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IOT WITH CLOUD BASED DISTRIBUTED HEALTHCARE SYSTEM FOR DISEASE DIAGNOSIS USING OPTIMIZED SUPPORT VECTOR MACHINE

[1]Z. JOHN BERNARD, [2]T. VENGATTARAMAN

[1]Assistant Professor, PG Department of Computer Applications, St. Joseph's College of Arts and Science (Autonomous), Cuddalore

[2]Department of Computer Science, Pondicherry University, Puducherry, India

[1]jbzbernard@gmail.com, [2]vengattaramant@gmail.com

Abstract

Internet of Things (IoT) and cloud computing technologies offers several applications in healthcare sector. On a distributed healthcare management, a number of IoT devices are utilized for monitoring the health conditions of the patients and transmit the data to the cloud server for further processing. This paper introduces a new cloud and IoT based distributed healthcare system using improved particle swarm optimization (IPSO) with support vector machine (SVM), named IPSO-SVM model. The proposed method initially involves the data acquisition process, where the data will be generated using IoT devices and benchmark medical data repositories. The IPSO-SVM model will be trained using repository data in the cloud server and is thereby employed to test the patient's data transmitted from the IoT devices. The proposed IPSO-SVM model performs disease diagnosis process in the cloud, which identifies the existence of disease effectively. At last, the generated test reports will be sent back to the patient's, healthcare centres, and physicians. A series of experiments takes place on diabetes disease to verify the effective performance of the proposed IPSO-SVM model. The simulation outcome indicated that the IPSO-SVM model has offered superior results with the maximum average sensitivity of 96.28%, specificity of 93.72% and accuracy of 94.44%.

Keywords: Cloud computing, Distributed systems, IoT, Healthcare, Parameter optimization

1. Introduction

IoT offers the design and development of Internet-connected Things via computer networks. The main aim of using IoT is that, rather to use small amount of powerful computing tools like laptop, tablet, and mobile phone, it is better to use large number of minimum powerful gadgets like wristband, air-conditioner, umbrella, and fridge. Some of the prominent human-applicable devices like air fresheners and transports are smartly designed by processing units, and sensors. It produces a practical simulation outcome that can be applied in day-to-day life. Thus, the embedded devices hold the computation and communication abilities that exceeds the requirements of small gadgets like a tiny lamp and umbrella and also it has been connected to the buildings by network communication. Such enlightened objects in IoT are composed of technical reasoning capability to perform the allocated work without holding the details of name and personality. The norm ''Ubiquitous computing'' varies from IoT in the way that, IoT can be applied all over the world through Internet connections. A ''Thing'' that exist in today's world could obtain inputs from users or living things and convert these data to the Internet, so that the data can be collected and computed. For illustration, a sewing machine can store the data of remaining number of threads, count of stitches sewn and number of stitches it can perform in future. It can be accomplished under the utilization of sensors which saves the function of objects within the given time limit. ''Actuators'' are also employed with the sensors to show the results to today's world by linking the things present globally. A sewing machine might provide an alert signal for the lack of thread and to place a new one into the system.

To maximize the efficiency of IoT, it is embedded with Cloud Computing (CC) so that the system's productiveness has been improved with massive benefits. An observation model is deployed under the combination of IoT and CC methodologies to observe the patients health at the distant site which is helpful for the doctors and care takers to know the person's present condition. IoT is one of the significant tools in CC, used to improvise the performance with respect to maximum resource application, memory, power and processing ability. Additionally, CC acquires the merits from IoT model by maximizing the potential to manage problems of the present world and establishes maximum services in a dynamic manner.

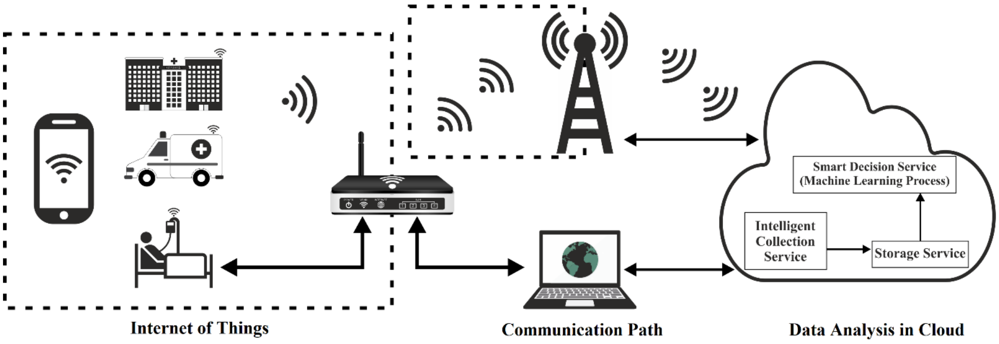

Fig. 1. Structure of IoT based Healthcare Model

The integration of CC and IoT centric online applications performs quite-well when compared with normal cloud based applications by means of efficiency. The newly deployed applications like medical, armed forces and banking sectors apply these combinations. In particular, the Cloud oriented IoT framework would be applicable to provide effective facilities in clinical fields to monitor and access the patient details anywhere and anytime [1]. IoT based Healthcare domains have applied these methods to collect the required details like enough modifications in health metrics on time and it upgrades the significance of medical variables within the provided ample of time. Also, IoT devices and medical constraints based sensor readings might be employed successfully for the disease identification process on correct time in prior to reaching a critical situation [23-28]. A basic overview of IoT based Healthcare Model is shown in Fig. 1 and the statistics in the rise of IoT devices in healthcare is shown in Fig 2.

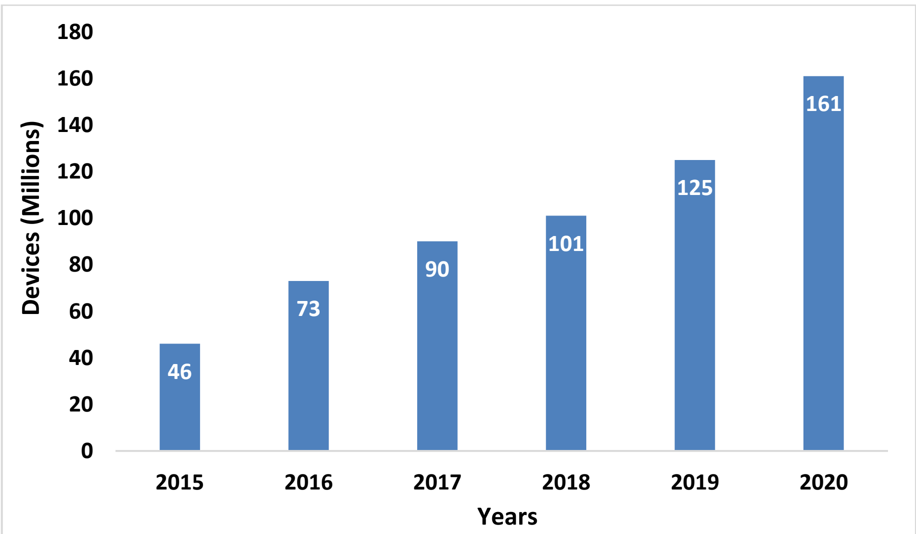

Fig. 2. Statistics of IoT devices in healthcare [Source: Business Insider]

Along with that, Machine learning (ML) technique plays an important role of making decision even at the time of managing massive amount of data. The application of data analysis models to the specified areas defines the data types such as velocity, variety and volume. A benchmark data analyzing methods are neural network (NN) model, classification model and clustering method along with some efficient methods. The data can be produced from diverse sources with specific data types that are highly useful in deploying the data handling approaches. In IoT, there are massive quantities of resources that establish essential data in practical world with no issues of scalability, velocity and to find the optimal data method. Therefore, these problems lead to deploy more number of models effectively. Here, maximum amount of big data have been collected from diverse data types like image, text and definite data using IoT devices as input. This information would be saved into the CC platform with higher security and can be accessed for the future healthcare applications.

This paper develops an effective CC and IoT based distributed healthcare system using IPSO with support vector machine SVM, named IPSO-SVM model. The IPSO algorithm is used for SVM parameter tuning which results in better classification accuracy. The proposed IPSO-SVM model performs disease diagnosis process in the cloud, which identifies the existence of disease effectively. Once the reports are generated, it will be transferred to the patient's, healthcare centres, and physicians. The sequences of experiments are carried out for validating the effective function of the newly presented IPSO-SVM model.

2. Related works

In this model, several techniques have been developed performed by many developers in the last decades. Fig. 3 illustrates the different concepts and applications involved in the IoT based healthcare sector [2]. [3] proposed a new technique for observing the severity of a disease and it is performed using CC and IoT. It has been majorly employed for predicting the disease severity. The goal of this method is to monitor the health condition of students. A programmatic health data is produced with the application of reputed UCI Repository. While a sensor in medical application is used in disease forecasting that affects the students. Several classification techniques are used to predict the disease types. It estimates the prediction accuracy with the application of parameters like F-measure, specificity and sensitivity. Consequently, the newly developed approach performs quite well when compared to conventional models.

[4] projected new energy approaches that work for cloud driven IoT platform. These energy mechanisms are mainly employed for analyzing the video stream acquired from vehicles cameras. These approaches are sampled real-time applications and simulate the model utilizing well-known simulators to analyze the improvement with IoT gadgets. [5] implied a review on CC and IoT methods on the basis of the security problems. Additionally, the list of contributions is provided at cloud to the IoT. At last, it has been stated that the responsibility of CC and IoT models is to enhance the working function. [6] developed and established a new multi-layer cloud mechanism that has been presented to boost the efficiency and flawless communications across the heterogeneous facilities which are offered by different vendors in smart home. Furthermore, ontology is applied to solve the heterogeneity problems that are projected in a layered cloud environment. Also, ontology is mainly applied to report the data representation, knowledge as well as heterogeneity application. In line with this, a security approach has applied ontology to support these security and privacy conservations of interoperations.

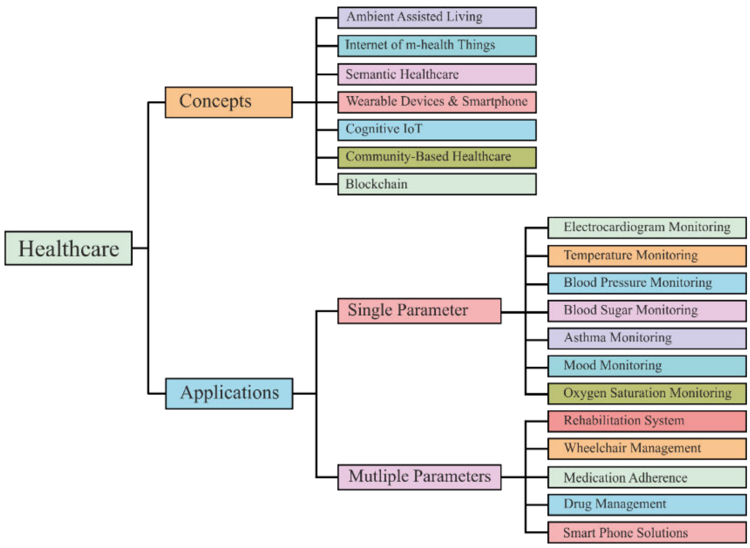

Fig. 3. Concepts and Application of IoT Healthcare

[7] established novel as well as scalable 3 tier architecture for saving more amount of sensing data. Initially, Tier-1 is responsible to gather data. Second, Tier-2 focused on the archival of collected data in CC. Finally, a predictive method is presented for heart diseases (HD). Then, ROC examination has been carried out to find the symptoms of HD. [8] implied a car camera system smartly that applies a mobile CC approach for deep learning (DL). It is applied for predicting the objects present in the saved videos at the time of driving a car. It is composed of training phase, recognition phase as well as data collection phase. Better prediction accuracy can be obtained from this method.

[9] concentrated to develop a novel cloud relied parallel ML method for machinery prognostics. In addition, Random Forest (RF) classifier has been applied for the prediction of tool wear in dry milling tasks. The parallel RF model is mainly employed under the application of MapReduce which is executed in Amazon Cloud. It is evident that the RF classification method is capable of properly predicting the accuracy. [10] carried a study for supervising the voice pathology of a patient using CC and IoT. Also, a new local binary pattern (LBP) driven prediction mechanism has been

introduced to predict the voice pathology within the given time limit. It reaches to better classification accuracy when compared with previous models. [11] defined the ground rules of IoT with applicable constraints suitable for u-healthcare. This healthcare system if found to be helpful and improved the performance of healthcare care service. [12] explained a framework that depends upon the IoT medical devices which can be connected over body area sensor networks. Here, a patient is under the observation of the application of diverse small power as well as minimum weighted sensor networks. Additionally, the security demands are also satisfied devising the healthcare system.

[13] presented an online observation model named as Healthcare Industrial IoT in order to observe the health status. This model is applied for analyzing the patients' health details to reduce the mortality rate. In order to eliminate the medical errors and thefts involved in clinical fields, the security mechanism like watermarking as well as signal enhancements is applied. [14] described numerous methods to develop the applications of m-healthcare. A website developer observes the patient's health status at remote site by applying the IoT based system.

Diverse web oriented applications are deployed for health data with respect to patients and physicians outside a medical setting. [15] developed a people-based sensing approach that is highly useful for elder and disabled people. The goal of this model is to offer service based adverse response for emergency condition of the patients. [16] established a modern as well as collaborative security framework to reduce the threats in IoT based healthcare platform. Also, it has been examined the advancements present in IoT healthcare. Then, the specific importance is provided to study the state-of-art networking environment, applications, and the business improvements in IoT centric healthcare solutions.

3. The Proposed IPSO-SVM Model

The overall process of the IPSO-SVM method is shown in Fig. 4. As shown, the proposed model works on 2 major stages, namely training and testing process. At the training stage, data acquisition process takes place where the data gets gathered from IoT devices, medical records, and repositories. The data is saved in the cloud database server where the preprocessing and actual classification process takes place. Once the model inference is developed, the testing process will begin. During the testing stage, the data from the medical IoT devices connected to the patients would be sent to the cloud database server, which performs the classification process. Then, the classified output is provided to the hospital, physician, and patients.

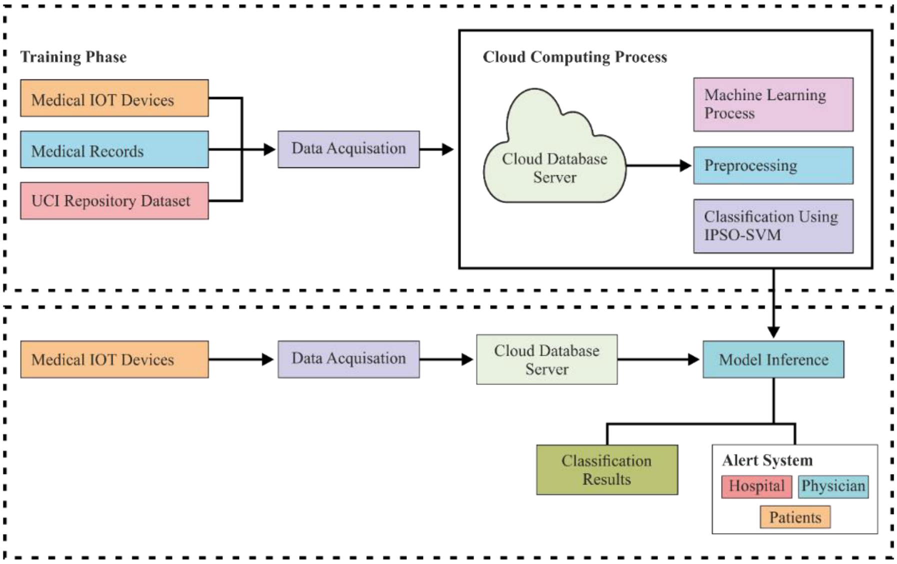

Fig. 4. Overall Process of Proposed Method

3.1. Data acquisition and Preprocessing

Initially, the data is acquired from IoT devices, data repositories, and medical records. The presented technique makes use of 5G network for sending the patient details to the cloud server. Besides, benchmark repositories data is used for mapping the actual data originated from the IoT devices. Once the data is gathered in the cloud server, pre-processing takes place in two levels. At the initial level, data transformation process takes place where the categorical values are transformed into numerical values. Then, data normalization process is carried out.

3.2. IPSO-SVM based Classification process

3.2.1. Support vector machine (SVM)

SVM is a popular data classification technique, which performs training process using the sampling data. Then, classification process takes place using the trained model [20-22]. Suppose $(u, v_1), \dots, (u_m, v_m) \in X \times \{\pm 1\}$ is a collection of training data, where X denotes the non-empty set from pattern x_i and y_i is named as target $v_p \in \{\pm 1\}$. SVM tries to find the hyper-plane in a multidimensional space. Let hyper-planes in dot product space is termed as H. The parameters w and b are defined as provided below:

$$(\langle w \cdot u \rangle + b) = 0, \textit{where } w \in H, b \in R. \quad (1)$$

When a hyper-plane meets the Eq. (1), then linear separation is applied. Here, w and b could be modified as provided below:

$$\max_{w \in H, b \in R} \min_{1 \le p \le N} \{ \| u - u_p \| \mid u \in H, \langle w \cdot u \rangle + b) = 0, p = 1, \dots, m \} \quad (2)$$

Suppose the distance from a data point to hyper-plane might be $1/\|w\|$. The dividing hyper-planes are optimal separating hyper-plane (OSH), which has a maximum distance among 2 supports vector points (SVP) on its two sides are existed. Due to the distance among 2 SVP is $1/\|w\|^2$, a smaller distance to OSH, $\|w\|^2$, can be derived from Eq. (2).

The margin $2/\|w\|$ of an SH has been named as the hyper-plane's generalizing potential, and OSH has higher margin between SH. $\|w\|^2$ could be reduced using Eq. (2) and Lagrange's polynomial. Assume α is $(\alpha_1, \dots, \alpha_m)$ and integrating Lagrange's polynomial with Eq. (2) generates the maximization function as given below:

$$W(\alpha) = \sum_{p=1}^{m} \alpha_p - \frac{1}{2} \sum_{p,q=1}^{m} \alpha_p \alpha_q v_p v_q \{u_p u_q\} \quad (3)$$

$$\textit{subjected to } \alpha_p \ge 0 \textit{ for } p = 1, \dots, m \textit{ and } \sum_{p=1}^{m} \alpha_p v_p = 0. \quad (4)$$

Quadratic programming (QP) is used to resolve the maximization issues.

A vector fulfils Eq. (3) in maximization, the OSH is represented as (w, b) which can be expressed as:

$$w = \sum_{p=1}^{m} \alpha_p v_p u_p \quad (5)$$

where the SVP should assure $\alpha_p \ge 0$ and Eq. (2). While assuming the restraint of Eq. (4), the function of hyper-plane is provided as follows:

$$f(u) = \mathrm{sgn}\left(\sum_{p=1}^{m} v_p \alpha_p \{u, u_p\rangle + b \right) = 0 \quad (6)$$

Mostly, a data is not a linearly separable, and mapped to high dimensional feature space. When a data could not be classified in an existing dimensional space, then SVM undergoes mapping of data to higher dimensional space to perform the classification task.

The input data is mapped with high dimensional feature space by allocating a non-linear curve. The OSH has been developed at the feature space. The feature space vectors u, u' are built with respect to kernel k estimate on input patterns $u, u', k(u, u') = \langle u, u^1 \rangle$.

The kernel function could be applied used since each feature vectors is carried out in dot product. The weight vector is expanded at feature space, and it does not correspond to the Φ −image of an individual input space vector. The decision function can be represented by:

$$f(u) = \mathrm{sgn}(\sum_{p=1}^{m} a_p\, v_p \langle \Phi(u), \Phi(u_p) + b \rangle) = \mathrm{sgn}(\sum_{p=1}^{m} a_p\, v_p k(u_p, u_q) + b), \quad (7)$$

The QP is expressed as,

$$\max_{\alpha \in R^m} W(\alpha) = \sum_{p=1}^{m} a_p - \frac{1}{2} \sum_{p,q=1}^{N} \alpha_p\, \alpha_q v_p v_q k\left(u_p, u_q\right) \quad (8)$$

$$\textit{subject to}\ \alpha_p \geq 0\ \textit{for all}\ p = 1, \dots, m\ \textit{and} \sum_{p=1}^{m} \alpha_p\, v_p = 0. \quad (9)$$

Various kernel functions are applied in the SVM to find the better conclusion. Some of the vital functions are polynomial kernel, sigmoid kernel as well as Radial Basis kernel function (RBF). Here, RBF has been employed commonly, as it classifies the multi-dimensional data, unlike a linear kernel function. Moreover, the RBF is composed of minimum parameters when compared with polynomial kernel. Finally, the RBF is considered to be efficient for kernel function. Hence, it applies an RBF kernel function with SVM to identify the best solution.

There are 2 main attributes utilized for RBF in SVM, C and γ, which has to be fixed in an appropriate manner. Here, parameter C refers the cost of penalty. The parameter C value tends to produce impossible outcomes. When C is larger, then the classification accuracy would be higher in the training stage, and lower in the testing stage. Alternatively, if C is smaller, then classification accuracy is not reasonable and reduces the system's efficiency. Then, parameter γ has robust effect when compared with parameter C interms of classification results, as the values results at inferior results. The additional rate for parameter Y tends to cause the problem of over-fitting, while the improper values lead to under-fitting [17]. Therefore, there is a need of an effective model to determine the parameters of C and Y to obtain optimal solutions.

3.2.2. PSO algorithm

PSO precedes the searching task through swarm of particles that is upgraded for each iteration. In order to get best solution, every particle moves towards the existing best position (pos_{best}) and best global position of swarm (g_{best}) as provided below:

$$pos_{best_p} = pos_p(k^*) \quad (10)$$

$$s.t.\,fitness\ (pos_p(k^*)) = \min_{k=1,\dots,z}, [\text{fitness } (pos_p(k))\ ],$$

$$g_{best} = pos_{p^*}(k^*) \quad (11)$$

$$\text{s.t. fitness } \left(pos_{p^*}(k^*)\right) = \min_{\substack{p=1,\dots,P \\ k=1,\dots,z}} \left[\text{fitness } \left(pos_p(k)\right)\right],$$

where p is the particle index, P refers the overall count of particles, k signifies the iteration index, z implies recent iteration value, and pos defines the position as defined in the provided equation:

$$vel_p(z+1) = wvel_p(z) + c_1 r_1 (pos_{best_p}(z) - pos_p(z))$$

$$+ c_2 r_2 (g_{best}(z) - pos_p(z)), \quad (12)$$

$$pos_p(z+1) = pos_p(z) + vel_p(z+1),$$

where vel is velocity. The inertia weight w is mainly applied for managing the global exploration as well as local exploitation. The r_1 and r_2 are uniformly distributed random variables from $(0,1)$, c_1 and c_2 are acceleration coefficients.

3.2.3. IPSO algorithm

The IPSO method depends upon the last eliminated process and improves the local-global information distributing ability to enhance the global optimization. The velocity and position of particles are initiated arbitrarily, while the fitness values of particles are evaluated. Data on the present individual as well as global optimal particles, such as the positions and fitness values are stored. In IPSO model, Eq. (13) is applied for extending the speed for managing the exploration and exploitation abilities of the particles in global optimization task. Eq. (14) is local-global data distribution as given below:

$$vel_{id}^{z+1} = \omega vel_{id}^{z} + C_1R_1(pos_{id}^{z} - u_{id}^{z}) + C_2R_2(pos_{gd}^{z} - u_{id}^{z})$$
$$+C_3R_3\left|pos_{gd}^{z} - pos_{id}^{z}\right| \quad (13)$$

$$\varphi_3 = C_3R_3\left|pos_{gd}^{z} - pos_{id}^{z}\right|. \quad (14)$$

Eq. (13) contains 4 portions as given in the following:

- Inheritance of existing speed
- Particle self-cognition
- Local information sharing
- Local-global information sharing

The IPSO technique is not a one-way communication among global and individual particles. The local-global information sharing system (ϕ_3) is used to perform the data exchange from local optimum and global optimal particles attained from new iteration. The population velocity is improved using Eq. (13). Initially, the whole search space can be explored with the relative speed for computing the random limit of best solution; and the obtained simulation outcome is highly applicable for attaining global search [18]. Followed by, the particle search space is slowly decreased and focused in the neighborhood of best value for deep search; and attained result is highly advantageous for local search.

The particle which does not exceed the predefined range maintains the actual speed throughout the entire system. The higher value of velocity is allocated to the particle which exceeds the assigned speed. If the particle goes beyond the predefined range, ineffective particles are avoided by including particles to the population inside the pre-determined range, which results in the formation of new population. The fitness measure of new population is re-evaluated, and the data regarding individual particle as well as global optimal position as well as FF value that attained by the recent iterations are conserved. The particles have best global search ability and individual particles that move nearby the local optimal particle and slowly reduce the particle diversity.

According to the suggestion of population, GA, and last-eliminated strategy is employed in IPSO algorithm to retain particle population diversity. If the PSO satisfies the local convergence condition, the best value is attained might be named as local optimal value. Particle population diversity is provisioned under the application of particle FF as the estimation criteria eliminate the particles with worst FF values. When the recent iteration achieves the essential predefined convergence accuracy, then the iteration gets terminated and better solution has been accomplished. The difficulty and implementation of the model gets improved because of the increase in local-global information sharing as well as last-eliminated principle. Regardless, experimental results depict that, the newly presented model could maximize the accuracy of the approach.

3.2.4. IPSO-SVM algorithm

For computing the best parameter of C and σ, conventional techniques applies trial-and-error concept. It leads to maximum computation overhead and there is no guarantee to identify best solutions. The PSO is a populated global optimization method, which has been evolved from the nature of bird flocking or fish schooling. It is simple and rapid to execute. On the other side, the cross-validation (CV) is developed to build the FF module for IPSO algorithm.

Here, a 10-fold CV is selected by assuming the optimal compromise among processing cost and stable estimates. The dataset has been partitioned into 10 mutual subsets with same size randomly, where 9 subsets are applied as training set, and remaining one subset is employed as validation set [19]. It has been repeated for 10 times, so every subset will be utilized for verification. The FF of PSO selects the classification accuracy of 10-fold CV is represented as:

$$FF = \frac{1}{10}\sum_{p=1}^{10} \left| \frac{v_s}{v_s + v_m} \right| \quad (15)$$

Here v_s and v_m are the number of effective classification and misclassification instances and IPSO is used to enhance the FF (classification accuracy).

Here, the model is defined in 3 stages.

Step 1: Gathering patients data using IoT devices

Step 2: Performs Pre-processing.

Step 3: Execute 10-folded CV.

Step 4: Computing the optimal parameter.

Step 4.1: Initializing IPSO. The particles correspond to $C$and σ.

Step 4.2: For every particle p, determine the FF values.

Step 4.2.1: Decoding the particle to parameters C and σ.

Step 4.2.2: Applying interior model to train SVM.

Step 4.2.3: Compute the classification error based on the FF values.

Step 4.3: Upgrade the g_{best} and pos_{best}

Step 4.4: Upgrade the velocity and position of every particle

Step 4.5: When stopping criteria is met, then jump to Step 4.6; else, return to Step 4.2.

Step 4.6: Decoding the best particle to corresponding parameter C^* and σ^*

Step 5: Developing SVM by the best C^* and σ^*

Step 6: Providing new data to the trained SVM and performs prediction.

4. Performance Validation

Table 1 and Fig. 5 imply the brief comparative analysis of the IPSO-SVM with traditional models with respect to accuracy. The table measures guarantee that the IPSO-SVM model has provided higher performance than the compared methods under varying number of records. For example, with the existence of 2000 records, the SVM and NB approaches have shown impractical result with the lower accuracy values of 74% and 77% correspondingly. On the other hand, the kNN model performs well than existing ones with the accuracy of 89%. Simultaneously, it is clear that the DT and FNC have showcases considerable results with the accuracy values of 92% and 93% correspondingly. But, the newly developed IPSO-SVM technique has produced best accuracy of 96%. Similarly, with the application of 10000 records, the SVM and NB methodologies have exhibited inferior outcome with the least accuracy values of 80% and 83% correspondingly. Then, the kNN model has performed better than other methods with the accuracy of 90%.

Table 1 Accuracy Analysis of Proposed IPSO-SVM with Existing Methods

No. of Records	k-NN	NB	SVM	DT	FNC	IPSO-SVM
2000	89.00	77.00	74.00	92.00	93.00	96.00
4000	91.00	81.00	76.00	94.00	94.00	94.00
6000	87.00	76.00	75.00	90.00	91.00	92.00
8000	88.00	82.00	78.00	93.50	94.50	95.00
10000	90.00	83.00	80.00	92.50	94.00	95.20
Average	**89.00**	**79.80**	**76.60**	**92.40**	**93.30**	**94.44**

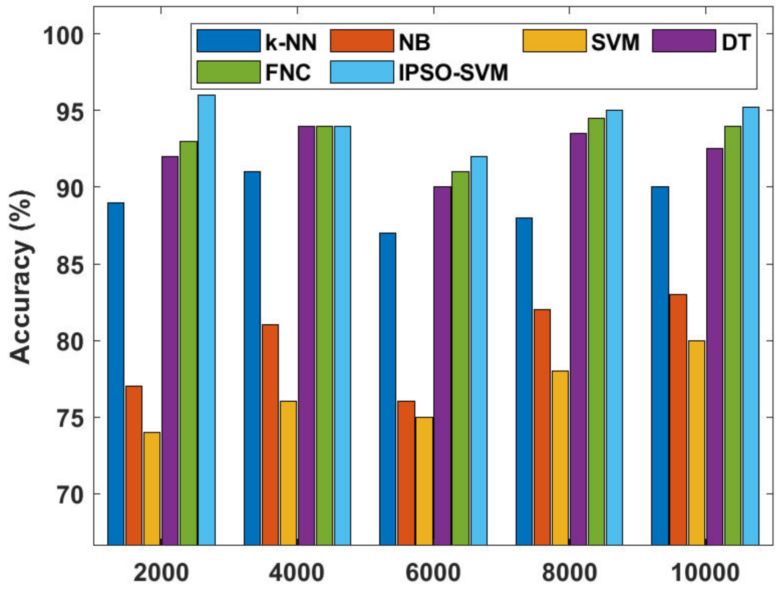

Fig. 5. Accuracy analysis of proposed IPOS-SVM model

Meanwhile, it is pointed that the DT and FNC have shown a reasonable result with the accuracy values of 92.50% and 94% correspondingly. Therefore, the proposed IPSO-SVM model has accomplished good accuracy of 95.20%. Besides, on determining the average performance, the SVM and NB frameworks have depicted poor outcome with the low accuracy values of 76.60% and 79.80% respectively. Followed by, the kNN approach has outperformed the compared techniques with the accuracy of 89%. Concurrently, it is evident that the DT and FNC have demonstrated moderate results with the accuracy values of 92.40% and 93.30% correspondingly. Thus, the proposed IPSO-SVM model has achieved a best accuracy of 94.44%.

Table 2 and Fig. 6 offered the expanded comparative analysis of the IPSO-SVM with previous models by means of sensitivity. The table measures confirm that the IPSO-SVM model has reached to a maximum performance than the earlier techniques under varying number of records. For illustration, under the presence of 2000 records, the SVM and NB models have displayed worst outcome with the lower sensitivity values of 83% and 87.50% correspondingly. On the other side, the kNN model performed quite well than traditional algorithms with the sensitivity of 92%. Simultaneously, it is evident that the DT and FNC have implied considerable results with the sensitivity values of 93% and 94.50% correspondingly. But, the presented IPSO-SVM model has attained a better sensitivity of 95.50%.

Table 2 Sensitivity Analysis of Proposed IPSO-SVM with Existing Methods

No. of Records	k-NN	NB	SVM	DT	FNC	IPSO-SVM
2000	92.00	87.50	83.00	93.00	94.50	95.50
4000	88.00	86.00	82.50	92.00	93.50	94.00
6000	92.80	88.00	83.80	93.00	94.50	95.20
8000	93.50	88.00	83.00	97.00	98.00	98.70
10000	94.20	90.00	83.40	96.00	97.00	98.00
Average	**92.10**	**87.90**	**83.14**	**94.20**	**95.50**	**96.28**

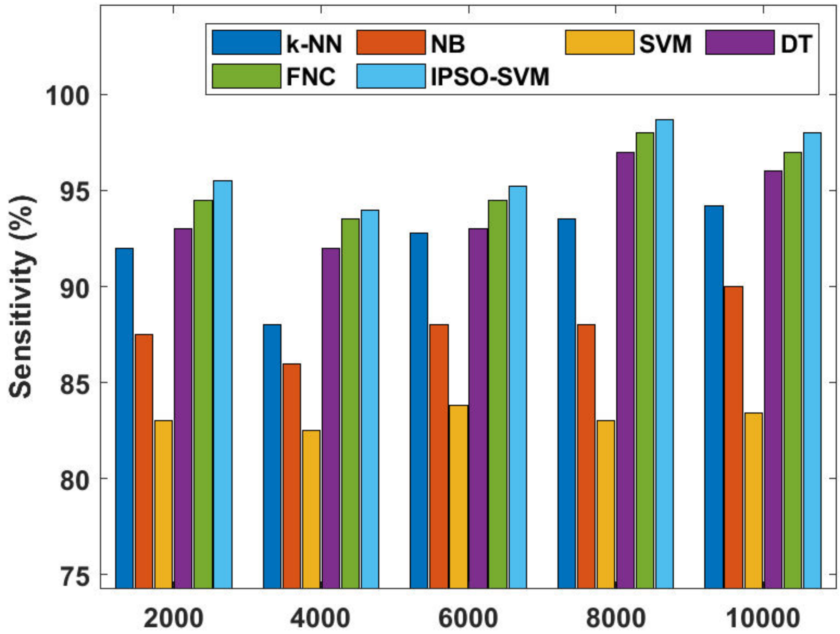

Fig. 6. Sensitivity analysis of proposed IPOS-SVM model

For example, with the application of 10000 records, the SVM and NB approaches have depicted inferior results with the least sensitivity values of 83.40% and 90% correspondingly. On the other side, the kNN model has outperformed the compared schemes with the sensitivity of 94.20%. Concurrently, it is noted that the DT and FNC have shown manageable results with the sensitivity values of 96% and 97% respectively. But, the projected IPSO-SVM model has provided a maximum sensitivity of 98%. On determining the average results, the SVM and NB models have exhibited impractical results with the low sensitivity values of 83.14% and 87.90% correspondingly. Next, the kNN model has shown slightly better sensitivity of 92.10%. Similarly, it is clear that the DT and FNC have reached appreciable outcome with the sensitivity values of 94.20% and 95.50% respectively. Therefore, the projected IPSO-SVM model has accomplished a good sensitivity of 96.28%.

Table 3 and Fig. 7 demonstrate the comparative analysis of the IPSO-SVM with previous approaches with respect to specificity. The table values proved that the IPSO-SVM model has shown a best performance than the compared methods under diverse number of records. For sample, with the application of 2000 records, the SVM and NB methods have implied poor outcome with the lower specificity values of 82% and 83% respectively. Then, the kNN model has outperformed the existing ones with the specificity of 84%. Meanwhile, it is clear that the DT and FNC have demonstrated considerable results with the specificity values of 92.50% and 94% correspondingly. Therefore, the projected IPSO-SVM model has achieved a maximum specificity of 96%.

Table 3 Specificity Analysis of Proposed IPSO-SVM with Existing Methods

No. of Records	k-NN	NB	SVM	DT	FNC	IPSO-SVM
2000	84.00	83.00	82.00	92.50	94.00	96.00
4000	90.00	83.00	83.00	91.00	94.20	94.80
6000	87.00	86.00	83.00	93.00	94.10	94.50
8000	87.50	85.00	80.00	88.00	90.00	91.00
10000	90.00	87.00	84.00	90.50	92.00	92.30
Average	**87.70**	**84.80**	**82.40**	**91.00**	**92.86**	**93.72**

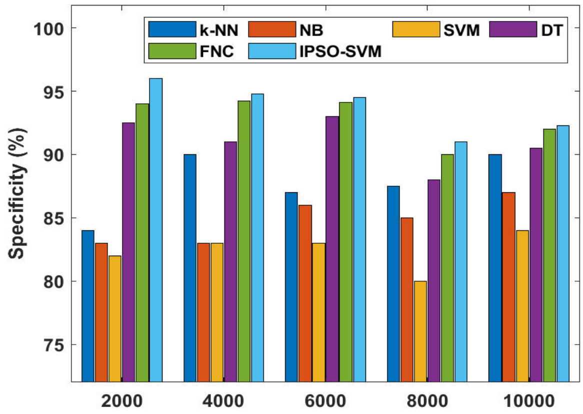

Fig. 7. Specificity analysis of proposed IPOS-SVM model

For instance, with the presence of 10000 records, the SVM and NB models have depicted worst outcome with the least specificity values of 84% and 87% correspondingly. On the other hand, the kNN model has outperformed the existing approaches with the specificity of 90%. Concurrently, it is clear that the DT and FNC have displayed considerable outcome with the specificity values of 90.50% and 92% respectively. Hence, the proposed IPSO-SVM model has exhibited best specificity of 92.30%. On determining the average performance, the SVM and NB models have implied poor outcome with the lower specificity values of 82.40% and 84.80% respectively. Next, the kNN model shows the moderate specificity of 87.70% than the compared approaches. Meanwhile, it is clear that the DT and FNC have achieved reasonable results with the specificity values of 91% and 92.86% correspondingly. Thus, the presented IPSO-SVM model has accomplished a maximum specificity of 93.72%.

Fig. 8 shows the comparative average analysis of existing methods interms of accuracy, sensitivity and specificity. The figure shows that the IPSO-SVM model has shown better performance than the compared methods under diverse number of records.

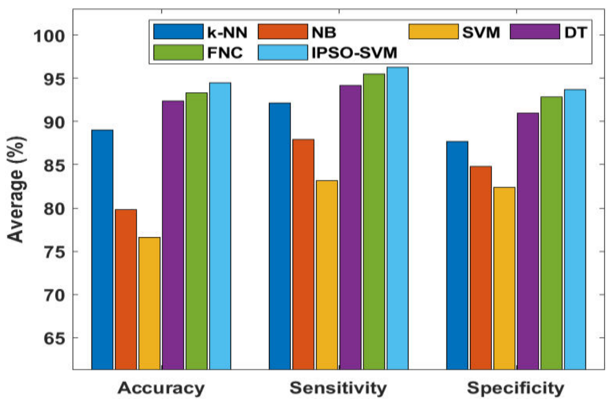

Fig. 8. Average analysis of existing methods interms of accuracy, sensitivity and specificity

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Table 4 Response Time Analysis of Proposed with Existing Methods

Methods	Response Time (ms)
SVM	35
ANN	105
NB	23
K-NN	55
FNC	20
IPSO-SVM	17

Table 4 and Fig. 9 show the response time analysis of distinct models. The figure stated that the ANN model has found to be inferior one, which has required a maximum response time of 105ms. Next to that, the KNN model has attained slightly lower response time of 55ms. At the same time, the SVM model has offered even lower response time of 35ms. But, the NB and FNC models have shown better results over the earlier methods with the response time of 23ms and 20ms. But, the proposed IPSO-SVM model has resulted to maximum results with the minimal response time of 17ms/.

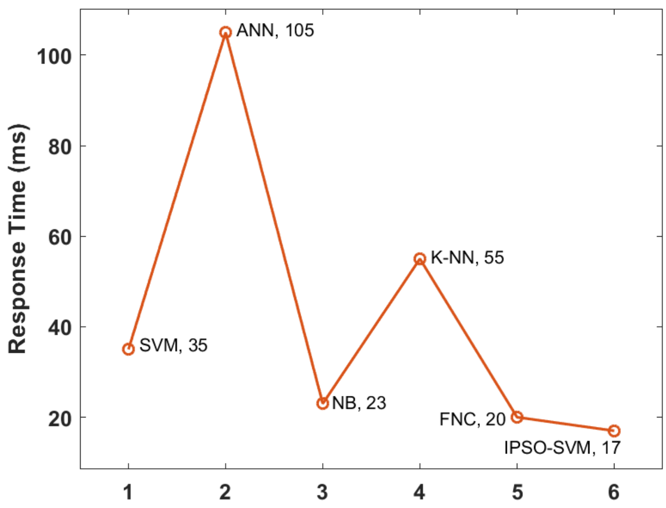

Fig. 9. Response Time Analysis of proposed IPSO-SVM model

5. Conclusion

This paper has developed an effective cloud and IoT based distributed healthcare system using IPSO with SVM, named IPSO-SVM algorithm. The IPSO algorithm is used to tune the parameters of SVM model to attain better classification outcome. The proposed method initially involves the data acquisition process, preprocessing and disease diagnosis. Once the data reaches the cloud server, the proposed IPSO-SVM model performs disease diagnosis process in the cloud, which identifies the existence of disease effectively. A series of experiments takes place to verify the effective performance of the proposed IPSO-SVM model. The simulation outcome indicated that the IPSO-SVM model has offered superior results with the maximum average sensitivity of 96.28%, specificity of 93.72% and accuracy of 94.44%. In future, the proposed method can be extended to the utilization of classifiers other than SVM model.

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