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# Research of a Multi-functional Crutch Based on UWB and Stepper Motor

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***Abstract:*** *As tools to assist elderly, crutches facilitate the life of the elderly to a large extent. But most of the crutches on the market have limited functions. In this article, a new type of crutch with multiple functions has been designed. This crutch has the function of picking up, locating and lighting. Firstly, the function of clamping is to drive the tightening and relaxation of clamp through the rotating output displacement of type 42 stepper motor, so as to realize the picking up of objects. Additionally, the positioning function is realized by ultra wide band(UWB) technology. The UWB technology provides the support to help locate the crutch's position precisely. Lastly, the lighting function uses LED, which shares the same battery with the stepper motor. According to researches and experiments, those functions presented above have been achieved. And this crutch provides a direction for future products to help the old people.*

***Keywords:*** *stepper motor; ultra wide band(UWB); LED*

## 1. Introduction

With people's desire to give birth and population mortality decreased year by year, aging population has gradually become a serious social problem that cannot be ignored, which has triggered tremendous attention. It is estimated that by 2023, the proportion of China's population aged over 65 years old will reach to 12.80645% [1]. Therefore, in order to cope with the trend of aging population, more and more products to help the old men appear on the market. Crutches are one of the most important products for helping the elderly, but the function of crutches is simple and cannot satisfy the demands of old people. What's more, multi-functional crutches are at the beginning stage of development and have a great space to improve in the future. Existing smart crutches have complex brands, uneven quality, miscellaneous and monotonous functions. Most of them focus on the grip feeling of the handle and the stability of the bottom, as well as the functions of talking, taking steps and playing music, which are not practical for the elderly. Thus, it is of great significance to design a multi-functional crutch.

There are three main functions about the crutch. The first function is picking up. Through the rotation of the stepper motor, the output displacement of the lead screw drives the movement of the gripper and controls the opening and closing strength of the gripper to control the clamping of items. All things people are supposed to do are pushing buttons to take charge of the stepper motor. Secondly, UWB technology can realize the positioning function, and using the characteristics of UWB technology can achieve the purpose of precise finding of the located items through Bluetooth device. This function help prevent the cane from being lost, and the family of old people can have a better known of the situation of old men. Last but not least, LED is a device that converts electrical energy into light energy, which can be illuminated by sharing power with the stepper motor.

In order to better understand the multi-functional crutch, the working principle of each component of this walking stick will be detailed in the article. These results could provide direction for future age-friendly products or boost the industry.

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## 2. Operating principle

### *2.1 Picking up*

Details of the crutch are at Fig. 1 and Fig. 2. The core of the picking up component is the stepper motor. Stepper motor is an actuator that converts electrical pulse into angular displacements. When the stepper driver receives a pulse signal, it drives the stepper motor to rotate at a fixed angle in the set direction, and its rotation runs step by step at a fixed angle. The angular displacement can be controlled by getting command of the number of pulses in order to achieve accurate positioning. Plus, the speed and acceleration of the stepper motor can be commanded by controlling the pulse frequency, so as to achieve the purpose of speed regulation [2]. This composition of the picking up module: including stick 1, stepper motor 31, accumulator, 41, chip 42, lighting system 43 and control button 4. The crutch's external settings have a store content box 2. The crutch's inside has the picking up component 3. The picking up component 3 includes the stepper motor 31, and below the connection is lead screw 32. The lead screw 32's external connection has nut pair 33. The nut pair 33 is externally connected with a connecting sleeve rod 34, and the lower part of the connecting the sleeve rod 34 is connected with a movable rod 35, and the upper and lower ends of the lead screw 32 are connected with a bearing sleeve 36. The output end of stepper motor 31 is fixedly connected above the lead screw 32, and the stepper motor 31 is connected in the upper surface of the bearing sleeve 36. There are two bearing sleeves 36, and the center of the bearing sleeve 36 is arranged with a ball bearing, and the inner part of the ball bearing is provided with the lead screw 32 and the upper and lower ends of the lead screw 32. Both upper and lower of the lead screw 32 are smooth and easy to install bearing sleeves 36, so as to realize the rotation of the lead screw 32. The outer part of the nut pair 33 is fixedly connected with the guide ring, realizing the nut pair 33 stably moving up and down. In addition, the bottom of the guide ring has connected the connecting the sleeve rod 34. In detail, there are four connecting sleeve rods 34, and the connecting sleeve rods 34 pass through the bearing sleeve 36 to the upper surface of the movable rod 35. The movable rod 35's upper surface connects with the disc, and a connecting sleeve rod 34 is connected above the disc. Through the use of handle 14, the cane can realize the nut pair 33 to adjust the movement of the movable rod 35, and through the setting of multiple connecting the sleeve rod 34, it can ensure the stability of the nut pair 33 moving up and down.

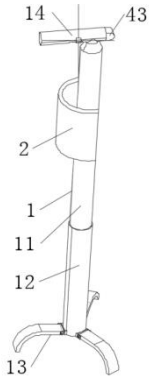


*Fig. 1 Crutch appearance*

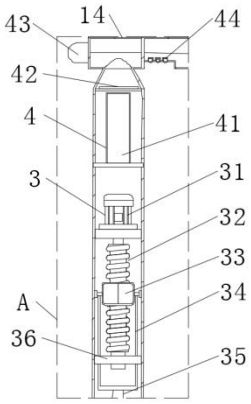


*Fig. 2 Diagram of stepper motor*

Our motor-driven mechanical cane is divided into four buttons: start button, stop button, forward rotation button and reverse rotation button. The start button is used to start the motor. The stop button controls the motor to stop the motor. The forward rotation button makes the motor move downward in a straight line. The movement of the lead screw is the closing of the picking-up component, while the reverse button makes the motor move upward and corresponds to the opening of the picking-up component. Further, when the elderly need to bend down to pick up items, the elderly should first press the start button and then press the forward rotation button to align the items to be clamped, so that the mechanical cane at the bottom of the crutch changes from open to closed, and the mechanical cane in the closed state can clamp the items we need to clamp. When ensuring that the object to be clamped have been clamped, press the stop button to stop the motor. When the elderly put the thing in the mechanical cane back to their original place, they can press the reverse button to make the motor start to reverse, and then drive the mechanical cane at the bottom of the crutch from the closed state to the

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open state, so that the crutch can continue to be used as the function of the original crutch. This function greatly improves the action capability of elderly people with leg problems and lumbar diseases to pick up items without assistance from others. For example, if the old man accidentally drops his key string while walking alone on the street, he can pick it up with his walking cane, which greatly facilitates his life and reduces the risk of injury to his lumbar spine.

### *2.2 Locating*

In order to achieve accurate positioning, the wireless positioning system must first obtain the positioning and required parameters, and then construct the corresponding solution model according to these parameters, and then use the solution model to get the target position. Because UWB has high temporal and spatial resolution, it can accurately acquire the time and angle information of the target, and convert time into distance information to gain the position of the target. UWB positioning technology usually adopts direction finding and ranging to achieve precise positioning. According to the different measurement parameters, it can be divided into four methods: Received Signal Strength method, Angle Of Arrival method, Time Of Arrival method and Time Difference Of Arrival method [3].

Inside the crutch is a positioning device based on UWB technology. Based on the high resolution features of UWB, crutches can be accurately searched by electronic devices equipped with Bluetooth modules, with an accuracy of 0.1-0.2 meters. Therefore, this function is not only convenient for the family to know the location of the elderly in real time, but also convenient for the elderly and the family to quickly recover the crutch after it is lost.

### *2.3 Lighting*

The crutch is equipped with a LED module, short for light-emitting diode, a device that converts electricity into light. LED, which is similar with common diode, is composed of a PN junction. When a forward voltage is applied to the LED, the electron holes injected from P to N and the electrons injected from N to P combine with the electrons in N and the electron holes in P, respectively, at a short distance near the PN junction, thus generating light [4].

The LED is powered by sharing a 12-volt power supply with the type 42 stepper motor. There is also a separate switch to control the LED switch. This function is convenient for the elderly with weak vision to walk on the poorly lit road at night, so that the elderly can clearly understand the road ahead and reduce the risk of falling down.

## 3. Conclusion

In summary, we describe the motivation for making this new multi-functional walking stick and explicate in detail how the various parts of the multi-functional cane work. For the three main functions, the working principle of the gripper driven by the stepper motor, the positioning principle based on UWB technology and the principle of LED lighting are explained in detail. At the same time, we also provide research direction for the future aging products. In order to create more and better products for the old people, researchers should better develop toward the direction of electronic, intelligent and multi-functional, but also need to pay attention to the operability of the products, which should be convenient for the elderly to use, in line with the use habits of the old men. While focusing on the multi-function of the products, producers also need to consider the weight of the products. Considering that the elderly with the increase of age, the physical function gradually declines, and their physical strength is naturally inferior to young people. When designing products, they should be lightweight and integrated. And in the selection of product materials should also give priority to light materials.

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