Abstract

Objectives: Presently, smart healthcare applications utilizing Internet of Things (IoT) offers vast number of features and real time services. They offer a real platform for billions of users to receive regular information related to health and better lifestyle. The usage of IoT components in the medicinal domain greatly helps to implement diverse characteristics of these applications. Methods: The huge volume of data created by the IoT devices in medicinal field is investigated on the cloud rather than mainly depends on available memory and processing resources of handheld devices. Keeping this idea in mind in this study, we try to devise an IoT and cloud based smart healthcare system to diagnose the disease. The IoT devices attached to the patient body gathers the needed data and stored in the cloud. Then, we present an optimal Support Vector Machine with Grey Wolf Optimization (SVM-GWO) algorithm to classify the presence of disease using the acquired data. For experimentation, we employ a benchmark heart disease dataset and a set of measures are used to analyze the attained results. Findings: The presented SVM-GWO achieves a maximum classifier results with accuracy of 84.07%, precision, recall and F-score of 84.10% respectively. Novelty: An optimal Support Vector Machine with Grey Wolf Optimization (SVM-GWO) algorithm is used to classify the presence of disease using the acquired data. The experimental outcome ensures the betterment of the presented model over the compared methods under different evaluation parameters.

Keywords: Cloud, Healthcare, IoT, Support Vector Machine

1. Introduction

Internet of Things (IoT) defines the way of modeling and linking devices using Internet. IoT indicates that a few powerful processing devices like laptops, tablets and phones are significant to have many low powerful devices. The most frequently using objects like air freshener and vehicle are intellectually programmed by processing devices with assistance from sensors and produces the output. So, the linked devices or objects have the ability to process and communicate the requirements of simple devices to interconnect building using network communication. They connect buildings as well through network communication.

IoT and cloud computing are equally beneficial when they are integrated together. The observation model designed by the integration of these technologies for observing the patient data efficiently even at remote areas finds helpful for doctors. The IoT technologies are greatly supported by the Cloud for enhancing the results based on more resource usage, memory, power and computationability. In ability, cloud computing achieve favor from IoT technologies for improving the scope for handling with the present world and to distribute various novel services in a lively and dispersed way. Even though, IoT based cloud model is enhanced to develop new services and applications in the smart environments. The integration of cloud and IoT based online applications operates well than traditional cloud-based applications based on efficiency. The rising applications like medicinal, defense and banking applications make utilize these combinations. Particularly, the cloud based
IoT and Cloud based Smart Healthcare System using Optimized Data Classification Algorithm

IoT method make use of offering effective services to the medicinal applications to monitor as well as access records from remote areas. IoT centric Healthcare application is employed to gather the needed data like often modifications in healthcare variable on time and it updates the rigorousness of the medicinal variables under default time duration.

Moreover, IoT components and medicinal variables related to sensor values can be used effectively to diagnose the diseases precisely at the earlier stage. Machine learning algorithms play a vital part in the decision-making process while managing massive quantity of data. The process of applying data investigation methods to the particular domains like neural network, classification clustering and also employs efficient techniques is used. The data can be created from different sources with specific data type and is essential to develop methodologies that have the ability of handling data characteristics.

In this study, we have gathered massive quantity of various kinds of data by the use of IoT devices which are used as input data. They are saved in the cloud and retrieved for various purposes. Here, we employ a machine learning approach to proceeds the learning procedure that maps the data under two classes namely Normal and abnormal. In this study, we try to devise an IoT and cloud based smart healthcare system to diagnose the disease. The IoT devices attached to the patient body gathers the needed data and stored in the cloud. Then, we present an optimal Support Vector Machine with Grey Wolf Optimization (SVM-GWO) algorithm to classify the presence of disease using the acquired data. For experimentation, we employ a benchmark heart disease dataset and a set of measures are used to analyze the attained results. The experimental outcome ensures the betterment of the presented model over the compared methods under different evaluation parameters. The upcoming sections of the paper are arranged as follows: Section 2 presents the proposed model and Section 3 validates the presented model. Section 5 presents the conclusion.

2. Proposed Model

The presented IoT and cloud based smart healthcare system first gathers the needed data from IoT devices, UCI repository and medical data. Then, the data will be saved in cloud. Finally, the data will be investigated by the SVM-GWO classifier for the identification of the diseases. The overall process is given in Figure 1.

![Figure 1. Overall process of the proposed model.](image)

2.1 Data Collection

The presented model contains three diverse types of data. It has the authority to gather patient data by the use of wearable IoT devices that operates on sensors. They are placed on the human body to collect the special patient data or data seamlessly in regular time intervals. In general, these devices ensure every patient healthcare data falls in normal level. When the observed patient data crosses the normal value, it raises an alarm and send an alert to the doctor. In addition, the data stored in the cloud will be investigated by the SVM-GWO classifiers.

2.2 Disease Diagnosis Model

SVM is a well-known and effective classifier developed by. It can be employed to detect the abnormalities in the healthcare data acquired by the IoT devices. Here, the structure of SVM is based on the following factors: Initially, the regularization variable C controls the trade-off among maximizing margin and number of misclassifications. Next, kernel functions of nonlinear SVM are employed to map the training data from an input space to high dimensional feature space. Every kernel function of linear, polynomial, radial basis function and sigmoid has few variables known as called hyperparameters. Presently, the kernel mainly employed in Brain-Computer Interface research is Radial Basis Function (RBF) kernel with width $\sigma$:

$$K(x, y) = \exp(-\|x - y\|^2 / 2\sigma^2)$$  \hspace{1cm} (1)
Where, $K(x, y)$ is the kernel function defined by the multiplication of two invariants $x$ and $y$. Appropriate trade-off and kernel parameters $C$ and $\sigma$ are needed for training the SVM classifier and generally attained using K-fold cross-validation approach. Here, we employed the standard 10-fold cross validation for effective results.

Here, we present an SVM-GWO method to classify the patient data for disease diagnosis. GWO algorithm is developed based on the nature of wolves\textsuperscript{14}. The intention of this method is to optimize the classifier results of SVM the automatic estimation of optimum feature subset and optimum values of the SVM variables of the SVM model. The presented SVM-GWO model has various sub processes which are shown in Figure 2.

![Figure 2](image)

Figure 2. Process involved in SVM-GWO.

### 2.2.1 Pre-processing and Feature Extraction using DWT

Initially, with aim to achieve effective performance in feature extraction, wavelet decomposition is employed to preprocess the medical data for extracting the attributes present in the instance.

### 2.2.2 Features Selection and Parameters Optimization using GWO

Effective classification can be attained by the removal of unwanted and repetitive data with the maintenance of discriminating power of the data by feature selection. GWO has the capability of generating optimum feature subset as well as SVM variables concurrently. The parameter settings of the SVM show significant results on its classifier performance. The unsuitable parameter settings will result in worse classifier performance. The parameters need to be optimized are $C$ and $\sigma$.

### 2.2.3 Fitness Function

The classification accuracy is selected as the solution qualifier in the searching procedure. The classifier accuracy ranges between $[0, 1]$, where each wolf Search Agent reflects a number of accuracies based on the applied cross-validation mechanism. In addition, every wolf shows ten accuracy values for every fold and every accuracy value are averaged to produce a fitness value to the search algorithm and is represented as:

$$\text{fitness}(w, t) = \frac{\sum_{k=1}^{N} acc_{w,t,k}}{N}$$

Where $\text{fitness}(w, t)$ is the fitness value of wolf $w$ in iteration $t$, $N$ is the number of folds chosen for cross validation and $acc_{w,t,k}$ is the resultant accuracy.

### 3. Performance Validation

#### 3.1 Dataset used

For ensuring the results of the applied SVM-GWO, a set of experimentation takes place on the applied Heart disease dataset\textsuperscript{15}. The information related to the applied dataset is available in Table 1. Generally, the dataset is downloaded from UCI repository. It has a total of 270 instances with 13 attributes. Among the 270 instances, 150 instances denote the absence of heart disease and the remaining 120 instances implies the presence of heart disease. The total number of 13 attribute distribution of the used dataset is shown in Figure 3. From the figure, it can be clearly shown the name of the attribute and the corresponding distribution.
Table 1. Dataset description

| Dataset Name | Source | Number of Attributes | Number of classes | Absence/Presence |
|--------------|--------|----------------------|-------------------|-----------------|
| Heart-statlog | UCI    | 13                   | 2                 | 150/120         |

3.2 Results Analysis

In this section, the obtained results of the proposed SVM-GWO is provided in terms of different measures such as False Positive Rate (FPR), True Positive Rate (TPR), precision, recall, accuracy, F-score, ROC and kappa values. The minimum values of FPR, at the same time, maximum values of TPR, precision, recall, accuracy, F-score, ROC and Kappa values imply effective classification performance. Figure 4 shows the values obtained by the presented SVM-GWO and compared methods in terms of FPR, TPR, precision and recall. Likewise, Figure 5 depicts the comparative results attained by SVM-GWO and other methods in terms of accuracy, F-score, ROC and kappa value. To compare the results of SVM-GWO, a set of well-known classifiers namely RF, MLP and DT are used. From the Table 2, it is apparent that the SVM-GWO attains a minimum FPR of 16.60. The DT and MLP classifiers depict ineffective results with a maximum FPR of 24 and 21.80 respectively. The RF classifier tries to manage to produce effective results with a FPR of 19.60, but not better than SVM-GWO.

Similarly, in terms of TPR, the maximum value of 84.10 is attained by the SVM-GWO implying effective classifier results. And, the MLP and DT offer lowest TPR of 78.10 and 76.70 respectively. At the same time, the RF exhibits somewhat better results with a high TPR of 81.50. However, it fails to outperform SVM-GWO. In terms of precision and recall, the DT shows worse results with minimum values of 76.60 and 76.70 respectively. And, the MLP is somehow better than DT with the precision and recall values of 78.40 and 78.10 respectively. But, the proposed SVM-GWO shows excellent results with a maximum identical precision and recall values of 84.10 respectively. On the basis of F-score, maximum value of 84.10 is obtained by SVM-GWO and minimum values of 81.40, 78.20 and 76.70 are achieved by RF, MLP and DT respectively. In addition, on measuring the classifier performance in terms of ROC, a lowest value of 74.40 attained by DT indicates its efficiency on the applied dataset. Next, the RF shows superior ROC with a higher value of 89.80 compared to MLP and SVM-GWO. The SVM-GWO shows competitive results with ROC value of 89.30.

Finally, the classifier results of the presented SVM-GWO are analyzed in terms of kappa value. It is shown that the lowest kappa value of 52.70 is obtained by DT. And, MLP achieves a kappa value of 56 which is higher than DT, but not higher than RF and SVM-GWO. Likewise, the RF attains a kappa value of 62 which is higher than MLP and DT, but not higher than SVM-GWO. The presented SVM-GWO exhibits maximum results with a highest kappa value of 67.67. The above table and figures reported the superiority of the presented SVM-GWO over the compared methods with a maximum TPR of 84.10, precision of 84.10, recall of 84.10, accuracy of 84.07, F-score of 84.10, ROC of 89.30 and kappa value of 67.67 respectively. These values indicate that the SVM-GWO is found to be an effective model to diagnose diseases in IoT and Cloud based smart healthcare systems.
4. Conclusion

In this work an IoT and cloud based smart healthcare system to diagnose the heart disease is developed. The IoT devices attached to the patient body gathers the needed data and it is stored in the cloud. In general, these devices ensure every patient healthcare data fall in normal level. When the observed patient data crosses the normal value, it raises an alarm and sends an alert to the doctor. In addition, the data stored in the cloud will be investigated by the SVM-GWO classifiers. Then, an optimal Support Vector Machine with Grey Wolf Optimization (SVM-GWO) algorithm is used to classify the presence of disease using the acquired data. For experimentation, benchmark heart disease dataset is used and a set of measures are used to analyze the attained results. The presented SVM-GWO achieves a maximum classifier results with accuracy of 84.07%, precision, recall and F-score of 84.10% respectively. The experimental outcome ensures the betterment of the presented model over the compared methods under different evaluation parameters.

5. References

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