Design Manual of Portable Intelligent Medicine Box

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Abstract. The device takes the elderly living alone with chronic diseases as the application object and provides a novel portable intelligent medicine box. The device realizes medicine storage and taking out through simple mechanism combination innovation, and realizes functions of timing reminding, light reminding, taking records and the like through the design of a control part. The device is designed by adaptive size, which can adapt to the palm size of most old people. Moreover, the operation flow is simple, the difficulty of taking medicine for the elderly living alone is reduced, and the safety of taking medicine for the elderly living alone is ensured. On the premise of complying with national standards, the device has superior performance, complete functions, low cost and high use value, and has a broad market prospect.

1. Introduction
Since our country entered the aging society, there has been an obvious trend of large population base, fast growth, aging, disability and empty nest for the elderly. In addition, the situation that our country is not rich before it gets old and the structure of family miniaturization are combined together, so the problem of providing for the aged is extremely serious. By the end of 2013, China's current aging population has exceeded 160 million, and the annual growth rate is nearly 8 million. According to the latest data of the Chinese government, the average annual population growth rate in the first decade of the 21st century is 0.57%. China's population is aging, and the problem of providing for the aged is becoming more and more serious. According to the survey of the elderly over 60 years old, it can be found that the proportion of the elderly suffering from chronic diseases is gradually increasing. At present, the prevalence of hypertension in Chinese adults is 25.2%, the number of patients is 270 million, and the number of deaths related to hypertension is 2 million every year. According to the survey of the elderly over 60 years old, the prevalence of hypertension is as high as 47%. At present, drugs for treating hypertension are easy to be wrongly taken by the elderly due to similar characteristics. However, due to lack of monitoring and no prompt, deaths caused by elderly people living alone forgetting to take drugs or taking more drugs have occurred frequently in recent years.
At present, the development of intelligent medicine box products is just starting. Some medicine box products in the market are mainly divided into portable and intelligent ones. On the whole, the research and application of intelligent medicine box products are still imperfect, and there are still many deficiencies in terms of their devices:

1. The portable medicine box lacks intelligent functions, such as reminding, etc. It cannot provide users with intelligent functions, such as reminding, etc. It is not practical enough.
2. The volume of the electronic control type intelligent medicine box is too large, which is generally only suitable for use in families and cannot be carried outdoors.

From the above, it can be seen that the usability and adaptability of the currently developed device still have many deficiencies and limitations in application, and there is still a certain gap from large-scale application.

This work is based on the structure of the existing medicine box for reference and improvement. It is designed based on the structure of the "seven-day" medicine box. It is designed in a functional and comprehensive way for hypertension patients. At the same time, it is assisted by intelligent hardware to realize the functions of portable intelligent medicine box:

1. The size design is based on ergonomics, the design is small in size, simple to operate, convenient to disassemble and suitable for the elderly;
2. The intelligent hardware can realize the functions of timing reminding, judging whether to take drugs, remote medication monitoring, remote prompting and the like, which is convenient for users to use, and also convenient for guardians to supervise and timely intervene the users;
3. Supporting the design of WeChat applet for information interaction and information reading, and at the same time generating medication files, the information can be exported as required for review.

2. Overall Introduction of the Device

The device consists of a switching module, a pushing module and a control module, and seven double-layer sub-body drug boxes are internally designed to be suitable for daily drug taking times of hypertension patients. The switching module realizes the switching of the sub-body medicine box by the joint action of the clamping groove and the sliding rail, and the pushing module realizes the pushing function of the medicine box by using the ratchet pawl, the crank slider mechanism and the clamping groove. The control module is mainly used for regular reminding and information interaction. With the use of WeChat applet, the user's daily medication status can be obtained so as to timely interfere with the user's medication status. At the same time, in order to monitor whether the medicine is taken or not, the control module uses PN532 as NFC to monitor whether the medicine box has been taken out or not.
If the two signal systems are detected to be taken out and put back, the correct taking will be recorded. The device uses different color marks to distinguish the medication time, and at the same time, a sticker with labels is used as an auxiliary way to distinguish medicine boxes, which can prevent the elderly from having problems when using. The overall size of the device is Φ 120 in diameter and 45mm in height. Design dimensions are derived from mathematical statistics of ergonomics. Statistical analysis of the palm size of people over 60 years old shows that the size is easy to operate.

The overall operation flow of the device is shown in Fig. 2:

![Figure 2. Schematic diagram of the overall operation](image)

The functional correspondence of the three modules of this device is shown in Fig. 3:

![Figure 3. Schematic diagram of module correspondence](image)
2.1. Mechanical design

2.1.1. Switching module. The switching module mainly uses a linear slide rail and a limiting clamping groove to act together, and only one group of medicine boxes can be clamped in the clamping groove after the medicine boxes are mounted on the slide rail. At this time, the structure is locked and cannot be switched. After taking out the medicine box and taking the medicine, the medicine box can be switched and put back at the same time. The hand wheel is rotated by matching with bull-eye ball KSM-8. Symmetrical number of bull-eye balls are installed on the base. Grooves exist at the bottom of the hand wheel to match with the bull-eye ball KSM-8, making its rotation smoother.

![Figure 4. Schematic diagram of the switching module](image)

2.1.2. Push out module. The push out mechanism is mainly composed of slide rail, connecting rod slider mechanism and ratchet pawl. After the switch module makes the cartridge drop to the push out plate, manually rotate the knob to make the ratchet rotate, so that the slider mechanism can drive the slider to move out, and move out the slide rail to bring out the cartridge. The purpose of using ratchet pawls is to prevent the ratchet from rotating in one direction due to disoperation.

![Figure 5. Schematic diagram of the launch module](image)

2.1.3. Disassembly mode. In order to facilitate the disassembly and use of the elderly, all connections of the designed shell are spliced and inserted. The upper top plate is cut and made of 3mm transparent
acrylic plate. The transparent material is convenient to observe the color and label of the medicine box inside the device to distinguish. When all the medicines for a week are taken, the user can open the top cover of the upper acrylic plate to take out the inner sub-body medicine box for cleaning and load new medicines for further use.

**Figure 7.** Disassembly of the medicine box

### 2.2. Design of electric control part

The RPI and pn532 NFC modules are mainly used in the control part. The RPI module is mainly used for regular reminder and information storage interaction. The pn532 module is used to monitor whether the drug is missed or taken wrongly, so as to remind the guardian to intervene in time. The work flow chart is as follows, and the working principle of the control part will be introduced next.

**Figure 8.** Work flow chart
2.2.1. **Medication Tips.** In this scheme, users can specify corresponding taking time rules for different medicine boxes through the touch screen of the intelligent medicine box. The program will store the user specified rules into the SQLite database inside the medicine box and compare with the built-in system time. If the system time matches the preset time in the database, the RPi control panel will output high/low level signals through GPIO to drive the external LED lamp to illuminate to remind the user to take the medicine on time. Meanwhile, the medicine taking time information will be sent to the guardian's binding account through a small program, which is convenient for the guardian to know the medicine taking situation of the user.

2.2.2. **Tips for Wrong or Missing Service.** In this scheme, the NFC detection program of the cartridge is run by an independent thread to continuously detect the existence of NFC label signal of the cartridge at the corresponding detection position. When the program detects that the unexpected NFC signal disappears or the NFC signal timeout exists, the display screen, LED lamp and speaker will give an alarm to remind the user of the possibility of taking the wrong medicine or missing the medicine.

2.2.3. **Information Interaction Based on WeChat Platform.** The intelligent medicine box of the scheme can realize two information interaction modes for users: local interaction and remote interaction. Local interaction is mainly realized through the 3.5-inch touch display screen of the intelligent medicine box, supplemented by speakers and LED indicators to improve the interaction convenience of the elderly population. Meanwhile, if the intelligent medicine box is used in an environment with wireless network access, the program can call open source code libraries such as itchat/wxpy to realize remote information exchange based on wechat platform. When the intelligent medicine box is online, users can realize the push of medicine reminder, remote view of historical records, treatment statistics and other data by focusing on the use of specific wechat applet. The operator of wechat applet can develop the secondary function according to the data from the drug box received by the platform, and can realize the functions such as drug use instruction information query.

3. **Innovation of Works**

   1) Functional innovation: switching operation is realized through a simple mechanism, and remote control and data storage are realized through data connection between WeChat applet and RPi;
   2) Mechanism innovation: use ratchet pawl and crank slider to realize the function of mechanism locking and pushing out;
   3) Application innovation: The systematic design and application of RPi and the intelligent medicine box are utilized to realize comprehensive functions, intelligence and miniaturization of volume.

4. **Summary**

At present, the problem of difficulty in taking medicine for the elderly is gradually prominent, especially for the elderly living alone who lack the company of their children and have great potential safety hazards in taking medicine. Although the existing intelligent technology is mature, there is still a big gap in the field of intelligent medicine box due to its high cost. In view of the shortcomings of the existing medicine box, we have combined the corresponding advantages to realize the functionalization of a simple structure, and to some extent, we have realized intellectualization and miniaturization by using integrated chips, which are relatively simple in use and sensitive and quick to operate. With the gradual increase of the elderly population and the increasing incidence of chronic diseases among the elderly, the device has broad application prospects.

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