Metaheuristics and Neutrosophic Sets for COVID-19 Detection: A review study

M. A. El-Shorbagy[*1], Hossam A. Nabwey[2], Mustafa Inc[3], Mostafa M. A. Khater[4]

[1] Department of Mathematics, College of Science and Humanities in Al-Kharj, Prince Sattam bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia
[2] Department of Basic Engineering Science, Faculty of Engineering, Menoufia University, Shebin El-Kom 32511, Egypt
[3] Science Faculty, Firat University, 23119, Elazig, Turkey
[4] School of Medical Informatics and Engineering, Xuzhou Medical University, 209 Tongshan Road, 221004, Xuzhou, Jiangsu Province, PR China

Emails: ma.hassan@psau.edu.sa; eng_hossam21@yahoo.com; minc@firat.edu.tr; mostafa.khater2024@yahoo.com

Abstract

The fast spread of COVID-19 has been a problem for several nations since February 2020. Computer-aided diagnostic technologies that are both effective and affordable are urgently needed to help ease the burden on healthcare systems. Researchers are delving further into the feasibility of using image analysis to detect COVID-19 in X-ray and CT-scan pictures of patients. In the past ten years, deep learning has surpassed every other method for classifying images. However, deep learning-based approaches' effectiveness is very sensitive to the design of the underlying deep neural network. In recent years, metaheuristics and neutrosophic sets have become more popular as a means of fine-tuning the structure of deep networks. Because of their adaptability, simplicity, and task dependence, metaheuristics have been extensively employed to tackle many difficult non-linear optimization problems. To correctly identify COVID-19 patients from their chest X-rays, the authors of this research made a review of a neurotrophic model and metaheuristics methods.

Keywords: Metaheuristics; Neutrosophic Sets; COVID-19; X-ray;

1. Introduction

The respiratory system of humans is a common target for coronaviruses. Its "crown-like spikes" inspired its moniker, "Corona." SARS, MERS, and the annual flu are all caused by this virus. In 1937, researchers found coronavirus in wild birds. Birds that contracted this infectious illness developed bronchitis. In the next year, 1960, researchers studying the common cold discovered a kind of coronavirus in human nasal secretions. The mild disease brought on by this corona kind often manifests itself throughout the winter (cold season)[1]–[5].

It was on December 1st, 2019 when COVID-19 was first found in Wuhan, China. Many nonstop flights began linking the globe, and the disease quickly spread. Within a few months after its first discovery in China, this illness had spread to almost every continent. According to the scientific community, the virus was first seen in an animal that had contracted a common infectious ailment. Numerous scientists think that bats were the first hosts of the COVID-19 virus and that it subsequently infected other animals including humans. However, researchers are currently looking for the origin and transmission pattern of this data since it has not been verified. Nobody knows where this virus came from. Acute Respiratory Syndrome (SARS Coronavirus (SARS-CoV) and Middle East Respiratory Syndrome (MERS) are two of the names this virus has gone by over the last several

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

decades. In any case, the Wuhan strain of this virus has been identified as the 2019 coronavirus (2019-nCoV). This virus has the potential to cause severe pneumonia[6]–[9]. The 2019 coronavirus was officially identified as SARS-Cov-2 by the International Commission on Taxonomy of Viruses (ICTV) in 2020. The illness was given the designation coronavirus sickness in 2019.

As of January 24, 2021, the WHO recorded 349,641,119 documented cases of COVID-19, with 5,592,266 deaths as a direct result of the virus. When compared to other nations, the United States has the highest recorded case total, at 69,727,991.

The global spread of the COVID-19 virus was exponential. The WHO officially classified it as a pandemic in March 2020. The rapid expansion may be attributed to the ease with which an infected individual can pass the virus to others through their bodily fluids, such as through a cough or a handshake. When a person infected with COVID-19 coughs, droplets are released into the air that may infect a healthy person via their mouth or nose. Maintain a minimum distance of 6 feet near COVID-19 carriers. If precautions are taken and a healthy range is maintained, the illness will be contained inside the bodies of the carriers[10]–[12].

Since COVID-19 has been designated a pandemic and there is currently no treatment, the only option is to stay far away from affected individuals. Since there is currently no effective treatment for this illness, it is crucial to identify COVID-19-positive patients as soon as possible. This will aid in identifying sick people and keeping them isolated from the general population. Standard confirming clinical tests, such as Reverse Transcriptase Chain Reaction (RT-PCR), and screening chest images for COVID-19 are only two of the many methods available. On the other hand, RT-PCR is a laborious procedure that requires a lot of time and effort to complete. Yet, it is difficult and costly to regularly test the whole population due to a lack of test kits, domain specialists in hospitals, and a sharp rise in the number of affected persons. However, CT scans of the chest take less time and cost less money than other imaging methods. Chest X-rays for the identification of COVID-19 might be a great help in certain cases. But it's important to have a very accurate system. Computer vision is the field that studies the categorization of chest scan images. And meanwhile, various research has been conducted to distinguish COVID-19 patients from healthy persons and other patients in photographs. Most of the studies included the categorization of chest x-ray images using machine learning and data mining methods[13]–[16].

On many different picture classification, DL and ML have demonstrated state-of-the-art accuracy. When it comes to the effectiveness of deep and machine learning models, high-energy choices are crucial. The number of layers, the number of neurons per level, transfer functions, acquisition rates, drop-out rates, and packet size are all examples of DL hyper-parameters. While certain image classification tasks may benefit from a more general hyper-parameter optimization setup, this is not the case for all of them. Manual optimization of these factors is possible, but it is time-consuming and requires specialized expertise. Grid search and evolutionary algorithms are computationally costly and time-consuming approaches that may be used to automate the optimization of high energy. To optimize the high energy of ML and DL models for various COVID-19 identification and other machine vision tasks, heuristic methods have been extensively and effectively applied in recent years. Metaheuristics, a kind of search algorithm, can identify near-optimal solutions more quickly than random search. They have performed well in feature engineering experiments for both machine learning and deep learning architectures[17]–[19].

To identify COVID-19 and other respiratory issues, Albahli and Yar created a deep-learning multilayer pipelines model. As a training resource, they utilized the ImageNet database. The first classification in the pipeline determines whether or not the picture is COVID-19, whether the image is normal, or if the image should be sent on to the next learner to be analyzed for the remaining 14 chest abnormalities[20]–[22].

During flu season, Wang et al. operated on a 1065 CT picture. Cases previously classified as COVID-19 and other viral pneumonia with comparable radiograph features have been verified in the dataset. To separate the COVID-19 instances, they applied deep learning as well.

Khan et al. trained a deep convolutional neural network (CNN) to identify COVID-19-positive patients in chest X-rays. First, they educated their model on ImageNet, and afterward, they used it to analyze data from two additional sources.

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

DarkNet, created by Ozturk et al., has an efficiency of 98.08% for classification algorithm (COVID-19 or regular) and an efficiency of 87.02%. We used 17 regular layers, each with its filter, to build DarkNet[23], [24].

There is a requirement for various options that can extract the most essential elements from X-ray pictures to differentiate between positive and undesirable COVID-19 instances. Overfitting and tweaking hyperparameters are only two of the issues that have been documented for certain learning models. The use of metaheuristic learning models is a direct result of this need.

With the use of a feature extraction method, Canayaz was able to improve the contrast of images. AlexNet, GoogleNet, VGG19, and ResNet were only a few of the deep learning models he employed to finish the feature extraction. He also used the metaheuristic optimization methods binary PSO and digital grey wolf. In the end, he classified the data using a support vector machine.

Similarly, AlexNet was utilized for feature extraction by Kaur et al. who also used Pareto evolutionary computation for tuning the hyperparameters. Applying it to the four-class dataset, they found promising results

Many medicinal uses may be found for the Neutrosophic Set (NS). Its adaptability to uncertainty made it a viable option for segmenting and labeling X-ray, CT, and Mri scans.

To isolate the liver from abdomen CT scans, Sangeeta and Mrityunjaya devised a three-step process. To create NS pictures from CT scans, they first undergo a phase of preprocessing to eliminate noise, then apply one of the three NS classifiers. In the last stage of processing, a transformation function is used to the fuzzification term to precisely determine the liver's borders.

For liver tumors shown on abdominal CT scans, neutrosophic-based segmentation was first proposed by Anter and Hassenian. The group used neutrosophic sets (NS), particle swarm optimization (PSO), and a quick fuzzy C-means method (FFCM). They started by applying a median filter to the photos to boost the contrast. After that, the image name was changed to the NS category. To further enhance the neutrosophic picture, FFCM and PSO were used.

Segmenting images using entropy data from a neutrosophic perspective was one of Singh's applications of this theory. He researched MR pictures of people with Parkinson's disease. When compared to other techniques of background subtraction, he was successful in isolating the crucial parts of the MRIs.

2. Data Pre-processing

X-ray and Computerized Tomography (CT) scan pictures are employed in COVID-19 identification studies. CT scans are more detailed than X-rays because they catch more anatomical structures, including bones, connective tissue, and blood arteries, all in one 3D colorful picture. It has been found that although some research exclusively employed X-ray pictures, others opted to use CT scans instead. Some people have even utilized both kinds of pictures.

It is sometimes possible to utilize raw photos as input, although it is usually not practical to apply different classifiers directly to determine the initial. Algorithm efficiency may also be impacted by other abnormalities, like image expansion in the quantity. Since this is the case, fixing these issues before implementing the methods is crucial.

To describe the architecture of the flesh and bones, the size and intensity of the image's pixels play a crucial role. What follows is a discussion of the three most common normalizing methods: MinMax, Image Resizing, and Gray Sizing.

Simply put, picture resizing is the process of altering an image's dimensions (width and height) or pixel count. If you want to classify images, neural nets are the way to go. Nevertheless, the duration of their contribution must be predetermined. Since the photos come in a variety of dimensions, they must be scaled down to be used as input by the neural network. The method most often used for this

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

purpose is interpolation. Using existing matrix templates of a specified size, it determines the median value of neighboring pixels and fills in the blanks.

Color values are treated as a separate feature and incur additional processing time and effort. This additional layer often contributes little to the overall success of classification assignments. Because of this, it is recommended to disregard this additional dimension throughout the preprocessing phase. For the most part, an eight-bit integer is used to hold the grayscale intensity of a Red Green Blue (RGB) picture. When using an eight-bit integer, you may store anywhere from 0 to 256 gray areas, from black to white. When grayscaled, RGB intensity values fall inside the interval [0, 255].

By synthesizing instances of subclasses with fewer items, data augmentation corrects the class imbalance. In the medical area, data imbalance is a typical issue in image processing and computer vision. There are often fewer photos available for a certain illness category compared to other categories. This inequality in socioeconomic status has the potential to add bias to the model. That's why it's smart to use augmentation before you start training the model. To provide an equal number of examples for each category, many augmentation methods are applied to produce synthetic pictures. All data is enhanced in the same way. Class labels are first equalized, and then characteristics are chosen and classes are sorted.

A system that uses machine learning or deep learning may identify classes of data points (pictures) based on the presence or absence of certain patterns or recurring patterns. Data cleansing is essential for reducing noise in original data. Extraction of higher-level characteristics, like borders, corners, and segments of an image, is aided by this stage of the process of feature extraction. In addition, it is reported as the second step following preprocessing in the vast majority of articles. Most academic works use Convolutional Neural Networks (CNNs) to extract features from data. In the sections that follow, we will go through the various feature extraction techniques that have been used for the identification of COVID-19 in photos.

3. Metaheuristics Techniques

Genetic Algorithm (GA)

This technique is inspired by Charles Darwin's "survival of the fittest" principle from his Darwinian theory of evolution. First, the population is initialized; next, initial solutions are generated (here, any problem-specific function may be specified); then, the best members are chosen; then, crossover and mutation are performed; and finally, the next generation's members are chosen. Following this procedure until the necessary number of individuals has been produced is recommended. A schematic of the genetic algorithm is shown in Fig. 1.

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

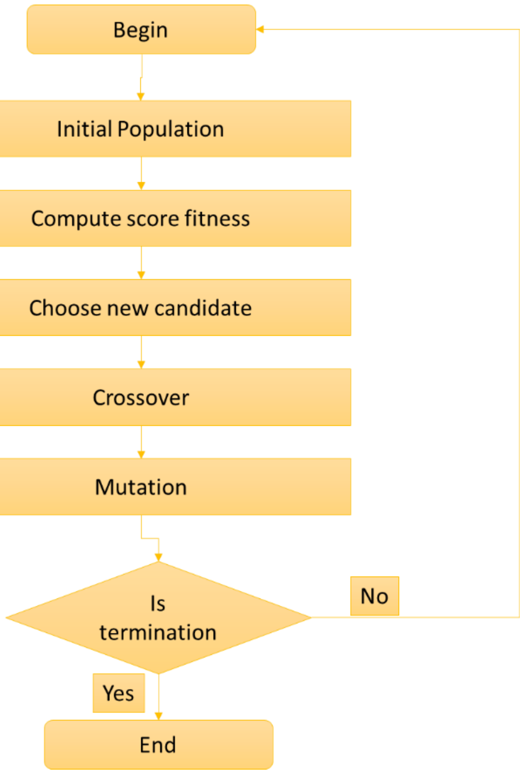

Figure 1: The flowchart of the genetic algorithm.

In image analysis, GA has been utilized for various optimization problems, such as hyper-parameter adjustment of deep learning algorithms. For issues with many factors and many potential answers, experts turn to a kind of GA known as a multi-objective genetic algorithm (MOGA).

Five investigations using different forms of GA have reported successfully detecting COVID-19 in pictures. Fig. 2 shows that this technique was utilized by the majority of studies to choose characteristics; its accuracy was high in all of these cases (over 90%), making it an excellent candidate for improvement[25], [25]–[28].

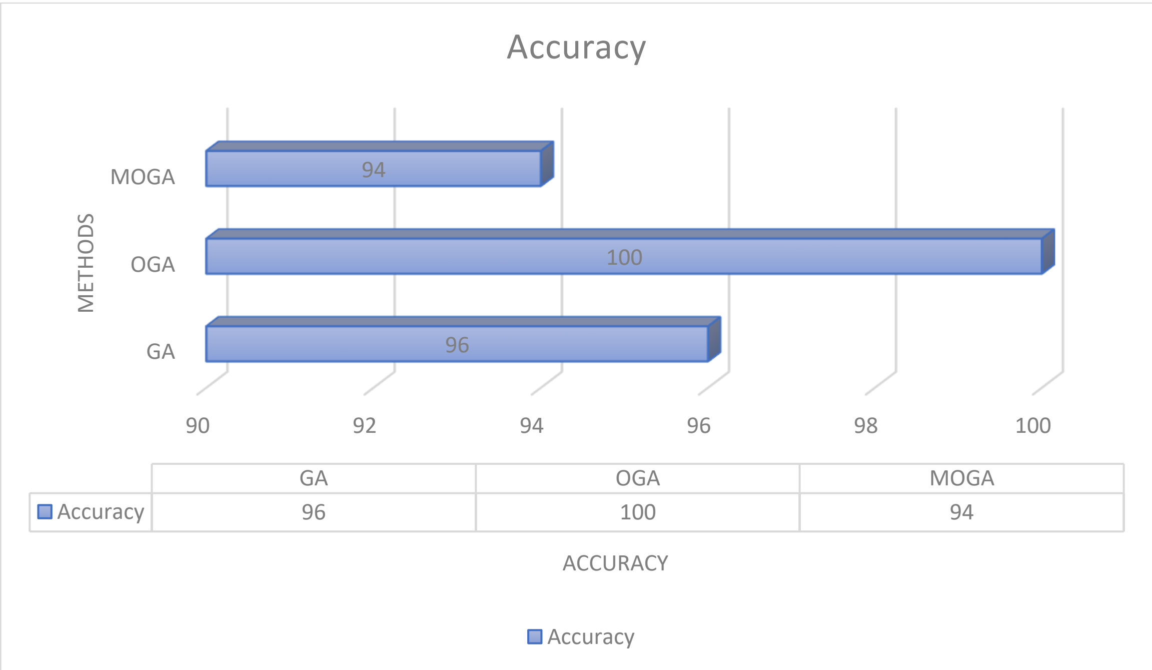

Figure 2: Different accuracies under GA.

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

Whale Optimization Algorithm (WOA)

The humpback whale's hunting strategy served as inspiration for this algorithm. There are essentially three stages: locating prey, enclosing it, and attacking it with a bubble net.

Real-life events show that whales can track down their prey and surround it once they've located it. Yet in search space, the best possible spot is a mystery until after the first stage has been completed. In WOA, the area around the current best choice is marked as the target area.

After the target's position has been marked, the algorithm does a "shrinking encircling" to try to surround the area with the best possible answer. The location is revised by computing the metric of separation between the old and new set of circles. The term "spiral updating position" describes this method.

Even when eating, whales are still looking around for food. Meanwhile, whales hunt for food based on the whereabouts of their friends. Finding the whale with the greatest fitness value is the first stage in an algorithmic process that iteratively repeats until the goal is reached or the maximum number of iterations is reached.

Particle Swarm Optimization (PSO) guided WOA, also known as PSO-WOA, is a variation of this technique developed by certain researchers who have added some more phases to the original approach. After the solution is updated using WOA, a new step is introduced in this variant. It then sends these solutions on to PSO to be optimized, returning a fresh set of solutions. Afterward, it does another round of solution updates[29]–[33]. Fig 3 shows the accuracy of the WOA and PSO.

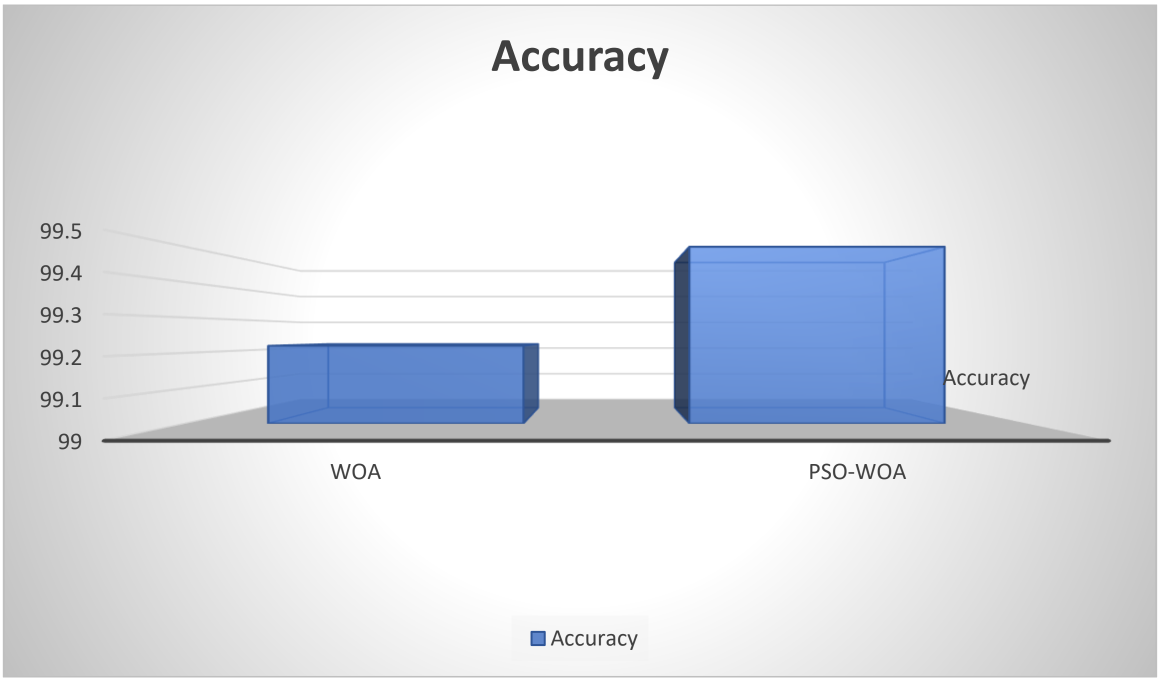

Figure 3: The accuracy of the WOA

From Fig. 3 the hybrid PSO and WOA is the highest accuracy.

Cuckoo Search algorithm (CSA)

This algorithm was developed after seeing how cuckoo birds arrange their nests to lay eggs. They use the nest of their hosts as an incubator for their eggs. This is why they go on the hunt for the most accommodating host. To improve their chances of hatching, they also kill the host's eggs. You may think of the eggs as the optimal solution and the locations of the eggs as the optimization candidate solutions. The distinction between the 2 vectors gives a measure of the answers' similarity[34]–[37].

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

The Fractional Order Cuckoo Search optimization was utilized by Hanon et al., who employed a variant of this technique that used Fractional Order calculus (FO) (FO-CS). In this update, we added the option to save the results of four cuckoo searches, which might be useful for generating more efficient globally optimized solutions[38]. The improved results of the updated CS are shown in Fig 4.

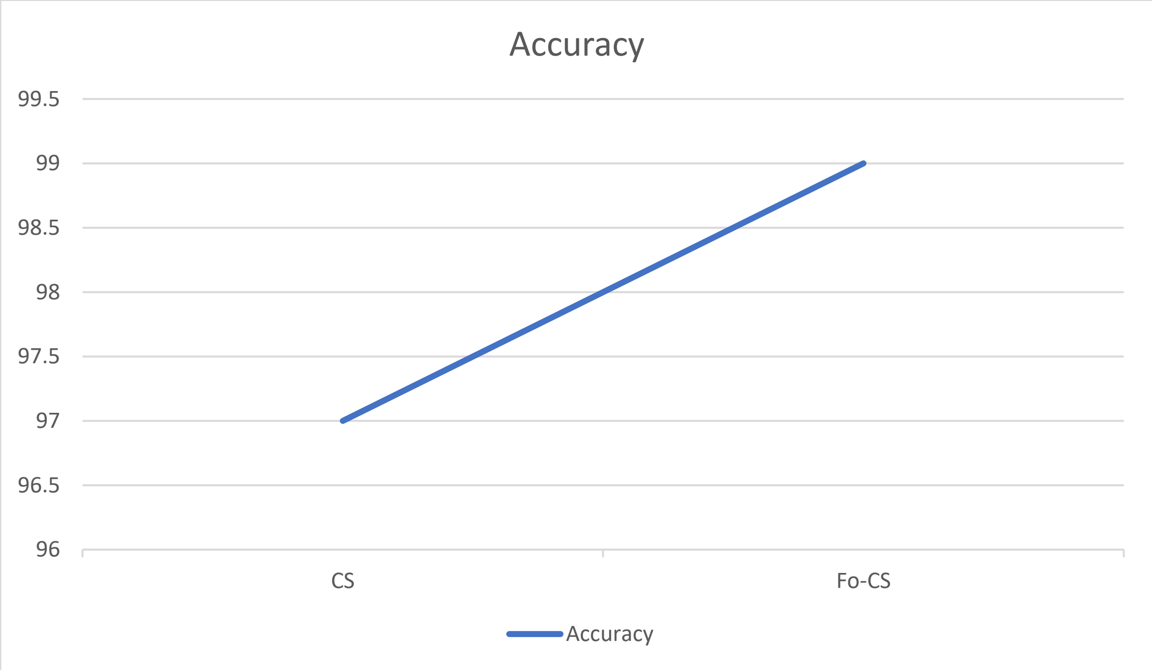

Figure 4: The accuracy of the CS.

4. Classification system based on neurotrophic rule-based (NRCS)

By substituting neutrosophic logic for fuzzy logic, the NRCS model generalizes the fuzzy rule-based categorization system (FL). In another sense, the "IF-THEN" rules included in the NRCS are not based on FL but on neutrosophic logic. There are three phases to the NRCS.

First, Neutrosophication. Our categorization approach begins with a step to transform the crisp inputs into a neutrosophic form. Create a neutrosophic KB by combining the truth, uncertainty, and falsity class labels from the NL.

Second, an inference engine. Applying "IF-THEN" rules to the KB's knowledge base to get philosophical results.

Third, Deneutrosophication. Restoring crispness by applying transformations similar to those used during eutrophication on the neutrosophic output.

DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023

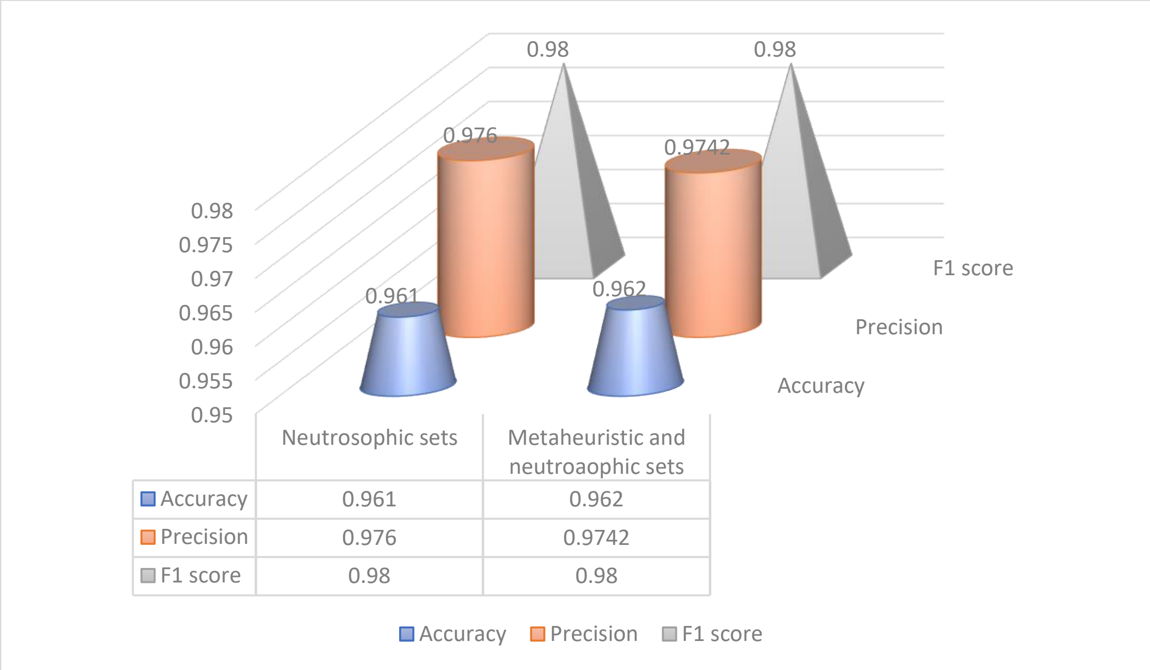

Figure 5: The comparison between the metaheuristic and neutrosophic sets.

Fig. 5 the comparison between neutrosophic sets and the metaheuristic algorithm. The neutrosophic sets only have a 0.961 accuracy. But when neutrosophic sets were integrated with the metaheuristic the accuracy increased to 0.962[39]. So, using neutrosophic sets with metaheuristic methods is the best solution instead of using neutrosophic sets or metaheuristic methods only.

6. Conclusion

An official declaration of a pandemic due to the rapid spread of the illness known as COVID-19. Since there is currently no treatment for this condition, isolation of the patient is necessary to avoid the spread of the illness. Early detection of the patient is crucial. Diagnostic examinations that are expensive, time-consuming, and impractical on a broad scale may serve this purpose. The early identification of COVID-19 may be aided by the automated categorization of chest pictures. Popular though they may be, deep learning methods for classification tasks are computationally expensive because of the high number of variables they need. To lower the computing cost, these parameters might be optimized with the use of algorithms derived from nature. To that end, we have surveyed the landscape of COVID-19 picture categorization and analyzed the efficacy of several metaheuristic-based approaches with neutrosophic sets. Most often, metaheuristics have been used for deep learning's feature selection and hyperparameter tuning processes. Dataset statistics for COVID-19 image categorization are presented in this research. This research also describes several methods and applications that draw inspiration from the natural world. Using the neutrosophic sets with the metaheuristic is the best solution to achieve the best accuracy.

Acknowledgments

This study was supported by Prince Sattam bin Abdulaziz University through the project number (2022/RV/06).

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DOI: https://doi.org/10.54216/IJNS.200114
Received: December 21, 2022 Accepted: January 11, 2023