COVID-19 Patient Classification Strategy Using a Hybrid BWM-SVM Model

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Abstract. The apparition of Covid19 represents a horrible disease that upset the human’s life. The difficulty of this disease is its rapid evolution through people contact. Hence, designing an efficient classifier model is mandatory. In this work, we present an effective hybrid multicriteria model for patients’ classification. Our approach is composed of two-stage: the first one consists of generating the criteria priorities using the multi-criteria Best Worst Method (BWM) tool used to estimate a set of alternatives concerning a data set of decision criteria, while the second is based on making the patient classification using the Support Vector Machines (SVM), are controlled learning models with related learning algorithms that analyze data used for classification. This combination proposed to classify the patient’s diagnostic as infected by COVID or not. In this study, we considered these criteria: fever, cough, fatigue, shortness of breath in severe cases, and the age of the patient). Predicting the right classification rapidly will reduce the number of affected people.

Keywords: Covid19 · Patient classification · BWM · Machine learning · SVM · Healthcare

1 Introduction

Coronaviruses have been known for a long time in humans as well as in animals [1]. Most of the time they cause mild illnesses like colds. However, some coronaviruses cause more serious diseases such as severe acute respiratory syndrome (SARS) [2] or the Middle East respiratory syndrome (MERS) which appeared in 2012 in Saudi Arabia [3]. The current virus is called COVID-19 [4]. It a new coronavirus which was revealed on January 7, after several cases of viral pneumonia appeared in China in the city of Wuhan. The first people affected by the COVID-19 went to the market in Wuhan, where live animals were sold. The zoonosis track (a virus which is transmitted from animals to humans) is therefore preferred to define the origin of the virus, although it has not yet been confirmed. Until now more than 2.2 million coronavirus cases were confirmed worldwide, including more than 151,000 deaths.

The coronavirus defined by many symptoms declared by The World Health Organization (WHO), among the symptoms [5, 6] at the onset of illness were fever [98%], cough [76%], myalgia or fatigue [44%], sputum production [28%], headache [8%]. the case
is confirmed after analysis test, this first way for confirmed the patient is case positive or negative. we can also as a technical and mathematical researcher to propose another way from the diagnostic for detected the case is positive or negative, we proposed the wireless sensor network using SVM for Classification of symptoms of coro-navirus. This technique is optimal, given the speed, the accuracy, the cost, optimizes the time of diagnostic and risk of Illness infection. Literature Review COVID-19 is a novel pandemic exceedingly contagious virus. This makes this coronavirus categorized as highly infectious compared by another virus, WHO [7].

Both experiential experience and developing scientific evidence show that this corona-virus is facilely transmitted from person to person and even from an animal to person, Huang and Wang [8]. The US Centers for Disease Control and Prevention (CDC) as-sessment that the virus’s imitation the number of added cases that probable result from an initial case is meanwhile 1.6 and 2.4, creation COVID-19 significantly more infectious than seasonal flu (which its imitation number is estimated at 1.2 to 1.4) [9]. The researchers in the technical and IT sectors offer several solutions, including systems, equipment and technology, to help the health sectors among the technology available, we find wireless sensor networks (WSN), An important constituent of ubiquitous healthcare and diagnostic is WSN. WSNs are a developing technology that is composed to transform healthcare. The WSNs troth to make life more contented by significantly improving and expanding the quality of diagnostic across a wide diversity of settings and segments of the population.

The healthcare industry appearances several challenges: skyrocketing costs, increasing incidence of medical errors, insufficient staffing, ageing population, etc. Healthcare consultant is under pressure to offer better services in the meanness of the challenges and hold modern technological advances. Omnipresent healthcare can decrease long-term costs and enhancing the quality of service [10]. WSN offers efficient solutions to the omnipresent healthcare.

Support vector machine (SVM) techniques are generally used machine learning model as shown in Fig. 1 that uses classification problems algorithms for two-class. These techniques are based on numerical learning theory, the main aim of this technique is to scheme nonlinear divisible samples onto another advanced dimensional space by using different types of kernel functions. The among feature and advantage of SVM technique, SVM models have simplification in practice, the risk of over-fitting is fewer in SVM, and are fully when we have no idea about our data.

There are many research work has been presented to detect the COVID-19 diagnostic using classification method, the authors in [11] propose DenseNet201 based deep transfer learning for classification of patients infected COVID-19 or not, this model is used to excerpt features by using its particular learned load on the ImageNet dataset along by a convolutional neural structure. In [12] purpose DenseNet to find the coronavirus infection in the patients, the sensitivities of COVID-19 or no. the authors in [13] proposed the convolutional neural network (CNN) models of COVID-19 in CT images for binary classification.

In this work, we purpose the model combined the approach of multicriteria BWM and SVM technique to evaluate the diagnostic of the patient.
This paper is planned as follows. Section 1 illustrate the work done in the field of BWM and SVM techniques for Data set. The proposed technique is designed in Sect. 2. The experimental and discussion of results are specified in Sect. 3. The concluding and perspective observation are drawn in Sect. 3.

2 Proposed Work

2.1 System Model

In our model, patients are characterized by various symptoms, where each one impacts directly the patient classification. We consider that our study is a multi-criteria problem, where the symptoms represent the problem criteria. We consider the fifth essential and important criteria defined: fever, cough, fatigue, shortness of breath in severe cases, and the age of the patient. Data are collected using sensors as shown in Fig. 2. After making the collection of data, we consider these values as inputs of the SVM classifier taking into account the preference of each criterion. The next sub-section explains the steps of calculating the criteria’ preferences using BWM. Figure 3 illustrates the system model, where we considered the symptoms data set are collected by BWM for generate the optimal weight and then classified of two groups: group positive infected by COVID-19 and groups negative not infected by COVID-19 for making the right decision for different patients.
2.2 The First Stage: BWM

BWM is a multicriteria tool, that is widely used for resolving decision problems [14–16]. It is a strong method which is exploited for making the right decision for several fields like the supplier selection problems.

- Step 1: Determine the different criteria for the study.
- Step 2: generate the pair wise-comparison for all criteria compared to the best criterion using the values between 1 and 9. This is lead to the next vector
\[ A_{best} = (ab_1; ab_2; ab_3; ab_n), \] where \( ab_j \) represent the value of preference of the most essential criterion Best compared to the criterion \( j \).

- **Step 3**: generate the pair wise-comparison for all criteria compared to the worst criterion using the values between 1 and 9. This is lead to the next vector:

\[ A_{worst} = (a_{1W}; a_{2W}; a_{3W}; \ldots; a_{nW})^T, \] where \( A_{jW} \) is the value of preference of criterion \( i \) over the worst one (W).

- **Step 4**: generate the optimal weights. Hence, finding the optimal weights imposes the minimization of \( |\frac{W_b}{W_j} - ab_j| \) and \( |\frac{W_j}{W_W} - a_{jW}| \) for each criterion \( i \). So, searching the optimal preference lead us to resolve the next min-max problem represented by Eq. 1:

\[
\min \max_j \left\{ \left| \frac{W_b}{W_j} - ab_j \right|, \left| \frac{W_j}{W_W} - a_{jW} \right| \right\} \quad (1)
\]

\[
\sum_j W_j = 1
\]

\[ W_j > 0; \text{ For all } j. \]

### 2.3 The Second Stage: Patient Classification Using SVM

SVM is one of the first statistical learning approaches put advancing by Vapnik et al. in 1995 [17]. It is major factor attainment of machine learning research in current years. This approach not only has a hard-theoretical basis but also suits to resolve the problem of extremely nonlinear classification and reversion compared with the conventional intelligent approaches such as statistical mechanisms and artificial neural networks. Temporarily, this approach has been generally used in image recognition, automatic text classification and more [18]. Meanwhile, this method has exposed exceptional performance over the current methods, the approach and technology have become novel research hotspots after neural network research and will help the research and application of machine learning theory and technology.

The classification algorithm SVM allows a binary decision to be achieved, assigning an M-dimensional feature-vector to one of two classes. The presence of a supervised approach, an SVM needs to be qualified using a proper dataset, which must be satisfactorily large and illustrative of the two classes, with concerning the selected features.

A training phase is then needed to regulate a subcategory of the training vectors named support vectors, that will be used for resolving the classification problem. One significant advantage of SVMs remains in the fact which the number of support vectors is normally much lesser than the cardinality of the training dataset. whence, though the training of the SVM can be a resource-in-tensive task, the real classification algorithm
can be very slight. Equation 2 represents the standard formulation for a two-class for classification problem [19]:

$$y(x) = V^T \phi(x) + b$$  \hspace{1cm} (2)

The algorithm used in the proposed work are as follows by two-level:

- Calculation of weight are Input, generate the optimal weights.
- Classified by SVM are training data, Pre-processing, Feature Extraction and Classifier SVM.
All the overhead cited stages and their interconnection for the planned handwritten recognition system is denoted in Fig. 4, which is a linear model where \( x \) is the \( M \)-dimensional input vector, \( M \) is the size of the feature space, \( V = v_1; v_2; \ldots; v_M \) is the vector of coefficients for the linear model, \( \varphi \) is a general feature-space transformation function and \( b \) signifies the bias of the model.

### 2.3.1 Numerical Illustration and Discussion

This section explains the numerical example of the present study. The first is based on determining the values of preference of each criterion compared to the best and the worst criterion. Table 1 and Table 2 show the preference predefined of all criteria in terms of the best and the worst criterion respectively. The next step aims to resolve the optimal problem to find the optimal values for the criteria weights. Table 3 depicts the optimal values of the study preferences. After calculating the importance.

**Table 1. Matrix of importance of the criteria compared to the Best Criterion.**

| Best to others | Fever | Cough | Fatigue | Shortness of breath | Age |
|----------------|-------|-------|---------|---------------------|-----|
| Fever          | 1     | 5     | 3       | 7                   | 9   |

**Table 2. Matrix of importance of the criteria compared to the Worst criterion**

| Best to others | Age |
|----------------|-----|
| Fever          | 9   |
| Cough          | 5   |
| Fatigue        | 3   |
| Shortness of breath | 3   |
| Age            | 1   |

**Table 3. Matrix of the optimal weights**

| Criteria       | Fever | Cough | Fatigue | Shortness of breath | Age |
|----------------|-------|-------|---------|---------------------|-----|
| Optimal weight | 0,53  | 0,20  | 0,12    | 0,08                | 0,05|

After calculating the importance value of each criterion, we classify the patients using the SVM. As show in Fig. 5 depicts the classification of the patient’s group considered for this study.
We observe that the proposed hybrid model allows us to make a diagnostic of patients by the classification of the patients in two classes: the positive class and the negative class (healthy). Among the advantages and feature of this model: the exactitude of diagnostic, the rapidity of diagnostic, and minimizing the risk by avoiding contact between the patients and the hospital staff.

3 Conclusion

In this paper, we investigated an efficient patient classification using a hybrid BWM-SVM model. For making an effective classification, we have simultaneously considered the fever, cough, fatigue, shortness of breath, and the age of the patient. In our novel strategy, patients belong to ill class or healthy class depending on their criteria values. Moreover, to make this classification more real, we have calculated the optimal weights of criteria using BWM. From the illustrative example and the classification results, we conclude that the hybrid BWM-SVM model has successfully classified the patients. We recommend the use of medical sensors in the banks, the industrial companies for easing the symptoms collection, and the rapid intervention of the hospital staff.

The future work proposes to evaluate a system for COVID-19 by combining deep learning and feature extraction using different approach of multicriteria analysis. In addition, the performance may be enhanced and evaluated using more datasets defined and more feature extraction approach and techniques.
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