International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

# Machine Learning-Driven Cutting-Edge Approach for Designing a Healthcare Chatbot

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**Submitted:**21/04/2023 **Revised:**13/06/2023 **Accepted:**23/06/2023

**Abstract:** The market for sophisticated Chatbot systems that can communicate with consumers and provide helpful information and support is rising, particularly in the healthcare sector. Developing a Chatbot for healthcare that can comprehend and reply to complicated medical questions in real-time, however, is still a complex undertaking. We suggest the grasshopper-optimized spiking neural network (GO-SNN) tackle this problem. The GO method is used to optimize the weight of synaptic and interconnectivity of the SNN, allowing the chatbot software to process data and make decisions effectively. Extensive tests are run utilizing a standard of actual health inquiries and a dataset containing medical texts from the Kaggle source to assess the efficacy of the suggested approach. The experiment's findings show that in terms of accuracy, reaction speed, and user happiness, the grasshopper-optimized SNN-based medical Chatbot performed better than the alternatives.

***Keywords:*** *Healthcare, Chatbot, communication, grasshopper optimized spiking neural network (GO-SNN)*

## 1. Introduction

A healthcare Chatbot is an intelligent interactive robot that communicates with users, provides data, and helps with various healthcare-related activities using machine learning and methods for natural language processing [1]. The use of chatbots in the medical field has completely changed how consumers and healthcare providers interact with the technology. The creation of advanced health chatbots is one example of the disruptive advances brought on by the rapid growth of technological advances in the healthcare sector [2]. Chatbots can comprehend customer inquiries, obtain accurate data from sizable medical records, and provide suitable replies using cutting-edge technology like machine learning. Healthcare is one of the many industries where chatbots are being developed and used more often. Through efficient data retrieval, individualized suggestions, and even early detection, these clever talking bots have an opportunity to revolutionize the way we engage with medical facilities [3].

The development and execution of a successful healthcare Chatbot, however, offer several difficulties, such as correctly comprehending user queries, responding effectively, and keeping a high degree of engagement among users [4]. A modern strategy incorporating machine learning methods has emerged as a viable answer to these problems. System functionality may be gradually improved as time passes, thanks to machine learning, a subset of artificial intelligence that allows computers to independently own from informatiThisthis kind of techno may create a healthcare Chatbotated that can analyze and understand massive volumes of client documents, research articles, and health-related data to give consumers precise and relevant details [5]. The modern method for creating a chatbot that provides healthcare includes several crucial elements. First, data comprising clinical recommendations, medical expertise, & information regarding patients are gathered and preprocessed. Machine learning algorithms may be trained on this data set to help them get relevant domain knowledge. Next, cutting-edge NLP approaches, such as models based on deep learning, are used to comprehend and efficiently handle user requests [6]. These algorithms can handle complicated phrase patterns, recognize pertinent medical ideas, and extract crucial data to produce suitable replies. Additionally, chatbots that are powered by machine learning may adapt to and learn from user conversations, resulting in constantly enhanced performance. The Chatbot may adjust its replies depending on user feedback by utilizing reinforcement learning methods, guaranteeing the data presented is accurate, current, and suited to specific needs. The Chatbot may modify and adapt to shifts in consumer tastes and medical expertise thanks to this adaptive method of instruction. Healthcare chatbots may be more capable and successful

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by incorporating machine learning techniques into their layout, a cutting-edge strategy [7]. These virtual assistants can deliver reliable and individualized medical data by utilizing the strength of machine learning techniques and SVM models, enhancing availability and customer experience. The Chatbot is a priceless resource in the healthcare industry because reinforced learning allows continual development and adaptability to new situations.

A chatbot is computer software that uses natural language to converse with people. Chatbots have been popular among businesses in recent years to satisfy client requirements. Although chatbots are utilized in many tech-related industries, they should not be used for tasks involving medical. Many of the issues facing the healthcare industry can be reduced by introducing chatbots. This project aims to enhance chatbot design so that it may be applied to a range of medical duties, like alerting patients of future appointments or routine checks, asking for advice, keeping track of their health issues, or marketing a healthcare organization. Healthcare professionals may now focus on caring for patients rather than performing unnecessary tasks. The main challenge in developing conversant bots is making the user-program communication feel accurate and human-like—a simple Graphic User Interface (GUI) for communicating with the Chatbot.

This study introduces the Grasshopper optimized spiking neural network (GO-SNN) for designing a Healthcare Chatbot. The remainder of the paper is divided into subsequent parts. Part 3 contains the proposed method explained. Part 4 includes the results and analysis. While Part 5 discusses the conclusions.

## 2. Related Works

This study [8] addressed all areas of artificial intelligence in business and its benefits for improving business efficiency. The research has also discussed using natural language processing to analyze sentiment, which can improve business results. The two main topics of this study [9] were [I] the application of machine learning to fundamental energy technologies and [II] machine learning scenarios for energy distribution providers. The application of machine learning in enhanced power materials, big data analytics in the context of smart grids, and energy-efficient intelligent energy production are a few of the significant energy advances. Electric vehicle charging and storage devices, strategic energy management, and the incorporation of power from sustainable sources. The health care system [10] is based on ontology, and they also highlight the Chatbot application's potential for further study. Their study aims to develop linkages between people and actual entities to integrate the healthcare system built around an ontology into the Chatbot software.

The impact of current technology advancements on healthcare and how they could change was examined [11]. With the help of this novel innovation, healthcare will become more affordable, efficient, and environmentally friendly. This study [12] proposed the Conversational Virtual Patient (CVP) prototype scenario for teaching medical learners to make decisions around thrombosis. The suggested CVP uses Natural Language Processing and ML approaches to enable learners to create phrases of their own and communicate with the virtual patient in natural language, in contrast with standard simulated patients that rely on predetermined, open-ended input. Security issues for machine learning-based software systems might be caused by ingrained flaws in the architecture or outside adversarial assaults, according to [13]; hence safe development practices should be followed through every stage of development. There isn't any similar evaluation work on machine learning, even though it has emerged as an exciting challenge to the status quo in the field of software engineering.

An intelligent Chatbot for medical applications was designed and put into use [14]. The major objective of the Chatbot is to offer patients a more practical and easy way to get health services and knowledge. This chapter will also look at the many elements and methods that went into creating the Chatbot and how they could have an effect on the medical industry. This study [15] introduced Disha (Direction), a machine learning-based closed-domain Bangla healthcare Chatbot. With the help of its database of information and by picking up on interactions between users, Disha can converse in Bangla with the individual who is using it. It helps the user identify potential ailments based on reported signs, keeps track of their wellness, and alerts them to potential health risks.

## 3. Proposed Method

### 3.1DataSet

The free and open-source Kaggle tournament for health care provided the dataset. There are themes and answers for each of the ten tags in this simple dataset. These patterns and responses seem like inquiries and responses. A dictionary linkage of dictionaries is present in the dataset. Before being associated with their respective queries and keywords, intentions are first mapped with tags, trends, settings, and replies. Due to the short information and excessive fitting that results from training it using a spike neural network model, suitable measures should be considered when creating the algorithm to determine the ideal pace of learning. Table 1 shows the Summary of the dataset.

**Table 1:** Summary of the dataset

| S. No | Attribute Name | Description |
|---|---|---|
| 1 | Tags | In order to train the Chatbot, words are assigned to patterns and replies. "Greeting" and "bye" are examples. |
| 2 | Patterns | Types of questions users ask the Chatbot. |
| 3 | Responses | Responses produced by the Chatbot in response to the relevant questions. |
| 4 | Context | For queries that call for a search and find operation, the context of the query is provided. |

### 3.2 Data preprocessing

For each of the ten tags in this set of textual information, there are various patterns and responses. When using text data, the text data must first be prepared before being used to build a machine Learning model. The most basic and straightforward thing that can be done with text data is tokenizing. It is simple to divide text information into independent chunks known as words. Utilizing the method of processing natural languages, trends are tokenized. The processing of natural languages is provided by Python's NLTK module. The list of words is then pared down by lemmatizing each term and removing any that are redundant. Lemmatizing entails breaking down sentences into their lemmatized forms, which is followed by the creation of a pickle document that includes all of the Python models needed for predictions. Data for instruction, including input and output data, are currently being developed. The design will act as the input, while the class that the design corresponds to will act as the result.

Tokens are used to first divide the input into smaller portions. Each of these lines is afterward lemmatized to allow evaluation of strings from the Chatbot database, which contains every response from the user, and delivery of an appropriate message as a reply to the user. Since the computer cannot understand words, it gets transformed into digits. This is comparable to a one-hot encode for divisional information. The outcome of this procedure is transmitted as input into the neural network. Fig 1 shows the full process. Training and assessment datasets are divided into two categories. 80% of the instructional dataset is used for training, while 20% is used for evaluation. The accuracy of the method is evaluated using test results, and the framework is trained using information from training.

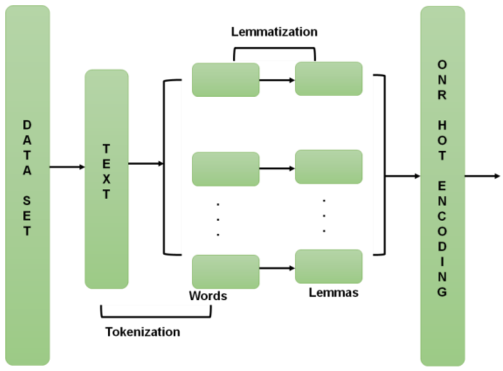


**Fig 1:** The Chatbot's operational flowchart

### 3.3 Grasshopper-optimized spiking neural network (GO-SNN)

#### 3.3.1 Spiking neural network (SNN)

Spiking neural networks (SNNs) have a structure that resembles that of conventional neural networks in structure. The nerve endings that are situated between each layer of neurons and the ensuing delay in synapses are thought to be the cause of the structural variance. Several mathematical frameworks have been developed to explain the behavior of spiking neurons. Fig 2 shows the SNN with feed-forwarding and many synaptic terminals.

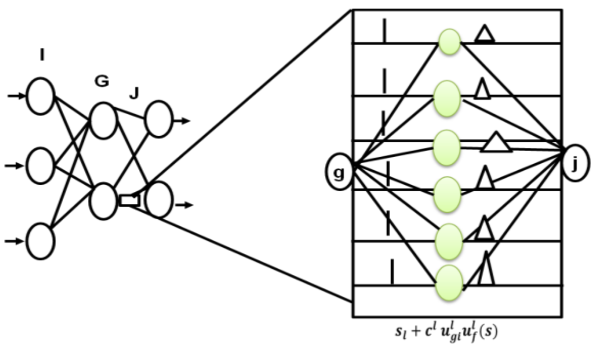


**Fig 2:** Spiking neural network with feed-forwarding and many synaptic terminals

The model consists of a spiking neural network coupled to a feedback loop delaying the delivery of multiple synaptic terminals. The model is depicted in Fig 2, which utilizes the letters I for input, G for hidden levels, and J for output layers on the framework. Spiking neurons have been used to describe the relationship between input spikes and several aspects of the internal state. The adoption of these spiking neurons was supported by the Spike Reaction Model or SRM. This approach accounts for a neuron j as well as a cluster of neighboring pre-synaptic neurons known as $C_i$.

A sequence of spikes with firing periods of $s_j, j \in C_i$ is delivered to the neuron. It is assumed that a neuron can create a spike more frequently throughout simulation intervals and can deliver when the internal state variable reaches the threshold. The following are definitions of the internal condition variable $x_s(s)$ dynamics:

$$x_s(s) = \sum_{j \in C_i} u_{ji} * y_i(s) \qquad (1)$$

In this Equation, the quantity $y_i(s)$ represents the unweighted contribution made by a single synaptic terminal to the state variable $x_s(s)$.

Pre-synaptic spikes that are produced at synaptic terminal k may be defined as follows using a post-synaptic potential (PSP):

$$x_j^l = \varepsilon(s - s_j - c^l) \qquad (2)$$

The duration of $s_j$ in the formula denotes the moment when pre-synaptic neurons fire. j represents the synaptic neurons. $c^l$ indicates the synaptic terminal while presenting the synaptic latency. It is known that when a connection has numerous synapses, the state variable $x_i(s)$ of neuron, 'I' get a sizable quantity of information from each neuron in the network before it. The following is stated as the weighted total of the pre-synaptic contribution:

$$x_i(s) = \sum_{j \epsilon C_i} \sum_{l=1}^{n} u_{ji}^l * y_j^l(s) \qquad (3)$$

The impact of the input pulses is defined by the spike response function$\varepsilon(s)$, and the synaptic potencies are weighted $u_{ji}$. To demonstrate how a leaky-integrate-and-fire spiking neuron may be created, $\alpha,$ the function of the spike response function, $\varepsilon(s)$ is utilized.

$$\varepsilon(s) = \frac{s}{\tau} f^{1-\frac{s}{\tau}}, for\ s > 0, else\ \varepsilon(s) = 0 \qquad (4)$$

In the presence of a temporal constant τ, the duration of the post-synaptic potential (PSP) might change. Synaptic terminals make up each connection in a certain quantity. Sub-connections are usually present at each termination. There are known differences in the linked delays and weights of each sub-connection. Pre-synaptic neuron firing and the beginning of the rise of the post-synaptic potential are separated by a synaptic terminal delay, denoted by the letter k. The threshold value is maintained constant by equal contributions from each neuron in the system.

### 3.3.2 Grasshopper optimization

Grasshoppers go through two developmental stages during their entire life cycle, starting as nymphs and ending as adults. Nymph grasshoppers are slow-moving, wingless herbivores. Adults develop wings as they become older and can fly quickly over a wide region. A gigantic swarm of grasshoppers forms, one of the largest ever recorded. The swarming behavior that grasshoppers display both as larvae and as adults make them easily identifiable. Grasshoppers move slowly and take little steps during the larval stage. At the same time, fast movements and a great range are the swarm's core characteristics as adults. The search for sources of nourishment is an essential component in grasshopper swarming.

To find food, grasshoppers naturally move quickly and selectively in restricted spaces. This separates the search procedure into two key phases that stand for exploration and exploitation. Three distinct forces that specify the precise position of the Grasshopper in the swarm may be seen while examining the swarm's movements. Every Grasshopper's location indicates a potential demographic solution. The grasshoppers' social relationships with one another, the force of gravity acting on them, and wind advection make up the three forces acting on every single Grasshopper. As seen below, the overall forces acting on each Grasshopper are: Examining the swarm's motion reveals three distinct forces that specify the Grasshopper's position within the group. Each Grasshopper's standing within the overall population indicates a potential resolution. Every Grasshopper is subject to three forces: the force of gravity acting on it $H_j$, the wind advection $B_j$, and the relationship that it has with other grasshoppers $T_i$. The following diagram illustrates the total forces acting on each Grasshopper:

$$Y_j = q_1 T_i + q_2 H_j + q_3 B_j \qquad (5)$$

Where $Y_j$ is the location of the ith Grasshopper. The unknown parameters q1, q2, and q3 are. Following is a definition of the social contact force among each Grasshopper:

$$T_i = \sum_{\substack{l=1 \\ i \neq j}}^{M} t(c_{ji}) c_{ji} \qquad (6)$$

Where the distance between the grasshoppers j and i is determined by$c_{ij}$, the separation between the jth and grasshoppers is measured in units of distance $c_{ij}$.

The term t, which may be written as follows, measures the relative potency of the two social factors of enticement and distaste among grasshoppers:

$$t(q) = ef^{\frac{-\tau}{1}} - f^{-q} \quad (7)$$

Where the attractive length scale and the attractive strength are represented by the letters e and 1, respectively, the function t splits the search space into zones of convenience, repulsion, and desire, but when there are over ten grasshoppers among two them, it loses all of its capacity to do so. This issue is solved by mapping the length between grasshoppers between 1 and 4. Repulsion occurs when the distance between two grasshoppers is between 0 and 2.079; attraction occurs when the range is more than 2.079, but it progressively decreases once it reaches 4. There will be a pleasant zone where there is no attraction nor rejection when two grasshoppers are separated by 2.079. Every Grasshopper experiences the following amount of force of gravity:

$$H_j = -hf_g \quad (8)$$

Where h is the center of the ground unity vector, and $f_g$ stands for the gravitational constant.

As they have wings, the nymph grasshoppers' mobility is greatly influenced by the course of the wind. As shown, one may predict the wind's guidance:

$$B_j = wf_u \quad (9)$$

Where $f_u$ is a vector indicating the direction of the wind and w denotes a continuous drift. Following are the calculations for the grasshopper location:

$$Y_j = \sum_{\substack{j=1 \\ j \neq 1}}^{M} t(|Y_i - Y_j|) \frac{Y_i - Y_j}{c_{ji}} - hf_h + wf_u \quad (10)$$

The following Equation has been rewritten as indicated to prevent any quick entry into the familiar, which may result in a locally optimal solution:

$$Y_j^c = d\left[\sum_{\substack{j=1 \\ j \neq 1}}^{M} d\,\frac{wa_c - ka_c}{2} T(Y_j^c - Y_j^c|) \frac{Y_i - Y_j}{c_{ij}}\right] + S_c \quad (11)$$

Where the upper and lower limits in the (dth) dimension are $wa_c$, $ka_c$, respectively. The best option up to this point is $S_c$, which is the goal value in the cth dimension. $S_c$ replicates the propensity to travel in the direction of the food supply. The value of c may be computed as follows: The variable d is a reducing content that achieves the balance between the GOA's exploration and exploitation methods:

$$d = d_{max} - 1\frac{d_{max} - d_{min}}{K} \quad (12)$$

where 1 denotes the present iteration and, k denotes its highest value, and $d_{max}$ $d_{min}$, respectively, denote the maximum and minimum values. The starting values of $d_{max}$, $d_{min}$, e, 1, and k are established at the start of the process. Initially, an audience is chosen by chance. The function of fitness determines the worth of each solution in the population before assigning the top solution. The content variable c is changed at the start of each new iteration to condense the three engagement zones, as depicted in Equation (12). According to Equation (11), each solution in the population is revised. The revised answers are restored to their original positions if any of them go outside of their lower or higher limits. The best overall answer is assigned once the revised solutions have been examined. The overall processes are continued until the method reaches L, which serves as the ending criteria, and the best global solution, S, is provided.

## 4. Result

Providing weights to the buried layers is the SNN's primary responsibility. Changes are made to the function of activation and values for weights as the model is trained to yield the highest result possible. Providing weights to the buried layers is the Spiking neural network's primary responsibility. The model is trained to obtain the highest result possible by changing the functions that activate and weight values. One of the quickest methods to make a straightforward GUI application is with Tkinter. Because it is cross-platform in nature, the same code functions on a variety of OSes. Tkinter is simple to use compared to other GUI creation programs since it is the de-facto standard GUI package for Python. Fig 3 depicts an instance of dialogue with the Chatbot.

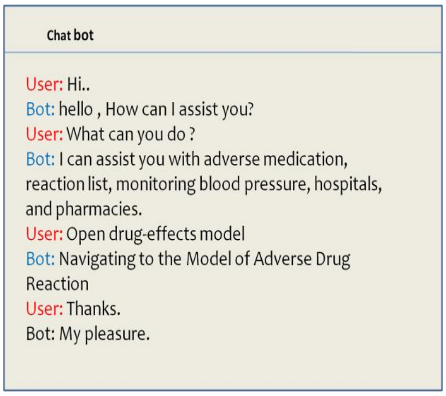


**Fig.3.** Dialogue with the Chatbot

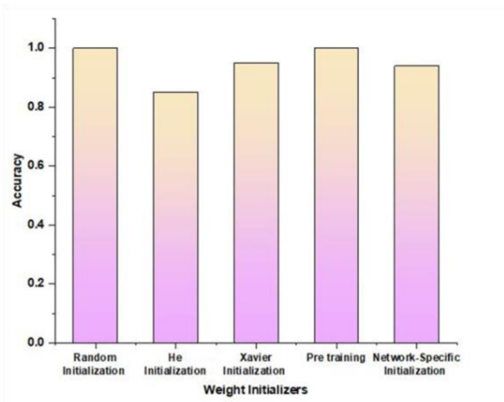


**Fig 4:** Accuracy of different weight initializers

**Table 2:** Accuracy of different weight initializers

| Weight Initializers | Accuracy |
|---|---|
| Random Initialization | 1 |
| He Initialization | 0.85 |
| Xavier Initialization | 0.95 |
| Pre-training | 1 |
| Network-Specific Initialization | 0.94 |

The information being studied is evaluated using an SNN. The performance is evaluated based on the analysis using the "Keras" machine learning framework, which is written in Python. Researching neural networks and the various methods employed in them is the major goal. The research shows that Grasshopper is the best optimizer and that the initialization of the He weight delivers quick results in terms of the total amount of sessions. In this case, Grasshopper achieves perfect precision. The activation function used for input and the buried layer is spike-driven ReLu. Softmax is the name of the activation function that is employed for the output. This model is constructed piece by piece. Using the Python library Tkinter, a Chatbot's graphic user interface (GUI) is made interactive. Table 2 and Fig 4 depict the accuracy of different weight initializers.

The analysis is done on accuracy (%), sensitivity (%), and RMSE. SVM [16], DNN [17], and LR [18] are the current methodologies and are compared with the suggested method (GO-SNN). The effectiveness of a classification model is measured by accuracy. It shows how many examples in a dataset are correctly categorized about all of the instances. To put it another way, accuracy assesses how accurate a model's projections are all in all.

$$Accuracy = \frac{(\text{True Positives} + \text{True Negatives})}{\text{Total Number of Instances}} \quad (13)$$

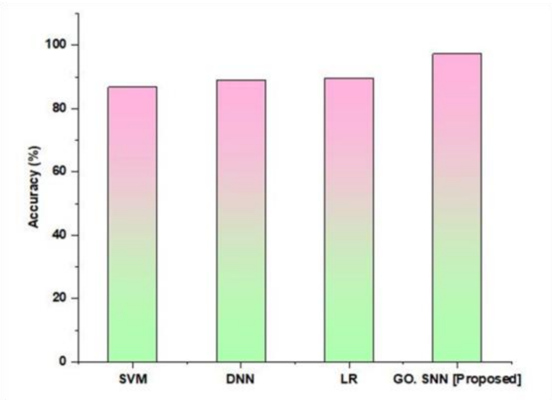


**Fig 5:** Accuracy (%)

The accuracy of the proposed and used procedures is displayed in Fig 5. While SVM, DNN, and LR only achieve an accuracy of 86.72%, 88.93%, and 89.54%, respectively, the suggested technique, GO-SNN, achieves an accuracy of 97.23%. The proposed approach by GO-SNN is more accurate than the established ones.

Sensitivity estimates the percentage of events that are positive that the model properly classifies as positive. It measures how well the model can distinguish the positive cases from all the other positive examples in the dataset.

$$Sensitivity = \frac{True\ Positives}{(True\ Positives + False\ Negatives)} \quad (14)$$

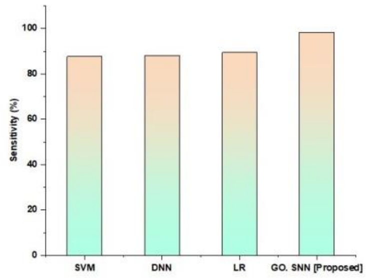


**Fig 6:** Sensitivity

The sensitivity of the recommended and approved procedures is shown in Fig 6. The suggested approach, GO-SNN, only manages to obtain a sensitivity of 87.62%, 88.13%, and 89.45%, whereas LR, DNN, and SVM all manage to achieve an accuracy of 98.35%. GO-SNN techniques offer a greater sensitivity percentage compared to conventional approaches.

To calculate RMSE, take the square root of the average of the squared differences between the projected values and the corresponding actual values. The squared variances are totaled up, multiplied by the number of occurrences, and then square-rooted to obtain the final RMSE result.

$$RMSE = \sqrt{\frac{1}{n} * sum\ (predicted - actual)^2} \quad (15)$$

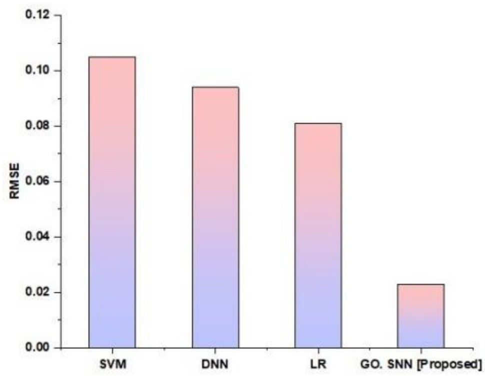


**Fig 7:** RMSE

The RMSE of the recommended and approved procedures is shown in Fig 7. An RMSE of 0.023% is achieved by the suggested approach, GO-SNN, but RMSEs of 0.105%, 0.094%, and 0.081% are only attained by LR, DNN, and SVM, respectively. Compared to conventional approaches, the GO-SNN RMSE is lower.

## 5. Conclusion

The study found that the GO-SNN method was developed to boost chatbot performance. The Chatbot might be made better by making a voice version available, which assists those who are blind or illiterate. It is crucial to understand the limits of the Chatbot, such as the correctness of the model, the lack of empathy, and privacy concerns about user data. We analyzed the accuracy (%), sensitivity (%), and RMSE value for the proposed method (GO-SNN). And the accuracy value is 97.23%, the sensitivity value is 98.35%, and the RMSE value is 0.023. Experimental evidence has demonstrated that the suggested approach to designing a healthcare chatbot was superior to the current approach in terms of effectiveness. While chatbots may do a range of tasks, they won't be able to fully replace people until they can understand how people think and perceive the world. In the medical field, this is much more true. Future studies might look at additional improved techniques that would raise the bar for chatbots even further.

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