Dual-Purpose Wheelchair Mechanism Designs

Meng-Hui Hsu, Hsueh-Yu Chen, Jen-Yu Liu and Chien-Liang Chen

***Abstract*—A wheelchair with dual-function of sitting and lying is usable to the users no matter what he sits or lies. In addition, if the rear wheels of the dual-purpose wheelchair are designed as movable ones, the whole mass-center of the wheelchair can move between the rear and front wheels of the chair. When the design concept is done, the dual-purpose wheelchair is stable and safe for the users under different operations. This work is to design the new mechanisms of the dual-purpose wheelchair. By applying the creative design method of mechanisms, two new mechanisms of the dual-purpose wheelchair are proposed. This paper also designed a prototype that can prove the proposed method is feasible.**

***Index Terms*—dual-purpose wheelchair, mass-center, creative design method, prototype.**

I. Introduction

Traditionally, a wheelchair is a wheeled mobility device in which the user sits. The device is propelled either manually (by turning the wheels by the hand) or via various automated systems. Wheelchairs are used by people for whom walking is difficult or impossible due to illness (physiological or physical), injury, or disability. People with both sitting and walking disability often need to use a wheelbench. Figure 1 shows an automated wheelchair [1].

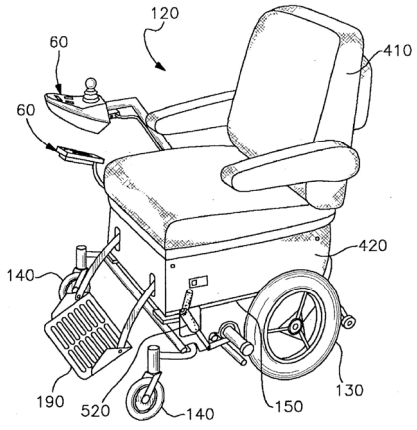

Figure 1 An automated wheelchair [1]

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The wheelchair with sitting function alike as shown in Figure 1 cannot provide enough functions to satisfy users when they need lie or stand. Hence, a multi-purpose is designed to satisfy with different needs. Figure 2 shows a wheelchair with dual-function of sitting and lying. It is usable to the users no matter what he sits or lies [1]. Figure 3 shows another wheelchair with dual-function of sitting and standing [2].

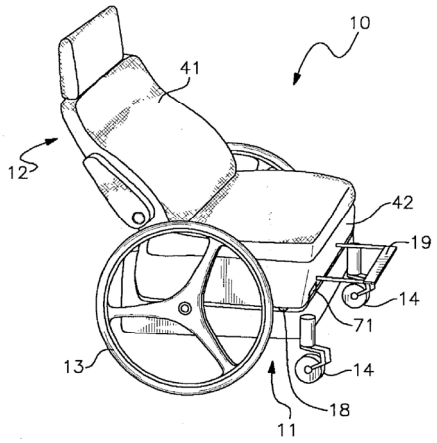

Figure 2 A dual-purpose wheelchair with sitting and lying functions [1]

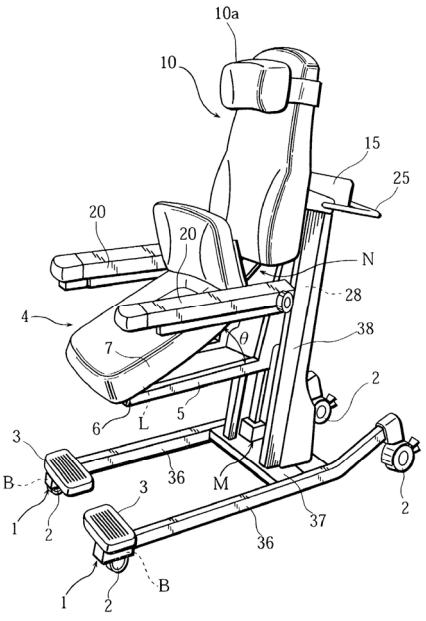

Figure 3 A dual-purpose wheelchair with sitting and standing functions [2]

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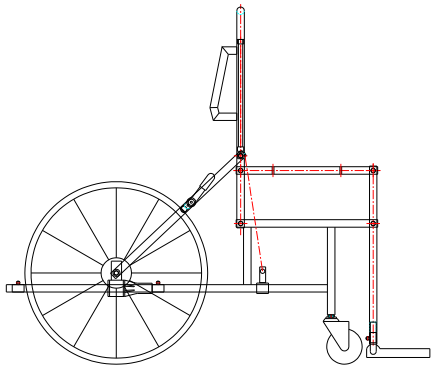
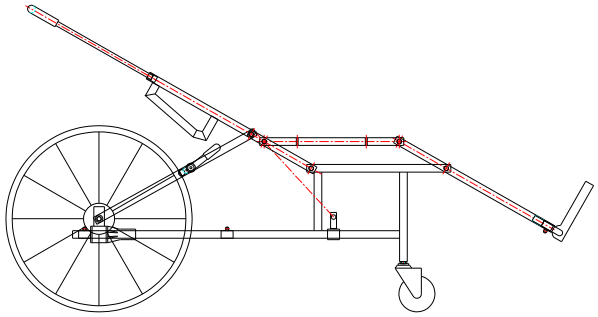
Unfortunately, there is one disadvantage of the dual-purpose wheelchair alike as shown in Figure 2. The disadvantage is that the back link of the wheelchair lies down, the mass-center of the chair moves outside of the wheels such as the gravity force of the chair and user makes the chair be unstable and turn over. Hence, the purpose of this paper is to find a method to avoid the above condition.

II. A New Dual-Purpose Wheelchair Design

We can design the rear wheels of the dual-purpose wheelchair as movable ones, so the whole mass-center of the wheelchair can move between the rear and front wheels of the chair. When the design concept is done, the dual-purpose wheelchair is stable and safe for the users under different operations. Based on the concept, we can design a dual-purpose wheelchair shown as Figure 4.



(a) Wheelchair under sitting state



(b) Wheelchair under lying state

Figure 4 A new dual-purpose wheelchair design

III. Creative Design Methodology

Based on modifications of existing mechanisms, Dr. Yan presents a creative design methodology for the generation of all possible topological structures of mechanisms [3]. Figure 5 shows the flowchart of the proposed methodology for the creative design of mechanisms. The steps are:

Step 1. Identify existing designs with required design specifications that designers would like to have, and conclude the topological characteristics of these designs.

Step 2. Select an existing design arbitrarily, and transform it into its corresponding generalized chain.

Step 3. Synthesize the atlas of generalized chains that have the same numbers of members and joints as the generalized chain obtained in Step 2, based on the algorithm of number synthesis, or simply select the needed atlas from available atlases of chains.

Step 4. Assign types of members and joints to each generalized chain obtained in Step 3, to have the atlas of feasible specialized chains based on the algorithm of specialization to meet needed design requirements and constraints.

Step 5. Particularize each feasible specialized chain obtained in Step 4 into its corresponding schematic format of mechanical device, to have the atlas of mechanical devices.

Step 6. Identify existing designs from the atlas of designs, to have the atlas of new designs.

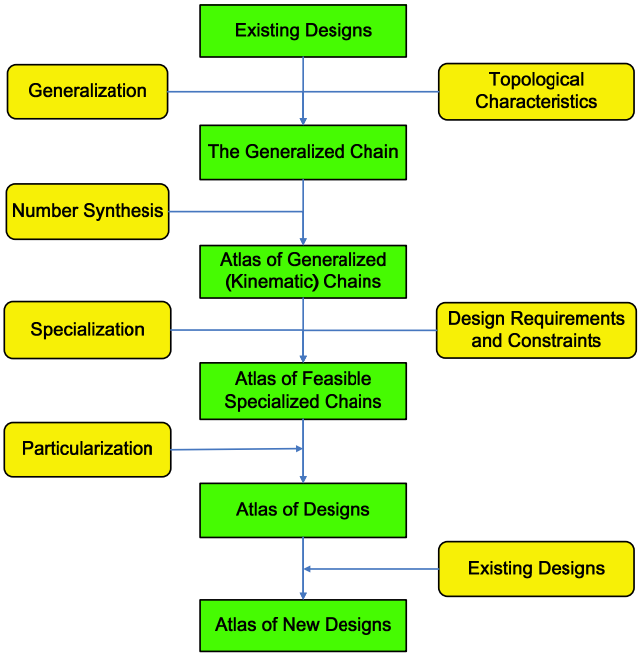


Figure 5 Flowchart of the design methodology [3]

IV. Existing Designs

The first step of the creative design methodology is to define the design specifications of mechanisms that design engineers would like to generate. In the beginning of the conceptual phase for creating mechanisms, only basic specifications regarding topological structures of the designs are of major concern. Then, the characteristics of the topological structure of this wheelchair design are concluded as follows:

1. It consists of five members and six joints.
2. It has one ground link (K_F , member 1), one treadle link (K_T , member 2), one back link (K_B , member 3), one support link (K_S , member 4), and one handle link (K_H , member 5).
3. It has four revolute joints (J_R ,), one prismatic joint

(J_P), and one cam joint (J_A).

4. It is a planar mechanism with one degree of freedom.

The schematic diagram of topological structures for the new dual-purpose wheelchair shown in Figure 4 is shown as Figure 6. The corresponding generalized mechanical structure is shown as Figure 7.

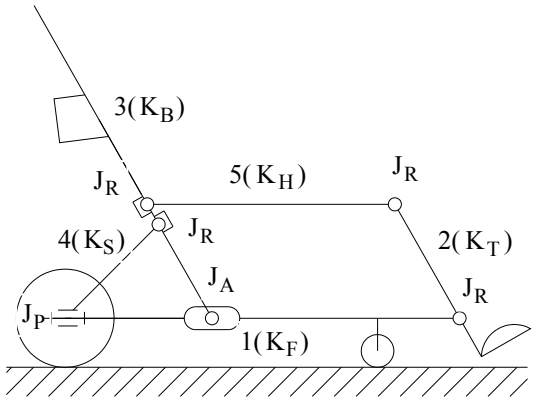


Figure 6 The schematic diagram of the original dual-purpose wheelchair

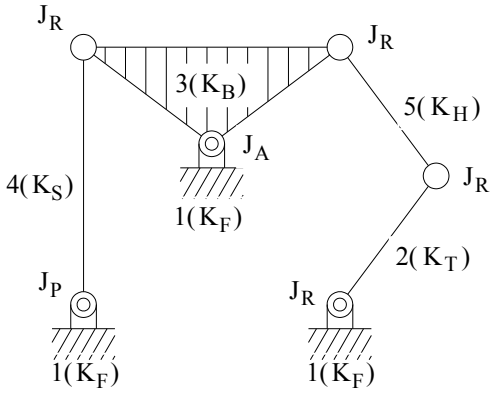


Figure 7 The generaliz mechanical structure of the original dual-purpose wheelchair

V. Generalization

The second step of the creative design methodology is to select a design from available existing designs to serve as an original design to continue the design process. Any existing design can be selected as the original design. This original design is then transformed into its corresponding generalized (kinematic) chain. A generalized chain hasd only generalized links and (revolute) joints. The corresponding generalized chain of the dual-purpose wheelchair is shown as Figure 8.

VI. Number Synthesis

The third step of the creative design methodology is to synthesize all possible generalized chains that have the same numbers of links and joints as the original generalized chain. One of all possible generalized chains is shown as Figure 8.

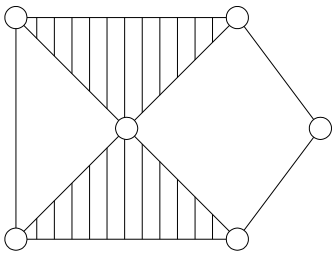


Figure 8 The generalized chain of the original dual-purpose wheelchair

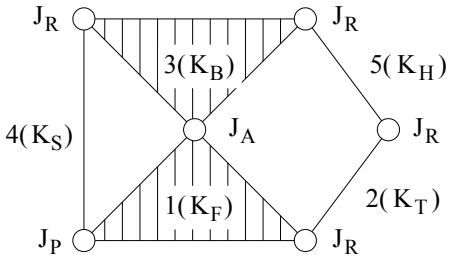
VII. Specialization

The fourth step of the creative design methodology is to assign specific types of members and joints to each available generalized chain, subject to certain design requirements to have specialized chains. Design requirements are determined based on the concluded topological structures of existing designs.

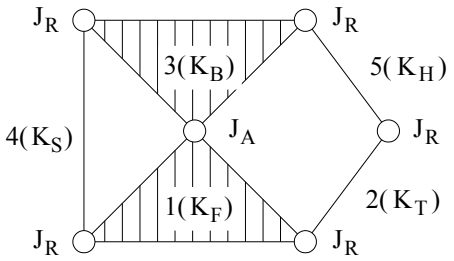
In the example of he original dual-purpose wheelchair, the design requirements are as follows:

1. There must be a ground link (K_F) as the wheelchair body.
2. There must be a handle link (K_H) to install the handle.
3. There must be a treadle link (K_T) to install the treadle.
4. There must be a back link (K_B) to support the back of user.
5. There must be a support link (K_S) to support the back link.
6. There are at least four revolute joints and one cam joint. And the joint incident to the back link and the ground link must be a cam joint.

Figure 9 shows the resulting atlas of specialized chains obtained from the generalized chain shown in Figure 8, subject to the above design requirements.



(a)



(b)

Figure 9 Atlas of (feasible) specialized chains of the original dual-purpose wheelchair

VIII. Particularization

Once a feasible specialized chain is obtained, it is particularized into its corresponding mechanism in a skeleton drawing.

Graphically, particularization is the reverse process of generalization, and can be done by applying the generalizing rules in reverse order. Figure 10 shows the corresponding atlas of designs for the atlas of (feasible) specialized chains shown in Figure 9.

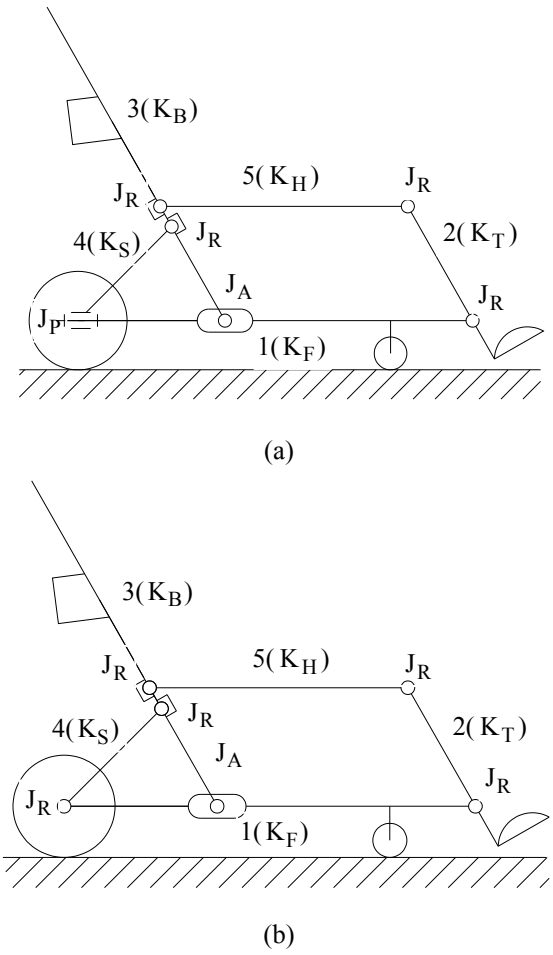


Figure 10 Atlas of designs for the the dual-purpose wheelchair

IX. Atlas of New Designs

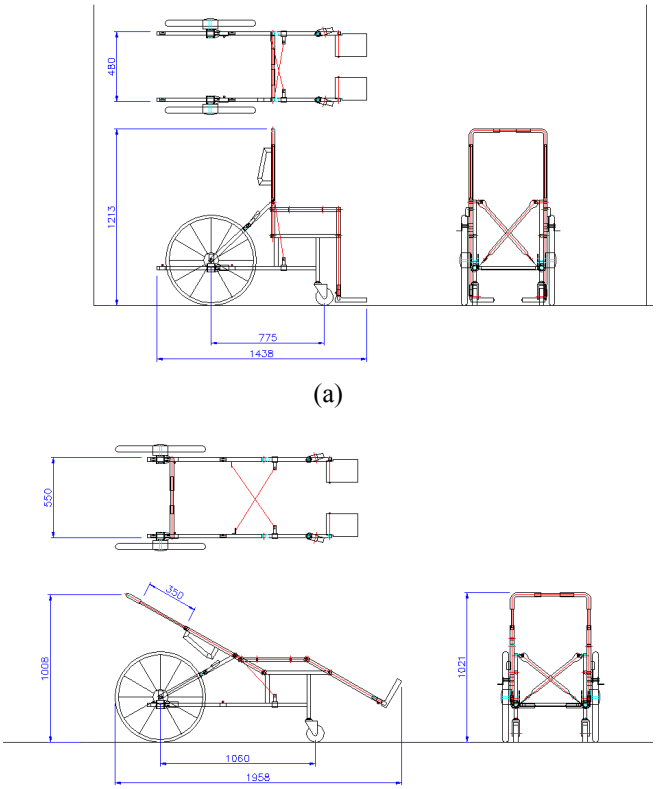
The last step of the creative design methodology is to identify all existing designs from the atlas of designs. Then, those that are not identified as existing designs are new designs.

Existing designs are normally identified from commercial products and exhaustive patent search. Each identified new design gives design engineers an opportunity to avoid patent protections of existing designs and may even lead to a possible new patent.

The design shown in Figure 10(a) is the original design. Therefore, the other design shown in Figure 10(b) is another one new designs for the topological structures of the dual-purpose wheelchair.

X. Setup Prototype

This paper also designed a prototype that can prove the proposed method is feasible and shown as Figure 11 .



(c)

Figure 11 A prototype for the dual-purpose wheelchair

Conclusion

This paper analyses the characteristics of the topological structures of existing dual-purpose wheelchair mechanisms with dual-functions of sitting and lying. This work designs the rear wheels of the dual-purpose wheelchair as movable ones, so the whole mass-center of the wheelchair can move between the rear and front wheels of the chair. The design makes the dual-purpose wheelchair be stable and safe for the users under different operations. This work also designs new

mechanisms of the dual-purpose wheelchair. By applying the creative design method of mechanisms, two new mechanisms of the dual-purpose wheelchair are proposed. Finally, this paper designed a prototype that proves the proposed method is feasible.

ACKNOWLEDGMENT

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