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# Image analysis and data processing for COVID-19

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## 1. Introduction

Coronavirus was first introduced in the 1960s as a human coronavirus accountable for infection in the upper respiratory tract in children. Five cases were subsequently found in 2003 with severe serious respiratory syndrome (SARS) coronavirus, which has significant morbidity and mortality. This virus affects both the upper and part respiratory systems. The wide spread of SARS put animal coronaviruses into the spotlight [1]. The enormous variety of animal coronaviruses was unsurprising considering the severe respiratory syndrome called SARS. The virus has spread throughout the world from southern China. In 2002 to 2003, SARS infection was verified in 29 countries. More than 8000 infected individuals were detected, 774 of whom died of SARS. In that period, human isolation was successful in eliminating the virus. Coronavirus triggers asthma in children and critical respiratory disease in adults. Within the bell-shaped curve of respiratory contamination, it may cause pneumonia and bronchiolitis infections. Researchers [2,3] revealed coronavirus SARS-CoV in bats, representing the near phylogenetic association between SARS-CoV and SARS-like coronavirus (SL-CoV). SL-CoVs were also discovered in rhinophids from Slovenia, Bulgaria, and Italy in Europe; in regions of Africa, novel beta coronaviruses connected to SARS-CoV were noted in *Hipposideros* and *Chaerephon* species from Kenya, Nigeria, and Ghana. Bat SL-CoVs such as Rp3 were unlikely be the reason for human infection. There may not be a direct connection to human infection through a bat virus. The Middle East respiratory syndrome (MERS) coronavirus, detected in a camel from a Middle East country, has shown similarity to human SARS-CoV. COVID-19 is a single-stranded RNA virus that is

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easily conveyed from one person to another, comparable to SARS and MERS; it is also primarily conveyed through respiratory systems and physical contact [4,5]. Health literacy is a crucial tool to prevent people from passing along the disease. In this pandemic situation, governments and citizens have to take immediate action to enhance health literacy among the world's citizens. The virus is speedily transmitted among people, so health guidelines have been issued to the public to be safe. Moreover, exercise is a simple and easy method to boost the immune system. It helps avoid airborne diseases and maintains the fitness of the body [6–8].

Image analysis improves the quality of images to perform segmentation and classification. In the health care system, analysis of medical images is done to recognize disease and treat patients efficiently. The analysis of chest computed tomography (CT) scanned images quickly detects pneumonia, and thus better distinguishes COVID-19 patients likely to need more supportive care. There are many techniques for recognizing coronavirus disease, including chest CT scans, blood tests, and detection kits. Image analysis provides an effective response with the assistance of deep learning algorithms to detect disease. The efficiency of image and data analysis provides segmentation results and iteratively adds more training data samples to update the model. After image segmentation, various metrics are computed to enumerate COVID-19 infection, including the capacities of infection in whole lungs and volumes of infection in each lobe and bronchopulmonary segment. The multiclass classification performance of a COVID-19 model was assessed for each fold, and the average classification performance of the model was calculated. The designed model is sensitive for detecting pneumonia. It also predicts pneumonia with positive symptoms of coronavirus disease [9–12]. COVID-19 is a pandemic disease; image analysis and data processing have an important role in analyzing patients' chest CT scan images to extract features and classify whether patients are in a risky or safe zone.

A chest CT scan image analysis of patient who has a disease helps medical staff diagnosis the disease accurately. Machine learning and deep learning solve many complex problems. The algorithms are used in health care systems to detect and diagnose disease efficiently to protect the lives of citizens. A deep learning algorithm was used to analyze data to predict whether patients are considering at risk or safe. The symptoms of Covid-19 and the other barrier precaution is to enhanced hand hygience using mask, goggles, gloves sometimes it fails to protect the health care staff. There is strong evidence that COVID-19 can easily be transmitted by patients who are mildly ill or have other health issues [13,14]. The influence of coronaviruses is not yet known because much remains to be revealed despite advances in research. The rest of this chapter is ordered as follows: Section 2 discusses the detection and analysis of COVID-19 patients. Section 3 illustrates data processing and analyzes the number of patients. Section 4 presents the deep learning algorithm used in image analysis. Section 5 concludes the chapter with references.

# 2. Explanations regarding detection and analysis for COVID-19

The health care system is highly concerned about patients' health. In recent years, The disease, diagnosis, and treatments are said to be performed with fewer side effects. Coronavirus is an infectious and highly communicable disease that is easily transferred from one person to another. Medical staff have to keep from being chronically stressed or being in poor mental health while treating patients to fulfill their role in a decent manner. It is also necessary to ensure that accurate updated information and good communication are provided to all medical staff [15]. If an infected person sneezes or coughs in front of a healthy person, the healthy person will become affected. Common symptoms of COVID-19 include fever, coughing, sneezing, and difficulty breathing. Other symptoms that indicate a person is infected by the disease are a loss of smell, sore throat, dry cough, muscle pain, and abdominal pain. The virus is mostly aerosolized among people in close contact by small droplets produced by sneezing or coughing, or is spread by touching contaminated surfaces [16]. The virus lives on surface up to 72 h. To prevent infection, measures need to be taken, including social distancing, lockdowns, frequently hand washing, wearing a mask when outside, and using a tissue when sneezing or coughing and disposing of the tissue in a closed container. No vaccine or antiviral treatment has been discovered for COVID-19. Patients are treated through supportive care, isolation, and experimental measures. This virus can be transmitted while exhaling and talking. The deadly virus mostly affects internal body parts; lungs are the most affected part because COVID-19 accesses the host cell via angiotensin-converting enzyme 2, which is most plentiful in type II alveolar cells of the lungs.

## 2.1 Data augmentation technique to analyze COVID-19 patients

Image data augmentation techniques refer to a method that can artificially magnify the size of a training dataset by generating a reformed version of images in the dataset. It generally focuses on reducing overfitting and benchmarking results thorough image datasets [17,18]. Despite the presence of fresh data points that are not self-sufficient and consistently detached, it establishes the models and enhances outcomes, as established by statistical learning. Data augmentation has long been used in machine learning and it has been acknowledged as an investigative element of several models. Image data augmentation reduces the overfitting of data to represent a wide-ranging set of likely data points and dip the space amid the training and validation set. This technique has made tremendous progress in classifying and segmenting images. It also useful for predicting whether a patient is infected. It has made it easier for researchers and doctors to segment lung CT scans of patients to provide effective results in less computational time.

## 2.2 Image analysis for detection of COVID-19

Researchers have proposed image processing and analysis of chest CT scans to detecting and track COVID-19. General symptoms include coughing, chest pain, and shortness of breath. The COVID-19 pandemic has had more than 2,404,249 confirmed cases around the world. The speed at which the virus has traveled has astonished the world and has had a massive influence on public daily lives and the world economically. As Anastassopoulou et al. discussed [19], the incubation period of COVID-19 is 2–14 days. There were infected but undetected people ($E$) in the natural environment of the susceptible population ($S$) when the first case was identified. Some people who were infected need to go through an incubation period before suspected symptoms can be detected ($Q$). Chest CT imaging was used to observe whether there were glassy shadows in the lungs to determine the diagnosis (Table 22.1).

To study the deeper COVID-19 transmission rule, the researchers performed a detailed analysis of parameters to transform the degree of infection into a form more conducive to data expression. Adopting the degree of infection of COVID-19 in susceptible populations $f(t)$, the mathematical expression is as described next.

Let us denote doubtful $D(t)$, septic $S(t)$, improved $I(t)$, and perish $P(t)$ at time interval $t$ in a population size $N$. To analyze a patient, we assume the population number is constant:

$$D(t) = D(t-1) - \frac{\alpha}{N} D(t-1) S(t-1) \tag{22.1}$$

**Table 22.1** Model parameters, computed values, and forecasts for Hubei province in two scenarios using exact values of confirmed cases or estimations for infected and recovered patients.

| Estimations | Symbol | Parameter | Computed values | 90% confidence interval |
|---|---|---|---|---|
| **Scenario I: exact numbers for confirmed cases** | | | | |
| Based on linear regression of data | $R_0$ | Basic reproduction number | | |
| | | Jan. 11–16 | 4.80 | 3.36–6.67 |
| | | Jan. 11–17 | 4.60 | 3.56–5.65 |
| | | Jan. 11–18 | 5.14 | 4.25–6.03 |
| | $B$ | Case recovery ratio | 0.05 | 0.046–0.055 |
| | $g$ | Case fatality ratio | 2.94% | 2.9%–3% |
| Based on the State Institutes of Rural Development Model (SIRD) simulator (Nov. 16 to Feb. 10) | $R_0$ | Basic reproduction number | 2.6 | – |
| | $a$ | Infection rate | 0.191 | 0.19–0.192 |
| Forecast to Feb. 29 (cumulative) | | Infected | 180,000 | 45,000–760,000 |
| | | Recovered | 60,000 | 22,000–170,000 |
| | | Deaths | 9000 | 2700–34,000 |

$$S(t) = S(t-1) + \frac{\alpha}{N} D(t-1)S(t-1) - \beta S(t-1) - \gamma S(t-1) \quad (22.2)$$

$$I(t) = I(t-1) + \beta S(t-1) \quad (22.3)$$

$$P(t) = P(t-1) + \gamma S(t-1) \quad (22.4)$$

These equations are defined in discrete time points $t = 1, 2, \ldots$ with corresponding initial conditions $D(0) = (N - 1)$, $S(0) = 1$, $I(0) = 1$, and $P(0) = 1$. Here $\alpha$ denotes infection rate $\beta$ and $\gamma$ denotes the effective daily recovery and fatality rate. These equations provide estimated parameters based on confirmed cases. The new cases of recovered and deaths at each time $t$ appear with a time delay with respect to the actual number of infected cases. Assumption of the effective daily recovery rate $\beta$ and effective daily mortality rate $\gamma$ were computed by solving the least-squares problems. The results obtained from the reported confirmed cases are shown in Fig. 22.1.

CT scans with visual quantitative evaluation perform well for analyzing chest images that correlate with clinical classifications. Early recognition of the disease is beneficial for handling and isolating patients to avert the spread of the virus. Reverse transcription polymerase chain reaction (RT-PCR) is the orientation standard; however, it has been reported that chest CT scans could be used as a rapid approach to screening for COVID-19 [20,21]. India has 17,265 confirmed COVID-19 cases, 2547 of whom have recovered; there have been 543 deaths. The main treatment for COVID-19 patients is isolation; to

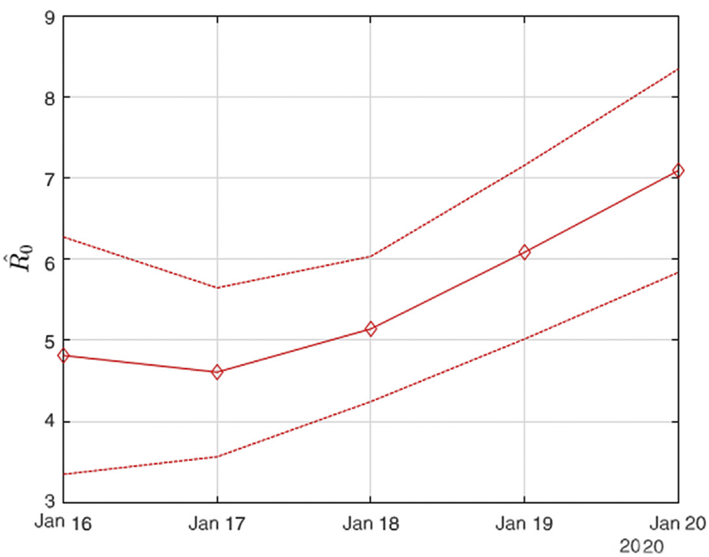



**FIGURE 22.1** Scenario I. Estimated values of basic reproduction number ($R_0$) as computed by least squares using a rolling window with an initial date of Jan. 11. *Solid line* corresponds to the mean value and *dashed lines* to lower and upper 90% confidence intervals.

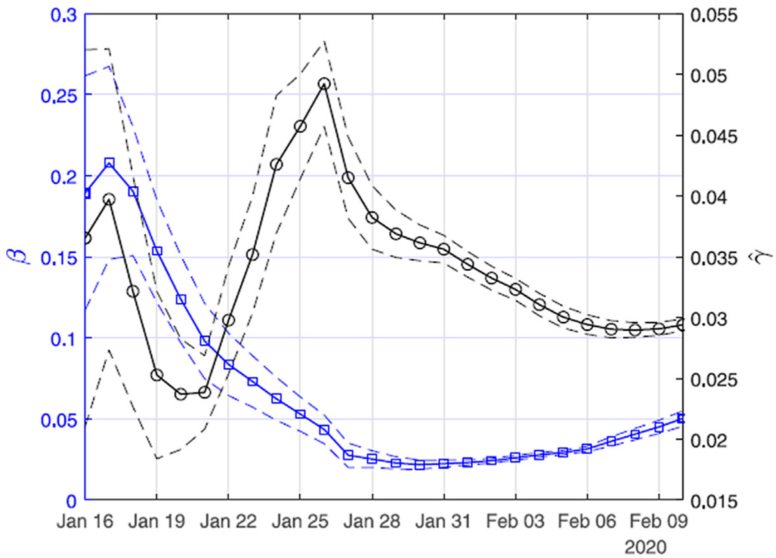



**FIGURE 22.2** Scenario I. Estimated values of case fatality ($\gamma$) and case recovery ratios ($\beta$) as computed by least squares using a rolling window. *Solid lines* correspond to the mean values and *dashed lines* to lower and upper 90% confidence intervals.

break the virus chain, people have to quarantine to be safe. Researcher have analyzed the data sources for COVID-19 patients to discover vaccines, but without success. A data augmentation technique has been used in retrospective experiments by testing the lung CT scan images of patients to detect coronavirus. The system block diagram is shown in Fig. 22.3.

The system diagram represents the detection of a coronavirus patient using lung CT scan images. The images are preprocessed to reduce noise using an image preprocessing technique. The preprocessed images pass through feature extraction to extract the region of interest. Use of deep learning techniques has achieved a good response in the analysis of images with high efficiency. For the detected abnormalities in the lung images, two responses are generated: the positive response of the images has the symptoms of coronavirus and the negative response has no symptoms.

The Dice similarity coefficient (DSC) is used to estimate the intersection ratio between an automatically segmented infected region ($S$) and the corresponding reference region ($R$) provided by radiologists:

$$\mathrm{DSC}(R,S) = \frac{2 \cdot |R \cap S|}{|R + S|} \tag{22.5}$$

where $|\cdot|$ is the operator to compute the number of voxels in the given region and $\cap$ is the intersection operator.

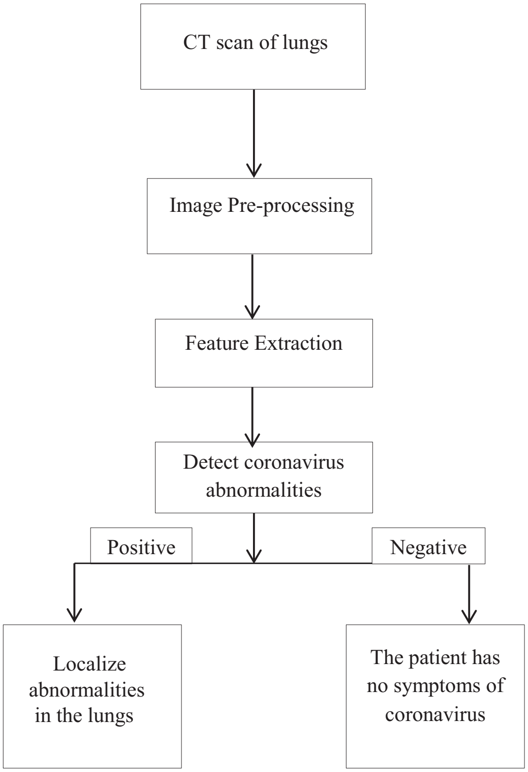



**FIGURE 22.3** System diagram for detecting the virus.

The Pearson correlation coefficient is used to evaluate the correlation of two variables:

$$r = \frac{N\sum_i x_i - y_i - \sum_i x_i \sum_i y_i}{\sqrt{N\sum_i x^2 - \left(\sum_i x_i\right)^2}\sqrt{N\sum_i y_i^2 - \left(\sum_i y_i\right)^2}} \tag{22.6}$$

where $N$ is the total number of observations and $x_i$ and $y_i$, $i = 1, \ldots,$ and $N$ are observations of the two variables.

# 3. Data processing to analyze the number of COVID-19 patients

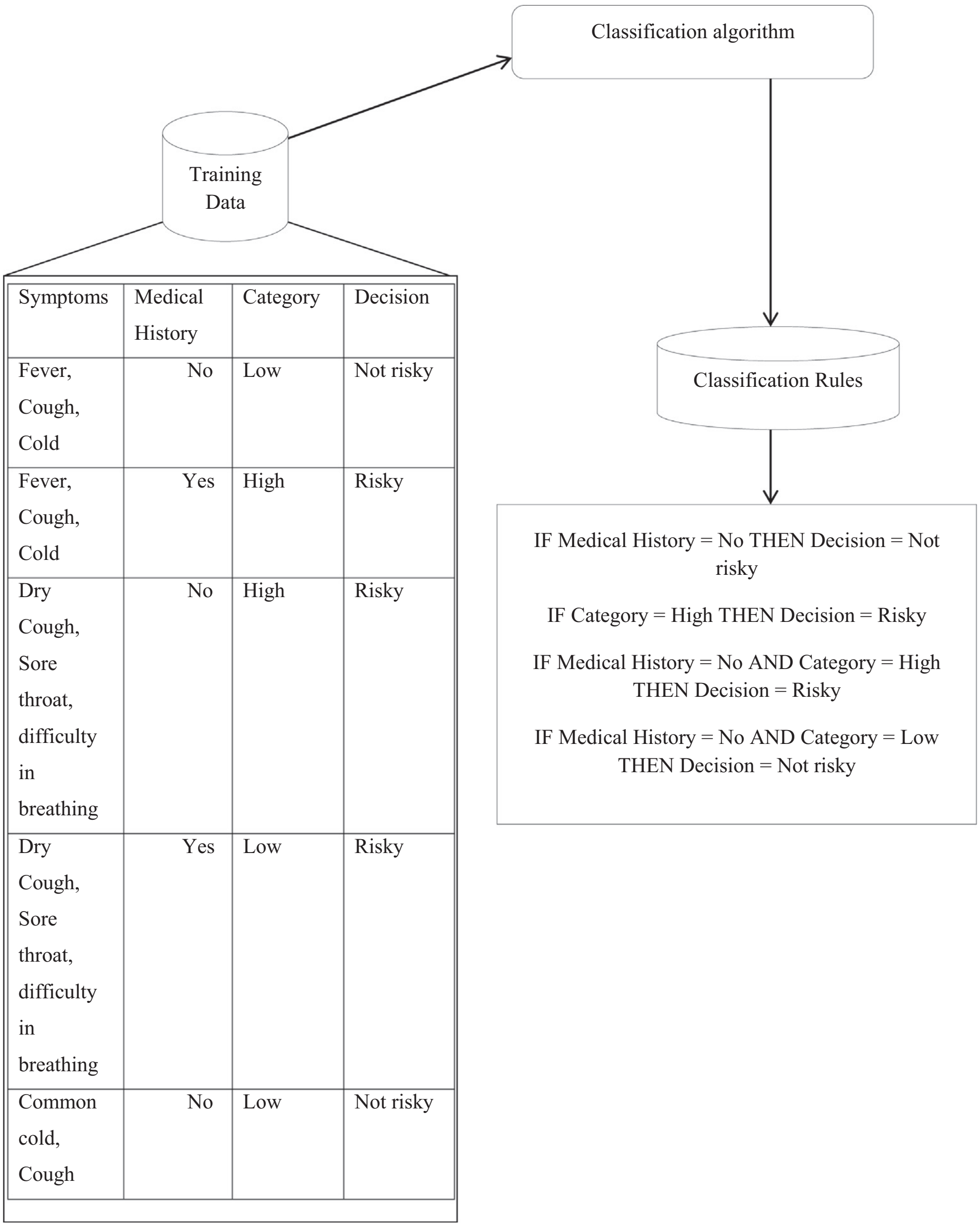
The world is now facing a tough problem: fighting a coronavirus disease. Researchers have to battle a deadly virus, and it is important to understand and collect the underlying data and develop a solution to COVID-19. Machine learning has an important role in the fight against COVID-19. It is an experience-based learning algorithm, a process of developing, testing, and applying a predictive algorithm to achieve a goal in a desired computational time. Several machine learning algorithm such as reinforcement learning, random forest, decision tree, naïve Bayes classifying algorithm, and k-means clustering are useful for analyzing data and making informed decisions that can initiate the search for virus-infected people. Machine learning algorithms help doctors identify people who have the highest possibility of infection from COVID-19 [22]. They can predict risk in three ways: infection, severity, and consequence. Infection comes from a single person or contact involved in COVID-19. If the person is infected through a virus-chain infection, travel data history records help to recognize the initial point of virus. The symptoms of an infected person describe whether hospitalization or intensive care is required. They also help predict the risk for COVID-19. Predicting the risk for infection to determine how individual contract COVID-19 is based on age, preexisting conditions, medical treatment, location, climate, human interaction, and hygienic habits. The machine learning algorithm such as logistic regression and decision tree algorithm is used to identify the risk factors in short and long term abstinence. Data analysis suggests risk based on age and other factors. It recognize the stage of the virus risk factor, which reflects vulnerability; analyzed data help doctors treat patients in the easiest way to recover from COVID-19. Decision tree works in both series and parallel; it depends on the amount of data, efficiency, and space available. The classification of data provides information to learn which applicants are safe and which is in a risk zone [23]. The data are analyzed regarding whether a patient with symptoms will have a virus. In the first steps, a classifier is fabricated labeling a predetermined set of data classes or concepts. A training dataset is made of database tuples and their associated class labels. Fig. 22.4 describes the classification of a patient based on risk for symptoms.

In Fig. 22.4, training data follow the classifying rule through a classifying algorithm model represented in the form of classification rules.

In Fig. 22.5 the test data were used to approximate the accuracy of classification rules provided when the accuracy is precise and acceptable; then, the rule is applied to the classifying the new data. The decision tree algorithm provides higher accuracy by analyzing the data for a patient. If the symptoms are available for the patient, the classifying rule determines whether the patient's health is risky.

## 3.1 Prediction of treatment consequences for COVID-19

Prediction is imperative in treating coronavirus-infected patients. It would be useful based on patients' symptoms and medical history to know the status of the virus. Because fewer people are around as a result of social distancing or lockdown, sometimes the symptoms of coronavirus takes a while to appear in infected people [24,25]. It is useful for doctors to know that all patients do not need the same treatment. It makes useful for the doctor to know that all patients won't need the same treatment, so that they can operatively treat the patient. The symptoms and risk assessment discussed earlier provide better results for efficiently diagnosing the disease.




| Symptoms | Medical History | Category | Decision |
|---|---|---|---|
| Fever, Cough, Cold | No | Low | Not risky |
| Fever, Cough, Cold | Yes | High | Risky |
| Dry Cough, Sore throat, difficulty in breathing | No | High | Risky |
| Dry Cough, Sore throat, difficulty in breathing | Yes | Low | Risky |
| Common cold, Cough | No | Low | Not risky |

**FIGURE 22.4** Training data analyzed by classifying algorithm to determine the decision.

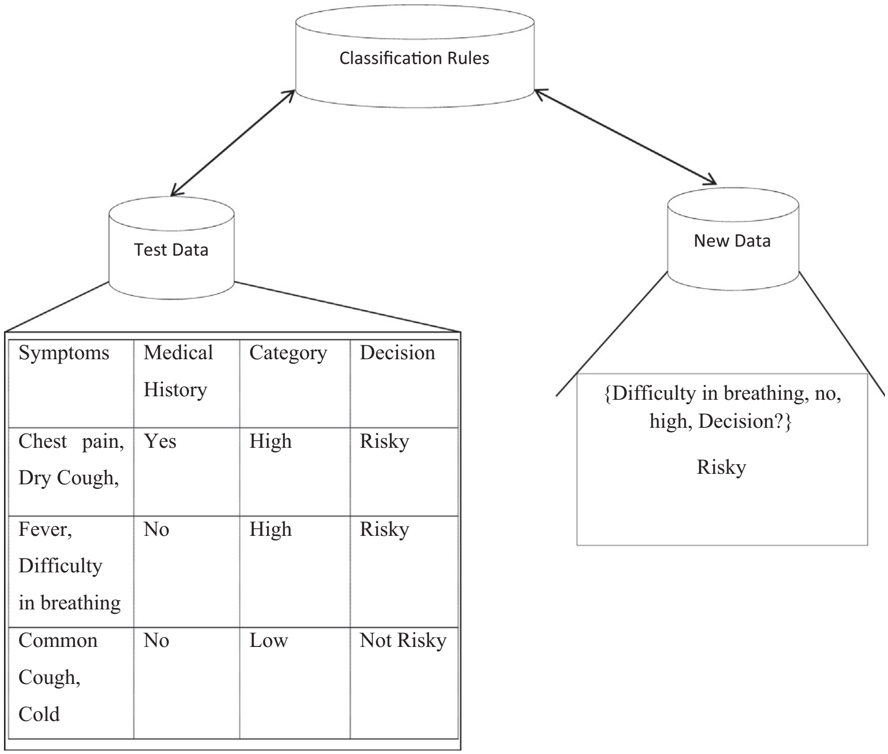



**FIGURE 22.5** Testing data analyzed using a classifying algorithm.

## 3.2 Recognition of existing drugs and drug development

COVID-19 is a pandemic disease; it is critical to manufacture new vaccines in a short time. Clinical researchers are experimenting with lots of trial-and-error techniques. It takes time to obtain a valuable vaccine. The Bayesian machine learning algorithm was used to analyze Ebola virus data with the best accuracy rate. That drug may be beneficial for treating patients, but it is important to be sure the drug has no harmful side effects. By analyzing the drug data hydroxychloroquine malaria drug is used for treating the coronavirus patients but it's not showing more effects on an infected patient, this drug is beneficial for malaria patient in India. It used as a trial to treat COVID-19 patients [26]. The clinical report was analyzed through a machine learning algorithm; it is insufficient to oppose or recommend the intake of hydroxychloroquine by virus-infected patients.

# 4. Explanation of patient chest computed tomography scan imaging analysis using deep learning

Remarkable achievements in machine learning algorithms for image processing and recognition tasks years provide good results in diagnosing patients by reviewing medical records. As the name implies, deep learning includes several layers between features present in images to achieve accurate results with higher accuracy. A deep learning algorithm accomplishes an extensive variety of tasks in the health care system to diagnose complex diseases in less computational time. The convolutional neural network (CNN) is normally suggested to solve image analysis problems because it splits segmented images into different portions, individually addresses them, and then integrates them to obtain final results. The higher level of a feature learned from the data itself. It minimizes the task of developing a new feature for every problem in a scenario. The collected X-rays and CT scan images data of an infected patient is used as an input data for CNN. The input images pass through the conventional neural network to split or segment images to obtain accurate results. Preprocessing is essential in a CNN; it is inferior to other classification algorithms. Lung CT scan images are a collection of pixel values, so we smooth the image vector and provender it to a multilevel perceptron for classification. The convolution layer excerpts high-level features such as edges from the input image. Comparable to the convolutional layer, the pooling layer is liable to decrease the spatial size of the convolved feature. It is valuable for extracting features to maintain the process of effectually training the model. After executing the process, we successfully enable the model to comprehend the features of images. Thus, it flattens the ultimate output and builds it into a regular neural network for classification determinations. The transformed of an input images into an appropriate form of multilevel perceptron which flatten the images into a column vector. The flattened output is sent to a feed-forward neural network and backpropagation algorithm applied to each iteration of training. Softmax classification is used to categorize the image. Finally, it defines images with coronavirus symptoms and no symptoms. The tangible enactment of the CNN approach is measured using accuracy, specificity, precision, and recall.

Accuracy defines the fraction of prediction in which our proposed system achieves the correct results. It is a metric for evaluating the classification model, shown in Eq. (22.7):

$$\text{Accuracy} = \frac{\text{True postive case} + \text{False negative case}}{\text{Total calculation}} \tag{22.7}$$

Specificity is defined as the actual and accurate classification of a brain tumor type. It is shown in Eq. (22.8), computed using formulas:

$$\text{Specificity} = \frac{\text{True negative case}}{\text{true negative case} + \text{false positive case}} \tag{22.8}$$

Precision is defined as the percentage of predictive positive values of results or output relevant to expected outcomes. It is calculated using the formula in Eq. (22.9):

$$\text{Precision} = \frac{\text{True positives case}}{\text{True positives case} + \text{False positives case}} \tag{22.9}$$

Recall is defined as the percentage of total relevant results or output correctly classified by the applied algorithm (Eq. 22.10):

$$\text{Recall} = \frac{\text{True positives case}}{\text{True positives case} + \text{False negative case}} \tag{22.10}$$

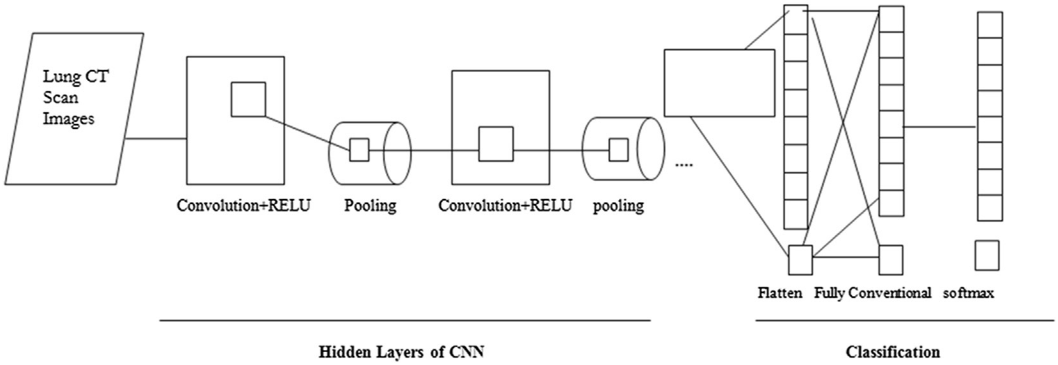



**FIGURE 22.6** Structure of convolutional neural network to detect images with COVID-19 symptoms. *CT*, computed tomography; *RELU*, rectified linear unit.

If the images are tested with some symptoms of covid-19 then it localize the abnormalities are in the lungs [27–29] (Fig. 22.6).

Machine learning and deep learning algorithms used to analyze data of patients deliver excellent results. Patients with confirmed COVID-19 infection sometimes have breathing problems and are admitted to the hospital. Patient with severe illness need to be admitted to the intensive care unit for oxygen therapy [30]. Clinical researchers predict that plasma therapy could be beneficial for treating COVID-19 patients. It is used to immunize people at a high risk for contracting the virus, the family of patients, health workers, and person who have been in contact with a patient. It is a simple therapy grounded on the principle of using the blood of patients who have recuperated from COVID-19, based on the antibodies' ability to fight the virus. SARS-CoV, MERS-CoV, and COVID-19 are highly contagious. The seriousness of an infection and lack of an effective licensed treatment for COVID-19 patients strengthens a more detailed in understanding of corona molecular biology to focused on structural protein and accessory proteins. The diagnosis of COVID-19 is confirmed by RNA tests with real-time RT-PCR. Viral RNA is detected in the nasal cavity and blood plasma of patients infected with coronavirus. A fast-performing serologic examination is needed for current and future outbreaks of coronavirus disease. Free virtual services such as medical counseling, teleconferencing, and health services are provided by health care representatives for better outcomes in seeking treatment [31–35].The antibody develops in patients as a part of the body's natural immune system in response to foreign pathogens, It is also useful to eliminate the coronavirus disease from the patient's body [3,36]. It is discussed above in the article, the collected data for a specific period of time is used to fit and estimate the basic regeneration number, infection rate, and recovery rate of COVID-19.

## 5. Conclusion

The purpose of this chapter was to contribute to an understanding of the concepts of machine learning and deep learning algorithms used to analyze the data of COVID-19 patients and provide efficient results to treat patients in better ways. The coronavirus pandemic is spreading rapidly through the direct contact of infected persons. The symptoms of COVID-19 have been discussed in this chapter to ensure that people are not in contact with infected persons under any circumstances without taking safety measures. The analysis of an existing data model was established to test infected patients. The main factor of spread for COVID-19 is human interaction. Patients' chest CT scan images were used to recognize whether patients were at risk. Hydroxychloroquine is an old drug used to treat malaria patients with immune-modulating activity. It has predicted and acceptable safety against pneumonia associated with COVID-19 in multicentric clinical trials. Finally, we hope that this chapter contributes information to clinical researchers and physicians to deal with this pandemic virus and provides some references for future research.

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