IoMT Based m-Healthcare model for Type-2 Diabetes

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***Abstract*—Nowadays, IoMT(Internet of Medical Things) is a revolutionary approach in the Medical sector. It plays a vital role in the healthcare industry. The modern m-healthcare system is making our life smoother by remote monitoring and collecting the real time data. People of different ages are facing many health related problems. But despite having an IoMT and modern medical system, the connection between patient and specialists is not so efficient in terms of cost,communication,daily check up etc. There are a huge number of diabetes patients in the world. It needs regular followup. But it is not possible to deal with the huge number of patients one by one in person. On the other hand, diseases can affect the mental health of a patient.The goal of this paper is providing better service to the diabetes patient using the m-healthcare system and reducing the diagnostic cost. We will use SRL(Self Regulated Learning) based wearable sensors, mobile applications and a smart design of doctor-patient communication system to get better results.**

***Index Terms*—IoMT, Diabetes, m-healthcare,SRL**

I. Introduction

Health is wealth. We need a smart management system to have good health and lead a beautiful life. So daily communication with a physician is important. Nowadays the number of diabetes patients is increasing day by day. Researchers are saying that Diabetes is the pandemic of the 21st century. According to WHO, there are 422 million people all over the world who have diabetes. The majority of the people belong to low and middle income countries and the number of directly attributed deaths are 1.5 million. The number is increasing day by day.

The following picture represents the number of people who have diabetes worldwide according to the IDF(International Diabetes Federation) statistics of 2021:

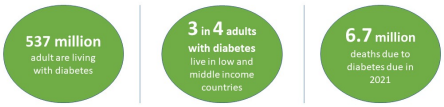


Fig. 1. World-Wide Diabetes Rates

The more information about statistics of IDF in 2021:

- There are 537 million adults between 20-79 are living with diabetes.
- They predicted that 643 million by 2030 and 783 million by 2045 will be affected
- There are 3 in 4 people who are affected by diabetes in the low and middle income countries.
- Almost 240 million adults (1 in every 2) are undiagnosed who don't know they are at risk of diabetes.
- 6.7 million deaths
- There are 541 million people who are adults at the risk of type-2 diabetes

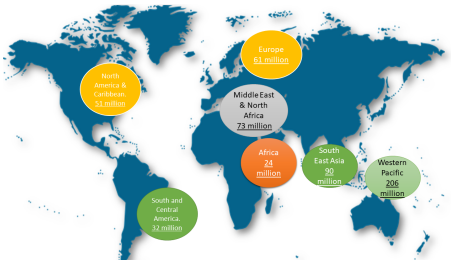


Fig. 2. Number of Diabetes Patient all over the world

Economical impact according to the American diabetes association, the people with diagnosed diabetes spend medical expenditures of $16,752 per year where 9,601$ is attributed to diabetes. On the other hand the daily medicine cost is very expensive, especially for the middle and lower-middle class people.[2]

There are also some social and emotional impacts for diabetes[1]. Social anxiety, stress, mode disorder, and anger are the psychological effects of diabetes. The diabetes patients are leading very stressful lives. Their immune system is becoming weaker day by day. That is a very bad sign for a nation.

On the other side, the people are not well connected with the physicians. This is not possible to prevent a disease soon. So,there should be a good management system between doctor and patient. Otherwise lack of follow up the disease will not be cure in a certain time.

That is why we need to take initiative to solve the issue as soon as possible because it has social,mental,physical and economical impacts.

To solve the problems mentioned above we are going to propose an approach which will bring all the diabetes patients under a shade and it will connect them with their physicians effectively. We will make a remote follow up system so that a physician can see his/her patient's condition with a single click.

II. Literature Review

Staying fit is a very important issue so the researchers all over the world are doing excellent work. Which helps us to brainstorm and develop new ideas.

1) Wasim Abbas, and Je-Hoon Lee proposed a method where they have created a mobile application architecture for Type-2 Diabetes.They used different sensors to collect the data from the body. They use Linux as an operating system.[3]
2) Haluk Gümüşkaya and Bekir Karlık used neural networks on small mobile devices for diagnosing diabetes. The wireless communication will be held between the mass patient and the server in two-tier pervasive healthcare architecture.[4]
3) Kyung-Yong Chung, and Dong Kyun Park designed a self diabetes management mobile healthcare application which can manage weight, diabetes, stress etc. In this system the application synchronized data with the hospitals EMR database for ensuring data accuracy. [5]
4) Abdul-Badi Abou-Samra, and Mowafa Househ analyze their experiment with their application named 'Droobi'. By using the application both patient and caregiver can manage diabetes easily. They downloaded the application in the device of their targeted patients and nurses then let them use the app for 6 to 12 weeks. [6]
5) Adu, M.D. Malabu proposed a self diabetes(Type-01 and Type-02) management system where they will take special look at some parameters such as behavior change strategy, involvement to the mobile application , data security and privacy consideration etc. It also provides the carbohydrate rate in Australian food. [7]
6) Gergely, T.; Thestrup, J presented a paper that k performed in the context of the REACTION project focusing on the development of a health care service which can handle diabetes in a different way. Actually they made an application. Through this they can manage risk,feedback etc. [8]
7) Gunawardena, K.C.; Jackson, R proposed a system where a glucose manager mobile application will take data from the patient and work according to this. The total patient was 67.In this system Glycosylated hemoglobin levels were measured at baseline and every 3 months afterward. [9]

   A lot of research has been done all over the world so far. There are some limitations. But the particular method we are proposing here is not done yet. They used a mobile application but how to take all the mass people into a system is not clear enough. We try to bring the mass of people in the same area through m-healthcare. If the patient is unable to say something, abnormal whatever is not a problem. On the other hand we try to save people from high intake of medicine and focus on their mental health rather than giving a healthy suggestion. Most importantly, we have tried to build a healthy communication between doctor and patient so that a doctor can keep the patients in the same group and give suggestions whenever they want.

III. Methodology

Let's give a little explanation of our work. We try to reduce the affected rate of type-02 diabetes. Type-02 diabetes is a lifestyle disease not a genetic disease. Researchers of modern science proved that. So we try to do some tasks which are related to our lifestyle.

First,after consulting a specialist an account has been created for the patient. The patient should have a user ID and password. The account contains some data such as previous prescriptions and doctor records.So that the specialist can see the details history and prescribe the right suggestion. The patient can also access his/her account. But the patient and doctor have some permission variation. After opening the account the doctor attaches the patient to a group where a lot of patients have joined. That means when the doctor wants to send any advice based on the present weather condition or update to the patients he/she just gives a status. In this way a doctor can serve thousands of patients and get attached with them. Because according to the statistics there are millions of diabetes patients all over the world and they need regular health service. The doctor-patient statistica will be described later.

As our system will always provide the real time data and the measured decision taken by the AI the doctor can always see his patient's condition. If the condition of a patient is bad or going to be bad that means an emergency then the doctor will be informed by notification. Then the doctor just takes a look at the patient's data and if necessary he can call the patient and take further steps.

In the system, a patient wears a wearable sensor (i.e. smart watch). The self regulated sensor can monitor the glucose rate and the blood pressure. After collecting real time data it sends to a mobile application through wi-fi/5G/6G/Bluetooth. The application is built up with some AI(Artificial Intelligence) related features. AI will analyze the data and come up with a decision. The data set and the decision will be sent to the database in the cloud. The doctor or specialists can see it and make the final decision.

Now, the details will be explained step by step.

A. Sensor

We have used the method of two sensors.

1) CGM (Continuous glucose Monitoring):-
   The sensor will be attached to the skin and take the glucose information from the blood. The sensor measures your interstitial glucose level. It will provide an update after every one minute.
2) Wearable wrist-type BP monitoring (WBPM):-
   The sensor will be attached to the wrist and it can read the blood pressure. It also provides updates after every one minute. By reading blood pressure the AI will make a decision whether the patient is under mental stress or not.

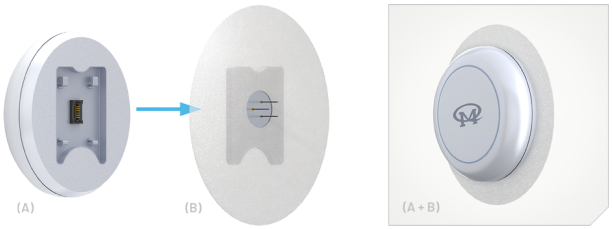


Fig. 3. Continuous glucose Monitoring

Fig. 4. Wearable wrist-type BP monitoring

3) The method we've used in the sensor:-
As the system is about real time updation so we think there should be a self regulated method called SRL(Self Regulated Learning).
Self Regulated Learning is an old method that can be applied in the living body or a machine. In this method the sensor will work on some criteria: 1. Planning and activation 2. Monitoring 3. Control 4. Reaction and reflection. [10]
On the other hand, we also have used the Cybernetics model. This is based on a mathematical model.Cybernetics means the science of communication systems. [11]
Using these two methods first the sensors will be taught by a teacher. Then it can take the exact data from the body rather than taking the unnecessary data .
4) Workflow(SRL):

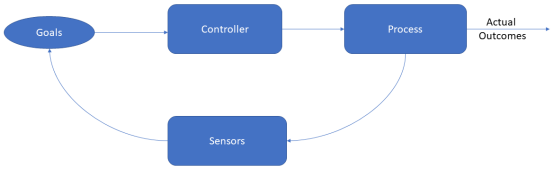


Fig. 5.

B. Mathematical Model

The most easy way of classical approach to learn by a passive trainer-learner model can be as follows:

$$x'(t) = a\tau$$

Variable	Description
τ	Input given by educators or external resources
a	unavoidable variability associated to different learning tasks

So, the equation,

$$x'(t) = -a'x + r$$

Variable	Description
r	The pursued goal
a	Constant. Which represents the individual's aptitudes.

From, (1) and (2), we can define a detail model for SRL in m-healthcare :

$$\begin{cases} x'(t) = \dfrac{\lambda u}{\gamma e^{x(t)}} \\ x(0) = k \end{cases}$$

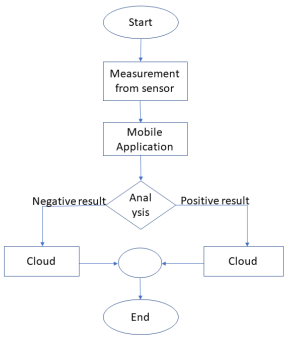
Here,
The initial condition $k \geq 0$ = It represents learner's basic knowledge about the topic

Variable	Description
λ	Concerns about some objectives that we fixed as a target
γ	strength of the impact of external influences

Now, the analytical solution for

$$x(t,k) = \log\left(e^k + \frac{\lambda}{\gamma}ut\right)$$

$x\ (t,k)$ represents the changes of available healthcare resources and experiencing better care.



IV. Pseudo code

```
Input user_id
Input finger_print
If already_have_an_acc
Do go_forward
Else Sign_up
then
login
for each_service_request
Do level_of_trust

If verified   then
    Go_to_cloud
    Access_to_data
If
    User_selected_a_service then

 Do enter_data
    save to the cloud = new_data
    update_Information
    again_verification
Logout
```

V. Type-02 Diabetes Statistics In Bangladesh

- 1200 Medicine specialists
- Number of diabetes patients 13.1 million.
- 10,917 patients per doctor.

This statistics represents the bad need of this system. There is no better way rather than using the m-healthcare system to prevent diabetes. Because our system can keep a smart track of the patients

VI. Discussion

We try to make the whole procedure as easy as possible. After all, there are some limitations. We proposed the method but some tasks need more updating. After implementing the whole project physically we can say it is a complete task. We need to blend two sensors and one sensor otherwise it can not be easier to wear. On the other hand we need to build the mobile application and the database. After doing all these things we hope to have a complete system for the type-02 diabetes patient. As we still have some limitations, we need to think more about it.

VII. Conclusion

To prevent type-02 diabetes this is a proposed method where we try to think of some innovative ways which can solve the problem. As this is a worldwide problem with millions of people, we need the solution badly. That is why we use the SLR method to get more accuracy. Because it can help us to prevent the so-called pandemic. On the other hand, doctor-patient communication will make the problem easier to solve. Because this feature will bring the huge number of patients in a group. So this can be another sector where we can do more research.

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