Application of artificial intelligence in the management of diabetes mellitus - An overview

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ABSTRACT
Diabetes, a metabolic disorder responsible for worldwide pandemic wherein, epidemiological studies suggest around 425 million people around the globe have been diagnosed for diabetes. Type 1 diabetes mellitus (T1DM) indicates a complete insulin deficiency which threatens lifestyle whereas, Type2 diabetes accounts to the obesity and lack of exercise that devastates the internal regulation of the body’s glucose that needs exogenous insulin. Research data summarized for the last ten years have shown that, rigorous treatment effectively prevents the development and reduces the progression of complications associated with diabetes. The lack of in hand clinical information required making informed decisions concomitant with intensive therapy and strict management of diabetes frequently impede adequate treatment for people with it. In recent years, several artificial intelligence techniques are being utilized for the management of diseases including diabetes mellitus. This review will focus on various artificial intelligence protocols utilized for effective control of Diabetes mellitus. Technology has found an important place in medicine as well as diabetology. In the meantime there are quite a number of DT applications ranging from direct therapeutic use to use in patients with foot ulcer diabetes. Artificial Intelligence has tremendous potential to enhance diabetes patient monitoring, diagnosis and management. Rapid advances in artificial intelligence (AI) intend to make structured and unstructured health data accessible in real time for treatment.

INTRODUCTION
Artificial Intelligence is defined as “the science of mimicking human intelligence by the use of advanced computational systems”. AI encompasses a comprehensive array of procedures to support human intellect and performing different tasks of thinking, such as perceiving visual images, recognizing speech patterns, ability to perform decision-making activities and language conversion abilities (Rigla et al., 2018). AI covers a broad variety of novel algorithms in terms of deep learning, machine learning, and cognition based computing.
Fuzzy logic and neural networks are the most commonly used AI technologies.

Clinicians and health facilities face growing strain due to shifting demographics, logistical demands, shortages in the workforce and rising morbidity, as well as increases in demand and standards for information technology (Dankwa-Mullan et al., 2019). Artificial Intelligence (AI) and its implementation in health care have made tremendous strides in recent years. These strategies are expected to take over some of the practices currently being performed by physicians and health care managers in the coming years. However, there has also been an extraordinary amount of speculation about the AI capabilities and often even expectations that AI could fully replace human interference (IDF, 2015).

In recent years, Diabetes management and treatment are streamlined due to the successful collaboration of artificial intelligence and cognitive computing tools. The challenges involved in diabetes prognosis and management have resulted in Artificial Intelligence (AI) being a crucial technology for delivering solutions that enable both carers and patients in their daily lives (Liu et al., 2018).

AI use has the ability to enormously expand the scope of diabetes treatment and thus make it more effective. AI / ML methods are commonly used in all research fields and are responsible for the revolutionization of companies worldwide. AI / ML can be useful in chronic disease management, that is, diabetes. Nevertheless, one field of diabetes research, which has seen very few attempts, is diabetes control strategies. As we are witnessing the development of closed-loop insulin delivery system with built-in AI / ML algorithms in type 1 diabetes to predict both hypo-glycaemic and hyper-glycaemic excursions. Such technologies are only in the early stages and still have an effect on long-term performance and quality of life. Treatment of type 2 diabetes is much more difficult than treating type 1 diabetes, as there are many treatment choices to be added linearly and progressively (The Diabetes Control and Complication Trial Research Group, 1993; Kavakiotis et al., 2017).

MATERIALS AND METHODS

Methodology adopted in various artificial intelligence techniques

Expert Systems in Medicine (ESM)

The expert systems tries to vie with the behaviour of clinicians by the use of inferential approaches to aid in making pronouncements or solving problems. ES is mainly used for image recognition, alert generation and diagnostic assistance. Most commonly used ESM (Corchado and Lees, 1995) used in the field of diabetes management are fuzzy systems, case-based reasoning (CBR) and Rule-based reasoning (RBR) etc.

Rule based reasoning (RBR)

The above reasoning scheme is focused upon the exchange of knowledge from a specialist to a workstation. The computational system then does the job of an expert and acts as a substitute for human intellect (Corchado et al., 1998).

Case based reasoning (CBR)

CBR (Matthias and Godfrey, 1994) is an evolutionary learning strategy. Each time a task is finished it is effectively stored for the future retrievals. While various metrics and strategies can be used for each of the CBR cycle steps, there are only a few that can render the CBR method automatic.

CBR working cycle consists of five steps,

1. A summary of current problem
2. Seeking a positive approach to a similar case
3. Adapting and reusing the solution to the new issue
4. Assessment
5. Proven storage solution

CBR could be effectively performed only when each cycle requires well developed model in order to perform the specific assignment. CBR systems uses the appropriate information of previously come across problem scenarios and do not follow the comparative steps unlike rule based reasoning method.

Fuzzy Logic (FL)

The word “fuzzy” unclear things. There are simply cases where the judgments might not be based purely on the Truth or False ends. Yet there’s something in between. Fuzzy Logic (FL) is a logical system which is close to human logic. FL’s methodology mimics the way human decision-making includes all intermediate possibilities between the YES and NO principles. The FL algorithm helps in solving a problem by utilizing all the available data. For the feedback provided, FL algorithm will take appropriate decisions (Klein et al., 1988).

Machine learning

The Machine learning is another form artificial intelligence (AI). The systems have their ability to learn
and evolve automatically from their inherent experience without the use of explicit software programming. Machine learning focuses on computer systems being created that can access data and use it to learn about themselves. Machine learning has following applications (Kolodner, 1993).

**Artificial neural network**

New advances in artificial intelligence (AI) allow artificial neural networks (ANNs) to learn to solve composite problems in a short time. Neural networks are undergoing a revitalization that not only transmutes AI but also brings new insights into biological processes around neural computation. The Adaptive Artificial Neural Network is a non-parametric strategy for categorizing subjects as safe or unhealthy within the medical sector based on input variables. The artificial neural networks are influenced by a complex human brain structure (Tresp et al., 1999).

**Decision tree algorithm**

The general concept underlying the construction of a decision tree is that, features are divided into subsets (nodes), each of which is homogeneous with respect to the result of interest. Decision Tree Algorithm is part of the directed learning algorithms family. It is used for solving regression problems and classification problems. The Decision Tree algorithm builds a training model that automatically predict the target variable. In diabetes, DT has been widely extended to a wide variety of functions, such as type 2 diabetes monitoring and blood glucose detection (Rasekaba et al., 2015).

**Genetic algorithm**

GA uses the principle of natural selection and Mendelian genetics. GA is a theoretical search tool, able to efficiently traverse broad search spaces, unlike other search algorithms that perform a small, greedy search. The three operators of GA are: reproduction, crossover, and mutation. Initial population of individuals is created at random as a first phase of GA. Within the genetic domain the individual are called chromosomes and is represented as 0s and 1s string (Reddy et al., 2016).

**Deep Learning Techniques**

Deep learning is a modern branch of Machine learning focused on the actions of neurons inside human brains. Deep learning utilizes back-propagation algorithm which provides layer to layer information. Deep learning helps multi-layered cognitive models to learn data structures with several layers of abstraction.

**Support vector machines (SVM) algorithm**

A supervised machine learning method, the support vector machine (SVM) algorithm, has demonstrated superior performance in several biomedical sectors, particularly in bio informatics, in fixing classification issues. SVM distinguishes between two classes by creating a hyper plane that effectively and efficiently divides classes after mathematically translating input data into a high-dimensional space. The points that are closest to the border are called “support vectors”. SVM can only operate with binary classification troubles in its most fundamental formulation but can also address multi class classification tasks with a relatively simple extension. SVM has been used in the field of diabetes to forecast pre-diabetes and diabetes disease and in diagnosis. Table 1 represents the various algorithms and their application.

**Closed-Loop Systems Based on FL**

Artificial Pancreas project was launched The Juvenile Diabetes Research Foundation in the year 2006 to speed up the research on “Closed-Loop” system. Continuous subcutaneous insulin delivery was used to physiologically mimic the pancreas of Type 1 diabetic patients. Such a program is thought to promote a healthier, easier and more efficient treatment of diabetes, leading to better clinical outcomes. The challenges in implementing closed-loop insulin delivery to create highly accurate controller algorithms to accurately calculate the insulin dose with respect to the plasma glucose levels. Delivery of appropriate amount of insulin can be achieved by applying “Fuzzy Logic” to the closed loop controller. The main advantage of fuzzy logic over other technology is that it depends only on glucose management parameters.

FL-based algorithms have found practical in the outpatient setting. The FL controller also has the benefit of providing established glycaemic control (GC) levels.

**Retinopathy Detection Using ANN**

Diabetic retinopathy (DR) is a manifestation of diabetes causing permanent retina damage. Ophthalmologists use features like haemorrhages to characterize Diabetic retinopathy. Long-term DR contributes to diabetic maculopathy (DM). In diabetic maculopathy, the fat and cholesterol-rich fluid spills out of damaged vessels. If the fluid builds up in the middle of the eye (the macula) the central vision would be blurred. The two types of maculopathy are Non-clinically significant maculopathy (non-CSME) and clinically significant maculopathy (CSME) (Alipour et al., 2012).

Non-clinically significant maculopathy (non-
Table 1: Examples of artificial intelligence applied to Diabetes

<table>
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<tr>
<th>Methods</th>
<th>Applications</th>
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<tr>
<td>Support vector machines algorithm</td>
<td>Assessment of Retinopathy</td>
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<td>Classification of blood glucose levels</td>
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<td>Assessment of Retinopathy</td>
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<tr>
<td>FL, +FL</td>
<td>Fixing of insulin dose</td>
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<td>Treatment suggestions for Type 2 diabetes</td>
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<tr>
<td>RBR, CBR</td>
<td>Decision support</td>
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<td>Automated control</td>
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<td>Bolus calculator</td>
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CSME)

CSME has no visible symptoms so patients can be unaware that they are affected. Exudates begin to leak from the damaged vessels that form in the retina due to diabetes which ultimately leads to spongy retina (Nayak et al., 2009). The patient’s vision is not adversely impaired as the exudate sites are well away from the fovea.

Clinically significant maculopathy (CSME)

In this stage, most retinal blood vessels get damaged and the area of leakage gets larger. The exudates leak out and accumulate near the fovea. As images cannot be accurately centred on the macula, visibility is therefore greatly affected. Better control of glycaemic and blood pressure can reduce the chances of occurrence of macular oedema (Alipour et al., 2012).

CONCLUSIONS

Artificial intelligence is a continuously growing area of science. It has made significant contribution to almost all the segments of human life. Particularly in health care segment, artificial intelligence has revolutionized the health care systems and reducing burden on the health care workers. In the future, artificial intelligence could be effectively utilized for personalized health care services. The developments have already started and the effects will be seen in near future.

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