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Bionic Nursing Bed

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Abstract: According to the principles of bionic theory, this paper provided a nursing bed. which can be used help user to turn over the body comfortably, exercise legs and back automatically, especially during turning over the body, the three roll-over board like three hands that can help the user to turn over the body, after turning over the body, one of the three boards can be driven back that left the other two boards supporting the body. At that moment, the place of user's back besides the place that supported by the other two roll-over board can be cleaned, in this way, it is very convenient to wash the user's back and help avoid skin ulcer. In addition, the bed can be used to exercise the user's back and legs and to promote recovery of those who are paralyzed. This paper focus on the mechanical design of the roll-over body function, moreover, considering how to design a mechanical to drive two roll-over boards just by one motor.

Key words: Medical equipment; Mechanical linkage; Care bed

I. Introduction

The problem that disabled or paralyzed patient that lying in bed who cannot look after himself without nurse is an important social problem. With the development of living standard, more and more people start to concern about dysfunction groups—elderly patients, disabled, etc and to think about how can take care of users by themselves[1-3]. In recent years, health care equipment has been greatly developed. Devicelink company produced a nursing bed（A.Garg，1991）that integrated care beds and wheelchairs. Japan Murate Machinery Co. Ltd. has developed a multifunctional electric care beds that can be operated at great distance. Chinese Academy of Sciences developed the country's first multi-modal interactive intelligent wheelchair that can communicate with user via voice. From above we can get that different beds has been researched. May be they can satisfied the function of aiding user to exercise the back or help user to roll over body and so on. At the same time, the bed with more function is being studied too.

This paper provided nursing bed. which can be used help user to turn over the body comfortably, exercise legs and back automatically, especially during turning over the body, the three roll-over board like three hands that help the user to turn over the body, after turning over the body, one of the three board can driving back that left the other two board supporting the body. At that moment, the place of user's back besides the place that supported by the other two roll-over board can be cleaned, in this way, it is very convenient to wash the user's back and help avoid skin ulcer.

II. Overall design

The bionic bed is designed for people those who lying in the bed and cannot look after themselves, the bed can help them to roll over body and exercise back or legs .Hence, when we design the bed should meet some requirements as follows:

（1）Security; Since this bed is used for patients, we must make sure that the bed cannot hurt the user firstly.

（2）Nursing function;

（3）Basic functions;

According to the requirements above and the roles of 《People's Republic of China Industry Standard—medical bed》, the overall design was established as follow:

Overall dimensions; According to the design requirements and standards, when Considering the actual needs of user, the overall dimensions of the medical bed was decided: Long*Wide *High=2000*900*500（unit：mm）

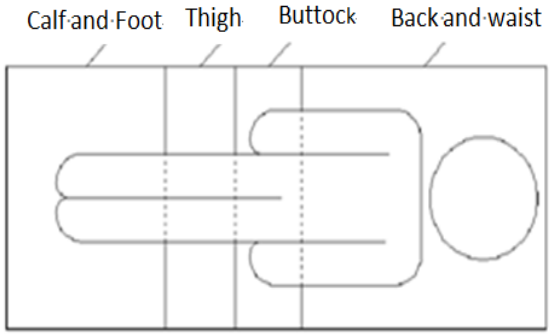

Figure 1 The distribution of body on the bed

In figure 1 we can find that the distribution of body on the bed

According to the data that measured from common people(GB10000-88)，the length of different board used to support the user. The board that used to support the back and waist is 900（mm）long, the board that to support buttock is 300（mm）long, the board that used to support the thigh is 300（mm）long，the board that used to support the calf and foot is 500（mm）long.

The main function of the bionic bed: aiding the user to turn over the body and exercising the back and the waist and thigh and calf. This paper focus on the function of roll over the body. The bed can help users roll over as stable as nurses, after rolling over the body it will be very convenient for cleaning the back of user, the bionic care bed as Figure 2.

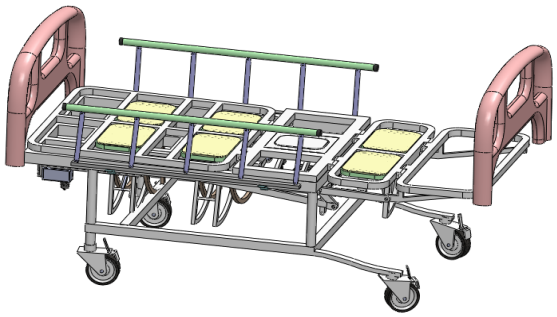

Figure 2 The bionic care bed

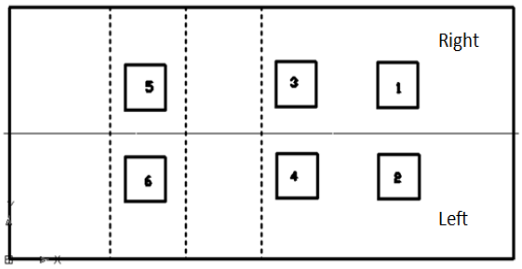

Figure 3 The distribution of roll-over board on the bed

There are six roll-over board distribute on the bed, the distribution of the roll-over board as Figure 3, the back was lying on board 1 and board 2, the waist was lying on the board 3 and board 4, the calf was lying on the board 5 and board 6, every board likes a hand of nurse that be used to aid user to roll over the body. When driving the board 1and board 3 and board 5 to roll over at the same time, the three board will support the right of body to turn towards left. After rolling over the body, one of the three board can be withdrawn and leaving the other two board supporting the body. At that moment, the place of user's back besides the place that supported by the other roll-over board can be cleaned. After driving back different roll-over board, the all the place of user's right back will be cleaned. When driving back the three board at the same time, it will make the user lying on the bed commonly[6-7]. In the same way, when roll over the other three board (board 2 and board 4and board 6), after driving different board ,it will make the user's left back clean.

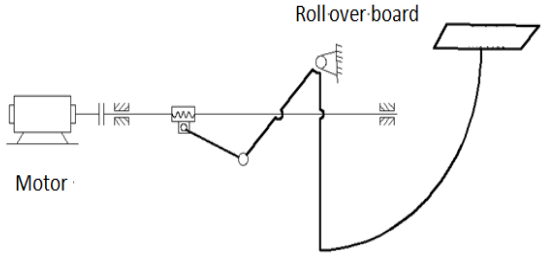

Figure 4 The Schematic diagram of roll-over board mechanism

In order to satisfied the function of turning over the roll-over board stably, the mechanism driven by Screw and the Screw driven by motor, as is shown in Figure 4.The DOF of the mechanical calculated as follow:

$$F = 3n - 2p \qquad (1)$$

We can find that $n = 3, p = 4$, from formula(1)know $F = 1$. That is to say one motor can drive the mechanical to turn over the roll-over board accurately, the function of the roll over the body as shown in Figure 4. In order to analyze the kinematics of the mechanical the coordinate system was established as Figure 5.

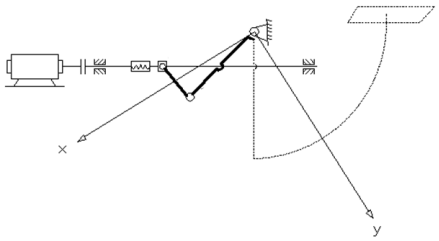

Figure 5 The diagram of the coordinate system

At the coordinate system, we can the fine the geometry relationship between slider and linkages as Figure 6.

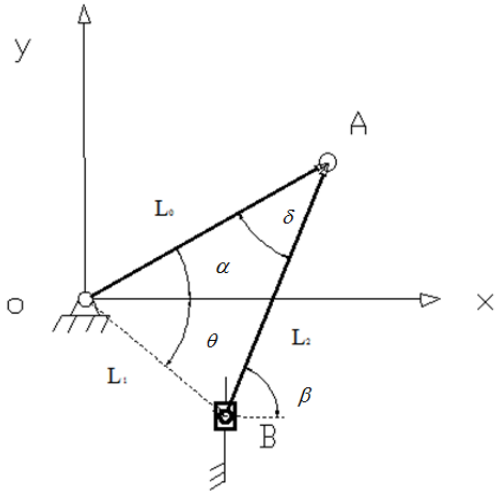

Figure 6 The relationship between slider and linkages

From the Figure 6 we can get the vector equation as fellow.

$$\overrightarrow{L_0} = \overrightarrow{L_1} + \overrightarrow{L_2} \qquad (2)$$

Be equivalent to

$$L_0 e^{i\alpha} = L_1 e^{i(360^0 - \theta)} + L_2 e^{i\beta} \qquad (3)$$

Since $e^{i\gamma} = \cos\gamma + i\sin\gamma$

Can get

$$L_0 \cos\alpha = L_1 \cos(360^0 - \theta) + L_2 \cos\beta \qquad (4)$$

$$L_0 \sin\alpha = L_1 \sin(360^0 - \theta) + L_2 \sin\beta \qquad (5)$$

From the equation (4)and (5) we can fine the relationship between $\theta + \alpha$ and L_1 as fellow.

$$\cos(\alpha + \theta) = \frac{L^2_0 + L^2_1 - L^2_2}{2L_0 L_1} \qquad (6)$$

From the equation (6) we can satisfied the rotation angle of roll-over board by changing the length of L_0. Moreover, we get equation (7)from equation (3) as fellow.

$$i\omega_0 L_0 e^{i\alpha} = L^{\bullet}_2 e^{i\beta} + i\omega_2 L_2 e^{i\beta} \qquad (7)$$

From equation (7) we can get equation(8) and (9)

$$\omega^2_0 L^2_0 = L^2_2 + \omega^2_2 L^2_2 \qquad (8)$$

$$\omega_0 = \sqrt{\frac{L^2_2 + \omega^2_2 L^2_2}{L^2_0}} \qquad (9)$$

In the equation (7) and (8) and (9), ω_0 is the angular velocity of roll-over board, ω_2 is the angular velocity of linkage. From above, we can get the relationship between ω_0 and ω_2.

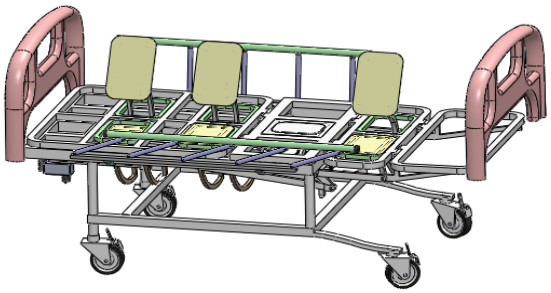

Figure 10 The function of roll over the body

In order to make the three boards on the same sides(likes board 1 and board 3 and board 5 or board 2 and board 4 and board 6) turn over at the same time and can turn back one of the three boards at different time, the three boards was driven by different motor. Since there is no need to drive the different sides boards(such as board 1and board 2) at the same time, we can use one motor to drive the two boards, which can reduce the cost.

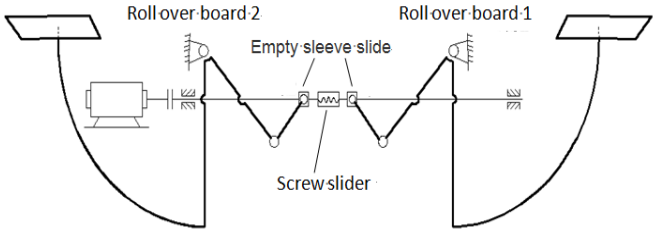

Figure 11 The mechanical linkage of different sides boards

The mechanical linkage of different sides boards as is shown in Figure 11, When the motor is transferred, it will driving the screw slider to slide towards right, and the screw slider will driving the empty slider, then the empty slider will driving the roll-over board 1 to turn over the body. On the contrary, when Motor reversal, it will driving the roll-over board 2 to turn over the body. In this way, one motor can driving two roll-over board effectively.

Besides the mechanical design of roll over function, we should make other mechanical design to exercise back and waist and calf, moreover, the design of some attachments, such as the head of the bed and fence.

III. Control System Design

The design of control system includes the selection of system architecture and the select of master controller. The control system architecture includes the centralized control system with a single CPU and the distributed

control system with multiple CPU.

The CPU of centralized control system complete the data collection and deal with the information and other duties alone, usually be used to some small scales system. Distributed control system consists of a main controller and many slave controller, the controllers are connected by bus and the commands sent to the slave control system from the main controller, usually be used to larger scales system. Since the system of the nursing bed is relatively simple, the centralized control system was selected.

In order to make each board can complete their action alone and action together, this requires a control system to coordinate the action of different boards. The control system is the core to achieve various actions, six boards is the actuator. The control system of the bed needs three AC motors and two straight push rod, the three motor used to driving the roll-over board to turn over the body, the two straight used to driving the mechanism to exercise back and waist and exercise calf and foot [8-9].

IV. Conclusion

This paper focus on the mechanical design of the roll-over body function, moreover, considering how to design a mechanical to drive two roll-over boards just by one motor. According to the principles of bionics theory, this paper given a nursing bed. which can be used help user to roll over the body stably and exercise legs and back automatically, especially during turning over the body, the three roll-over boards on the same side like three hands that help the user turn over the body, after turning over the body, it is very convenient to wash the user's back. In addition, the bed can be used to exercise the user's back and legs.

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