THE MEASURING OF GLYCEMIA BY SIGHTLESS PEOPLE

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Abstract: For purblind or sightless diabetics people it is impossible to read the current data showed on displays of the personal diagnostic systems (mainly glucometers). Those who are sightless need a help of another person at disposal when measuring. The newly designed unique electronic construction in conjunction with the personal diagnostic system enables a purblind or a sightless people to identify measured data and use them suitable for the further treatment processes. The purblind or sightless people will be able to perform selfmonitoring (observation of disease trend and a dosage adjustment by a person himself).

Introduction

The Diabetes mellitus is a chronic disease which is caused by malfunction of use of blood sugar as an energy source. In the wake of this malfunction there may arise typical pathological changes in small blood vessels and neural fibres. There is a higher sensitivity to specific organ complications such as dysfunction of eyes, nerves, kidneys and others. The main consequence of the disease is higher level of blood sugar (hyperglycaemia).

There is no way how to cure the diabetes nowadays. The treatment is based on compensation of the diabetes best as possible which means to reach such a balance by which the level of blood sugar would be as close as possible to the levels of healthy people.

The diet is a basic way of treatment of diabetes compensation. It is based on regular consumption of energy-defined food. This is closely bound to daily schedule of a patient, mainly in terms of physical load and adequate weight. Diabetes may worsen not only by breaking the basic diet requirements but also by stress events, feverish disease or injury. If the compensation by a diet is inefficient the tabs must be used. If it's still insufficient, it's necessary to apply cure using diet and insulin.

Prevention and timeout treatment of this disease is one of the most serious tasks both of an oculist and a patient. A patient makes it possible to affect eye complications by its own effort both in right and wrong way. It's necessary to prevent from final stage of eye harm and preserve this most important human sense [2].

Loss of sight is leads to the impossibility of insulin application and pursuing independently the check-ups which is shocking especially for young patients and causes anxiety. A diabetic often partly or fully depends on his neighbourhood although his habitus is good enough and it would let him full integration to the life.

Measurement of glycaemia during the day serves for evaluation of diabetes compensation and at the same time as a clue to treatment adjustments of patient's activities such as physical load, sleep and stress.

Each healthy person has a certain level of glycaemia which varies from the low levels on an empty stomach (about 3,9 mmol/l) to 8,8 mmol/l after meal. Glycaemia thus changes during the day. The range of glycaemia levels of diabetics is generally wider than of healthy people especially if they are treated by insulin. If the glycaemia level is below 3,3 mmol/l it is called hypoglycaemia and if it exceeds 9 mmol/l it is called hyperglycaemia.

The limits of normal glycaemia (or hypo- or hyperglycaemia) can not be exactly specified but they are determined by WHO.

The glycaemia levels of untreated or badly treated diabetics can be extremely different from normal levels. The levels below 2 mmol/l and above 30 mmol/l are very dangerous because they can cause a coma in which one can faint of even die.

Materials and Methods

Measurement of glycaemia during the day serves for evaluation of diabetes compensation and at the same time as a clue to treatment adjustments of patient's activities such as physical load, sleep and stress.

Glucometer is an electronic device that uses various principles to measure patient's glycaemia. This makes it possible to promptly prevent incipient unfavourable changes of diabetes. The significant thing is that a patient can perform the measurement by his own and therefore react to hypoglycaemia by giving additional food or in case of hyperglycaemia to apply insulin. It is called self-check up of glycaemia, so called selfmonitoring. A patient can change the portions of insulin between visits at the doctor and thus watch the trend of glycaemia and therefore diabetes compensation.

Glucometer is usually provided with inner memory (up to 500 records) where the measured data are stored (including date, time and insulin doses) for further processing by a doctor's PC. At the same time a doctor can perform glycaemia curves and profiles. The accuracy of glucometers is in the range of 5-10 %. On the figure 1 you can see three examples from the left

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side One Touch Profile Lifescan, Medisence Card Medisence and FreeStyle Therasence.

Figure 1. Glucometers

The style of stripes is given by a producer and type of scanning. Each glycaemia measurement using a glucometer needs new stripe which means the stripes are one-off. The measurement consists of two steps that hold for all glucometers: A drop of blood taken from a finger or a forearm is put on the measuring place and it's necessary to wait some time, then the result is showed on a glucometer display.

The goal is to design a voice output for using by a sightless diabetic that could be connected to a glucometer without a need to interfere to a glucometer. The voice output will contain a speaker saying the level of glycaemia and additionally other data from the glucometer display. The whole device should be portable and battery-powered. The required features are an easy manipulation, low price, minimum of control elements and comprehensible announcements.

Some glucometers can be connected to a PC which is physically done through an output connector (Jack) or through a connector for a sensor plug-in (in case it's not being used for glycaemia measurement at the moment). There are 3 wires to connect PC and a glucometer: input data, output data and the ground. After the connection to PC and installation of needed software an user can communicate with a glucometer. The goal is reading measured data into PC and consequently tables and charts are created from the values of glycaemia stored in the memory after previous measurements. There are variety of software tools such as Diabass or InTouch.

Glucometers communicate by bidirectional serial lines in asynchronous mode of transfer, in a standard 8-bit format, no parity, using ASCII code. Voltage levels of serial line of glucometer match either voltage levels of RS 232 used by PC (so it's possible to use direct connection glucometer-PC) or TTL levels; then it's necessary to add RS232/TTL converter which is usually supplied with a glucometer or can be purchased. Three wires are used – TxD, RxD and the ground. Glucometers contain communication protocols that define which ASCII characters serve for communication between a glucometer and PC. A computer is a master in this type of communication. The brief description of communication is as follows: PS sends out ASCII characters which means it defines the requests and a glucometer respond. According performed experiments it was found out that besides communication in the form of requests and responds, One Touch Profile glucometer itself sends other ASCII independently on PC and they match the data being showed on glucometer display. The block schematic that describes use of serial interface is on the figure 2.

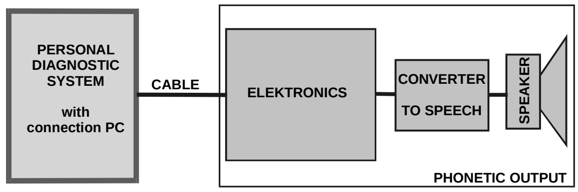

Figure 2. Block diagram

Glucometer is connected by three wires with electronics that process and send data through serial interface. Electronics sort out useful information and then it is processed by voice converter. Needed values, such as glycaemia level or other data, are heard from the speaker.

In cooperation with the sightless people there have been tested the blood samples by glucometer with biosensoric type of sensor (Medisence), with coulometric type of sensor (Freestyle) and photometric type of sensor (One Touch Profile). According to sightless ones the way blood sampling is not significant but blood sampling methodology must be tried and trained when using any of the types mentioned above.

The usual way of creating voice synthesised signal is to choose basic acoustic elements, process them and store in the memory and consequently, at seasonable time, to generate the signal by integration of suitable segments from the stored database. As for choice of basic units, it's possible to consider either whole sentences, or words, syllables or phones. It's obvious that the longer the unit is, the more speeches must be processed and stored. Requirements on such a number of recorded speeches are often extreme, even in cases when number of various words is small. A visual example of this situation can be automatic time annunciator that regularly says the precise time every 10 seconds with typical voice. If it came to record all of the variations, we would reach 8640, while there are only 35 various words can be used for these reports. This example speaks for us to use more likely smaller units for creating of synthesised reports. From this point of view it seems that the optimal solution would be use of phonemes as basic structural units of synthesised speech. Unfortunately, the smaller a structural unit for synthesised report is, the bigger influence of improper articulation caused by integration of the unit arises. This also holds true in case of using words and syllables as structural units. For implementation of voice output of glucometers, there may be used the following units as solutions of speech synthesis: phonemes, syllables, words. Implementation using phonemes and syllables requires excessive complexity of recording into the memory and final comprehensibility is inadequate to this complexity, refer to bibliography [1] and [3]. That's why this way of implementation is not so suitable. Implementation using words as basic units is more suitable concerning the table of required words for reports. Storing of the words itself and their playback according to required reports can be done either by recording through processor with A/D converter into the memory (e.g. EEPROM), or using voice processor of the firm ISD, refer to [5]. Voice processor includes the whole structure of recording and reproduction of particular reports in its capsule. Using of the voice processor for this problem is then very suitable.

For the practical implementation of the voice output connected to glucometer it was used a scheme with voice processor ISD 2560 and microprocessor ATMEL 89C4051 [4] which is showed on figure 3.

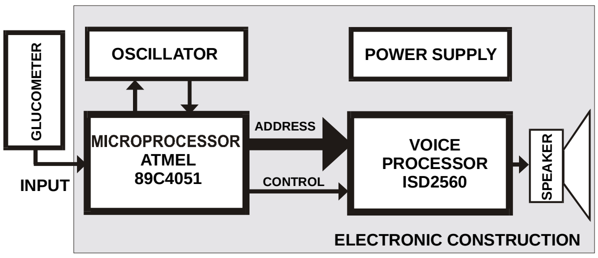

Figure 3. Scheme of the electronic construction

Voice processor ISD2560 is made by the firm ISD using patent technology ChipCorder. The basic principle is based on analogue storing of the signal in its original form as an electric charge of a capacitor – the similar as EEPROM memory. It contains inner oscillator, microphone pre-amplifier, automatic print control, input filter, output filter, terminative amplifier, memory array of 480 000 elements, address bus, power block, control of the functions and terminative multiplexer.

After switching on the voltage source or after reset of microprocessor it's necessary to wait for coming data on serial bus in 8-bit format with 9600 Bd. Data is only being received. If there's no signal in 30 seconds microprocessor lets itself to PowerDown mode. After coming of data it is recorded in the interruption through SBUF register as array of characters. Data is received by frames containing ASCII characters.

All the characters received in one frame are written into an array of 40 characters. The array is then divided into single parts from which the following needed data is generated: There is a list of all words could be spoken by a speaker, each word is added by information about its length and address in the memory. By means of comparing received characters and characters included in the words on list a word that matches the word on glucometer display. Consequently the address is sent to the port according to the length and location in the memory for a time period of duration of the word. Then it keeps decoding next word.

Results

The final product (Figure 4) composes of box and fixed cable including connector jack 3,5. This is a connector for the voice output to be connected to glucometer.

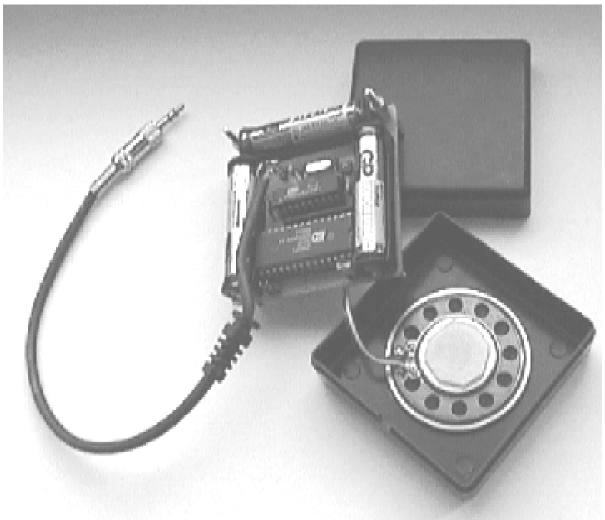

Figure 4. Final product

Its dimensions are 65x65x30 mm, it's powerde by 3x AAA battrery cells. If electronic construction doesn't receive data anymore, it switches to stand-by mode with the current consumption less than 5 uA. In an operating mode it consumes about 10 mA, but during the playbeck it may reach up to 50 mA. It doesn't contain any control elements such as buttons and switches and it works without necessity of intervention into a glucometer, because it uses a connector for connection with PC. Electronic construction switches off automatically.

Conclusions

The contribution The purblind or sightless people will be able to perform selfmonitoring (observation of disease trens and dosage adjustments by themselves).

The features of electronic construction were practically tested by a blind diabetic. If we ignore problems with dosage of sample into a glucometer (which is a matter of time and practise), the patient's statement was much more positive.

Concerning that electronic construction can be applied to glucometers of various types (by different producers) after some adjustments, a contact with glucometer producers has been established. Further development of voice output and establishing of new contacts will continue with the intention of starting serial production.

Acknowledgement

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