Original Research Paper　　　　　　　　**Engineering**

AI BASED EXPERT SYSTEM FOR PREDICTION OF DIABETIC EYE MORBIDITY

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ABSTRACT　**Aim:** to design an AI based expert system for prediction of diabetic eye morbidity.
Method: This research gives a prediction of diabetes retinopathy in diabetic patients using the Artificial Intelligence based expert system. This work divided in two parts, first part is examination of eye vision by the Ophthalmologist and also other examination such as PPBS, Hypotension, Cholesterol, duration of diabetes. Second part is 400 patients medical records are taken in 2019 year. And it is examined in the artificial expert system for prediction of diabetes retinopathy. It gives the accuracy, prediction, eye vision threatening, and morbidity in diabetic eye.
Result: The artificial intelligence expert system has 6 input parameters and in output one parameter which gives the prediction of diabetic neuropathy. The input parameters such as Post Prandial blood sugar, Hemoglobin A1c Test, duration of Diabetes, Hypotension, Cholesterol, and Vision in eyes. The output parameter was the morbidity in diabetic retinopathies which are Non proliferative, Proliferative, CMSE. This system gives accuracy, specificity, prediction of diabetic retinopathy.
Conclusion: This system is design for the endocrinologist and ophthalmologist to diagnosis diabetic retinopathy more quickly and prediction of eye morbidity.

KEYWORDS : Artificial intelligence, Diabetic retinopathy, Fuzzy set theory, HbA1c test.

INTRODUCTION

Artificial Intelligence is an emerging technology nowadays. It is used in every field such as mechanical, electrical, aerospace, and medical applications also. Fuzzy expert system formulates the reasoning process of human language by means of fuzzy logic and controls the presence of uncertainty for variety of problem domains[1]. Fuzzy logic gives a characteristic system to knowledge portrayal and inference from information bases which are inexact, inadequate, or not absolutely dependable[2]. The use of fuzzy logic concepts in the development of expert systems of medicine field increases enormously[2].

One of the biggest challenges currently experienced by healthcare organizations is the increasing burden of chronic diseases posing serious threats to public health in developing countries[3]. Diabetes is one of the world's most common and costly chronic diseases, and the number of patients suffering from diabetes has been showing an increasing trend in many countries[3]. Diabetes Mellitus (DM) is a serious chronic hormonal condition in which the body is unable to properly use the energy from food especially glucose or sugar[4]. Diabetes mellitus general symptoms are polydipsia, polyphagia, polyuria, weight loss, vision blurred, exhaustion, and an impaired healing. Diabetes mellitus has divided in few types, which are Type 1 Diabetes, Type 2 Diabetes, Prediabetes and Gestational Diabetes. It creates complications such as, heart diseases, stroke, neuropathy, retinopathy, deafness, foot damages; healing process slows down, fungal infections, depression, and dementia. Type-1 diabetes is also known as insulin dependent, it caused when the body stops producing insulin or produces too little insulin to regulate blood glucose level and typically recognized in childhood[4]. In Type-2 diabetes is also known as insulin resistance, it caused when the pancreas secretes insulin, but the body is unable to use the insulin[4]. Usually it is seen in adulthood, after age of 40years. Gestational diabetes is high blood glucose level in pregnant women, when body can't meet the extra insulin demands during the pregnancy[4].

In 2015, World Health Organization surveys on 457 million people worldwide have diabetes[5]. In 2004, an estimated 3.4 million people died from the consequences of high fasting blood sugar[5]. In 2015, World Health Organization survey on Diabetic Retinopathy is the fifth leading cause of visual impairment and the fourth leading cause of blindness in the world, 285 million people worldwide are visually impaired[5]. In 2010, diabetic retinopathy is the cause of visual impairment for 4.2 million people[5].

Author has do retrospective study in Rajkot city, Diabetes mellitus diseases are seen in 400 peoples, from that every 86 people have a Diabetic Retinopathy. In 2019, prevalence of Diabetes Retinopathy in Rajkot city is 22%, it's a geographical statistical analysis.
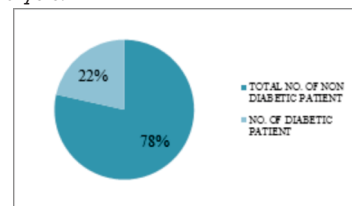

Figure 1: Prevalence of diabetes

Eye morbidity in diabetes mellitus is 45.30% in Rajkot city. Also percentage of CSME in diabetic patients is 16.20%, NPDR (Non Proliferative diabetic retinopathy) is 34.80%, and PDR (Proliferative diabetic retinopathy) is 10%. Vision threatening in diabetic retinopathy is 26.75%. Also percentage of vision threatening morbidity in Rajkot city is 5.75%.

Figure 2: Eye morbidity in Diabetes

DIABETES RETINOPATHY:

Eye is most important organ for human beings; it helps them to sense the color, shape and state of physical objects[6]. Diabetes Retinopathy is a complication of diabetes that causes damage to the blood vessels of the retina; the light sensitive tissue that lines the back part of the eye, which allowing seeing fine details[7]. Generally it is shown in working age people. As many people with type 1 diabetes suffer blindness as those with the more common type 2 diseases[7]. Sometimes diabetic patients don't observing the symptoms of diabetic retinopathy. May be it occurs in one or both eyes damages. Symptoms includes blurring in vision, difficulty in reading, floaters in vision, shadow in eyesight, eye pain, eye pressure, difficulty color perception.
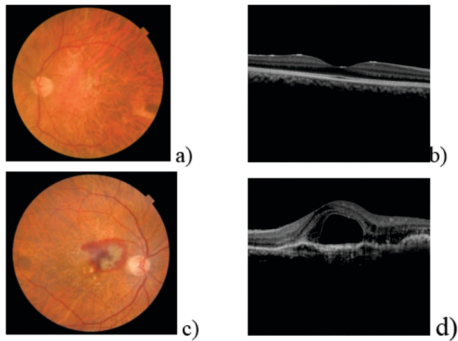

Figure 3: a) Normal b) NPDR c) PDR d) CSME

DR is classified in two types Non proliferative and proliferative. It terms for the lack or presence of abnormal new blood vessels coming from the retina. Non proliferative, eyes doesn't make new blood vessels during the first stages of DR. In the first stages, damaged in blood vessels frequently leak blood and fluid into the eye. Sometimes swell in the center of the retina or macula. NPDR have three stages mild, moderate, and severe and its fourth stage is known as proliferative retinopathy. Proliferative retinopathy, in which new blood vessels begin to grow within retina, but these new blood vessels are generally abnormal and grow in the center of the eye.

PROPOSED METHOD:

Fuzzy expert system is design for prediction of diabetes retinopathy based on the clinical examinations and ophthalmic test.

In the first phase, 400 people are diagnosed in the hospital from that 86 peoples are suffering from diabetes. These medical records were related to those patients who visited Swami Vivekananda Eye Care Hospital, Rajkot city, Gujarat during the year of 2019. this study is based on retrospective, inclusion criteria are middle aged patients between 40 to 70 years irrespective of gender, PPBS more than 140 and/or patients are on antidiabetic therapy; and exclusion criteria are juvenile diabetic mellitus, drug induce diabetes. Also some different clinical examinations are hypotension, cholesterol, duration of diabetes.

In the second phase, artificial intelligence expert system gives the prediction of diabetes retinopathy by giving some input parameters and trains fuzzy rules for making a output of the system.

Proper examination of diabetic eye should always begin by gathering during a history from the patient [medical student]. Ophthalmologist asks about any visual symptoms and risks for diabetes retinopathy such as pregnancy, hypertension, cholesterol levels, and retinal status, check their last hemoglobin A1c over the past 3months. And eye examinations start from the visual acuity, intraocular pressure measurement, slit lamp exam, fundus exam and OCT exam.

The standard range of PPBS, normal is 140mg/DL, Prediabetes is 180mg/DL and diabetes is 180mg/DL and above. The HbA1c test is normal range is below 5.6%, Prediabetes range is 5.7 to 6.4% and diabetes is 6.55% or above. The normal range of blood pressure is 120mmHg/80mmHg, hypotension generally range is low blood pressure less than 90/60mmHg. Cholesterol level is normal level is 100mg/DL, LDL is less than 100mg/DL and HDL is more than 200 to 400mg/DL.

ARTIFICIAL INTELLIGENCE EXPERT SYSTEM:

Author used fuzzy set theory as an artificial intelligence. Fuzzy set theory is the process of formulating the mapping from a given input to an output using fuzzy logic[6]. The process of fuzzy set theory involves membership functions, fuzzy logic operators, and "IF THEN" rules[6]. There are two types of fuzzy set theory that can be implemented in the fuzzy logic toolbox are Mamdani and Sugeno[6]. Fuzzy set theory applied in fields such as computer vision, automatic control, data classification, expert system, and decision analysis[6].

Fuzzy expert system steps are started from the first step is the fuzzification stage consists of collecting a crisp set of 6 input data and then converting it into a fuzzy set using fuzzy linguistic variables such as PPBS, HbA1c, Duration of Diabetes, Hypotension, Cholesterol, Vision in eye; and then in fuzzy linguistic terms and in membership functions; then, an Mamdani inference system is executed according to a set of fuzzy rules; finally, the defuzzification steps converts the result fuzzy output into a crisp output using the membership functions; crisp output such as non-proliferative, Proliferative and CSME.
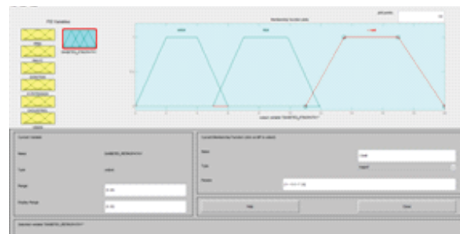

Figure 4: Membership function

PPBS which is >140 and <140 mmHg, the prevalence of any retinopathy was 8% at 3 years, 25% at 5 years, 60% at 10 years, and 80% at 15 years. Hypertension and cholesterol is also responsible for the diabetic retinopathy. High blood pressure is responsible for the hypertension in patient. Cholesterol is responsible for blockage in blood vessels in retina or macula so that vision threatening in eye.

TABLE 1
Parameters of Input & Output

Sr. No.	Input Parameter	Membership Functions	Fuzzy Set Values
1	Post Prandial blood sugar	Trapezoid	Normal [120 140 160 180]
			Medium [170 199 247 280]
			High [270 308 360 400]
2	Hemoglobin A1c Test	Trapezoid	Normal [3 3.71 4.39 5.17]
			Medium [5 5.36 6 6.5]
			High [6.29 6.27 7.47 8]
3	duration of Diabetes	Trapezoid	Normal [2 3 4 5]
			Medium [5 5.36 6 6.5]
			High [6.29 6.27 7.47 8]

4	Hypotension	Trapezoid	Normal [120 128 138 145.3]
			Medium [140 152 164 175]
			High [170178.5 189 200]
5	Cholesterol	Trapezoid	Normal [150 166 183 200]
			Medium [190 204 225 239]
			High [230 252 282 300]
6	Vision in eyes	Trapezoid	Normal [2 3 4 5]
			Medium [4 6.26 8 10]
			High [9 11 13 15]
Sr.no.	Output Parameter	Membership Function	Fuzzy Set Values
1	Diabetic Retinopathy	Trapezoid	NPDR [0 2 4 6]
			PDR [5 7 9.85 9]
			CSME [11 13.5 17 20]

The fuzzy rules for the prediction of diabetic retinopathy are:

- If PPBS is Normal, and HbA1c is Medium, and Duration of Diabetes is Normal, and Hypotension is Medium, and Cholesterol is Medium, and Vision is Normal, Then Diabetic retinopathy is NPDR.
- If the PPBS is Medium, and HbA1c is High, and Duration of Diabetes is High, and Hypotension is Medium, and Cholesterol is High and Vision is Medium, Then Diabetic Retinopathy is PDR.
- If PPBS is High, and HbA1c is High, and Duration of Diabetes is High, and Hypotension is High, and Cholesterol is High, and Vision is High, Then Diabetes Retinopathy is CSME.

RESULT:

The output this fuzzy set theory expert system is for prediction of diabetes retinopathy in Rajkot city patients. The prediction of visioning in eye is most important for patients who are suffering from diabetes, hypotension and cholesterol. In NPDR, most patients have diabetes, and cholesterol but duration of diabetes is not greater than the 8years. In PDR, patients are suffering from diabetes, cholesterol, hypotension and duration of diabetes is 10years. In PDR, less number of patients are seen. In CSME, vision in eye is lost by the patients fully.
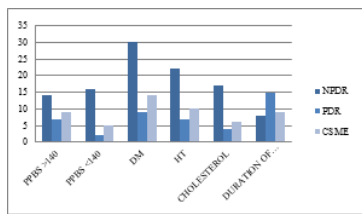

Figure 5: Results of prediction of DR

CONCLUSIONS

Author has made a artificial intelligence expert system for Prediction of diabetic retinopathy. From the examination of retina using the OCT, and other physical examinations performs for checking the morbidity in eye. More number of diabetes patients is suffering from the NPDR after 3 to 8years. In NPDR, PPBS, diabetes, cholesterol, hypotension and duration of diabetes, all are responsible. In PDR, duration of diabetes is 10years up so that it is less number of patients in Rajkot city. In CSME, the vision is fully lost, and diabetes is responsible for it.

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