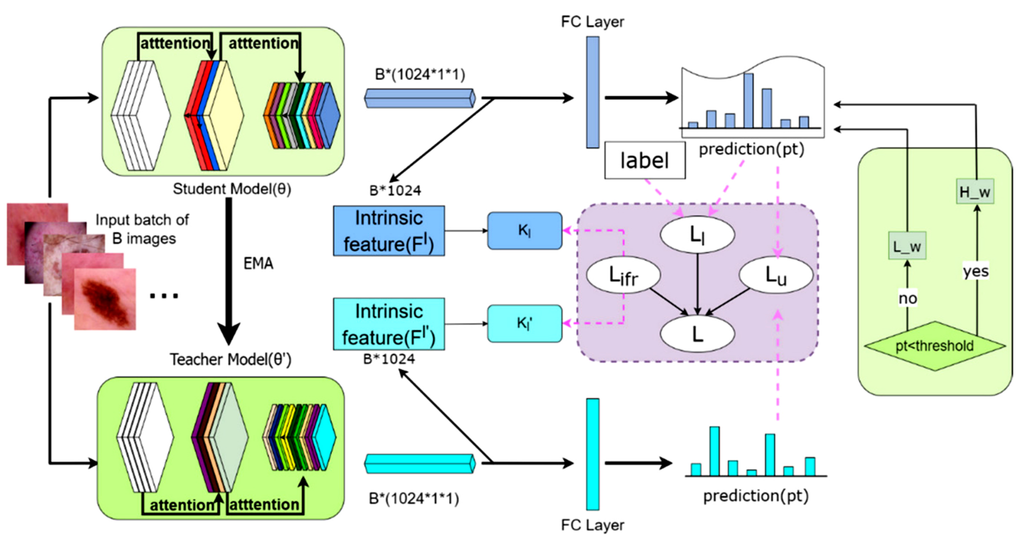

Fig. (3). Semi-supervised framework for medical image classification [3].

CHAPTER 4

Unsupervised Algorithms

Abstract: The broad term "health care" refers to a system that focuses on improving medical services to meet the needs of patients. Patients, doctors, vendors, health companies, and IT companies all work to keep and restore health records in the healthcare industry. It uses machine learning. Healthcare analysis addresses a variety of diseases, including cancer, diabetes, stroke, and others. Both the labeled value and the target value are known. Training the data for unsupervised learning is also involved. Because the label value is either unknown or absent, it is impossible to evaluate the model's performance in unsupervised learning. The chapter details different unsupervised algorithms.

Keywords: Healthcare, Unsupervised Algorithms, Unlabeled Data.

4.1. INTRODUCTION

The process by which a network can study to signify some input designs in a manner that reproduces the numerical arrangement of the total collection of input designs or patterns is called unsupervised learning. The assumption of a function to define the hidden structure from unlabeled data is a machine learning charge. It is learning algorithms that lack labels to monitor learning and training. The algorithm accepts data and characteristics specific to each observation as inputs but not the desired output. Typically, unsupervised learning is used to divide the images into two sets or clusters based on inherent characteristics like color, size, shape, and so on. Because there is no external source of information for the network, it is referred to as either an adaptive learning algorithm or a self-organizing algorithm. It is contingent on the internal mechanism and local facts. The system receives the training figures and input patterns, which it organizes into categories or clusters. At the stage of the input layer, the system receives a group of training patterns or data. The output layer's nodes compete to adjust the network association weights, with the winner being the node with the highest value. The majority of algorithms for clustering and association make use of unsupervised learning.

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A novel strategy [1] for unsupervised component condition identification is presented in this study. For modelling, it uses test cycle data of machine components under various faulty and healthy conditions. A test cycle is performed on any machine tool component without engaging the workpiece and outside machining times. It ensures that the requirements for generating and acquiring data are comparable. The test cycles' used to train the model and the model used to make predictions are the same. While the process of measuring and modeling remains the same for each machine component, each component undergoes its independent analysis. The method is shown to be effective for machine axes in this study. The test cycle's results in healthy and various faulty states are gathered for each axis. Similarly, a rotatory axis is rotated from its starting position to its limit of outward movement and then back to its starting position. There are four segments in each trajectory direction: a constant velocity segment, an acceleration ramp with a transient response, and a deceleration ramp with a quick response until the vehicle comes to a complete stop. It recreates the operating conditions necessary for detecting and quantifying anomalies. The test cycles are carried out with the standard process dynamics and velocities of the machine components that are currently in use. In addition, the test cycles are repeated multiple times to enable the detection of outliers in the recordings and reduce sample variation. The resulting data set is divided into test and training sets. Test cycle data of machine axes under unknown conditions are used to evaluate their health status during a prediction model deployment. The aggregated feature sets can train a model to learn similarities and differences between feature set samples. It predicts a time series sample of an unidentified machine condition. The time series is divided into the defined ROIs. After selecting and calculating the model's retained features, the model scalar normalizes the resulting characteristics and applies the trained HDBSCAN model to the unknown feature set. Fig. (**1**) Solution approach for both model training and prediction of test cycle samples.

This work [2] first shows that the unsupervised learning paradigm can also be used to classify images of HEp-2 cells. A deep convolutional autoencoder with an encoding-decoding method for feature extraction is proposed. It can identify the two components of the network: the encoder, which gradually reduces the input's spatial size, and the decoder, which gradually expands the input's spatial scope while decreasing its depth. As we progress within the network until we reach the space of the latent representations, the input image is systematically down-sampled before the decoding or up-sampling begins. It has the outcome that the organization loses the spatial data of the picture in many layers. This distortion complicates the reconstruction process. It employs two approaches utilized in the segmentation issues. The encoder's maximum pooling process entails storing the positions of the selected activations. The unpooling process in the decoder will only consist of setting all remaining values to zero and placing the activations at the stored posts. It obtained the outcomes by using the SNPHEp-2 dataset. There are five types of cells in the SNPHEp-2 dataset-homogeneous cells, coarse and fine speckles, cells with nuclei, and cells with the centromere. This dataset has two levels of fluorescence intensity: powers, both positive and negative. It used all 40 different cell samples to extract the images. Twenty of the forty specimens were utilized for the training sets, while the remaining twenty were used for the testing sets. There are separate 905 and 979 cell pictures for the preparation and testing sets. Fig. (**2**) denotes the same.

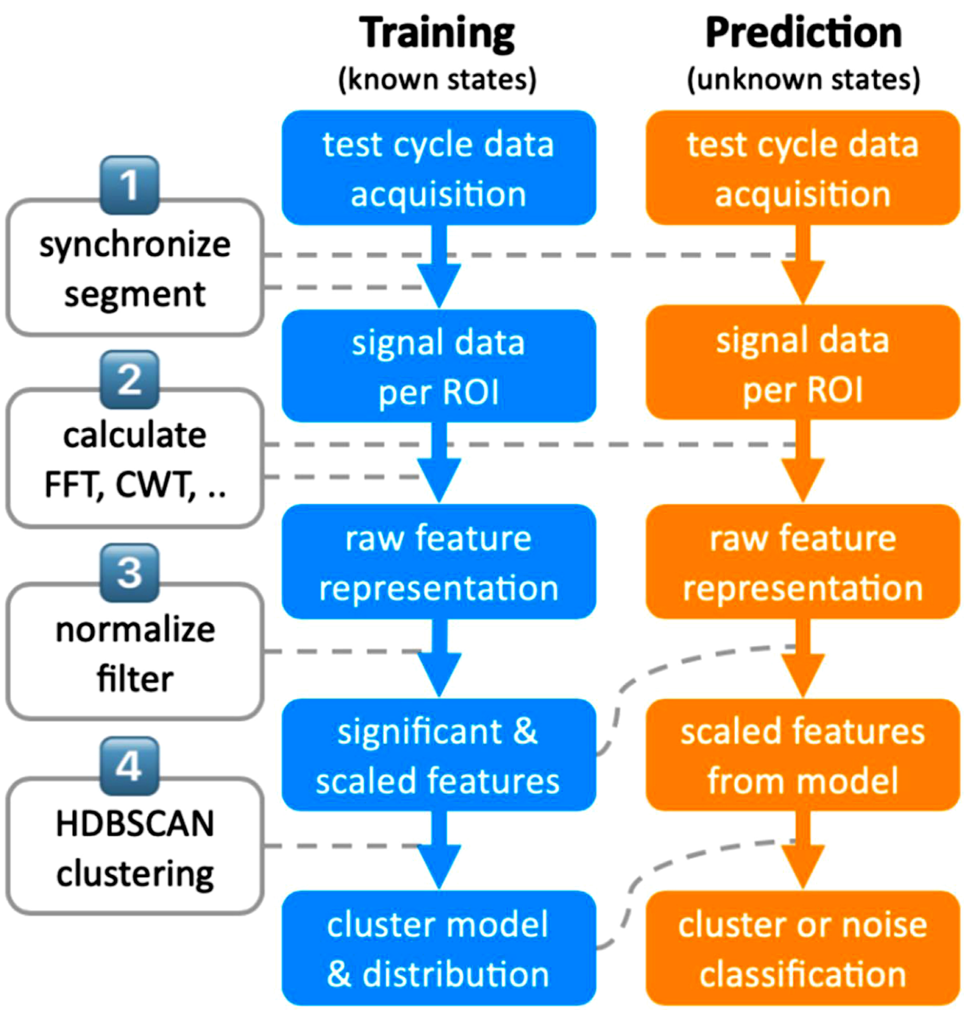

Fig. (1). Solution approach for both model training and prediction of test cycle samples [1].

CHAPTER 5

Role of Internet-of-Things During Covid-19

Abstract: In December 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection that caused pneumonia spread to Wuhan City, Hubei Province, China. Fever, dry cough, and fatigue are typical clinical manifestations of COVID-19, frequently accompanied by pulmonary involvement. SARS-CoV-2 is highly contagious, making most people in the general population susceptible to infection. One of the most popular technologies, the Internet of Things (IoT), has much potential for combating the coronavirus outbreak. It has transformed real-world objects into sophisticated virtual ones. The Internet of Things (IoT) aims to connect everything in our world and assist users in controlling the objects in their immediate vicinity and keeping them informed of their current state. IoT devices sense the environment without human or machine interaction and send the gathered data to the Internet cloud. Tens of millions of devices are connected *via* the Internet of Things (IoT), and the number of connected devices is rapidly increasing.

The chapter aims to highlight the role of IoT devices in detecting Covid-19. It details the different architectures of the system. Various domains, like the role of machines in healthcare, transportation, entertainment, retailing, and education, are detailed. It addresses challenges - awareness, accessibility, human power crisis, affordability, and accountability. Some of the future directions managed including edge architecture, cryptography, blockchain, machine learning, digital twin, unified network integration, context-aware accessibility, edge and fog computing, and sensor and actuator integration are summarized.

Keywords: Coronavirus 2, Covid-19, Detection, IoT, Prevention, SARS-CoV-2.

5.1. INTRODUCTION

Due to its significance in numerous applications in education, industry, and commerce, Internet of Things research looks promising. The process of connecting machines, equipment, software and things in our environment is what the Internet is all about. Instead of thinking of the Internet as a collection of connected computing devices, it is now thought of as a collection of related things in a person's living space, like machines, transportation, goods, business storage, and home appliances, among other things. The living space contains more objects than the entire human population. An item in the Internet of Things [1] should

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have a unique address for each component. The technology known as radio-frequency identification (RFID) is used for communication. There should be a way for IoT [2] to determine its users are and their rights and restrictions. Fig. (**1**) portrays the applications of IoT.

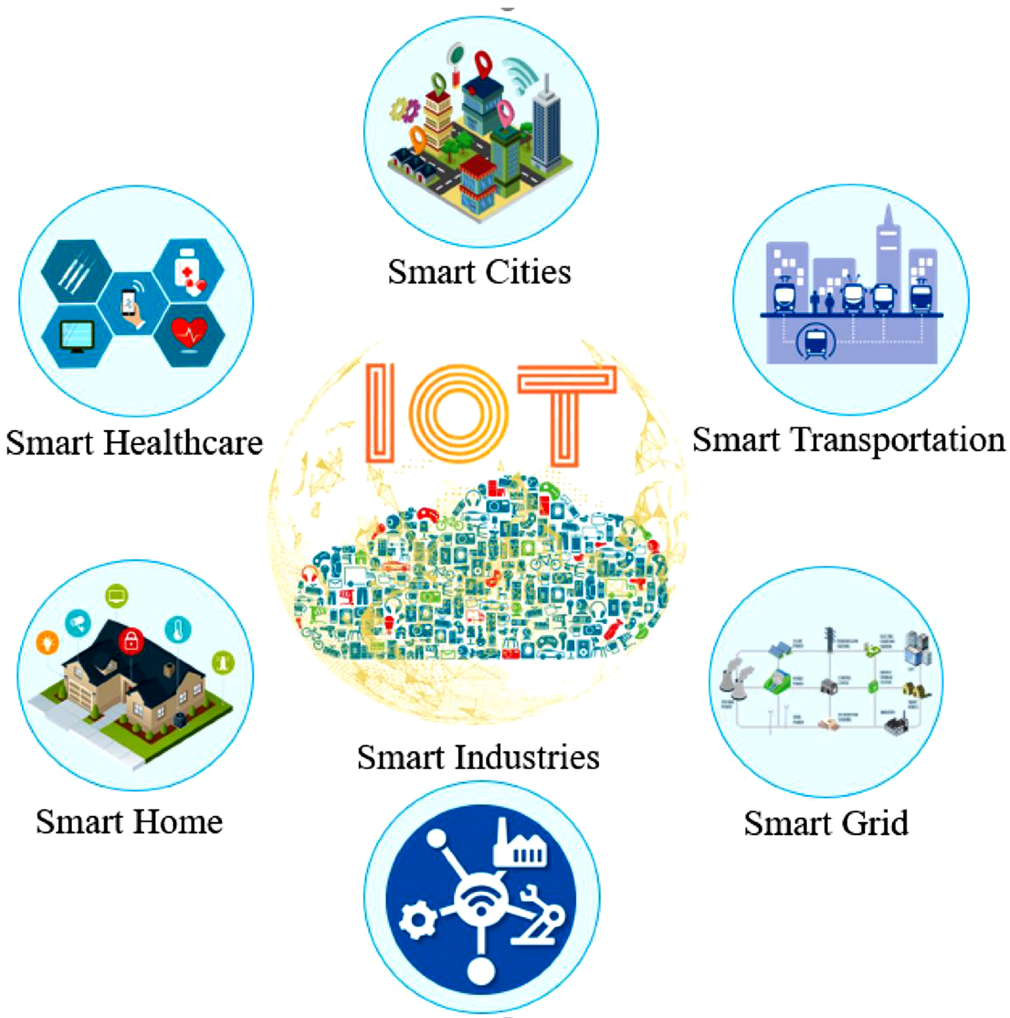

Fig. (1). IoT-based applications [3].

5.2. ARCHITECTURE

The term "Internet of Things" (IoT) [4] refers to a system of devices that are connected, have computing power (smart objects), can be identified, and can transfer data over a network without the need for human interaction. To be incorporated into everyday objects, IoT [5, 6] requires a few components. The incorporation of silicon components into metallic or fabric materials has the potential to broaden the field of component miniaturization and integration. Fig. (**2**) represents the 3-tier architecture of IoT.

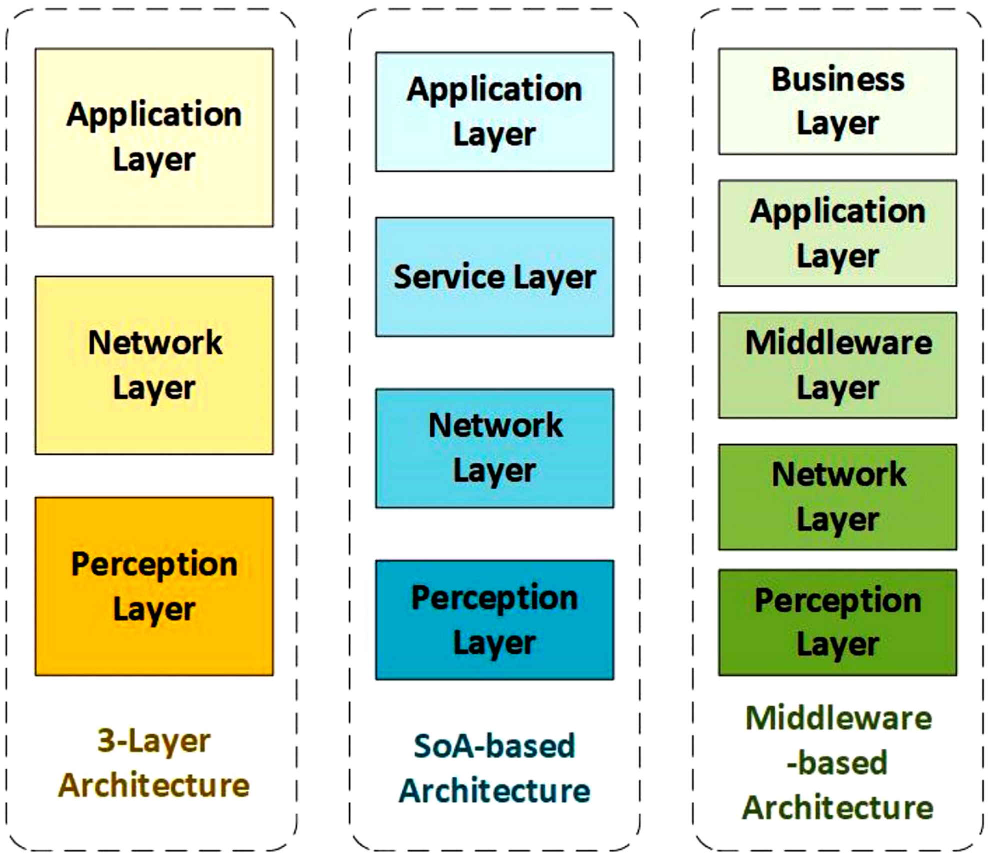

Fig. (2). - 3-tier Architecture [7].

The perception layer collects and processes information to interact with the environment and represents the physical level of objects. This level has things that can communicate with the outside world. The data provided by the perception level must be transported to the application layer by the network layer. It includes all of the protocols and technologies that enable this connection. The software required to provide a particular service is all contained in the application layer. Databases, analysis software, *etc*., that are used to store, aggregate, filter, and

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Prof. Ambika is an MCA, MPhil, and Ph.D. in computer science. She completed her Ph.D. from Bharathiar University in the year 2015. She has 18 years of teaching experience and works for St.Francis College, Bangalore. She has guided BCA, MCA, and M.Tech students in their projects. Her expertise includes wireless sensor networks, the Internet of things, and cyber security. She also delivers guest lectures. She is a reviewer of books, conferences (national/international), encyclopedias, and journals. She is an advisory committee member of some conferences. She has many publications in the national & international books and journals, conferences, and encyclopedias. She has some patent publications (national) to her credit and she is also registered for copyright in the computer science division