Assist the elderly bathing machine

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Abstract. Data show that the degree of aging in my country is increasing year by year. Moreover, the elderly’s bathing problem still plagues families. Based on the above situation, the project team designed an auxiliary bathing machine for the elderly. The bathing machine can wash the head, back, limbs and other parts of the elderly that are not convenient for washing, and at the same time assist the elderly to lie down and get up, and monitor the vital signs of the elderly during the bath. The control mode of the bath machine is independent control of each module, and the elderly can activate each functional module by voice or manually. The coordination and cooperation between the various modules effectively deal with the problem of bathing for the elderly living alone, which has high practical value and promotion value.

1. Research background and significance

1.1. Research background

China is one of the countries with a high degree of population aging in the world, with a large number of elderly people, and the speed of aging is accelerating. Most of these elderly people aged 80 and above living alone have limited mobility and have many difficulties in daily life. Especially when taking a bath, the body is prone to fatigue, inconvenience, and poor time control. In order to be safe, many elderly people will try to reduce the frequency of bathing as much as possible, and they will be frightened and psychologically stressed when bathing. In addition, there are few bathing devices specially tailored for the elderly in the market. Some bathing devices put into production still require other people to help the elderly use them, and some fully functional bathing devices have not been widely promoted due to high prices and other reasons. The problem of independent bathing troubles many elderly people and families, so families and nursing homes look forward to comfortable bathing facilities and safe bathing environment.

In order to solve the bathing problem of the elderly living alone and improve the quality of life of the elderly, the project team designed an intelligent auxiliary bathing machine for the elderly. The design is based on ergonomic principles, using three-dimensional virtual design, statics and dynamics simulation analysis and other technical means. The bathing machine mainly includes four functions: head cleaning, back cleaning, limb cleaning, and assisting getting up and lying down. Through the
cooperation of various mechanisms, it can realize the cleaning of the inconvenient parts such as the head, back and limbs of the elderly, and at the same time assist the elderly to lie down and get up, and monitor the vital signs of the elderly during the bathing. The control mode of the bath machine is independent control of each module, and the elderly can start each function module by voice or manually.

The bathing machine is easy to operate, strong in practicability, and high in safety. It focuses on solving the problem of bathing difficulties for the elderly, and has huge market value and development potential.

1.2. Research significance
(1) Help the elderly to complete the bathing process safely and conveniently when living alone, so that the elderly can relax physically and mentally, promote metabolism, enhance sleep and enhance the ability of the elderly to live alone.

(2) Respond to the call of the times, care for the elderly, and improve the quality of life of the elderly in their later years.

(3) At present, there are few products with complete functions, intelligent automation and reasonable price on the market. This design has a broad market prospect.

2. Overall design

2.1. Mechanical structure design
The mechanical structure design is the focus of the research on the bathing machine for the elderly, and the research on the mechanical structure that meets the requirements of complete functions, small footprint, convenient use and a sense of security during use is the focus of research. The mechanical structure of the system mainly includes: the pumping device of the bathing machine, which delivers the water flow to various parts; the head cleaning and massage device using the ball joint linkage mechanism, as far as possible to fit the curve of the human head, the massage component is in the ball head Driven by the linkage mechanism, the massage parts with non-parallel rotation axes rotate synchronously; the back cleaning device adopts a sine mechanism to control the up and down reciprocating movement of the scrubbing device through a large motor; the limb cleaning device that combines a screw motor and a waterproof steering gear, The steering gear drives the bathing drum to rotate through the gear set, and the screw motor controls the reciprocating movement of the folding mobile cleaning device; the auxiliary lifting device of the push rod motor can adjust the angle of the back and legs to facilitate the elderly to get up and improve The overall safety of the device.

2.2. Control system design
The design of the control system is an important part of the research of helping the elderly bathing machine, and the executive elements and interactive system modules are the focus of this part of the research. This system adopts the concept of modular design combined with main control and auxiliary control. The main control part uses Arduino mega 2560, including power supply module, crystal oscillator circuit, reset circuit, serial port circuit, etc., to detect pump pressure and use pressure information to control pump power. Undertake the responsibility of opening the solenoid valve. The auxiliary system can detect the change of current in the circuit to ensure the safety of electricity. The main control system detects the change of the heart rate of the elderly to ensure the physical condition of the elderly during the bath. The auxiliary system is controlled by the cost-effective Arduino nano. Start-up, forward and reverse control of DC motor and steering gear, collection of position information of the limit switch of the mechanism and corresponding response, etc.
Figure 1. Auxiliary bathing machine for the elderly

3. Module design

3.1. Head cleaning module
The head cleaning module includes a top massage cleaning device, a bottom massage cleaning device, a screw mechanism, a high-power steering gear, a water jet, etc. Figure 2 is a three-dimensional schematic diagram of a head cleaning module. The screw motor is fixed in the middle of the frame, and the bottom massage and cleaning device is moved forward and backward through the rotation of the screw motor. The top massage and cleaning device is driven by the high-power steering gear to rotate, and the waterproof steering gear drives the top massage and cleaning through the linkage mechanism. The left and right massage moving modules in the device move back and forth, and the print massage fingers in the top massage moving block and the print massage fingers in the bottom massage cleaning device are driven by the ball head linkage. At the same time, the water spray head is working in the massage cleaning module. Spray water to clean the human head in all directions. The schematic diagram of each part of the head cleaning module is shown in Figure 3 and Figure 4.
3.2. Back cleaning module

Figure 5 is a schematic diagram of the back cleaning module. The scrubbing cushion is installed on the sine mechanism. The sine mechanism can move back and forth along the steel slide under the drive of the steering gear to simulate the process of manual back rubbing, so as to realize the hard-to-clean parts of the back Clean, help the elderly clean the most difficult parts to wash, reduce the difficulty of bathing for the elderly, and improve the working performance of the bathing machine. Figure 5 is a schematic diagram of the sine mechanism.

3.3. Limb cleaning module

Figure 7 is the arm cleaning module, and Figure 8 is the leg cleaning module. The arm cleaning module includes a folding mobile cleaning device, a steering gear, a screw motor, and a bottom fixed cleaning device. In the cleaning device, the steering gear drives the scrubbing roller to rotate through the gear set to realize the scrubbing function. The folding mobile cleaning device is driven by the waterproof steering gear to complete the folding, and moves up and down along the arm under the drive of the screw motor to complete the cleaning of the upper part of the arm. The fixed cleaning device installed on the lower part of the arm, which runs under the driving of the steering gear, completes the cleaning of the lower part of the arm. The mobile cleaning device and the fixed cleaning device cooperate with each other to realize the cleaning of the arm. The working principle of the leg cleaning module and the arm cleaning module are basically the same. Compared with the arm cleaning module, the leg cleaning module changes the steering gear that drives the rotation of the scrubbing drum to a higher-power waterproof motor, which improves the power while meeting the waterproof requirements.
4. Feasibility analysis

4.1. Auxiliary lifting device
The structure mainly bears the weight of people. The static stress analysis of the frame is carried out using ansys software. It is found that the maximum force that the structure bears meets the rigidity and strength requirements of the design. The use of a push rod motor with a power of 500N can achieve the requirements of assisting the elderly to get up.

4.2. Waterproof device
The bathing machine involves the reliability of mechanical structure waterproofing and electrical waterproofing, and the circuit setting of the bathing machine is more complicated, and the number of original moving parts is also relatively large. In order to ensure the safety of the elderly in the bathing process and the reliability of the bathing device, Waterproof safety is particularly important. In the selection of parts, we choose waterproof products to ensure that each part itself meets the waterproof requirements. The connection of each part adopts a sealing design, and the waterproof treatment of the mechanism is realized by adding a sealing ring and pouring epoxy resin.

5. Innovation point
(1) Novel structure and clever design. It adopts innovative spatial linkage mechanism and sine mechanism to realize all-round cleaning for the elderly, and the structure is novel.
(2) Complete functions and convenient operation. The device integrates the functions of head cleaning, back cleaning, and limb cleaning, and can selectively clean body parts. Multiple interactive modes, button control or voice control.
(3) Safe, reliable, intelligent and automatic. It has the function of detecting pulse blood oxygen concentration and heart rate signal, which can detect and monitor the physical condition of the elderly in real time. When the elderly is unwell, the machine can be suspended and an alarm will be issued; it has overload and short-circuit protection functions. When a fatal and dangerous person gets an electric shock, the power can be cut off in time to ensure the safety of the elderly and high safety.

6. Conclusion
By analyzing the current situation of the elderly product market and combining the problems encountered by the elderly in real life, we have designed this auxiliary elderly bathing machine, which can effectively assist the elderly living alone to complete the bathing process by themselves, safe and reliable, improve the quality of life of the elderly and let old people have a happier life in their old age. Compared with the existing market, this device has a broad market prospect and hopes to help more elderly people.

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References
[1] Pu, L.G. (2019) Mechanical Design. Higher Education Press, Beijing.
[2] Liu, H.W. (2017) Mechanics of Materials. Higher Education Press, Beijing.
[3] Sun, P.X. (2017) Engineering Drawing. Mechanical Industry Press, Beijing.
[4] Guo, W.D., Li, S.Z., Ma, L. (2015) ADAMS2013 application examples detailed tutorial. Machinery Industry Press, Beijing.
[5] Li, Y., Zhou, H.Y., Ma, S.Z., Han, X. (2020) The design of the safety protection control system of the smart bath machine based on Arduino. Southern Agricultural Machinery.