Non Invasive Blood Glucose Monitoring

Abraham David Solomon, Devang Mathur, Anurag Joshi

Author Abraham David Solomon is currently pursuing bachelor's degree program in computer science engineering in Government Engineering College, Ajmer, India,
Co-Author Devang Mathur is currently pursuing bachelor's degree program in computer science engineering in Government Engineering College, Ajmer, India,
Co-Author Anurag Joshi is currently pursuing bachelor's degree program in computer science engineering in Government Engineering College, Ajmer, India.

KeyWords
Non-Invasive Glucose monitoring, pain-free, economical, Acetone Sensor, Arduino UNO, Blood Glucose, BMI, Exhaled Breath, Linear Regression, Node-Red

Abstract

According to IDF Diabetes Atlas (2021) reports that **10.5%** of the adult population (20-79 years) has diabetes, with almost half unaware that they are living with the condition. And mostly in proper countries many don't know if they have diabetes, almost every diabetic patient has to monitor their sugar level for proper medicine dosage and food intake. But it takes blood to measure glucose by measuring the amount of electricity passing through blood, and this method could be unhygienic , as accidentally or intentionally one may use same needle for different people and which may lead to diseases like human immunodeficiency virus (HIV), hepatitis B (HBV) and hepatitis C (HCV). This method also requires strips which are costly and hence many patients don't check their glucose levels as frequently as they should.

We are suggesting a method in which we no longer need to take blood from patient and just using their breathe and some other parameters the algorithm will predict their sugar levels, and their would be very minimalistic apparatus so it would be far more economical than the apparatus in use today.

There are other researches like this to predict glucose from breathe but we had taken other parameters in making our model for predicting, which has increased it's reliability and making it more robust, as you will se our dataset was very diversified and was taken keeping in mind to make this research more robust and helpful for healthcare. We couldn't use ANN cause our dataset was diversified and not very large (<50), on basis of this data if we would have used ANN accuracy would have been decreased, hence we used Linear Regression which increased our accuracy to +-7mg/dl.

Introduction

Diabetes is a chronic metabolic disorder characterized by high blood glucose levels resulting from defects in insulin production, insulin action, or both. It is a global health concern that affects millions of individuals worldwide and is associated with significant morbidity and mortality.

According to IDF (International Diabetes Federation) till 2021 9% of the total population in the world is suffering from diabetes and almost half of them are still un aware that they have diabetes, many poorer countries are still un able to conduct proper surveys and find early diabetes patient and try to stop this disease from causing severe damage to their body as if it is clarified at an early stage the effect of diabetes would be less, for measuring glucose the apparatus cost is at a higher side and for each person they require a new needle and a new strip to take blood sample, in many places to save money on needles the often re-use needle or mistakenly they use previously used needles which may lead to other disease (like HIV, HBV, HCV) and is very unhygienic.

The two main types of diabetes are type 1 diabetes (T1D) and type 2 diabetes (T2D), with the latter being the most common form.

T1D is an autoimmune disease in which the body's immune system mistakenly attacks and destroys the insulin-producing beta cells in the pancreas. As a result, individuals with T1D are dependent on exogenous insulin to maintain normal blood glucose levels. On the other hand, T2D is primarily characterized by insulin resistance, in which the body's cells become less responsive to the effects of insulin, and insufficient insulin secretion by the pancreas. T2D is often associated with lifestyle factors such as obesity, sedentary behaviour, and poor dietary choices.

Acetone and glucose can be correlated in the context of diabetes. The relationship between acetone and glucose is indirect and complex, primarily involving the metabolic processes occurring in the body.

In individuals with poorly controlled diabetes, especially those with type 1 diabetes (T1D) or in a state of diabetic ketoacidosis (DKA), the body may enter a state of increased fat metabolism. When glucose is not adequately available for energy, the body starts breaking down fat as an alternative fuel source, leading to the production of ketones, including acetone, as byproducts.

The presence of acetone in the body can be an indication of increased fat metabolism, which may be associated with elevated blood glucose levels. In this context, higher acetone levels can be observed in individuals with hyperglycemia (high blood glucose).

Objectives of this study:

- To make Blood glucose monitoring economical.
- To make Blood glucose monitoring more pain-free.
- To make Blood glucose monitoring more hygienic.

Proposed Method for Non-Invasive glucose monitoring:

We used a acetone gas sensor to measure the levels of acetone from breathe and took reading of other parameters like temperature and humidity of breathe from sensors. Other than these we also took other parameters like age, gender and BMI of patient we took these measures to observe how these are affected for diabetes patient and if there is any change in breathe acetone levels.

We wanted to see if other than glucose if these other factors also affect acetone in breathe, as most of the other research paper that used this technique were only considering acetone levels, but after extensive study our team figured that these factors may also affect how these factors combined with glucose levels may vary acetone levels in breathe.

After evaluation we measured all these criteria and prepared a database with people with different diversity, these diversification was as follow:

- Based on gender (Male & Female)
- Based on ages (15-20, 21-30, 31-45, 46-60, 60&above)
- Based on diabetes (Diabetic , Non-Diabetic)
- Based on BMI (15-20, 21-25, 25&above)

What we were looking for was mainly how acetone levels were changing for all these different groups and how these groups shows acetone levels in correspondence to their glucose level (measured by blood invasive method).

After seeing the findings we prepared a exquisite database that included all the parameters that we suspected will affect acetone levels, we now just needed to know how and to what extent these parameters affect the acetone levels so that we can start making prediction on glucose based on breathe acetone.

Dataset parameters:

B	C	D	E	F	G	H
Age	Gender	Acetone	Hum	Temp	Glucose-level	Bmi

Technology used:

We used different sensors for measuring these parameter and also used certain frameworks for live data monitoring and capturing then we pandas and sklearn for prediction.

Sensors:

Figaro tgs-822: used for measuring acetone levels, the TGS 822 sensor consists of a sensing element made of a metal-oxide semiconductor material, typically tin dioxide (SnO2). The surface of the sensing element is coated with a catalyst that enhances its sensitivity to acetone.

DHT-11 sensor: The DHT-11 sensor is a commonly used digital temperature and humidity sensor. It is a low-cost sensor that provides basic temperature and humidity measurements for various applications. The DHT-11 sensor operates based on the principles of capacitance and resistance changes in response to temperature and humidity variations.

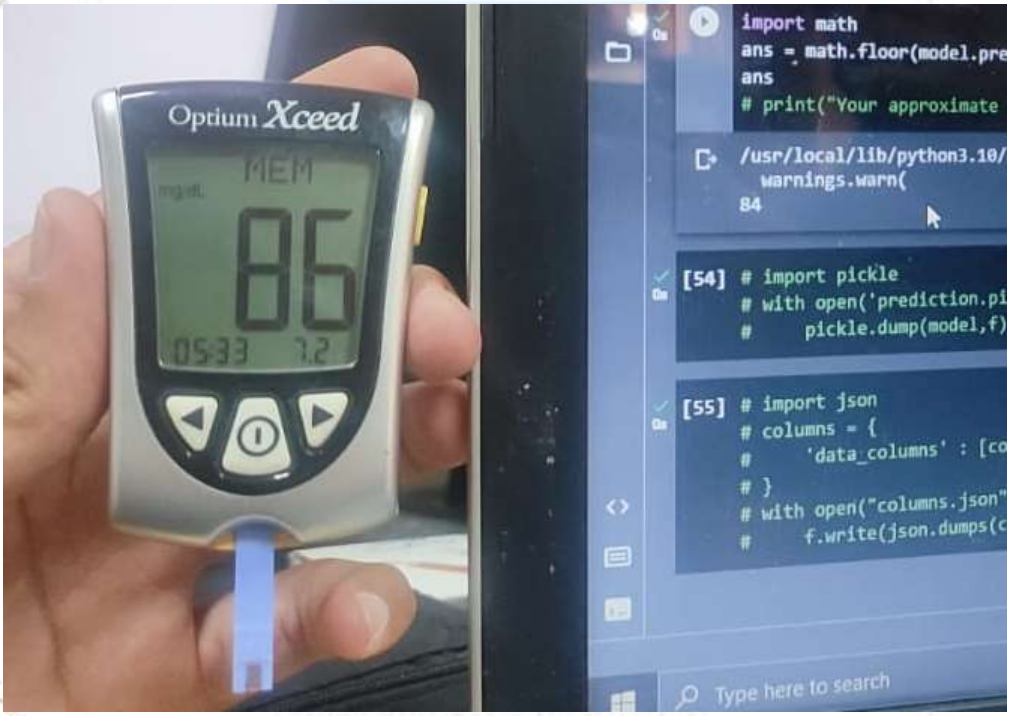
Software Used:

- Node-RED: Node-RED is an open-source flow-based programming tool designed for connecting hardware devices, APIs, and online services in a visual manner. It provides a browser-based editor that allows users to create, deploy, and manage flows that automate tasks and data integration.
- Arduino IDE: The Arduino Integrated Development Environment (IDE) is a software platform that provides a user-friendly environment for programming Arduino boards.
- Python & Sklearn: scikit-learn, also known as sklearn, is a popular open-source Python library for machine learning. It provides a wide range of tools and algorithms for tasks such as classification, regression, clustering, dimensionality reduction, and model evaluation.

Results & Findings:

After all the dataset collection we used linear regression to make prediction on our dataset. According to our predictions we were able to get predictions close to +-5 mg/dl. But we had different diversified groups so taking all under consideration and smaller dataset of 30 patients worst we had was +=7.5 mg/dl.

We couldn't use ANN (Artificial Neural Network) as the dataset that we gathered was very small and for using ANN and getting better accuracy than linear regression we needed dataset of approx. 100-200 patients.



As we can se in this above prediction glucose measure from blood was 86 and what our model predicted was 84.

Future Scope & Conclusion:

As we can see from the above predictions the experiment we conducted showed results, and from all the tests we can say that the accuracy of this Non-Invasive glucose monitoring system is +-7.5mg/dl and this could be further improved with a larger dataset and could help a lot of people in early prediction and making it affordable to be used by anyone and also it would require minimal cost to reuse for testing.

With bigger dataset this system could be made more robust using different prediction algorithm i.e. using ANN. With all the technological advancement and with sensors made exquisitely for this purpose the accuracy could be even better.

References:

[1] Tang, L., Chang, S.J., Chen, C.J. and Liu, J.T., 2020. Non-invasive blood glucose monitoring technology: a review. *Sensors*, *20*(23), p.6925.

[2] Galassetti, P.R., Novak, B., Nemet, D., Rose-Gottron, C., Cooper, D.M., Meinardi, S., Newcomb, R., Zaldivar, F. and Blake, D.R., 2005. Breath ethanol and acetone as indicators of serum glucose levels: an initial report. *Diabetes technology & therapeutics*, *7*(1), pp.115-123.

[3] Li, W.Q., Ma, S.Y., Luo, J., Mao, Y.Z., Cheng, L., Gengzang, D.J., Xu, X.L. and Yan, S.H., 2014. Synthesis of hollow SnO2 nanobelts and their application in acetone sensor. *Materials Letters*, *132*, pp.338-341.

[4] Louis, L., 2016. working principle of Arduino and u sing it. *International Journal of Control, Automation, Communication and Systems (IJCACS)*, *1*(2), pp.21-29.

[5] Lekić, M. and Gardašević, G., 2018, March. IoT sensor integration to Node-RED platform. In *2018 17th International Symposium Infoteh-Jahorina (Infoteh)* (pp. 1-5). IEEE.

[6] McMILLIN, J.M., 1990. Blood glucose. *Clinical Methods: The History, Physical, and Laboratory Examinations. 3rd edition*.

[7] Egan, A.M. and Dinneen, S.F., 2019. What is diabetes?. *Medicine*, *47*(1), pp.1-4.

[8] Chen, Z. and Lu, C., 2005. Humidity sensors: a review of materials and mechanisms. *Sensor letters*, *3*(4), pp.274-295.