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Wearable Device for Prognosis of Diabetic Autonomic Neuropathy

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***Abstract*—** A Pupillometer is designed, which comprises of a spectacle mounted Pi-NOIR Infrared Camera system to detect pupil dilation, constriction and saccades of the eyes of the patient. These parameters will be tracked using IR Illuminators mounted on spectacle frame that will be interfaced to a Raspberry Pi 2 Model B Development board. The Raspberry Pi 2 Model B will be programmed to map the visual acuity parameters. To achieve constriction and dilation, a bright LEDs will be Turned ON and OFF respectively, at rapid rate, while the tracking is going on. The saccade velocity assessment is done by showing a rapidly moving pattern between 2 points. Thus, by obtaining these ranges for the patient and comparing them with a pre- calibrated diabetes proneness scale, the patient's proneness to diabetes and also an accurate measure of his/her Visual Acuity will be obtained. A standard deviation of plus or minus five percent with respect to the database values of normal and diabetic patients is mapped and the proneness to Type 2 Diabetes will be evaluated. This Project is a preventive diagnostics, cost effective and a prick free modality for early diagnosis of Type 2 Diabetes.

Keywords- *Infrared camera, Visual Acuity, Raspberry pi 2 Model B and Diabetic Autonomic Neuropathy.*

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I. INTRODUCTION

The Type 2 diabetes is the most prevailing disease affecting people at a very large scale. Maximum population is suffering from Type 2 diabetes and minor of them are affected by Type 1 diabetes the reason for which is unknown. Type 2 Diabetes can cause neuropathy which can lead to damage of Autonomic Nervous system which handles involuntary functioning of important organs of body. The reason of these two types of diabetes are said to have reason of high blood sugar level. To avoid it, work with your doctor to manage your blood sugar by periodic testing of blood sugar levels. Below figure gives you statistics of diabetes diagnosed of different nations and explaining the reason why diagnosis of diabetes is necessary in future to avoid increase deaths due to diabetes and Diabetic Autonomic Neuropathy.

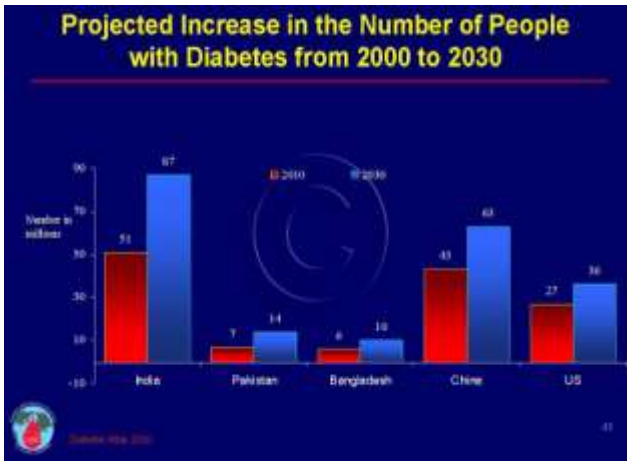

Fig. 1.Statistics of number of Diabetic patients in India and selected nations around the world

The pupil mydriasis and miosis is affected due to Diabetes and Diabetic Autonomic Neuropathy. The recorded IR-illuminated images have been displayed which shows differences in pupillary reaction. The last image hardly has any pupillary reflex in mydriasis (constriction) and miosis (Dilation). Hence proved that pupil dynamics/reflex gives prominent information of Diabetes and Diabetic Autonomic Neuropathy

Fig. 1 (a) Recorded IR-illuminated images of the eye if three subjects showing pupil at its maximum mydriasis (Dilation) for (a) healthy volunteer, (b) diabetic subjects without DAN and (c) diabetic subjects with DAN [7]

Fig. 1 (b) Recorded IR-illuminated images of the eye if three subjects showing pupil at its maximum miosis (Constriction) for (a) healthy volunteer, (b) diabetic subjects without DAN and (c) diabetic subjects with DAN [7]

II. OBJECTIVE AND SCOPE

1. Objective:

The Primary Objective of the system proposed is to develop a prick free method for early diagnosis of diabetes especially in young patients. Different from the existing Diabetes detection modalities that depend on checking the blood sugar level, our design helps to predict accurately the degree of proneness of the patient to Type 2 Diabetes which can be prevented by healthy changes in lifestyle. The design is a preventive diagnostics modality. It will be a boon to the world of science as it is a non-invasive method, inexpensive and more reliable.

This device restricts itself not only to diabetes detection but can also be extended to ophthalmic applications.

2. Scope:

This is a cost effective assembly and also gives an accurate understanding of both Visual Acuity and Diabetes proneness by prick free analysis. In coming years this modality can serve as an excellent cost effective tool to check juvenile diabetes at an early stage and help kids combat and prevent it from occurring by taking necessary precautions. Also in adults it can be excellent way to check for diabetic traits and take necessary preventive measures. Its design being less intricate, it can be made commercially viable and it can assist in periodic monitoring and preventive care from Type 1 and Type 2 diabetes. Also the associated Autonomic Diabetic Neuropathy can be diagnosed beforehand and prevented beforehand. It also has a wide range of ophthalmic applications. Various steps can be taken to make the device portable.

III. PROBLEM STATEMENT

Generally the diabetes detection depends largely on blood sugar levels for which the patient has to be subjected to various tests such as

1. PATHOLOGICAL TESTS: To detect proneness to diabetes the patient has to undergo tests on regular intervals to ensure that blood sugar levels don't go beyond control. The patients generally are uncomfortable when it comes to pricking the skin in order to obtain blood samples required for the test. There does not exist, low cost prick free modality which will help in calculating diabetes proneness. Apart from this, diabetes retinopathy is detected using various forms of test.
2. PUPIL DILATION TEST wherein the physician places drops into the eyes to dilate the pupil. This allows the physician to see more of the retina and look for diabetic signs. After examination, vision may remain blurred for several hours. This procedure has to be repeated every time the patient needs to undergo dilation test. Very severe problems may arise due to diabetic retinopathy which in worst circumstances can result in loss of vision. There is no such modality that will help in preventing this condition without causing discomfort to the patient.

The existing pupillometer devices are generally employed to measure pupil to pupil distance or to calculate the pupil response to stimuli with dilation being parameter of interest. This device will be used for detection of Type 2 diabetes and diabetes retinopathy.

IV. BLOCK DIAGRAM

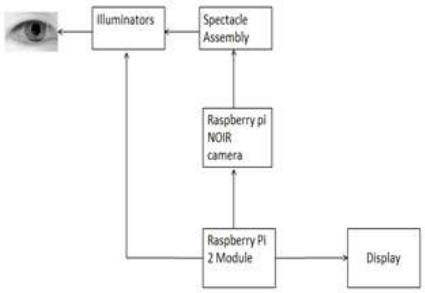

Fig. 2 Block Diagram of the System

1. Raspberry pi 2 Model B will be used as development board in which images captured by the raspberry pi NOIR camera will be digitally formatted by raspberry pi board without any need of ADC convertor. As per literature survey all circuitries need ADC convertor since we use analog CCD camera and processors not capable of converting analog data to digital. Hence the above circuit will reduce the need of unnecessary components.
2. Raspberry pi NOIR camera has capability of 90 fps with 5mp resolution which gives detailed information of the pupil characteristics.
3. The data can be displayed on any monitor having HDMI as input port or we can also use convertors.
4. Python language helps in coding for raspberry pi circuitry with detailed and accurate precision.

[A] Hardware

The Raspberry pi 2 Model B is used as development board which consist of 900 MHz speed with Arm 7 processor. It consists of 40 GPIO pins which are used in this system for illumination of LEDs, CSI connector for connecting Raspberry pi NOIR camera, DSI connector which can be used to connect display, HDMI port, 4 USB ports and 1 audio-video jack. The Debian and Arch Linux ARM distributions are provided for downloading by Raspberry pi foundation. The programming language C, C++, Java, Perl and Ruby are available as tools for python. [8]-[11]

Next we use Raspberry pi NOIR camera consisting of 5 mega pixel resolution and it does not consist of IR cut filter hence using IR illuminators we can get satisfactory images even in low light. This feature is not supported by general purpose Raspberry pi camera.

Next we need LED circuit consisting of 4 colors of LEDs white, green, red and blue to detect the behavior of pupil in different wavelengths of lights. Hence understand proneness of Diabetes of the patient. The LEDs are connected to Raspberry pi 2 Model B using on-board GPIO pins.

Fig. 3 Raspberry pi 2 Model B interfaced with Raspberry pi NOIR camera

[B] Software

The NOOBS is the install manager for raspberry pi. The operating systems included with NOOBS are: Archlinux ARM, Pidora, RISC OS are all the operating system of the first ARM-based computer and Raspbian (recommended for Raspberry Pi). Wheezy software (image file) consists of all important

softwares complied in it maintained by the raspberry pi foundation. A SD card of 4 GB minimum is required.[8][9][10]

a. VNC Viewer

VNC Viewer is used for making your laptop support virtual desktop having some other OS. In this project it is used to start virtual desktop for Raspbian OS on Windows

b. Putty

PuTTY works as emulator and also used as SSH connection. It is also featured with tunnels to help any device to be configured to VNC Viewer. Putty helps to open root terminal of Raspberry pi. If you need something more than root terminal then your device must have IP address and must be given local host number so that it can be tunneled with VNC Viewer. The local host number and configured password is used to start the virtual desktop on Windows System.

c. Open Source Computer Vision Library

Open CV libraries are necessary to start configure any OS to GUI.

d. Python Libraries

Python libraries are necessary for working with Python idle 2 or Python idle 3. Numpy (Numerical python) works as fundamental package of python.

All these above software's are necessary to install onto the system for working of this project.

V. WAYS OF RASPBERRY PI 2 MODEL B TO THE LAPTOP

1. Raspberry Pi 2 connection with wifi router providing Laptop as monitor (for Internet Connection)

Raspberry direct connection to wifi router provides wireless internet to raspbian OS on laptop. The connection is established by scanning IP address of devices through Advance IP Scanner, adding that IP address in putty and opening Virtual Raspbian Desktop on Laptop using VNC Viewer. No connection is required to laptop from raspberry pi required your raspberry pi must be connected to the wifi router.

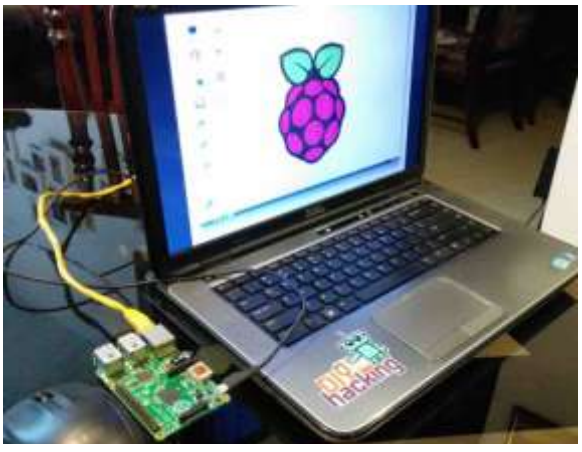

Fig. 4 Laptop connection to Raspberry Pi through router for Internet connection

1. Direct Laptop connection to Raspberry Pi 2 without router

Laptop connection to Raspberry Pi 2 Model B through standard Ethernet cable can be established by adding IP address of LAN connection of laptop to Raspberry Pi 2 SD card. Now with the help of Putty and VNCserver (for virtual RPi desktop) we can access Raspbian OS without need of external mouse and keyboard.

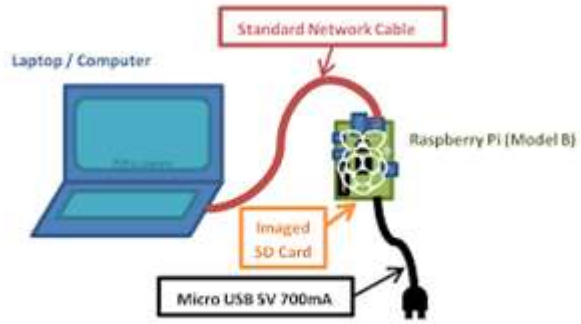

Fig. 5 Direct Laptop connection to Raspberry pi 2 Model B

VI. RESULTS

The pupil contours have been tracked and the pupil radius changes are measured. Stimulus is provided by the WRGB breadboard PCB which pulses White, Red, Green and Blue wavelengths of light. The Saccade Velocity is calculated by a programmed algorithm by asking the patient to observe different areas in the vicinity only by moving the pupils rapidly. These values are tracked for normal and diabetic patients both .A standard deviation of plus or minus 5 percent is permissible. However if the mean for all stimuli is abnormal then the patient has a high probability of Type 2 Diabetes.

Variations also account according to the age and sex of the patient which can be determined to scale subsequently. The ON time of each LED can be accurately controlled by the assigned keyboard interrupts.

The scotopic and photopic threshold levels of the patient under screening are taken care of with the designed adjustable HSV track bars so that pupils of all people with different pupil features can be tracked real time with equal ease.

Table 1: Data Analyzed

Sr. No.	Age	Type_of_patient	Sex	Dialtion	Constriction
1	21	0	0	0.56	0.45
2	19	0	1	0.58	0.49
3	18	0	0	0.55	0.44
4	26	1	0	0.49	0.42
5	27	0	1	0.57	0.482
6	30	1	1	0.52	0.398
7	32	1	0	0.476	0.401
8	29	0	1	0.55	0.4965
9	35	0	0	0.48	0.3884
10	40	1	1	0.4992	0.4108
11	43	1	0	0.4523	0.3665
12	45	0	1	0.5766	0.457
13	47	1	0	0.433	0.4224
14	42	1	1	0.51	0.37
15	31	0	1	0.56	0.47
16	30	1	1	0.5	0.3667
17	18	0	0	0.51	0.47
18	24	0	0	0.52	0.461
19	22	0	1	0.571	0.5
20	20	0	0	0.525	0.445

Type_of_patient : 0= Non-Diabetic 1= Diabetic

Sex: 0= Male 1= Female

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