Research and design of a multifunctional intelligent walking stick

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Abstract: This paper designed a multifunctional intelligent walking stick for the elderly. The mechanical structure of the walking stick is provided with a hook, auxiliary mechanism for standing up, an anti-tripping mechanism, a small table board and telescopic adjustment. The auxiliary mechanism for standing up can make it easier for the user to stand up. The anti-tripping mechanism makes it safer for the elderly to walk without tripping. The retractable adjustment can meet the needs of people with different heights. The walking stick is also equipped with intelligent elements, such as lighting lamp, automatic time alarm, fall alarm system, manual alarm system, GPS positioning and MP3 music functions. When the elderly feels unwell, they can press the alarm switch, and the alarm bell will turn on, which can attract passers-by and improve the chance of rescue. When the fall alarm system is turned on, if the user falls, the alarm bell will ring. At the same time, the GPS positioning module will send the crutch position to the intelligent terminal to remind the guardian in time. Compared with the traditional crutches, the crutch has many functions and it is more convenient to use and safer.

1. Introduction
At present, China's population has entered the elderly type. It was estimated that by 2040, the proportion of the elderly aged 65 and over in the total population would exceed 20%. At the same time, the aging trend of the elderly population was becoming increasingly obvious: the elderly aged 80 and over were increasing at a rate of 5% per year, and would increase to more than 74 million by 2040 [1]. In order to adapt to the current aging trend and help the elderly go out safely and conveniently, the author studied and designed a multifunctional intelligent walking stick with flexible length and simple operation to meet the needs of the elderly.

2. Overall structure of the walking stick
The multifunctional intelligent walking stick designed in this paper is composed of four parts: top handle, crutch body, crutch foot and circuit control unit. The physical sample is shown in Figure 1. The walking stick was designed with both mechanical innovation and intelligent control. The mechanical structure was mainly considered from the aspects of safety, convenience and practicality. The utility model was provided with a hook, an auxiliary mechanism for standing up, an anti-tripping mechanism, a small table board and a telescopic adjusting device. In terms of intelligent control, in addition to the daily lighting and time reporting functions, the alarm of emergencies and entertainment also were considered. A lighting lamp was set in front of the top handle, which can be adjusted up and down. The automatic time reporting function was set, and the time will be reported automatically at
the whole hour (except from 8 p.m. to 8 a.m.), the function can be turned off manually. A fall alarm and manual alarm system were set. When the fall alarm system is turned on, if the elderly suddenly falls or faint and the crutch falls, the alarm bell will automatically turn on to call for help and warning. At the same time, the GPS positioning module will send the location of the walking stick to the intelligent terminal to remind the family in time. Entertainment features included MP3 and radio.

![The picture of the walking stick sample](image1)

**Fig. 1** The picture of the walking stick sample

![Flexible bending structure](image2)

**Fig. 3** Flexible bending structure

3. Design of key mechanical components

3.1 Design of auxiliary mechanism for standing up

Considering that it is difficult for some elderly people or people with bad waist to stand up after sitting down, the knee joint lifting assistance and flexible bending parts were provided, as shown in Figure 2 and Figure 3. The design of the knee joint boosting structure conformed to the human structure. According to the lever principle, the auxiliary mechanism supports the knee and the hand to form a labor-saving device. Considering the difficulty of standing with straight rod support, a flexible bending structure was added, so that the original straight support rod can be bent at a certain angle, which makes it easier for the user to stand up. The auxiliary mechanism also can be retracted upward and locked, as shown in Figure 2 (b).
3.2 Design of anti-tripping mechanism

The bottom of the crutch was composed of a spherical pair and a rigid spring, which can realize 360° omni-directional inclination with an inclination angle of 10°. This design was in line with human structure and could effectively prevent tripping. The structure can also be adjusted by bottom screws. The structure is shown in Figure 4.

3.3 A hook design

In order to facilitate the elderly to go out, a forward and reverse hook was designed, which was connected with the walking stick through two buckles. The forward installation can hang shopping bags, garbage bags, keys, etc., which is very convenient for the elderly to free up their hands to do other things. The reverse installation can hang the walking stick on the edge of the table and cabinet, which is convenient for storage when not in use and does not occupy space.

3.4 A foldable small table design

In order to facilitate users to place small things when they go out and rest, a small table was set, which can be opened and closed freely and the height can be adjusted freely.

3.5 Stress analysis of the walking stick

The stress analysis of the whole walking stick, the top handle, the support frame of auxiliary mechanism for standing up and the small table board was carried out by using the finite element analysis software[2]. From the results of the finite element analysis, it can be seen that all parts of the walking stick meet the use requirements. Fig. 5 shows the static stress analysis of walking stick assembly, the maximum bearing capacity is 3.0×10^7 N/m²; Fig. 6 is a static stress analysis of the end...
handle; Fig. 7 shows the static stress analysis of the support of auxiliary mechanism for standing up, and Fig. 8 shows the static stress analysis of the small table board.

4. Intelligent system design
In this product, AT89S52 single chip microcomputer system was used as the main control unit, supplemented by MPU6050 sensor, ESP8266WIFI module, NEO-7N GPS positioning module, voice module and many other modules, so as to realize a series of functions such as WIFI connection, GPS positioning, voice prompt, automatic time telling, MP3, radio and so on.

4.1 Design of Alarm Module
The alarm module can alarm manually and automatically when falling. When the elderly find that they are unwell and can't solve it alone, they can press the alarm switch, and the alarm bell will turn on, so as to attract passers-by and improve the chances of rescue. When the automatic alarm system is turned on, if the user suddenly falls down and the crutch falls, the alarm bell will turn on automatically. At the same time, the GPS positioning module will send the crutch position to the intelligent terminal. Remind the guardian in time.

Gyroscope MPU-60506 and NEO-7N GPS locator were selected for the alarm system. MPU-6050 is a very popular space motion sensor chip, which can obtain the current three acceleration components and three rotational angular velocities\[3,4\]. NEO-7N GPS positioning module has the characteristics of high sensitivity, low power consumption, miniaturization and extremely high tracking sensitivity, which greatly expands its positioning coverage. In this system, the inclination of
crutches is calculated by the gyroscope built in MPU6050 sensor. When the crutches start running, they will always pay attention to the inclination of the crutch. If the crutch falls to the ground or the inclination angle exceeds the safety threshold, the information will be transmitted to the mobile phone APP, and then the information and the place of occurrence will be sent to the user's family through the GPS function\[5\]. The schematic diagram of the positioning module is shown in fig. 9, and the internal address configuration and initialization of MPU6050 are shown in figs. 10 and 11.

![Fig. 9 Schematic diagram of GPS module](image)

![Fig. 10 Internal address configuration of MPU 6050](image)

![Fig. 11 initialization and synthesis of MPU 6050](image)

### 4.2 TEA5767 Radio Module

TEA5767 radio module rate ranges from 76-108MHz, which is automatically digitally tuned. It is a radio module with high sensitivity, high stability and low noise. TEA5767 has built-in digital signal processor with the main frequency up to 75MHz, which can realize the playback of high-quality MP3 music files at MD level of 384KBPS/48KHz. and save power at the same time $[6, 7]$. 

```c
#define SMPLET_DIV 0x15
#define CONFIG 0x1A
#define WDT 0x1B
#define ACCEL_CONFIG 0x1C
#define ACCEL_XOUT_H 0x38
#define ACCEL_XOUT_L 0x39
#define ACCEL_YOUT_H 0x3A
#define ACCEL_YOUT_L 0x3B
#define ACCEL_ZOUT_H 0x3C
#define ACCEL_ZOUT_L 0x3D
#define USER_CTRL 0xF4
#define BIT_FORCE 0x08
#define BIT_WAKE_UP 0x01

void InitMPU6050()
{
    Single_WriteI2C(PWR_MGMT_1, 0x00);
    Single_WriteI2C(SMPLET_DIV, 0x07);
    Single_WriteI2C(CONFIG, 0x06);
    Single_WriteI2C(WDT, 0x18);
    Single_WriteI2C(ACCEL_CONFIG, 0x01);
}

int GetData(uchar REG_Address)
{
    char k, L;

    k = Single_ReadI2C(REG_Address);
    L = Single_ReadI2C(REG_Address+1);
    return (k<<8) + L;
}
4.3 **MP3 voice broadcast module**
Use memory card to import voice broadcast information, and directly trigger the broadcast through 9 trigger ports. 31 voice messages can be played by combining with IO port coding of single chip microcomputer.

4.4 **DS1302 timing unit**
DS1302 is a real-time clock circuit with high performance, low power consumption and RAM, which can time year, month, day, week, hour, minute and second, and has leap year compensation function. The working voltage is 2.0 V ~ 5.5 V. Three-wire interface is used to communicate with CPU synchronously, and multiple bytes of clock signal or RAM data can be transmitted at one time in burst mode.

4.5 **Wireless communication module**
The AS32-TTL-100 wireless module with SX1278 as the core and Lora spread spectrum technology are adopted in wireless communication, which has the characteristics of low power consumption, long transmission distance, strong anti-interference and good confidentiality.

4.6 **SCM system design**
Each module was connected by single chip microcomputer to form a complete control system. The schematic diagram of the system is shown in Figure 12.

![Fig. 12 Schematic diagram of single chip microcomputer system](image)

5. **Conclusion**
According to the market demand, this paper designed and manufactured a multifunctional intelligent walking stick, which has GPS positioning, anti-fall alarm, automatic/manual time telling, LED flashlight, MP3, radio and other functions. Mechanically, there are a hook, auxiliary mechanism for standing up, an anti-tripping mechanism, a small table board and telescopic adjustment, etc., which are powerful and can meet various needs of users. It provides convenience for the elderly to go out. With the further study of the crutch, the works will be improved in the future, so as to maximize the effect of the crutch on the elderly.
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