Structure Design of Smart Reminder Medicine Box

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Abstract. With the aging of the population, the situation of pension problems is getting more and more serious. Aiming at the problems of old people forgetting to take medicine, taking wrong medicine, etc., a smart reminder medicine box that can be divided into medicine is designed to assist the old people to take medicine on time and take medicine quantitatively. The use of mechanical design to realize the convenience of adding medicines, the use of single-chip microcomputers to realize time reminders and control of the amount of medicines, and at the same time to realize the collection of information on the amount of medicines, can assist doctors in diagnosis and help businesses understand the market.

Keywords: The elderly, medicine distribution, smart medicine box.

1. Introduction
Since my country has entered an aging society, it has shown a trend of large elderly population, rapid growth, aging, disability, and empty nesting, and the problem of elderly care is extremely serious. According to statistics, the frequency of problems such as forgetting to take medicine, repeated taking of medicine or taking the wrong medicine is very high in the elderly, which seriously threatens the health of the elderly. In response to these problems, a smart reminder medicine box that can be divided is designed to better solve the problem and reduce the safety risks of the elderly in the process of taking medicine.

2. Research background
In February 2017, the Ministry of Industry and Information Technology, the Ministry of Civil Affairs, and the Health and Family Planning Commission jointly issued the "Smart Health Care Industry Development Action Plan (2017-2020)", which required to focus on the development of key technologies and products for smart health care, and to promote Prioritize the use of smart health care products in elderly care and medical institutions, and encourage financial subsidies to families and individuals to purchase smart health care products.

Among the key tasks of the "Thirteenth Five-Year Plan" for healthy aging, it is clear that information technology must be promoted to support the development of healthy elderly care and the development of new formats of smart healthy elderly care. Make full use of information technology such as the Internet, the Internet of Things, and big data to innovate health and elderly care service models, carry out smart health and elderly care application demonstrations for families and communities, and improve the coverage and quality efficiency of health and elderly care services.
At present, the development of smart pill box products is in its infancy. Some pill box products on the market are mainly divided into portable and electronic control types. In general, the research and use of smart pill box products are still incomplete. As far as the device is concerned, there are still many shortcomings, and there are many limitations in application, and there is still a certain gap between large-scale applications.

3. Technical solution

3.1. Overall design

This design intelligent reminder can divide the medicine box, which is composed of a unit medicine box, a conveyor belt, a medicine hopper, a medicine cartridge and a shell. The unit medicine box is composed of a water wheel turning medicine dispensing part and a rotating medicine discharge tank part.

![Figure 1. Overall schematic diagram of the device](image)

1—shell; 2—unit medicine box; 3—conveyor belt; 4—medicine hopper; 5—take the cartridge

The shell of the medicine box is mainly used to hold the unit medicine box. Two magnetic suction cover plates are installed on the shell, one is located above the unit medicine box and the other is located next to the cartridge to ensure the sealing of the device. The survey shows that the elderly generally cannot take too many kinds of drugs at a time. At present, the daily use of elderly people ranges from 3-5 kinds to as many as 7-9 kinds. According to the number of different types of drugs required by different users, the specific specifications are different. According to the above data, two general specifications of 6-box and 10-box shells are designed, which can be freely selected by users according to their needs, and can be customized separately if necessary.

After the user inputs the name of the medicine, the time of taking the medicine, and the dosage of the medicine into the unit medicine box according to the needs, the unit medicine box is placed in the grid in the correct direction. Then according to the system instructions, the medicine particles are pressed in from the entrance of the unit medicine box, and the tablets are transferred into the sub-storing holes through the water wheel to the medicine-dispensing part, and each sub-storing hole contains the same amount of medicine as the input dosage. When the rotating medicine tank is full, the medicine box stops operating, reminding the user to stop pressing the medicine, press the extra medicine, and continue to stay in the interdental distance, waiting for the next medicine delivery. When the set time is reached, the medicine in the sub-storage hole of the rotating medicine out tank will fall, and it will fall into the medicine-taking cylinder along with the conveyor belt. The elderly only need to take out the medicine from the medicine cartridge.
Figure 2. Schematic diagram of the basic operation process of the device

The medicine box control part adopts Raspberry Pi Zero W, uses PWM to drive the ULN2003 module to control the stepping motor of the medicine box, uses L298N to drive other DC motors to work, uses MIPI_CSI interface to connect OV2640 camera to scan the medicine QR code, and uses photoelectric The switch obtains the medicine dispensing signal from the medicine outlet of the medicine box and calculates the quantity. The Raspberry Pi Zero W has a built-in WLAN, which can access AIOT platforms such as Ali, Huawei, and Xiaomi by calling APIs, and accept unified platform management. The user can input the name of the drug through the button or directly scan the barcode, and the program can query the relevant information of the drug online and enter it automatically. After the user enters the time and dosage of the medicine, the program compares the content entered by the user with the limit dosage of the medicine. If the time and dose entered by the user may cause health risks, a warning will pop up on the display to remind the user to pay attention. When the user puts the medicine, the photoelectric switch counts the medicine that enters the device, and when the quantity reaches the maximum value, the user is reminded to stop the dosing and the motor transmission track is stopped. After the time set by the user arrives, ULN2003 receives the square wave drive signal from Zero W, rotates the medicine tank angle according to a certain step length to send the medicine out, and counts the medicine data through the photoelectric switch, when the medicine quantity and input data are correct Send out medicines. In addition, when the photoelectric switch arrives at the set time and the medicine cartridge is still sensed within half an hour after the medicine is output, that is, when no one takes off the medicine cartridge, the medicine box will remotely send a warning message to the mobile phone APP to remind the elderly’s children or Nursing staff taking care of the elderly, the elderly did not take medicine on time.

Figure 3. Schematic diagram of the overall process of the device
3.2. Unit Pill Box Module

The unit pill box module is mainly divided into the water wheel to divide the medicine part and the rotating medicine out tank part. The gears and housings of the water wheel rotating and distributing part are fixed on the rotating shaft by keys and nuts, and the rotation of the rotating shaft only drives the gear part to rotate. The center of the shell of the rotating medicine tank is a through shaft sleeve, which can be fixed on the short shaft at the bottom of the unit medicine box shell by a groove. The top surface of the short shaft is connected to the connecting rod of the inner ring by the motor to drive the inner ring to rotate.

The unit medicine box is divided into three specifications of 10mm, 15mm and 25mm according to the different medicines. Each unit medicine box contains different medicines.

![Diagram of unit box housing](image)

**Figure 4.** Unit box housing (partial section view) and internal schematic

The medicine enters from the entrance of the unit medicine box, then slides into the water wheel to transfer the medicine part, and is divided into each meal and stored in each storage hole of the rotating medicine tank. When the set time is reached, the well-divided medicine in a hole will fall out.

In order to facilitate the replacement of medicine types, the unit pill box is set with an empty mode, and the water wheel turning to divide the medicine part and the rotating medicine out tank part are run for a week according to the program, thereby all the medicines in the two parts are completely emptied.

![Diagram of work flow](image)

**Figure 5.** A diagram of the work flow of the unit cartridge

3.2.1. The water wheel transfers the medicine part. The rotating part of the water wheel is divided into a gear part and a housing part, divided into three specifications of 10mm, 15mm and 25mm. Different
specifications, different tooth pitches of gears, and different sizes of inlets and outlets of the casing to adapt to various sizes of medicines.

![Figure 6](image1.png)

**Figure 6.** Schematic diagram of the gear part (left) and the housing part (right) of the rotating part of the water wheel

![Figure 7](image2.png)

**Figure 7.** Schematic diagram of assembling the gear and housing of the water wheel rotating part

After the medicine slides in from the inlet, a medicine occupies one tooth pitch of the gear, and the gear rotates to send the medicine to the bottom outlet to slide out. When the user puts the medicine, the photoelectric switch counts the medicine that enters the device, and when the quantity reaches the maximum value, it reminds the user to stop adding medicine and stop the motor conveying track.

3.2.2. Rotate the medicine tank part. The rotating medicine tank is designed to resemble a revolver, and is divided into an inner ring and a shell with separate storage holes. There is only one outlet at the bottom of the casing, and the rest are closed, and medicines fall from there.

![Figure 8](image3.png)

**Figure 8.** Schematic diagram of the inner ring (left) and outer shell (right) of the rotating medicine tank

Different specifications can be rotated out of the medicine cans to contain different medicines. According to the medicine specification, each sub-storage hole of the inner ring contains the quantity of each medicine. When the set time is reached, the ULN2003 module drives it to rotate, and statistics the medicine data through the photoelectric switch, and sends out the medicine when there is no error.

3.3. Conveyor belt, medicine hopper and medicine cartridge module

The conveyor belt is designed to install a baffle on both sides of the track to prevent the medicine from falling off the track from both sides due to bounce or rolling when the medicine falls.
When the medicine is dropped, the medicine data is calculated through the photoelectric switch. When the medicine quantity and the input data are correct, the L298N module drives the DC motor to drive the conveyor belt to send the medicine.

The medicine collecting hopper is designed as a funnel. There are grooves on both sides, with long keys, inlaid on the shell for easy installation and removal.

The cartridge is designed to be cylindrical and screwed under the medicine hopper. When the medicine falls into the cartridge, the user only needs to unscrew the cartridge to take out the medicine needed this time. The external design pattern increases friction and is convenient for the elderly to unscrew the cartridge. At the same time, considering the hand feeling of the elderly when using it, rubber wrap is used as the outer wrapping material to improve the user experience.

4. Design rationality analysis

4.1. Size calculation

4.1.1. Design and calculation of unit pill box specifications. According to national standards, capsule shells are divided into different models, and the sizes of capsule shells are also different. The size parameters of some models are shown in Table 1:
Table 1. Capsule shell model and parameter table

| Project                              | 0°   | 1°   | 2°   | 3°   | 4°   |
|--------------------------------------|------|------|------|------|------|
| Risk length (mm)                     | 11.6±0.4 | 10.8±0.4 | 9.8±0.4 | 9.0±0.3 | 8.1±0.3 | 7.1±0.3 |
| Body length (mm)                     | 19.8±0.4 | 18.4±0.4 | 16.4±0.4 | 15.4±0.3 | 13.4±0.3 | 12.1±0.3 |
| Wall thickness (mm)                  | 0.110±0.015 | 0.110±0.015 | 0.100±0.015 | 0.100±0.015 | 0.095±0.015 | 0.095±0.015 |
| Body wall thickness (mm)             | 0.110±0.015 | 0.110±0.015 | 0.110±0.015 | 0.095±0.015 | 0.095±0.015 | 0.095±0.015 |
| The outer diameter of the port (mm)  | 8.48±0.03 | 7.58±0.03 | 6.82±0.03 | 6.35±0.03 | 5.86±0.03 | 5.33±0.03 |
| Body mouth outer diameter (mm)       | 8.15±0.03 | 7.34±0.03 | 6.61±0.03 | 6.07±0.03 | 5.59±0.03 | 5.06±0.03 |
| Total length (mm) after locking      | 23.3±0.3 | 21.2±0.3 | 19.0±0.3 | 17.5±0.3 | 15.5±0.3 | 13.9±0.3 |

By Table 1 it can be known that the total length of the locked capsule shell will not exceed 25mm, the relatively short capsule shell lock after the total length is basically about 10mm. The size of the tablet drug countries do not specify, most pills in diameter of 4-7mm, thickness of about 2-5mm.

According to the above data, in order to make the size can meet the storage of drugs in general, we designed the unit medicine box mainly divided into 10mm, 15mm and 25mm three specifications, different specifications of the size represents the rotating part of the gear tooth spacing and rotating the size of the inner ring of the sub-storage hole, the user can choose the appropriate size of the drug they eat according to the size of the unit box.

4.1.2. The size design of the cartridge. According to the average elderly hand size, the design shape needs to be easy to hold, and try to meet the one-handed operation. In addition, consider its main function of pill storage, according to Table 1 and other data can know the size of the pills, and according to research, the elderly generally take a few tablets of drugs at a time to dozens of tablets, not more than 30 tablets at most. Therefore, the design of the drug barrel for the cylinder-shaped, size of 60mm diameter, height of 65mm, to meet the general number of drugs stored.

4.2. Material selection
Commonly used medicine packaging materials are divided into 4 categories: glass, rubber, plastic and metal materials according to their material composition.
Rubber materials can be divided into two types: natural rubber and butyl rubber. For natural rubber, the State Food and Drug Administration has clearly stipulated that the use of ordinary natural rubber stoppers (excluding rubber stoppers, gaskets, and gaskets for oral solid medicine packaging) should be stopped. Packaging of medicines (including hospital preparations) \(^4\). Therefore, the crawler of the conveyor belt uses butyl rubber as the material.

Glass material is the most commonly used medicine packaging material, which has the advantages of stable chemical properties, good barrier properties, transparency, beauty, low price, and recyclability. At present, there are three types of glass materials used in my country: Type I, Type II, and Type III. Type I glass is borosilicate glass, which has excellent chemical and thermal stability. Type II glass is soda lime glass, but it is limited to disposable containers. Non-I non-II type glass is a unique low borosilicate glass in our country, and glass bottles made of this type of glass sometimes exhibit neutral failures, flaking, and freeze-drying explosions \(^4\). Therefore, the inner ring of the rotating medicine tank is made of type I glass.

Pharmaceutical plastic packaging materials have the advantages of non-toxicity, corrosion resistance, high strength, good barrier properties, heat resistance and moisture resistance, light barrier transparency, autoclave sterilization, light weight and convenient portability \(^5\). The properties of several commonly used plastic packaging materials are shown in Table 2:

| Table 2. Performance table of several commonly used plastic packaging materials \(^6\) |
|------------------------------------------|----------|----------|----------|----------|----------|
| Pilot project                           | Polyethylene | High-pressure polyethylene | Vinyl chloride | Partial vinyl chloride | Polypropylene. Polyester. |
| Depth (μ)                                | 30~100    | 30~100   | 30~200   | 30~70    | 30~100   | 10~100   |
| Proportion.                              | 0.92      | 0.95     | 1.40     | 1.6~1.75 | 0.09     | 1.38     |
| Oil resistance (h)                       | 730       | 750      | 100      | ∞        | 735      | ∞        |
| Absorption rate (%)                      | <0.1      | <0.1     | 0.1~0.5  | <0.1     | <0.1     | <0.1     |
| Permeable humidity (g/m²/24h)           | 16~22     | 5~10     | 25~90    | 1~2      | 8~12     | 22~30    |
| Gas pass-through (cm³/m²/h) (Dry air pressure at 20 degrees C) | 312       | 96~144   | 96~884   | 0.72     | 120~192  | 16.8~33.6 |
| Softening point (C)                      | 85~95     | 115~125  | 60~90    | 60~100   | 94~140   | 140      |
| Brittle temperature (C)                  | -55       | -80~55   | -30~0    | -30~0    | -35      | -60      |

Therefore, based on the above information, we use polypropylene to make the shell of the rotating medicine tank, the water wheel to turn the medicine part, the medicine bucket and the medicine cartridge.

5. Conclusions
This design of intelligent reminder can divide medicine medicine box can realize semi-automatic medicine distribution, centralized medicine service, intelligent management of medication time, intelligent voice reminder, intelligent information display and other functions. It is convenient for users to add medicines, and it is also convenient for the elderly to obtain medicines. Elderly people living alone in empty nests have safety hazards such as mistaking, missed medication, and mildew of the medication; at the same time, understand the medication situation of the elderly, carry out information statistics and feedback, and provide references for doctors or pharmacies. It can be popularized in nursing homes and medical care places.
Acknowledgments
This work was financially supported by 2020 National University Student Innovation and Entrepreneurship Training Program Project fund. (Project Number: S202010497079)

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