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DESIGN OF BRACELET FOR PERSONAL HEALTHCARE USING IOT

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ABSTRACT

Technologies are changing very rapidly and Internet of Things (IoT) technology gives a lot of scope for new innovation, products and user applications. Most of the devices are becoming truly personal and medical sector is one of them. Telemedicine can be a new approach to diagnostic and treatment, while use of smart healthcare devices provide the user an ultimate health control. The scope of this paper is to understand needs and requirements of healthcare IoT, IoT user experience, security and so on. Finally, I applied all collected theoretical knowledge and tried to design a smart bracelet acting as insulin pump which will be new, innovative product on today's market

Keywords: Diabetes, IoT, insulin pump,CGM, BLE.

I. INTRODUCTION

The motivation behind this research work was born some time ago when the understanding of medical automation, healthcare IoT arises. However, such healthcare devices are very important and their use in day to day life is increasing rapidly. First of all, I want to share why insulin pump is a good and really demanding product. The people with diabetes require something more than just data tracking and statistics. It is achieved by automation capability of engineering. Moreover, according to survey, it is clear that people are ready to accept and wear smart appliances and they can trust technologies, but the questions of privacy, price, security and technical reliability are relevant. Hence, the task is to develop innovational, a reliable device with high-security focus, and high interconnection capability for future healthcare IoT using use open standards, application of security-by-design approach and to develop an initial ecosystem.

There is no personal background motivation for designing bracelet having insulin pump. By analysis of medical market, I found that any types of insulin injectors are popular in Indian market. The average count of person with diabetes injects insulin 4 times per day. In practice, the number of diabetics is much bigger and 46% out of the whole amount is undiagnosed, making the total amount almost twice bigger.

All present devices could be divided into two big groups:

- Devices developed by leading medical companies
- Healthcare Devices created by enthusiasts and startups

The first group provide solutions which lack intelligence and mostly adopted before 10-15 years ago. Such devices can measure sugar levels and inject a proper dose of insulin based on human manual calculations and some static algorithms. This work of statistical calculations are cumbersome and difficult to keep running. The second group is mof special importance as there is some intelligence included in systems, however, most of them require a special control device, which is not effective as everyone owns a smartphone with powerful calculation and communication capabilities. After research and survey, the list of problems to solve and challenges is clear:

- Make a comfortable device.
- Focus on targeted audience.
- Avoid using extra devices and use a smartphone.
- Maximizing the facilities in a single device.
- Future compatibility with other devices.
- Make a modern, attractive and good-looking device.

- Use open standards.
- Develop an supporting application or smartphone App and intuitive device controls.
- Focus on security.

Of course, this list is not full, but these aspects are crucial.

After initial survey, the idea of the bracelet was born. It fulfills the medical prescriptions and requirements of proper smart healthcare wearable.

II. DIABETES

Diabetes is an endocrine disease, which is characterized by a chronic blood sugar (glucose) levels increase. Insulin is a pancreatic hormone. The disease produces disruption of all types of metabolism, vascular, nervous system and other organs damages. There are several types of diabetes:

- Type 1. Insulin-dependent diabetes.
- Type 2. Insulin-non-dependent diabetes.
- Secondary diabetes. Also named symptomatic.
- Gestational diabetes.
- Diabetes caused by malnutrition.

Treatment of diabetes is very important to save life. Daily use of insulin is necessary only for patients with diabetes of the type 1 diabetes and in the case of the progression of diabetes of the second type. When type 2 diabetes becomes also insulin-dependent, it could be considered to be type 1. There are different types of insulin to be injected:

- high-speed (simple) insulin
- short-acting insulin
- intermediate-acting duration insulin
- insulin of prolonged or long activity
- combined (mixed)

The following factors can be added while designing bracelet for insulin injection :

- The cartridge must contain few daily doses of insulin
- The cartridge should be filled by patient based on selected by doctor type of insulin

Insulin is inserted under the skin, hence, the needle should be 4-6mm at 90 degrees level.

III. BRACELET DESIGN & TECHNOLOGIES

According to study of disease and market survey, I am focussing to develop a smart healthcare IoT based bracelet for automation, see Figure 1 .

Figure 1: Bracelet design for insulation injection

The proposed bracelet is targeted for all adults. It will be designed to carry 300 IU of insulin liquid. It will be enough for 10-15 days for average diabetics person. There is no need to wear the proposed bracelet for whole period, as it is restricted due to the injection needle and CGM sensor (which is also a needle). The needles should be changed with new ones when bracelet is removed from the shoulder.

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IV. PROPOSED MODEL AND FEATURES

The bracelet is a wearable flexible unibody object. It can be made with soft-touch plastic. The stripes which touch the body are changeable and are made of bactericidal silicone. Between them, there rechargeable insulin cartridge fitted in between and is connected with needle and operating module, where the pump is located. The same box holds the CGM module. Depending on the sizes of bracelet, the BLE module and used CGM appliance, battery, and wireless charger could be put to the same metal box or a new one. The button can be used to control the bracelet mechanically in case of discharge of operating smartphone. It can be possible to deliver a minimal dose of insulin by putting the bracelet in the special mode. By inserting several doses, normal levels could be achieved. Specific button presses combinations are used to control bracelet in the mechanical mode. The button is surrounded by LED tape used for intuitive feedback. See Figure 2 .

Fig 2 : Proposed bracelet view from top and bracelet strap.

4.1 Mechanisms

The proposed bracelet consists of different mechanical and electronic parts :

- Insulin delivery mechanism
- Needle injection mechanism
- Clasp mechanism
- CGM module mechanism
- Button
- Charging facility for bracelet

Charging and bracelet-smartphone communication principles will be discussed in the Section

4.2. Control Mechanism

The flexible tube is connected to pump on one side and there is a one-way valve on other side. The pump forces the needed amount of pressure to the tube, which makes the piston to move, pushing the insulin which will be put on patients solder to the body through the needle. One-way valve then allows air to substitute the liquid insulin in the tube, normalizing the pressure. The tube could be changed to new one after all the insulin is used,, or just new insulin could be injected inside, by removing the tube and pushing the piston to start position with insulin from the other side. The clasp mechanism is very simple. The strap is designed with “tooth” and is put to the clasp hole, where a special plate flips and allows “tooth” only to go inside, which allows the user to tight the bracelet as much as needed. To let loose the clasp, bracelet should be pushed quite hard near clasp hole, which will release the plate. Such mechanism has some benefits. There is no need to manufacture bracelets of different sizes. It is durable and water resistant. The whole bracelet will be waterproofed and it could be washed easily.

The button is a round element, made of stainless steel or plastic with . As bracelet is worn on the shoulder, the button must be secured from occasional pushes. It is done so that it should be pressed hard and long enough to transfer the bracelet to mechanical control mode. Moreover, there is a facility to lock the bracelet from smartphone application. A facility can be done in case of phone discharge that it can be unlocked automatically with LED notification and vibration .

The CGM module is difficult to implement. The sensor is inserted under the skin, where it remains for several days, detecting glucose in the surrounding fluid. The sensor uses the same enzymes to measure glucose levels as a test strip: glucose oxidase. These enzymes convert glucose to hydrogen peroxide. The peroxide reacts with a platinum plate inside the sensor, generating an electrical signal. A smartphone converts the electrical signal data into a glucose reading based on existing algorithms. These basic features are shared by all CGM sensors. The

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chemical layers on top of the glucose oxidase keep the sensors functional under the very poor working conditions that exist inside the body. There are several manufacturers of CGM modules and it is more cost-effective to use them, instead of designing and manufacturing proprietary ones. The module of needed size could be purchased and placed on the existing components infrastructure.

The automatic needle insertion is done by a ball screw. Such type of solution requires the bracelet to be around 1.5 cm thick to allocate the needed elements. Also, the CGM needle uses same mechanics. The main drawbacks of such solution are precision and price.

4.3. Communication Mechanism

The proposed bracelet must be connected to the mobile application, which requires some communication protocol. Also, the bracelet must be charged somehow. Open standards can be used for both processes. According to Continua guidelines for healthcare device making, QI and BLE should be used. Qi is the only globally accepted wireless charging standard. It was created by Wireless Power Consortium, which consists of more than 100 different companies. The Qi standard is designed for the transmission of energy to various devices using magnetic induction. Technically it is very similar to the solution that is used to charge electric toothbrushes.

V. APPLICATION DESIGN

The mobile application is used to control the insulin bracelet. It gets data from CGM permanently and analyses the information to predict doses and critical picks, based on current blood indexes and nutrition. Moreover, it provides statistics and insights. Also, it is capable of contacting the personal doctor and community. All in all, the application is the management unit of the whole appliance. The app design was one of the biggest issues to solve. According to my studies, any smart healthcare application should be easy and intuitive. I decided to remove all controls which are unnecessary for glucose level tracking.

VI. CONCLUSION

Healthcare and medicine are very important social sectors and the need for technological support there is increasing permanently as tools and treatment techniques are becoming more advanced. Modern telecommunications and machine learning open new paths for diagnostic process and treatment procedures. Internet of Things offers the concept of the interconnected world, where medical services are supported by every aspect of being, from nutrition to transportation. All in all, the benefits of smart services in personal healthcare observed through the study are overcoming all drawbacks. However, security and privacy, user experience and adoption are huge points to be studied and improved.

This study that now concludes has focused on personal healthcare Internet of Things, which provides the user with digital medical and wellbeing services or application. It is the biggest part of the whole medical sector, as a number of healthy people is bigger and it is important to catch their attention and focus it on health before serious troubles when medicine starts

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