Identification of Diabetes with Mobile Applications using Cloud based Expert System

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Abstract—The integration of expert systems, mobile intelligence, and the cloud for diabetes diagnosis was the study's main objective. An expert system is a computer programme that makes use of a knowledge base and an inference engine to resolve problems considerably more quickly and effectively than they would otherwise. To lessen the limitations of mobile applications, the cloud has provided developers with a variety of services to create, manage, and deploy. Because of population expansion, ageing, addiction, urbanization, obesity, lack of exercise, and other complex diseases, there are more people with diabetes than ever before. Furthermore, these issues are made worse by a lack of specialists, inaccurate diagnoses, and inadequate medical facilities. Thus, diabetics require ongoing care such as dietary restriction, exercise, and insulin management. A hospital's knowledge was drawn from in order to create the prototype using a purposive sampling technique. Case studies are chosen for testing and assessing the prototype system in order to determine whether or not it is accurate and meets end-user criteria.

Keywords—Artificial Intelligence, Expert System, Diabetes, Cloud Computing, Google platform, Firebase.

I. INTRODUCTION

Due to insufficient insulin production, improper insulin uptake by cells, or both, diabetes is a disordered metabolic illness with inappropriate hyperglycemia (Ibrahim M.Ahmed, 2015). Because glucose plays a significant part in providing the human body with the fuel it needs for daily life, a person with diabetes has difficulty using it as a source of energy. In addition to the fact that it cannot be healed, particularly in the case of type-1, it can also lead to several consequences including heart, kidney, eyesight, nerve damage, amputation of the leg or foot, death, etc.[1-10] As a result, diabetes requires regular monitoring since, according to research by Dr. Abdullah Al-Malaise Al-Ghamdi, Majda A. Wazzan, Fatimah M. Mujallid, Najwa K. Baksh et al. (2011), fasting plasma glucose (FPG) levels can fluctuate from normal to as high as 100 mg/dL in a single day. When FPG values are 126 mg/dL, blood glucose in a diabetic person is diagnosed (Ketan D. Bodhe, 2017). The International Diabetes Federation (IDF) predicts that 387 million people globally affected by diabetes in 2014, and that figure will increase to 592 million by 2035. Up to 179 million people have diabetes who have never had it diagnosed. Diabetes was responsible for 4.9 million fatalities in 2014, with a corresponding annual health care cost estimated at USD 612 billion, or 11% of total spending on adults (Zarkogianni , 2018). There are several subfields of AI that deal with voice, vision, A.N.S., expert systems, robotics, natural language, comprehension and learning, etc. The development of systems that exhibit some of the characteristics of human intelligence is one of the objectives of study in this field (Alma, 2014). An expert system is a computer software that employs a knowledge base and inference engine to solve problems that are complex enough to require a lot of human expertise to solve considerably more quickly (Pannu, 2015). Inference engine is a programme component of the system that imposes a general control approach on how the system is working by applying the rule in the knowledge base to solve a problem. Knowledge base is a set of rubrics and facts that represent the domain of an application. The user interface, working memory, and explanation facility are just a few of the additional components that an expert system may include in addition to those already listed. Yet, the collecting of extremely exact and accurate knowledge and the method of drawing conclusions are what greatly influence an expert system's performance(Anjaneyulu, 1998). The expertise of the expert is accessible when a human expert might not be, enabling knowledge to be made available whenever and wherever it is required. In addition to this, experts are also perishable, unpredictable, expensive, incomplete in their explanations and responses, subject to misunderstanding and inconsistent findings, sluggish in processing and reproduction, and unfortunately not always available when diabetics need it. [11-15] Expert system has its own approach to give a service that is reasonable, long-lasting, reliable, fast processing and quick replication, high performance, emotion-free, and openly explains the logic.

The lone expert system, though, does not provide patients with all-encompassing options. [16-21] To overcome these difficulties (accessibility of networked computers, ability to get information from the internet through a computer, etc.) of the expert system, other emerging technologies are required, such as mobile intelligence and cloud services. An application that may run on a mobile platform is referred to as a "mobile application" or "mobile app". There are numerous installed applications on our smartphone. For those programmes to install, run, communicate, and update, they must have a lot of memory space, power, and processing. Hence, the cloud contains solutions for issues that arise with mobile-based expert systems. Governmental and non- governmental organisations benefit greatly from cloud computing technology, which suggests a variety of cloud facilities through a variety of cloud models, liable on the needs and usage patterns of clients.

SaaS - Software as a Service, PaaS -Platform as a Service, IaaS - Infrastructure as a Service, and Everything as a Service are some of the fundamental cloud computing delivery services (XaaS). These cloud stacks offer many services, which can be managed by either a service provider or a user, as we illustrated in **Fig 1**. (Tata, 2012). The term "Software as a Service" (SaaS) mentions a capacity in which consumers are prepared to use the provider's requests that are located in the cloud. Customers essentially pay for the right to access and use services that are hosted in the cloud. Google offers services including Facebook, Twitter, and web-based email systems (Grance, 2011).

Platform-as-a-Service (PaaS), platform that enables the growth of applications on cloud platforms. Developers can use this platform to host applications created by clients, deploy them on the cloud infrastructure, and manage them there using tools or programming languages provided by the service provider quickly and easily, all without the hassle of having to purchase and maintain the underlying infrastructure and software. Google provides PaaS services like Google App Engine and Firebase, which are two popular examples (Samir Tata , 2012).

The most basic cloud service is infrastructure-as-a-service, or IaaS. In terms of ready-to-use storage, processing, and/or network resources, operating systems, and other basic computing resources, the end users can arrange and manage the systems so that they can deploy and use the programme. An illustration of an IaaS is Amazon's EC2 (K E Narayana, Sailesh Kumar, Dr.K.Jayashree et al., 2017).

Everything-as-a-Service (XaaS), which we illustrated in **Fig 1**, refers to one or a combination of cloud services, is a good platform because it offers dependability, conditional security, high availability, low maintenance level, and

scalability (Perakovic, 2011). As users' businesses expand, it enables intelligence applications to be created, implemented, scaled, and repurposed (Accenture, 2017). As a result, XaaS demonstrated many cloud services like SaaS, PaaS, and IaaS. The study integrates a mobile-based expert system with the cloud using a variety of tools and approaches, as can be seen and inferred from the study's title. As a result, end users can execute their programmes and other cloud-based services using memory in the clouds that has strong security features in place of using a powerful processor and a lot of memory on their mobile devices. So, any diabetic who wants to retain his or her profile for usage in the future connects to a cloud using a mobile device after authenticating with a username and password. When the greatest security practises are used, it is simple to retrieve and store data in the cloud in a safe and secure location. Physicians will maintain the dataset which relates the diabetic's history and test results through his or her smart mobile phone and though the diabetic is at a remote location, he or she can prescribe the physician through e-mail, mobile SMS and other notification mechanisms based on the most recent felling tested through a mobile phone.

Since smartphones and the cloud have advanced in technology, doctors and diabetics may now access and test a patient's rapid plasma glucose and emotions for a more accurate diagnosis and treatment of the disease. This is made possible by the mobile cloud platform and tool called firebase. The task of collecting knowledge from two domain experts through semi-structured interviews and document analysis is supported by the knowledge engineer to create an expert system. Using a decision tree the extracted knowledge was modelled, added to the knowledge base using methodologies for representing knowledge that are based on rules, and then turned into a computer programme. By combining this data with the knowledge base's rules, the hybrid inference process was able to glean further details about the issue at hand. Using the user interface, end users provide data or other important information to the expert system. Eventually, the system could identify the type of diabetes, make decisions and suggestions based on that type of diabetes, respond to user questions, and explain its decisions depending on input from the user.

II. DIABETES

As blood sugar levels rise over normal, diabetes develops. In other words, there is a problem with the way the body turns sugar or glucose into energy. Our body uses sugar as fuel. When pancreas fails to make insulin enough, cells' disability on utilize insulin or both occurs, diabetes occurs. Diabetes is currently the world's most difficult disease (Kumar, P S Jagadeesh et al., 2015). Most diabetics who have type 2 diabetes are unaware that they are at risk for the disease (Ahmed, Ibrahim M et al., 2015). Thus, the sickness is spreading quickly. Amputations of the legs and feet, blindness, nerve damage, heart disease, renal disease, and other disorders can all be brought on by various types of diabetes, making it crucial to monitor and control them all. In order to successfully lower the risk of problems and enhance the patient's quality of life, regular monitoring is necessary. But, since there is no cure, there are technological means of control, including as medication, a carefully planned diet, frequent exercise, and other measures (Ahmed, Ibrahim M etal., 2015).

Based on discussions had in the interview with subject matter experts and analysis of numerous secondary sources, including manuals and literature reviews. For the construction of the research work's prototype, the following numerous

general symptoms of diabetes have been solicited. The symptoms of diabetes which are mentioned are not applicable in the case of females like Impotency (Sexual erectile dysfunction) and vice versa the symptoms which are not applicable in case of males are only considered in case of females like previous pregnancy, baby over 9 pounds during previous pregnancy, Nausea, vaginal mycosis infection, loss of menstruation, polycystic ovary syndrome, low blood sugar in the baby immediately after delivery (Anouncia, Margret et al., 2013).

Classification

Most cases of diabetes fall into the three broad categories of type 1, type 2, and type 3 or gestational diabetes (Patra, P Santosh Kumar et al, 2012).

In type 1 diabetes, diabetic body is incapable to create the required amount of insulin. The old name for type 1 diabetes (IDDM) is Insulin-dependent diabetes mellitus. Because people with type 1 diabetes require insulin to survive (Akter, 2015), insulin regulates the amount of glucose that is present in our blood. Pancreas produce insulin. When the cells in the pancreas responsible for making insulin are damaged, people with type-1 diabetes are no longer able to produce this hormone. When there is insufficient insulin, sugar does not enter the cells, where it is used for energy, but ratheraccumulates in the bloodstream.

Diabetes type 2 is also known as adult- onset diabetes or Non-Insulin-Dependent Diabetes Mellitus (NIDDM). Because it happens when the body produces enough insulin but does not properlyuse lean (Akter, 2015). 90% to 95% of all cases of diabetes that have been identified may be type-2 diabetes. Older age, obesity, family history of diabetes, past gestational diabetes, poor glucose tolerance, physical inactivity, and race/ethnicity are risk factors for type-2 diabetes (Food, 2016).

Gestational diabetes mellitus (GDM), also recognized as type 3 diabetes, a disorder wherewomen develop high blood glucose levels following the conception process, which involves fertilisation, implantation, or both. Many women experience

gestational diabetes during pregnancy, often aroundthe 24th week (Ibrahim M.Ahmed, Abeer M.Mahmoud, Mostafa Aref, Abdel-Badeeh M.Salem et al., 2017). When a pregnant woman whohas never had diabetes has high blood glucose levelswhile pregnant, it can develop (Al-ghamdi et al., 2011). The GDM woman's chance of having GDM in subsequent pregnancies and in later life increases once she returns to normal. It appears in between 2% and 5% of pregnancies but typically goes away afterdelivery (Akter, 2015).

III. CLOUD COMPUTING

By offering a variety of services, including applications, platforms, and infrastructures /services on demand through web browsers, scalableand elastic runtime environments, virtualization (in the form of storage, hardware, and networking), as well as the combination of two or more of those services, cloud computing technology shows a significant part in governmental and non- governmental organizations. The cloud facilities listed above are segregated into several categories, including platform as a service (PaaS), software as a service (SaaS) , infrastructure as a service (IaaS), and everything as a service (EaaS) (XaaS). To carryout this investigation, the cloud platform (Firebase)has been chosen by us. Both users and service providers can control some or all service layers in a cloud computing environment. For example, as shown in **Fig 1**, SaaS layers manage operating System, middleware, data, runtime, application, virtualization, server, storage, and networking fromtop to bottom. In this sense, Google and Salesforce are common cloud service providers (Tata, 2012).

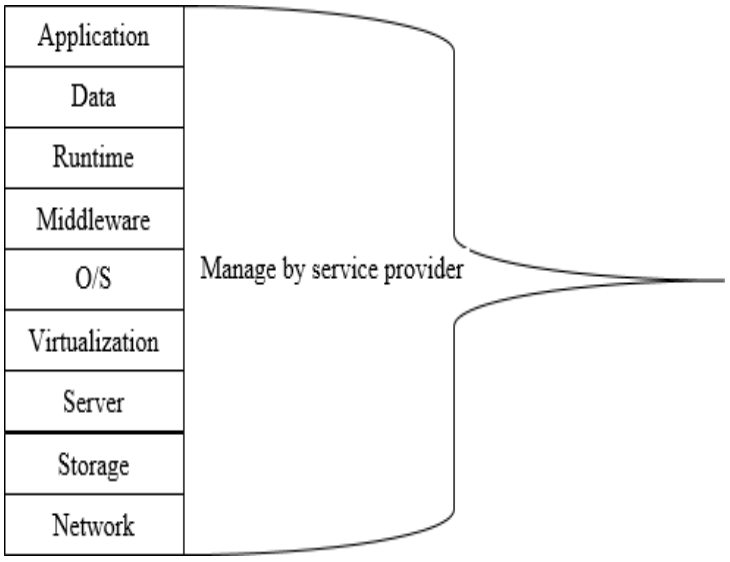


Fig 1. SaaS Layers

The first two top levels (Application and Data), as seen in **Fig 2**, are controlled by the user asopposed to the services provider. If the services theyused did not exceed the permitted quota, companieslike Google, Microsoft, Amazon Web Services (AWS), OrangeScape, and Salesforce.com, among others, could manage the vast majority of the bottomlayers to serve their customers without the expense and complexity of purchasing various resources andmanaging the underlying hardware and software layers with a fee. In another speech, the above mentioned different services providers could provide PaaS in different manner and purpose (Tata,2012). **Fig 3** illustrates IaaS Layers.

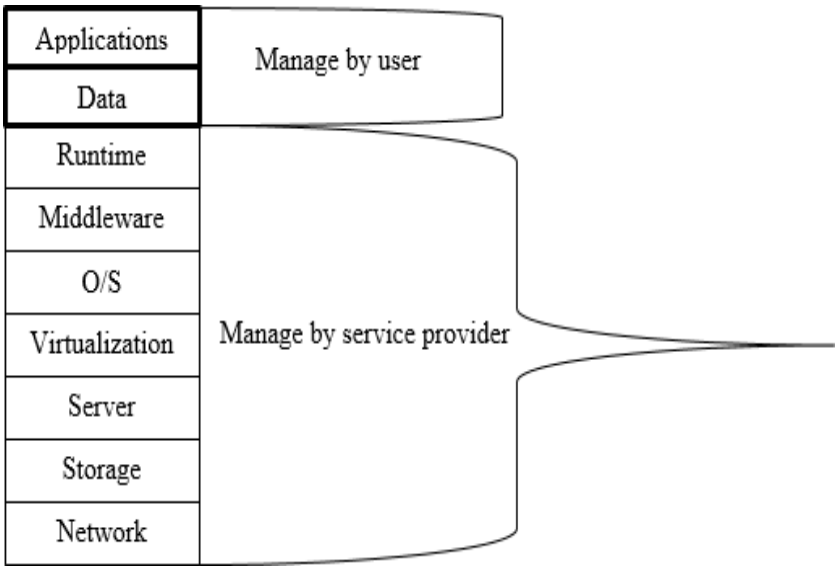


Fig 2. PaaS Layers

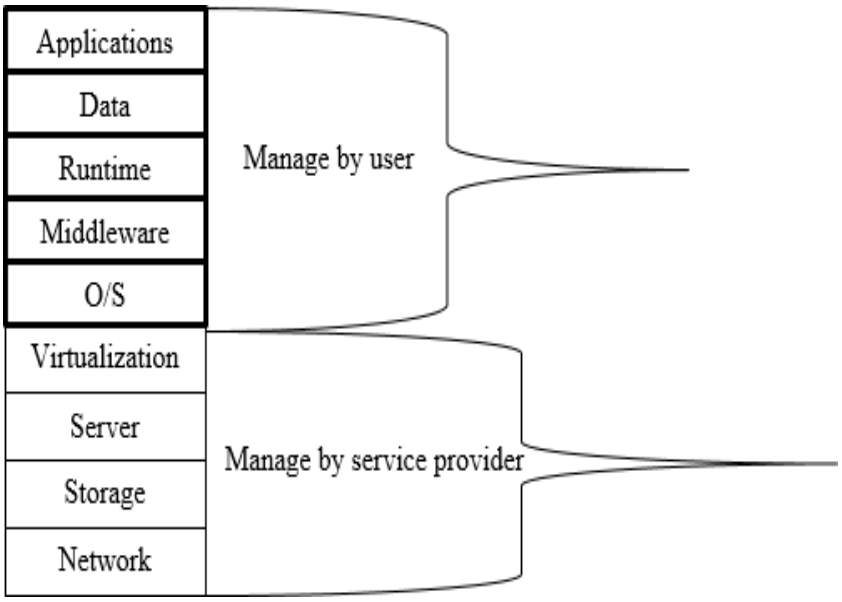


Fig 3. IaaS Layers

Cloud Computing Model

Depending on the target audience, service constraints, or clouding strategy, cloud services canbe divided into various deployment types. The public, private, hybrid, and community cloudmodels are among the four types of cloud models that are described (Kavitha, 2014).

Under the public cloud model, the cloud infrastructure is owned by a third party company that provides the cloud service and is made available for free use by the general public or a sizable industry group over the internet on a commercial basis. The services can be used for free or for a fee. Customers can utilise the service without setting up,

managing, hosting, backing up, or updating the software, hardware, or data centre. Public cloudservice providers provide the necessary infrastructure and pool resources to meet consumer demand. Examples of public cloud suppliers who make their services available to the broader public include Google, Amazon, and Microsoft. Consumer-generated and -submitted data is often kept on the servers of the third- party vendor. Another problem with using a public cloud is that you might not be aware of how and where your data is being backed up or stored, or whether unauthorized individuals have access to it. Another issue with public cloud networks is reliability (Al- roomi, May et al, 2013).

Any employee within the firm has access to the data, services, and web applications under the private model, but people outside the corporation arenot permitted to use the cloud (Al-roomi, May et al,
2013). The cloud infrastructure is run exclusively for an organisation, and only that organization's members and/or authorised third parties have access to it. Instead of providing cloud services to the wider public, the firm will use them internally. It might grant the organisation more authority over the infrastructure. The only big advantage that private cloud has over the public cloud is that of data security and privacy. The major drawback of a private cloud is its higher cost (Goyal, 2014).

The infrastructure of a hybrid cloud is made up of multiple clouds of any kind or a combination of two or more different cloud infrastructures (private, community, or public), each of which is still an independent entity but is connected by standardisedor proprietary technology that enables data and application portability (Kavitha, 2014). At least onepublic cloud and one or more private clouds isneeded o make a hybrid cloud. It is often provided in one of two ways: either a vendor partners with a public cloud provider while maintaining a private cloud, or a public cloud provider partners with a vendor that offers private cloud platforms.

In a community cloud, several organisations from the same community who have comparable goals and needs (such as mission, security requirements, policy, and agreement considerations)share the cloud infrastructure (Al-roomi, May et al, 2013). It may be retained, accomplished, and run byone or more communal organisations, a third party, or a mixture of them. It may also be positioned on oroff-site. It is somewhat comparable to a privatecloud, but rather than being restricted to a single entity, the infrastructure and computational resources are shared by two or more organisations that have similar privacy, security, and regulatory concerns (Goyal, 2014).

Firebase

It is possible to create high-quality mobile applications using the Firebase platform and tool, which unifies the services for doing so with a platform that is remarkably simpler (Srivastava, Neha et al., 2017). Firebase is a cloud service provider and backend as a service, not a service in and of itself. Firebase offers a unique framework forcreating mobile and online applications. The application can be created and updated in real time.Firebase saves data in JSON format and is relatively simple to use. While using Firebase, we don't need to configure our server. Firebase will take care of everything automatically. Thus, server side code is not necessary. We'll be more productive and save time as a result. Obviously, creating a web application requires both server- side and client-sidecode. It needs a backend that manages a database tostore the records and authentication to verify the user accessing it is who they say they are (Srivastava, Neha et al., 2017).

The cloud-based database used by Firebase doesn't require SQL-based queries to save or retrieve data. Database systems are encoded as JSON objectsand saved in the cloud. Each piece of information iskept in the database as a node coded in JSON with acorresponding key, resembling a tree. Define your application state as a Key/Value structure since data should be kept in that format. When new data is added to a Firebase database, a node is added to the existing structure. Secure file uploads and downloads are possible without being impacted by network performance (Srivastava, Neha et al., 2017). In addition to being utilised for hosting, Firebase also provides highly quick and safe delivery of online content. A firebase database must be hosted on firebase servers and cannot be hosted locally. However, the Firebase Command Line Interface, a component of the Firebase Database Manager, allows for local testing. This interfaceenables database management, testing, and deployment (Srivastava, Neha et al., 2017). In addition to offering login via Gmail, GitHub, Twitter, and Facebook, Firebase also allows developers to establish bespoke authentication (Mehta, Bhavin M Madhani , Nishay Patwardhan, Radhika et al., 2017). In order to address this demand, Firebase provides its own backend servicesfor the allow authentication. We need to know the identity of the user in order to safely keep a user's data and customise the user page. A password, phone number, or federated identity (such as Google, Facebook, or Twitter) may be used forauthentication (Nicolas, 2018). You may design eye-catching push alerts with this functionality. Youhave the option of sending to certain people or all users. Making and sending notifications is quick and simple (Mehta , Bhavin M Madhani , Nishay Patwardhan, Radhika et al., 2017). You can send messages for free to another platform using Firebasecloud messaging. Moreover, messaging is employedfor alerting purposes (Nicolas, 2018). This functionis used to compile a report of all application crashesand errors (Srivastava, Neha et al., 2017). The ability to test your application before making any adjustments is a very useful tool. Examining how a user interacts with your programme allows you to test their behaviour (Mehta , Bhavin M Madhani , Nishay Patwardhan, Radhika et al., 2017). With the help of this capability, users can update their applications without first installing the most recent version (Srivastava, Neha et al., 2017).

IV. IMPLEMENTATION OF THE PROTOTYPE SYSTEM

The development of the mHealth solution for diabetes self-management was carried out in three phases. In phase I, we extracted features from his Android apps with user ratings of 4 stars or higher and reviewed relevant studies related to mHealth for diabetes self-management. Expert opinions were then obtained to determine which features of the app were essential. In Phase II, researchers selected behavioral change and structural theories to apply to the app and designed the website. Finally, in phase III, the usability and user experience of the mobile his app by a diabetic patient and the portal by a healthcare provider were evaluated using a user experience questionnaire. Overall, this research appears to be focused on creating mHealth solutions that are user-friendly and effective for diabetes self-management. (Raheleh Salari et all.,2021).

In this paper, The actual structure of the system aimed at the diagnosis and dealing of diabetes is included in the execution of the prototype system. The next stage is to code the represented knowledge using the Android Studio editing tool to develop the prototype system into a appropriate format that is intelligible through the inference engine after the essential knowledge has been expressed using arule-based knowledge representation technique.

User Interface

It is a key element of the system that offers a channel for user communication and facilitates simple system interaction. It enables users to communicate with the system using any common I/O device and obtain answers to their requests.

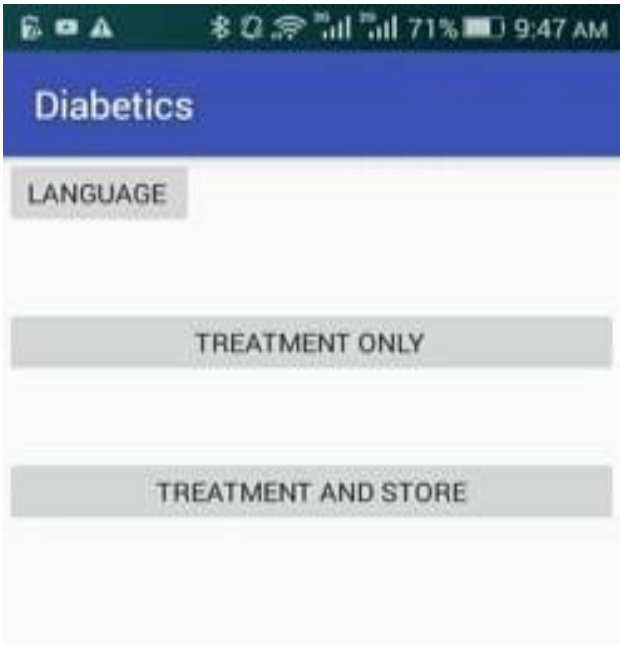


Fig 4. Prototype system home page

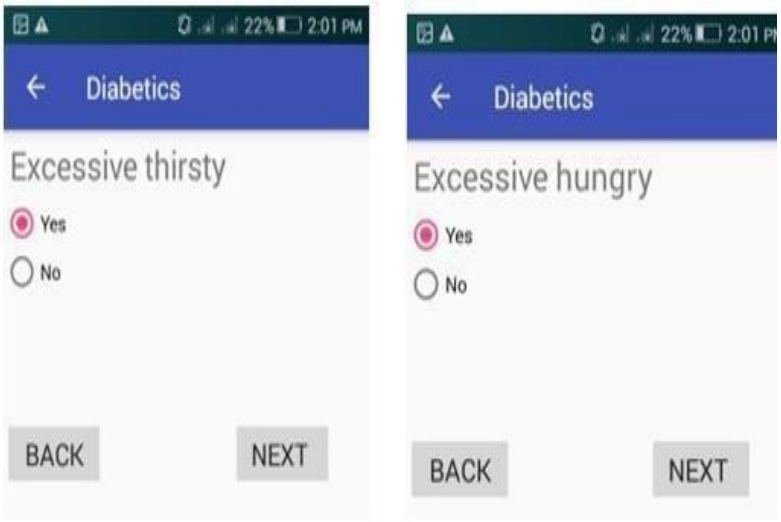
In order to give the best comprehension and accuracy about diagnosis and treatment, the end- user can begin the diagnostic by selecting a convenient or local language, as shown in **Fig 4**. The technology enables users to communicate with it by letting them choose between English and other supported languages on mobile platforms. The system has two choices for diagnosis and treatment, as indicated in Fig 4 below. The first choice is "TREATMENT ONLY," which allows the end user to access and test their blood glucose level without having to store their profile for future treatment. The end-user might keep his or her profile after diagnosis and treatment under the second option, "TREATMENT AND STORE," for use in future diagnoses and treatments.

Explanation Facility

The explanation facility offers a justification for the judgment it renders. The prototype system offers the choice of diagnosis and therapy using either the FPG test or merely symptoms by pressing yes or no in several local languages, in addition to presenting the final results. According to **Fig 5**, the prototype system asks the user to respond to the question "Do You Have FPG Test Result?" in English. If the user selects the "Yes" response, the system will show the next page. Sadly, the patient could not always have the results of the quick plasma glucose test, so the patient should choose "No" and try to diagnose themselves by describing their symptoms.

5(a) Treatment selection page

5(b) FPG Request page of the system



5(C) Sample symptom identification request page

5(d) Symptoms request page of the system

5(e) Sample explanation page of theprototype system

Fig 5. Sample explanation page for the prototypeimplementation

If the end-user chooses option "No," as illustrated in **Fig. 5(a),** the system then displays the series of questions that the patient must answerbased on how they feel. The system asks user to enter his or her blood glucose level by means of theresults of an FPG lab test. The end-user submitted the FPG test result of 89 mg/dL into the prototype system depicted in **Fig 5(b)** and **5(c).** Without further diagnosis, the method determines that the patient is "free from diabetes" if the FPG test result is less than 100 mg/dL. Lastly, the system has provided an explanation service and a suggestion forthe task that the patient will complete in the manner described below. The system gives the end-user guidance based on doctors' recommendations to maintain a healthy weight, engage in physical activity, and consume a variety of nutritious foods, as shown in **Fig 5(d)** and **5(e)** of the system's explanation. You do, however, remember to routinely check your blood glucose levels. Since these characteristics are the main causes of diabetes.Family history and age degree of obesity If not, the patient could be anticipated to live a long life with diabetes while continuing to use the proper control measures and other conditions including high bloodpressure, kidney disease, and others.

V. EVALUATION OF THE PROTOTYPE SYSTEM

Once we implemented the prototype system through android studio editor tool and firebase Google platform, the performance of the system is evaluated to ensure it's accuracy and satisfaction bythe end users with their requirements. To determinethe correctness of the prototype system, Systemperformance testing is used. In this study, two physicians are selected from hospital for the drive oftesting and evaluating the prototype system. Selected physicians are different from whom we collected the domain knowledge. The criteria for selecting the evaluators are because of the current availability on working place, and their willingness.

Thirty patient's test cases are dispersed equally to the assessors, which is 15 patients' test cases for each assessor. When prototype system is applied, domain experts evaluate correctly and incorrectly diagnosed cases of diabetes by comparing their judgement on a similar patient's test case with that of Domain Experts.

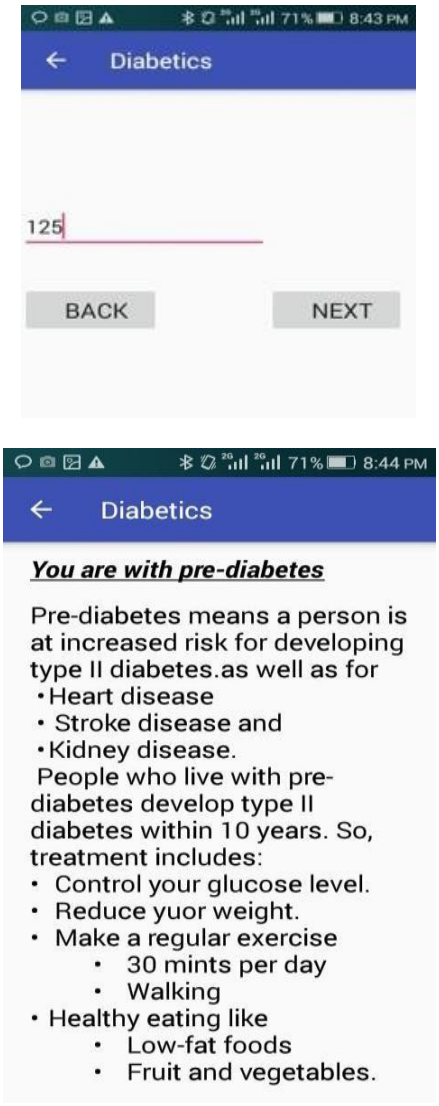


Fig 6. Sample page of system explanation

The figures in the matrix is often used to assess the performance of this prototype system. Asshown in **Fig 6**, if the end-user inputs an FPG test result of between 100 and 125 mg/dL, the system will automatically determine that the patient "has pre-diabetes" without performing any additional diagnostic testing. Finally, the system has provided instructions on how the patient should use it in theirdaily lives. The method determines the patient has diabetes if the laboratory test result is greater than 126 mg/dL, although it does not specify the type of diabetes at this level. The system needs to ask the patient more questions to determine whether they have type-1, type-2, or type-3 diabetes. As we shown in Fig 6, to predict whether the patient has type-1, type-2 and type- 3 diabetes, the decision reflects the risk factors of diabetes such as family history of diabetes, age, obesity, gender or pregnancy and overweight in following way.

As shown in **Fig 7(a)** and **7(b),** If the end-user inserts the “age”, which is >=35, the system gave priority for diabetes type-2, but now also, not determine specific diabetes type.

As shown in **Fig 7(c),** and **7(d),** the system again demands the end-user to enter the“family history of diabetes” and “pregnancy”. Finally the system settles “The patient has type-2 diabetes” in the following way.

As shown in **Fig 7(e)**, after the system identified the diabetes type, the system offered advices about the diet information, medication, exercise and foods you should eat and foods avoid or limit.Also, the system instructs the patient tomonitor his/her glucose level to live along life with a disease.

7(a) Sample page to determine the diabetes type

7(b) Sample age to determine diabetes type

7(c) Sample page to determine the existence offamily history

7(d) Sample page to determine the existence ofpregnancy

7(e) Sample identifying diabetes type and systemexplanation

Fig 7. Sample Page for identifying diabetes type and system explanation.

Testing

Following the prototype system's implementation using the Google Firebase platform and the AndroidStudio editor tool, we assessed and tested the system to see if it performed accurately and met user needs. The procedure of establishing whether or not the prototype system is correct is known as system performance testing. It verifies whether or not the proper prototype system was constructed. Two doctors from the hospital are chosen for this study'sevaluation and testing of the prototype system. The doctors who were chosen are different from the ones from whom we gathered the subject knowledge. The criteria for choosing the assessors were based on their willingness and current availability in the workplace. By contrasting the conclusions obtained by the prototype system with the conclusions made by the domain experts on test cases involving the same patient, the domain experts identify cases of correctly and erroneously diagnosed diabetes duringthe performance of the prototype system. The data in the matrix is often used to evaluate the performance of this prototype system. Theconfusion matrix for the three types of diabetes— type 1, type 2, and type 3—is displayed

in **Table 1**below.

Table 1. Confusion Matrix of the Prototype System

Expert System Offered				Experts Offered
Type 1 diabetes	Type 2 diabetes	Type 3 diabetes	Class names	
8	1	0	Type 1 diabetes	
2	9	1	Type 2 diabetes	
0	0	9	Type 3 diabetes	

30 cases of diabetics with a diagnosis are presented by professionals, as shown in **Table 1**. Based on their prior assessment, they chose 10 cases of "Type-1 diabetes" among the thirty diabetics that were diagnosed. Out of 10 cases of diagnosed diabetes, 8 are accurately classified, and 2 are wrongly classified, as seen in the initial column. As seen in the additional column, experts additionally chose 10 cases of "Type-2 diabetes" among the thirty diabetics. Of of 10 confirmed diabetic patients, 9 were correctly categorised as having "Type-2 diabetes," whereas 1 case had the wrong classification.Diabetics' cases are correctly classified, which translates to an accuracy rate of 86.7%. Four diabetics, or 13.3% of diagnosed diabetics, had their cases wrongly classified. As demonstrated in **Table 2**, the prototype system's performance is thoroughly estimated using a confusion matrix. After being reviewed by subject-matter specialists, the prototype system's accuracy result of 86.7% in detecting diabetes is encouraging. **Table 2** displays the compiled generated result for this performance metric. The true positive rate (TP rate), false positive rate (FP rate), precision (P), recall (R), and F- measure are all included in this table's detailed accuracy by class. In a classification task, a class's precision is intended by dividing the total number of items categorized as fitting to the positive class by the number of true positives (i.e., Precision=TP/(TP+FP)). It is denoted as positive predictive value. In this application, recall is defined as the ratio of the total number of components that genuinely belong to the positive to the number of true positives (i.e., recall=TP/(TP+FN)). It's referred to as sensitivity. The mean of precision and recall is a measurement that combines both precision and recall.

Table 2. Full Accuracy of the Prototype System

	TP Rate	FP Rate	Precision	Recall	F-Measure	Class name
	0.8	0.83	0.88	0.8	0.84	Type-1
	0.9	0.55	0.75	0.9	0.82	Type-2
	0.9	0.47	1	0.9	0.95	Type-3
Weight Average	0.866	0.061	0.876	0.866	0.87	

The expert system's judgment successfully diagnosed 87.6% of the anticipated positive cases, according to the weighted average precision. Similar

to the proportion of positive cases amongst all cases that truly correspond to the pertinent subset shown by the weighted average recall, 86.6% of all cases are positive. In system performance testing, the misdiagnosis of all types of diabetes by experts trying to determine the diabetics' types and the absence of modern laboratory facilities are the main causes of this issue. The experts try to determine the patient's type of diabetes by using two or more fast plasma glucose checking and other factors like age, family history of diabetes, pregnancy, weight, and other symptoms. The expert-provided case outcomes for thirty diabetics have an impact on those inputs.

VI. CONCLUSION

The study's goals are met by the prototype system, which performs well. However, more research is required to create the system useful in the area for the diagnosis and treatment of all forms of diabetes. For example, cloud facilities and the automatic updating of the system's knowledge base's rules are needed. The technique is especially helpful in rural areas, where there is a dearth of knowledgeable, skilled staff who can work close to diabetes. Experts in the field have acknowledged the system's importance because it provided accurate and trustworthy information on diabetes and made recommendations for end users. By repeating this prototype system, it could decrease the available knowledge gap observed in remote areas where transferring skilled experts is difficult as well as miss diagnosis rate of diabetes.

References

[1]. R. Salari, S. R Niakan Kalhori, M. GhaziSaeedi, M. Jeddi, M. Nazari, and F. Fatehi, "Mobile-Based and Cloud-Based System for Self-management of People With Type 2 Diabetes: Development and Usability Evaluation," Journal of Medical Internet Research, vol. 23, no. 6, p. e18167, Jun. 2021, doi: 10.2196/18167.

[2]. O. A., O. N., and J. O., "Online Support System for Diabetes Management," International Journal of Computer Applications, vol. 152, no. 10, pp. 6–11, Oct. 2016, doi: 10.5120/ijca2016911454.

[3]. M.Ahmed, M. Alfonse, A. M.Mahmoud, And A.-B. M.Salem, "Knowledge Acquisition for Developing Knowledge-Base of Diabetic Expert System," The 7th International Conference on Information Technology, May 2015, doi: 10.15849/icit.2015.0004.

[4]. M. Akter and M. Shorif Uddin, "Android-based Diabetes Management System," International Journal of Computer Applications, vol. 110, no. 10, pp. 5–9, Jan. 2015, doi: 10.5120/19350-0071.

[5]. Al-ghamdi, A. A., Wazzan, M. A., Mujallid, F. M., & Bakhsh, N. K. (2011). An Expert System of Determining Diabetes Treatment Based on Cloud Computing Platforms, 2(5), 1982– 1987.

[6]. J. L. ALTY, "Expert System Building Tools," Topics in Expert System Design - Methodologies and Tools, pp. 181–204, 1989, doi: 10.1016/b978-0-444-87321-7.50012-0.

[7]. V. Bhandari and R. Kumar, "Comparative Analysis of Fuzzy Expert Systems for Diabetic Diagnosis," International Journal of Computer Applications, vol. 132, no. 6, pp. 8–14, Dec. 2015, doi: 10.5120/ijca2015907424.

[8]. Jian-xun Chen, Shih-Li Su, and Che-Ha Chang, "Diabetes care decision support system," 2010 2nd International Conference on Industrial and Information Systems, Jul. 2010, doi: 10.1109/indusis.2010.5565846.

[9]. B. R. Gaines and M. L. G. Shaw, "Eliciting knowledge and transferring it effectively to a knowledge-based system," IEEE Transactions on Knowledge and Data Engineering, vol. 5, no. 1, pp. 4–14, 1993, doi: 10.1109/69.204087.

[10]. Gebremariam, S. (2013). Self-Learning Knowledge Based System For School Of Graduate Studies, (January). Gebrye,

[11]. H. M. (2016). Integrating Expert System For Vegetable Disease Diagnosis And Treatment In Tigray Region , Ethiopia : Focus On Tomato And Onio, (November).

[12]. George, J. (2014). Cloud Based Diabetes Management and Research - Blue Circled Cloud,3(1), 1–6. Guidance for Industry and Food. (2016).

[13]. Ibrahim M.Ahmed, Abeer M.Mahmoud, Mostafa Aref, A.-B. M. S. (2017). A study on Expert Systems for Diabetic Diagnosis and Treatment. 65 International Diabetes Federation. (2018). What is Diabetes.

[14]. R. A. Kowalski, "The early years of logic programming," Communications of the ACM, vol. 31, no. 1, pp. 38–43, Jan. 1988, doi: 10.1145/35043.35046.

[15]. Kumar, P. S. J., & Chaithra, M. A. S. (2015). A Survey on Cloud Computing based Health Care for Diabetes : Analysis and Diagnosis, 17(4), 109–117. https://doi.org/10.9790/0661- 1741109117

[16]. Mehta , Bhavin M Madhani , Nishay Patwardhan, R. (2017). Firebase : A Platform for your Web and Mobile Applications, 2017.

[17]. Patra, P. S. K. (2012). Automatic Diagnosis of Diabetes by Expert System, 9(2), 299– 304.

[18]. Singh, T. (2001). Prototype Expert System for Diagnosis and Treatment of Diabetes, 2001.

[19]. Tan, C. (2008). A Prototype of Knowledge- Based System for Fault Diagnosis in Automatic Wire Bonding Machine, 32, 235–244.

[20]. WHO, N. (1999). Definition, diagnosis and classification of diabetes and its complication, 1999.