Multi-Scale and Context Aware Optimized Glucose Forecasting Using Neural Network

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Abstract: Diabetes is a chronic illness that affects a sizable portion of the global population. For diabetic patients to keep their blood sugar levels within the normal range, accurate blood glucose prediction is crucial. In this study, we employ a well-known data-driven prediction algorithm that exclusively uses previous glucose measurements as input for multi-step predictions. Recently, deep learning has been used in medical research and healthcare to produce cutting-edge outcomes in a variety of tasks, including disease diagnosis and patient condition prediction, among others. We describe a deep learning model that can forecast glucose levels for simulated patient situations with the highest level of accuracy. This paper presents the findings of a study on LSTM-based blood glucose level forecasting systems for individuals with insulin-dependent diabetes. For both continuous subcutaneous glucose measurements and continuous subcutaneous insulin injections, forecasts are created. On the accuracy of forecasts, the impacts of the network architecture, neuronal count, training algorithm, and tapping delay line were examined. The research is a part of the work being done to create an algorithm for figuring out the right amount of insulin to take. This algorithm will be a closed-loop system that performs artificial tasks and works in conjunction with the continuous glucose monitoring and insulin pump devices. The gradient disappearing or exploding problem was solved by developing a cell based network architecture. The hidden neurons used in traditional neural networks are replaced by a hidden layer that is created by the cell. The input is processed locally by the neural network of the hidden layer node. When the input is close to the central range of the base function, the buried layer node will produce a sizeable output.

Keywords: Long Short-Term Memory, future glucose forecast, cell-based network.

INTRODUCTION

A. ABOUT:

A large fraction of the world's population suffers from the chronic ailment diabetes. Accurate blood glucose prediction is essential for diabetic people to keep their blood sugar levels within the normal range. In this study, multi-step predictions are made using only historical glucose measurements as input, utilising well-known data-driven prediction algorithms. Deep learning has recently been applied in medical research and healthcare to yield cutting-edge results in a range of tasks, including the prediction of patient condition and the diagnosis of diseases, among others. In this paper, we present a deep learning model that has the greatest level of accuracy for predicting glucose levels in simulated patient scenarios.

B. DEEP LEARNING:

Deep learning is built on machine learning, a branch of artificial intelligence. Deep learning will succeed because neural networks reproduce how the human brain functions. Deep learning uses no explicit programming. In essence, it is a class of machine learning that does feature extraction and transformation using a large number of nonlinear processing units. Each of the next layers uses the output from the one below as its input. Deep learning models are quite useful in resolving the dimensionality issue since they are able to focus on the accurate features by themselves with just a little programming assistance. Particularly when there are many inputs and outputs, deep learning methods are used. Since machine learning, a subset of artificial intelligence, is where deep learning originated, and since the goal of artificial intelligence is to mimic human behaviour, so too is "the goal of deep learning to construct such algorithm that can mimic the brain." Neural networks are used to implement deep learning, and the biological neurons—basically, a brain cell—serve as the inspiration for these networks. Deep Learning played a significant role in everything from medical picture analysis to illness cure, especially when GPU processors are involved. It also helps physicians, clinicians, and medical professionals save people from danger and diagnose and treat patients with the proper medications.

C. TYPES OF DEEP LEARNING NETWORKS:

i) FEED FORWARD NEURAL NETWORK:

An artificial neural network, commonly referred to as a feed-forward neural network, prevents cycles from forming between the nodes. This kind of neural network has layers made up entirely of perceptrons, with the input layer accepting input and the output layer producing output. The levels with no external connections are referred to as "hidden layers." One of the perceptrons found in the layer below is connected to each node in that layer. It can be claimed that all of the nodes are fully connected. The nodes on the same layer don't have any connections between them, either visible or invisible. There are no back-loops in the feed-forward network. Updating the weight values and lowering prediction error can both be accomplished via the back propagation process.

ii) RECURRENT NEURAL NETWORK:

Another form of feed-forward networks is recurrent neural networks. Each neuron in the buried layers is given an input here after a particular delay in time. The previous information from previous iterations is mostly accessed by the recurrent neural network. For instance, one needs to be familiar with the words that were used before in order to guess the next word in any sentence. In addition to processing the inputs, it also distributes the length and weights over time. It prevents the model's size from growing as the size of the input increases. The only issue with this recurrent neural network is that it processes data slowly and does not take into account any incoming data for the present state. It struggles to recall previous facts.

iii) CONVOLUTIONAL NEURAL NETWORK:

Convolutional neural networks are a particular type of neural network that are mostly used for object recognition, picture classification, and image clustering. The creation of hierarchical image representations is made possible by DNNs. Deep convolutional neural networks are recommended more than any other neural network to attain the best accuracy.

iv) AUTOENCODERS:

Another sort of unsupervised machine learning algorithm is an autoencoder neural network. Simply said, there are fewer hidden cells in this instance than input cells. However, the quantity of input cells equals the quantity of output cells. In order to force AEs to identify common patterns and generalise the data, an autoencoder network is trained to display the output similarly to the fed input. The smaller representation of the input is mostly handled by the autoencoders. It aids in the decompression of data and the reconstruction of the original data.

*D.**FEATURES** OF MACHINE LEARNING:*

There are so many features that comes under Machine Learning, here some of the features,

- DL detect various patterns in each dataset.
- It can learn from past data and improve automatically.
- It is a data-driven technology.
- DL deals with the huge amount of the data.
- High-Quality Predictions when compared with humans by training tirelessly.
- Parallel computing can be done thus reducing overheads.

SYSTEM STUDY

A. EXISTING SYSTEM :

A significant public health issue affecting more than 451 million people is diabetes. These learning strategies can considerably increase the accuracy of glucose predictions. Physiological and experimental factors affect the precision of non-invasive glucose monitoring. This study aims to improve the sensitivity and selectivity of glucose detection in an aqueous solution by using light sources of various wavelengths. It may be possible to correct for mistakes brought on by variations in blood and tissue composition between and within individuals by using several wavelength measurements. In this work, 18 different wavelengths between 410 and 940 nm are used to analyse the transmission data of a specially constructed optical sensor. The connection between glucose concentration and transmission intensity for four wavelengths has a high value (0.98), according to the results (485, 645, 860 and 940 nm). For glucose predictions, five machine learning techniques are studied. 9% of glucose forecasts made using regression techniques are incorrect (normal, hypoglycemic or hyperglycemic). By using classification techniques on data sets divided into 21 classes, the prediction accuracy is increased. Each class of data has a distinct range of 10 mg/dL glucose values. Regression is outperformed by classification-based models, and the support vector machine, which has an F1-score of 96%, is the most effective of them. Additionally, in an emergency patient condition, the Clarke error grid is directed toward critical diagnosis.

***B. DRAWBACKS OF EXISTING SYSTEM* :**

- Does not support transition matrix probability.
- Does not deal with non-linear data regression problem.
- Sensitivity to noisy and missing data.
- Does not work well with high dimensionality.
- Does not work well with large data set.

C. EXISTING ALGORITHM :

- Multiple Linear Regression
- Feed Forward Neural Network
- K-Nearest Neighbour
- Decision Tree
- Support Vector Machine

D. PROPOSED SYSTEM :

Systems for predicting blood glucose levels using neural networks are discussed in this research for people with insulin-dependent diabetes. Forecasts are created for both continuous subcutaneous glucose monitoring and subcutaneous insulin injections. Investigated were the effects of the network architecture, neuronal count, training algorithm, and tapping delay line on forecast accuracy . The research is a component of the effort being done to develop an algorithm for determining the appropriate insulin dose, which will be a closed-loop system that will perform artificial functions and complement the continuous glucose monitoring and insulin pump systems. A deep network with one layer for each time step that can be taught over time steps via back propagation can be used to describe the neural network's structure over time. A cell-based network architecture was developed to address the issue of gradient disappearing or exploding. The cell creates a hidden layer in place of the hidden neurons that are employed in conventional neural networks.

The hidden layer node's neural network responds locally to the input. The hidden layer node will have a large output when the input is near to the base function's midpoint. The output will exhibit an exponential decrease when it is far from the central point. The output is finally the linear weighted sum of the hidden layer neurons' output.

Long Short Term Memory is being employed in the system that is being presented. Recurrent neural networks include long short term memory. The output from the previous step of an RNN is supplied into the current stage as input. It addressed the issue of long-term RNN dependency, in which the RNN can predict words from current data but cannot predict words held in long-term memory.

The performance of RNN degrades as the gap length grows. The data can be saved by LSTM by default for a very long time. It utilises time-series data for processing, forecasting, and classification.

In the structure of LSTM, there are three gates i.e Forget gate, Input gate and Output gate.

i) FORGET GATE:

The forget gate purges the data that is no longer relevant in the cell state. The gate receives two inputs, x and y, which are multiplied with weight matrices before bias is added. The output of the activation function, which receives the outcome, is binary. If a cell state's output is 0, the piece of information is lost, however if it is 1, the information is saved for use in the future.

ii) INPUT GATE:

The input gate updates the cell state with pertinent information. The information is first controlled using the sigmoid function, which filters the values to be remembered using the inputs x and y. Then, using the tanh function, a vector is produced that contains all possible values for x and y and has an output range of -1 to +1. To extract the useful information, the vector's values and the controlled values are finally multiplied. This is the function of the input gate.

iii) OUTPUT GATE:

The output gate's job is to take meaningful information out of the current cell state and deliver it as output. The tanh function is first used to the cell to create a vector. The data is then filtered by the values to be remembered using the inputs x and y, and the sigmoid function is used to regulate the information. The vector's values and the controlled values are finally multiplied and supplied as input and output to the following cell, respectively.

E. PROPOSED ALGORITHM :

- Long Short Term Memory – it works completely on sequences of data of varying input length is mostly known for multiple functions, uses recurrent neural networks. The previously gained knowledge of the state is given as input for the next prediction by the RNN.

F. ADVANTAGES OF PROPOSED ALGORITHM :

- Maximum utilization of Unstructured data.
- LSTM has a feedback connections ie. It is capable of processing the entire sequence of data apart from single data such as images.
- Ability to deliver high quality results.
- Used for time-series data processing, prediction, and classification.
- It can handle not only single data but also complete data streams.
- Language Modelling
- Machine Translation
- It is a special kind of RNN which shows outstanding performance on a large variety of problems.

G. ADVANTAGES OF PROPOSED SYSTEM :

- Enhance correlation strength with finer and more compact information.
- Achieve a well-balanced trade-off among various parameters.
- Have well-understood properties.
- It has the ability to handle large and complex data
- It has been used to achieve state of the art performance on a wide range of problems.
- It is highly scalable due to its ability to process the massive amounts of data.
- It performs a lot of computations in a cost and time effective manner.

ARCHITECTURE

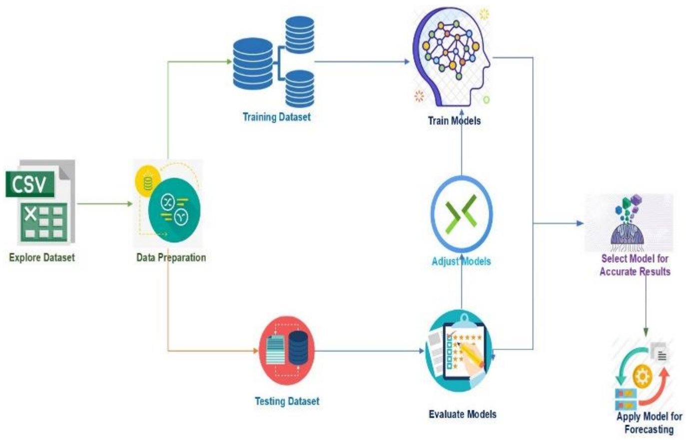

Fig.1 Architecture Diagram

PROJECT DESCRIPTION

A. EXPLORATORY DATA ANALYSIS

Exploratory data analysis mainly relies on graphical representations of data and visualisations. Although statistical modelling offers a straightforward, low-dimensional depiction of the relationships between variables, it typically necessitates a thorough understanding of statistical methods and mathematical concepts. You can quickly investigate many different features of a dataset because visualisations and graphs are often more easier to create and much more interpretable. The final objective is to produce concise summaries of the information supporting your inquiry. Although it is not the last step in the data science process, it is nonetheless crucial.

CHARACTERISTICS:

- Graphs produced with EDA are different from the final graphs. You will typically generate dozens, if not hundreds, of exploratory graphs in the course of analysing a dataset.
- Of these graphs, you may end up publishing one or two in a final format.
- Exploratory data analysis is a data analysis methods to analysis data.

B. KNOWLEDGE DISCOVERY AND ANALYSIS

Utilising different feature extraction approaches, such as statistical explication, association, pattern analysis, and similar ones, to process data.

Data reduction: Using crucial features for mining techniques, this stage aims to reduce altered data. After the data has been thoroughly analysed, remove irrelevant data and estimate and delibrate the interesting patterns for the training phase.

C. MODEL TRAINING AND PREDICTION

The methodology uses supervised learning and the gradients descend method to construct an error back propagation neural network. Nodes, the building blocks of this kind of neural network, resemble neurons. Layers are used to organise the nodes. The neural network sends the input information forward to hidden layers notes and the hidden layer information to output nodes via the activation function between the input and hidden layer, hidden and output layer. The output layer can provide the results. There are two components to neural networks: forward propagation and backward propagation. At the input layer, scaled data are fed into the network. The connectivity weights are initialised with numerous little random data at the start of the learning process. Forecasting the unknowable future energy consumption is the goal of the prediction model evaluation. As a result, we used the data from one week as our training set and the data from the following week as our testing set. the quantity of samples used for training and testing, respectively. Additionally, the data needs to be normalised into the interval before to training.

EXPERIMENTAL RESULT

As a useful technique for glucose prediction, a convolutional recurrent neural network was put out in this research. A modified neural network is used after a multi-layer neural network in the design, which might be used to capture the features or patterns of the multi-dimensional time series. It is possible to analyse previously sequential data using modified deep learning and provide prediction glucose. The technique uses each diabetic subject's personal data to train models for them. Once the neural network has been trained, it can be used locally or on portable devices. Based on our findings, we explored various model migration strategies in subsequent research and employ transfer-learning to streamline the model selection calculation process. By using the arrived dataset references, we forecasted the glucose level of the person in prior manner with the help of specified algorithm. Since, the level changes in a frequent manner, the datas will get updated and the updated values will be taken into prediction. This model will give a accurate result of 97%.

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