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Glucose Monitoring using Deep Learning

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Abstract: ***Diabetes is a chronic disease that occurs when blood glucose levels are abnormal. Blood glucose is the carbohydrate in the blood that provides the body with energy to perform biological work. The carbohydrate levels in the blood change dynamically depending on various factors such as exercising and fasting. Blood glucose is crucial to healthy metabolic function within the human body and thus is essential to monitor the blood glucose levels of diabetic patients. Various methods of measurement are in use to report glucose levels ranging from the Yellow Spring Instruments 2300, the gold standard, to handheld glucose monitors, also called continuous glucose monitors (CGMs), a compact medical system that continuously monitors glucose levels in more or less real-time.***

Diabetes is a fast-growing global problem with huge social, health, and economic consequences. The estimates in 2019 showed that 77 million individuals had diabetes in India which is expected to rise to over 134 million by 2045. Considering these facts there is a need to build a better system to control diabetes. Monitoring the patient glucose levels daily and keeping him updated with their health every day will help them to come out of the danger even a little bit. Predicting blood glucose levels and displaying them on a website to help ease monitoring for diabetic patients, along with notifications and alerts about their health condition, diet and exercise recommendations, etc. The diabetic patient's data is used to predict glucose levels using machine learning. The glucose levels are predicted continuously and displayed in a graphical form on the website. Depending on the glucose levels, necessary suggestions and pieces of advice are provided. By displaying the glucose levels, user will be able to know about their health status and be able to take sufficient measures to lead a happy life. The advanced features will be that include connections of patients with personal doctors, notifications and alerts about their condition, diet and exercise recommendations, etc.

Keywords: CGM, Convolution Neural network, Deep Learning, LSTM, Recurrent Neural Networks

I. INTRODUCTION

Diabetes is a chronic condition that affects millions of people worldwide, and managing blood glucose levels is a critical aspect of diabetes care. Continuous glucose monitoring (CGM) systems have been developed to assist individuals with diabetes in monitoring their glucose levels. However, interpreting and understanding the data generated by these devices can be challenging, especially for individuals who are not healthcare professionals.

Deep learning, a subset of machine learning, can be used to analyze and interpret large amounts of data, including data from glucose monitoring devices. By training deep learning models on large amounts of glucose monitoring data, it is possible to predict glucose levels, identify patterns and anomalies in the data, and provide real-time predictions to help individuals better manage their glucose levels and improve their overall health outcomes. Additionally, this technology could be integrated into existing glucose monitoring devices, making it more widely accessible. The goal of this project is to develop a deep learning-based system for glucose prediction that can help individuals with diabetes better manage their glucose levels.

A. Problem Background

There are many glucometers in the market that come along with the a mobile application to store users glucose levels that can be connected to only that specific company products like Accu chek Guide glucometers that can be connected to Accu-Chek Connect mobile application, Contour Next from Ascensia with which the users can use Contour diabetes application. Such glucometers are not compatible with third party digital platforms for diabetes data review. There are also glucometers that do not have any application to store the data like Walmart ReliOn Confirm (Micro) from Arkray, Glucospark and Dr Morepen BG 03 Gluco One Blood Glucose Monitoring System. In the first case, if the user switches to a different brand product, the data is lost, if the application is deleted or he will need to download 2 applications and check both to review past glucose levels. In the latter case the glucose levels can only be used as one-time readings, but this cannot be used for diagnosis by doctors and the user cannot know how the user's glucose levels are changing based on what time he has taken the readings if he took before or after meals, and at what time of the day has he taken the readings, as they play an important role in telling the user if his glucose levels are in limit or not.

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B. Problem Definition

Diabetes is a chronic disease that occurs when blood glucose levels are abnormal. Blood glucose is crucial to healthy metabolic function within the human body and it is necessary to monitor the blood glucose levels of diabetic patients. Various methods of measurement have come into use for reporting glucose levels ranging from the Yellow Spring Instruments 2300, the gold standard, to handheld glucose monitors, also called continuous glucose monitors (CGMs), a compact medical system that continuously monitors glucose levels in more or less real-time. Very few handheld glucometers that have succeeded, in consideration of their cost, accuracy, and performance, have been introduced to the market.

II. RELATED WORK

There are many glucometers in the market that come along with the a mobile application to store users glucose levels that can be connected to only that specific company products like Accu chek Guide glucometers that can be connected to Accu-Chek Connect mobile application, Contour Next from Ascensia with which the users can use Contour diabetes application. Such glucometers are not compatible with third party digital platforms for diabetes data review. There are also glucometers that do not have any application to store the data like Walmart ReliOn Confirm (Micro) from Arkray, Glucospark and Dr Morepen BG 03 Gluco One Blood Glucose Monitoring System. In the first case, if the user switches to a different brand product, the data is lost, if the application is deleted or he will need to download 2 applications and check both to review past glucose levels. In the latter case the glucose levels can only be used as one-time readings, but this cannot be used for diagnosis by doctors and the user cannot know how the user's glucose levels are changing based on what time he has taken the readings if he took before or after meals, and at what time of the day has he taken the readings, as they play an important role in telling the user if his glucose levels are in limit or not.



Figure 2.1 Accu Chek Guide Glucometer

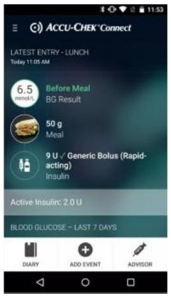


Figure 2.2 Accu Chek Connect Set Mobile Application

The LibreLinkUp app lets caregivers and/or parents see glucose data shared by people who use the FreeStyle LibreLink app and FreeStyle Libre sensors, whenever they scan their sensor. LibreLinkUp lets as many as 20 people check the numbers on a single FreeStyle LibreLink account. Fingersticks are required for treatment decisions when you see the Check Blood Glucose symbol when symptoms do not match system readings when you suspect readings may be inaccurate, or when you experience symptoms that may be due to high or low blood glucose

The reader can capture data from the sensor when it is within 1 cm to 4 cm of the sensor.

The FreeStyle LibreLink app and the FreeStyle Libre and FreeStyle Libre 14-Day reader have similar but not identical features. Fingersticks are required for treatment decisions when you see the Check Blood Glucose symbol when symptoms do not match system readings when you suspect readings may be inaccurate, or when you experience symptoms that may be due to high or low blood glucose. When using the FreeStyle LibreLink app, access to a blood glucose monitoring system is required as the app does not provide one.



Figure 2.3. Libre Free Style Glucometer

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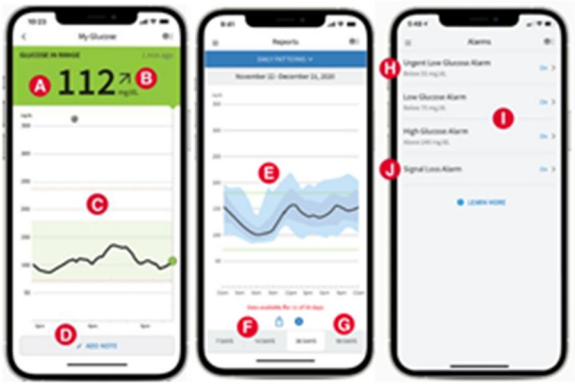


Figure 2.4 FreeStyle LibreLink Mobile Application

III. METHODOLOGY

The proposed system is a website that has all the features a diabetic person would need to monitor their health condition. It contains various features from providing recommendations to the user on various topics like diet and exercise to predicting future glucose levels based on previous data collected by the application from the user, which is going to be implemented in the next phase of this project. This website also has a very interactive chatbot that helps the user to navigate through the website easily. It can also answer users questions related to diabetes.

This module is concerned with the development of a web interface as an interactive medium between the device and the user. The web page can be used by the user to view the results inferred by the machine i.e., view or monitor his live glucose levels. Access to the page is restricted to valid user credentials. The page can also be used to provide useful recommendations both in terms of exercise and diet that a person associated with certain glucose levels should do in order to stay healthy and maintain ideal levels. These are nothing but very well-known and medically advised options.

The page intends to provide additional user-friendly features like the ability to create a unique profile for each user. In addition, it looks to send notifications of updates to the users. It also contains an interactive, automatic chatbot that responds to and answers users' queries and provides help in various forms needed. This was created as part of module 3. Created using HTML, CSS, and JavaScript, the page is aimed to be attractive, interactive, and easy to navigate.

As part of this module, a chatbot is created in order to increase the utility of the website. It provides three options as part of the initial interaction. These options are About Us, Find Doctors and Talk to us.

"About Us" informs the user about the process of how using the data collected that the user provides, their live glucose levels are predicted. The second option pertains to "Find Doctors" i.e., letting users choose to form a wide array of specialists that they can interact with online to enquire or consult them regarding their health queries. The third option enables users to connect to support in person. By providing their details, they can let customer service contact them at their specified time. This bot was built using a free online chatbot tool-engage. It is a platform that provides various options and customization tools to help create the chatbot. It balances automation with the human touch. Sets up quick replies and collaborates with customers in real-time. Each node is created and customized individually. They are then connected into one flow path that is then deployed onto the website.

A. Algorithms Used

Time series forecasting is a technique used in data analysis to predict future values of a variable based on its past observations. This technique is particularly useful when dealing with data that is collected over time, such as stock prices, weather patterns, or website traffic.

The first step in time series forecasting is to analyze the historical data to identify patterns and trends. This can be done using various statistical techniques such as trend analysis, seasonal analysis, and autocorrelation analysis. Once these patterns and trends have been identified, a mathematical model is developed to describe the underlying relationship between the past and future values of the variable. There are various methods available for time series forecasting, such as ARIMA (AutoRegressive Integrated Moving Average), exponential smoothing, and neural networks. ARIMA is a popular method that models the autocorrelation and stationarity of the time series, while exponential smoothing models the trend and seasonality of the time series. Neural networks use a combination of statistical and computational techniques to predict future values of the time series.

Regardless of the method used, it is important to evaluate the accuracy of the forecast by comparing the predicted values to the actual values of the time series. This can be done using metrics such as Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE).

Overall, time series forecasting is a powerful tool for analyzing and predicting future values of time-dependent data. It can be used in a wide range of industries, from finance and economics to healthcare and transportation, to help make informed decisions and improve outcomes.

LSTM: LSTM stands for long short-term memory networks, used in the field of Deep Learning. It is a variety of recurrent neural networks (RNNs**)** that are capable of learning long-term dependencies, especially in sequence prediction problems. LSTM has feedback connections, i.e., it is capable of processing the entire sequence of data, apart from single data points such as images. This finds application in speech recognition, machine translation, etc. LSTM is a special kind of RNN, which shows outstanding performance on a large variety of problems.

Moving averages: Time series forecasting using moving averages is a simple and popular method for predicting future values based on past observations. The moving average model works by taking the average of a certain number of past observations to forecast the next value

To use moving averages for forecasting, we typically calculate the moving average for a certain time period and then use it to forecast the next value. For example, if we want to forecast the next day's closing price of a stock using a 5-day SMA, we would take the average of the last five days' closing prices and use it as our forecast for the next day's closing price.

It is important to note that moving averages are a lagging indicator, which means that they are based on past data and may not be accurate predictors of future trends. They also do not take into account any external factors that may influence the time series, such as changes in market conditions or economic events. We used the Simple Moving Averages method to find the forecasted data.

After working on these two algorithms and based on the performance and the output, we choose the LSTM method.

IV. RESULTS AND DISCUSSION

A. Deep Learning Model

The algorithm that we developed will show the output in the user interface as below. The predicted glucose level will be displayed in the interface with the condition of the user at that particular time.

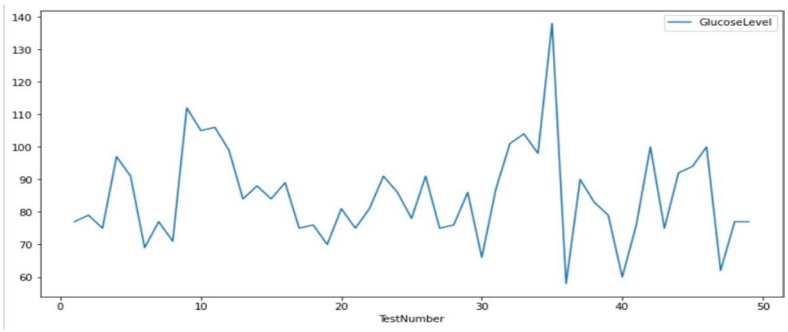


Figure 4.1 Plot of the dataset taken

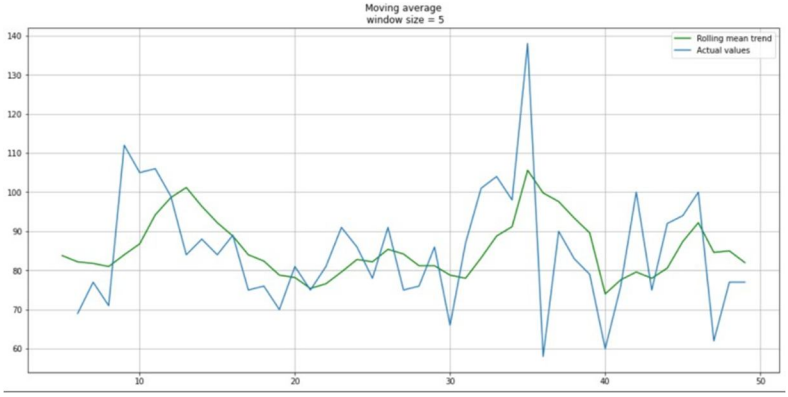


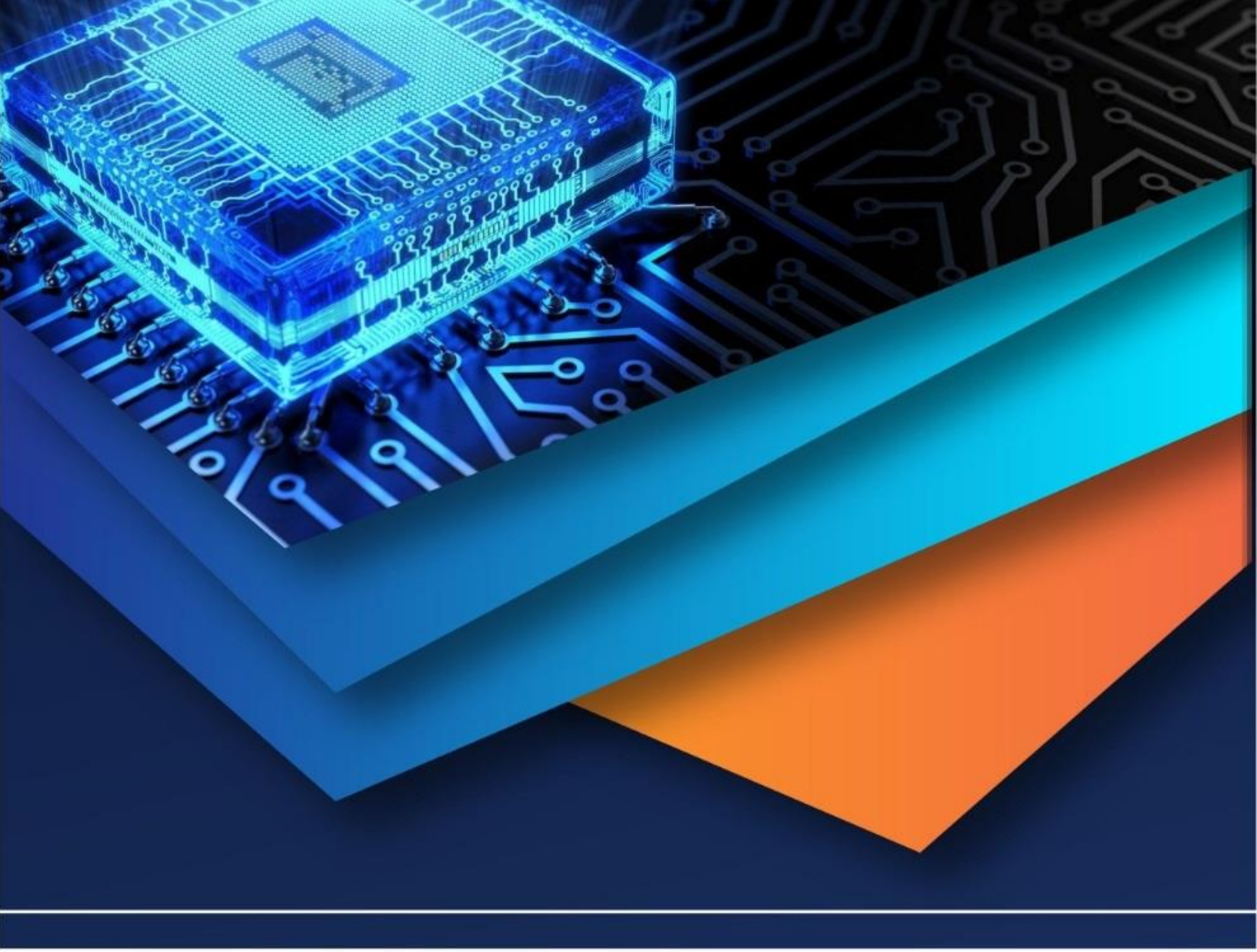
Figure 4.2 Taken Dataset and Predicted Glucose Level Plot using Moving Averages

V. CONCLUSION AND FUTURE SCOPE

In conclusion, using a website to store glucose levels, can be very useful to the user in various ways. Being aware of their own health condition and checking their health status in the comfort of their home can help not only diabetic patients but also make it easy to monitor our family members health condition. This website could especially be useful for people who have a difficult time with technology as this website also has an interactive robot, which is very easy to use and helps the user to use the website. This website can further be improved by adding a voice bot that can capture, interpret, and analyze vocal input given by the speaker to respond in similar natural language, so that even if the user cannot properly see the screen or is having a hard time chatting with the chatbot they can use voice bot instead.

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