Demanslı Hastalar için IoT Destekli İlaç Kutusu
IoT Supported Pill Dispenser for Patients with Dementia

Mustafa Berkant Selek[1], Alparslan Onder[2], Yalcin Isler[3]

[1] Ege Vocational School, Ege University, Izmir, Turkey
mustafa.berkant.selek@ege.edu.tr
[2] Institute of Biomedical Engineering, Bogazici University, Istanbul, Turkey
alparslanonder@hotmail.com
[3] Department of Biomedical Engineering, Izmir Katip Celebi University, Izmir, Turkey
islerya@yahoo.com

***Özetçe*—Demans tüm dünyada en sık görülen hastalıklardan biridir. Demans hastalarının sayısı gün geçtikçe hızla artmaktadır. Demans hastaları genellikle 65 yaşın üzerindedir ve diğer hastalıklar için başka ilaçlar kullanmaktadırlar. Özellikle demans hastaları başta olmak üzere, bu yaş grubundaki bireyler için ilaç saatlerini kendi başlarına takip etmek büyük bir zorluk haline gelmektedir. Bu amaçla, bu çalışma ilaçların doz miktarını ve kullanım düzenliliğini takip etmeye olanak veren bir cihaz geliştirmeyi amaçlamaktadır. Cihazda beş farklı hap bölmesi bulunmaktadır. Ayrıca, cihazda ilaç alım zamanlarını hatırlatmak için beş ayrı alarm da bulunmaktadır. Saat önceden ayarlanan zamana ulaştığında, hastayı uyarmak için bir alarm ses vermeye ve bir LED yanıp sönmeye başlamaktadır. Kullanıcı alarmdan sonraki iki dakika içinde yeşil butona basarak ilaçlarını alabilmektedir. Bu durumda, servo motorlar hap bölümlerini cihazın raf bölümüne bağlamaktadır. Rafı çekerek, hasta ilaçlarına ulaşabilir. Aksi takdirde, cihaz hastadan sorumlu olan kişiye önceden ayarlanan bir eposta adresine eposta göndermekte ve telefon numarasına kısa mesaj yollamaktadır.**

Anahtar Kelimeler— Demans, Step Down Konvertör, IoT.

***Abstract*— Dementia is one of the most common diseases in the world. The number of patients with dementia is increasing rapidly day by day. Patients with dementia are commonly older than 65 years, and they already use additional drugs for other diseases. It becomes a challenge for individuals in this age group to keep track of their drug timings themselves for dementia patients especially. This study aims to design a device that allows the following dosage and usage regularity of the pills for this purpose. There are five different slices for the pills. This device also has five distinct alarm hours to remind to take pills. When the clock hits a scheduled time, an alarm starts to beep, and an LED flashes to warn the patient. The user can take the pill by pressing the green button within two minutes after the alarm. In this case, servo motors connected pill sections to the "shelf" part of the device. By pulling the shelf, the patient can reach the pills. Otherwise, this device sends an e-mail to the preset e-mail address (and a short message to the phone number) of the person who is responsible for the patient.**

Keywords—Dementia, Step Down Converter, IoT.

I. INTRODUCTION

Nowadays, dementia is one of the most common diseases all over the world, especially people older than 65 years old who are non-resistant to this disease [1]. Gustafson made the definition of dementia as “a clinical syndrome characterized by deterioration of mental functioning in its cognitive, emotional and conative aspects” [2]. Patients with dementia forget everything they know day by day. At the end of the dementia journey, the patient may not be able to remember even the name of himself/herself [2,3]. This disease makes the life of the patient harder than a healthy person. As everybody knows, life can be a lot harder for those who are older than 65 and this disease makes it even worse.

According to the Dementia Maintenance Model Report of the Ministry of Family and Social Policies in Turkey, in the year 2012, the number of patients with Alzheimer's disease in Turkey was 331.512. This number was 0.44% of all the population of Turkey (74.508.771). Also recording to this report again, this percentage is nearly 1/3 of the European countries because the younger population is more than the older population in Turkey [4].

Patients with dementia may have other diseases, especially if they are older than 65 years old. Cardiac, renal, hepatic, etc. problems are common in this age population [2]. Because of these problems, elders have to use lots of pills for regulation or treatment of them. Using pills regularly is a hard thing even if you are a young person. This situation gets even harder when a person's age up. If you are a patient with dementia, this situation becomes a

vital problem. A patient with dementia is likely to forget the usage hour of the pills which are vital for them. Forgetting the usage hour may not be a big problem for just a single time but, if a patient forgets these usage hours regularly, this journey may end even with death. This death is not directly because of dementia or Alzheimer but these diseases play a major role in this scenario.

Pill dispenser devices are devices to remind and give the pills of the patient to him or her when the programmed time has come [5]. The wider availability of powerful, low-cost mobile devices deeply changes the healthcare, and helps improving new devices including pill dispensers [6-10]. In this study, we aimed to design a brand new pill dispenser device that can warn the patient on time and can warn the responsible person in case the patient don't take the pills within 2 minutes after the scheduled time.

II. PROPOSED DESIGN

When the programmed time has come, this device activates its alarm. The buzzer and the led included in the device start to work with this alarm. If the patient pushes the green button on the device just onetime during alarm time, pills of the patient fall to the shelf part of the device. With dragging outward this shelf from the device, the patient can easily reach his or her pills. If the patient does not push the green button on the device during the alarm time, the device will send an email and a notification to the Blynk application which is installed into the smartphone of the relative of the patient. With these notifications, the relative of the patient is able to reach the patient and warn him or her.

If the patient pushes the red button on the device, the device will send an email and a notification to the Blynk application which is installed into the smartphone of the relative of the patient. The working diagram of this device seen in Figure 1.

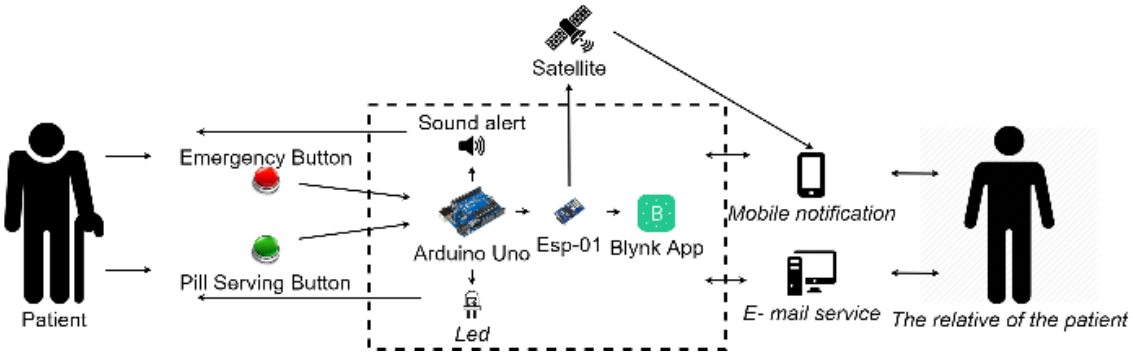

Figure 1. Basic working diagram of "Pill Follower"

A. *Hardware*

Hardware parts of this device are an Arduino Uno R3 SMD, an Esp-01 serial wifi module, an Esp-01 adapter module, an LM2596 based dc to dc voltage regulator, 5 servo motors, a buzzer, a red led, a green button, and 2 9v batteries. Arduino Uno Rev3 SMD is the main board. The software of the device is in the microcontroller of this board.

Esp-01 serial wifi module gives the IoT part of the name of the device. In this way, Arduino boards can communicate with the Blynk application which is installed into the smartphone of the relative of the patient. Esp-01 adapter module makes it easy for the integration of Esp-01 to the Arduino board. Lm2596 based dc to dc voltage regulator converts 9 volts to 5.5 volts. 5.5 volts are used by servo motors. Servo motor moves the part which carries a pill. This part carries this pill to a gap that opens to the shelf. They are 5 different pill containers and 5 servo motors for each of them. A buzzer and a red LED warn the patient when the programmed time has come.

The green button on the device activates the movement of the servo motors if it is the programmed time. If the patient pushes the button just onetime during alarm time, pills of the patient fall to the shelf part of the device. If the patient does not push the button during the alarm time, the device will send an email and a notification to the Blynk application which is installed into the smartphone of the relative of the patient. The patient can push the button and reach to pills until the next alarm time.

The red button on the device sends an email and a notification to the Blynk application which is installed into the smartphone of the relative of the patient when it is pushed. This is too helpful in case of an emergency. Two 9 volts batteries are used as power supplies of the device. One of them is just the power supply of the servo motors, the other one is the power supply of the Arduino board. Figure 2 summarizes the whole study.

B. *Software*

The software of the device is written in the Arduino IDE software. The whole code is 850 lines. 5 different alarm times are included in this code. The alarm hours and the number of the pills can be set easily by the relative of the patients in the Arduino IDE software. Also, the selection of the pills which are specified for a specific hour is done in Arduino IDE.

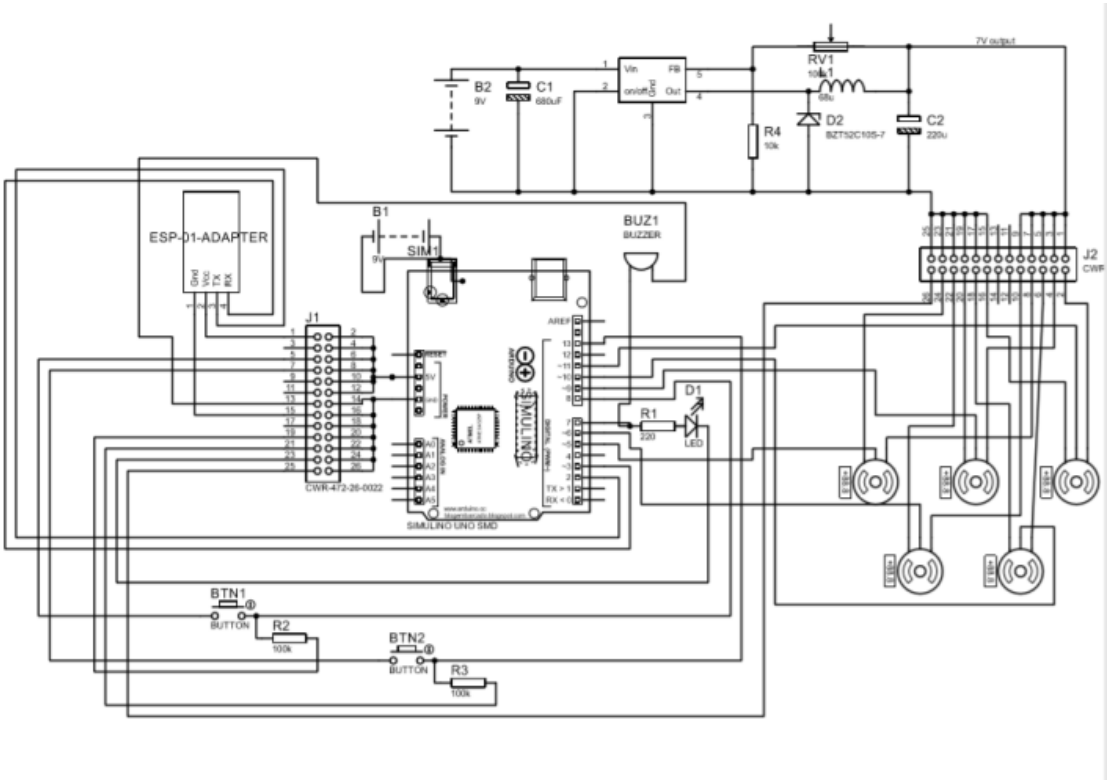

Figure 2. Schematics of whole hardware schematics in the Proteus

The Blynk application is free to use application and it is used for sending email and smartphone notifications to the relative of the patients. On the other hand, the real-time clock widget in this application is used by the device.

The whole circuit design is done in the Proteus software. All of the mechanical parts of the device are designed in the SolidWorks software.

C. Mechanic

The SolidWorks 3D CAD software is used for the mechanical design. The Millimeter unit is used in the mechanical design of the device. This device is designed modular. By modifying some of the parts, the capacity of the device can be increased. There are 7 different parts. These parts are named as “Base”, “Container”, “Shelf”, “Bottom Cover”, “Top Cap”, “Separator” and “String holder”. There are one “Base”, “Shelf”, “Bottom Cover” and “Top Cap”. There are five “Containers”, “Separator” and “String holder”.

“Base” is the base part of the mechanical design. There are 5 “Containers” on the “Base” and every container has a servo motor behind it. A “Container” part contains the pills inside it. There is a gap under the “Container”, and it matches with the blank part of the “Separator”. One pill waits here. When servo -which is responsible for the serving of the pill inside this container- works, the tip of the servo moves the “Separator”. “Separator” part caries the pill to another gap part under the “Container”. Pill falls into the “Shelf” part which is under the “Base”. If the patient drags this “Shelf” part towards the outside of the “Base”, can easily reach the pills. When the pill carrying function of the “Separator” is done, a string which is integrated to the “String holder” part moves the “Separator” to its initial position. This process repeats for every pill and every “Container” in a pill usage time. All of the mechanical parts are printed with a 3D printer and the total weight of the mechanical parts of the device is 1792 grams.

III. SUMMARY AND CONCLUSION

As mentioned, “Pill Follower” device works with two 9 volts batteries. At first, batteries should be plugged into their sections inside the bottom side of the “Base” part of the device. When the batteries are plugged, the Arduino board should be connected to the computer for uploading the code again to modify for pill usage hours of the patient.

If a relative of the patient modifies the code with the right method, there will not be any problem. After changing the code, code is ready to be uploaded into the Arduino board. When the uploading process is done, the device will be ready to use, after disconnecting the USB connection of the Arduino board and the pc. When the pills usage time comes, alert starts to work. While this alert duration, if the patient pushes to the green button; servo motors start to work, and the pills are served. Otherwise, the device sends the notification and an e-mail to the relative of the patient at the end of the alert duration.

(a) **Front view**

(b) Back view

Figure 3. Views of the proposed pill follower device

Figure 3 shows both the front view and the back view of the proposed device. The patient may push to the pill usage button and take the pills until the next pill usage hour. When the patient pushes to the emergency –red button- device directly sends a notification and an e-mail to the relative of the patient. “Pill Follower” device is designed as a mobile device. Hardware parts are working with two 9 volts batteries. At first, using 9 volts batteries looks identical because these batteries are easy to find and not expensive. But when we look at the power consumption, the Arduino board cannot work for a long time with 9 volts battery. Board may work nearly about 4 hours and this time is not enough.

If this device will be powered with an external power supply, it will work perfectly. A new battery can be integrated into the design for having longer usage hours.

The total weight of the mechanical parts of the device is about 1800 grams. Hardware parts of the device are about 250 grams. An average pill is nearly about 1 gram and there are 30 pills in every “Container”. There are 5 Containers. The device is 2200 grams in total.

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