

A movable steering-wheel system for car driving at older ages

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D-A. Wang, T-Y. Wang, Y-C. Lin, M-S. Chiang. A movable steering-wheel system for car driving at older ages. Gerontechnology 2009; 8(2):104-108; doi: 10.4017/gt.2009.08.02.003.00. We propose a new cabin design for cars in use by older adults with disabilities. By using a steer-by-wire system the steering wheel can be retracted in the dashboard and an electric auxiliary seat could function on both the driver and passenger positions to help persons with disabilities and older persons to easily access the vehicle.

Key words: cabin design, movable steering wheel, steer-by-wire

'Driving in old age' has become a significant issue for gerontechnology in the aging society¹. Farber² investigated the potential of telematics applications for enhancing mobility of older people. Charlton et al.³ reviewed the literature relating vehicle design to the safety of older road users. Warmink⁴ discussed vehicle adaptability design for specific disabilities that sometimes occur among older drivers. Motor companies set 'welfare-vehicles' in the market to help older persons and persons with disabilities. Two types exist: barrier free vehicles, and operation-modified vehicles for challenged people. The majority of welfare-vehicles belongs to the first type and solves the problem of get-

ting in and out of the car. They are usually refitted general purpose cars with some assistive equipment. Some motor companies in Japan have included the 'universal design' concept in the vehicle development to satisfy the requirements of the rapidly aging population⁵⁻⁷.

The steer-by-wire technology^{8,9} allows for a novel movable steering wheel concept. The steering wheel may then move automatically into the dashboard since no mechanical linkage exists between steering wheel and the electric assist actuator. This way the driver space becomes roomier and more comfortable, and various interior styles may be

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implemented. We propose a 'geront-vehicle' for both driving assistance and improving the ease of getting in and out of the vehicle.

In order to install assistive equipment in a car, the cabin space must be roomier. Steering wheel, seat mounting brackets, shift rod and central storage box may be in the way when installing an electric auxiliary seat. If the steering wheel could be retracted into the dashboard of the vehicle, most of the assistive equipment normally placed in the passenger seat position could be installed instead on the driver seat position.

STEER-BY-WIRE

The traditional power steering system includes four major components: steering wheel, steering shaft, hydraulic assist case, and steering arm that are linked by mechanical elements (Figure 1a). In modern electrically assisted steering the hydraulic assist case is replaced by electronically controlled sensors and actuators. The sensors determine which way the steering wheel is turning and cause the actuators to provide additional force in that direction to aid the mechanical linkage^{10,11}.

In the next step in steering system evolution, steering column and shaft are omitted. This substitution of mechanical and hydraulic controls by electronic systems is called 'by-wire technology'¹². This idea originates from airplane design. This completely electrical

system is called 'steer-by-wire' (Figure 1b) and has been studied for over a decade⁸⁻¹³. It includes a steering wheel control sub-system and a road wheel control sub-system. Currently, reliability is still a critical issue with studies on fault tolerance, redundancy of the control system and mechanical back up components¹³.

Using steer-by-wire allows for the whole steering wheel component to retract into the dashboard when desired. This results in a squarer cabin space (Figure 2). The movable steering wheel system rotates around the horizontal axis and moves along the linear guide automatically. Combining this with additional advanced vehicle technologies, such as brake-by-wire¹⁴, acceleration-by-wire¹⁴, global positioning system (GPS)¹⁵, and other assistive equipment, will help older adults to use the vehicle conveniently, safely and independently.

PROPOSED CABIN DESIGN

The sedan car is chosen as the platform of a 'geront-vehicle' as proposed by us. It has the flat cabin floor, long guides and the movable central storage box. When the driver parks the car and takes a rest in the cabin, the front seats could be pushed very far back. Since the steering wheel is retracted, the space between the front seats and the dashboard will be very wide. The movable central storage box could slide anywhere along the long floor guides. This design suits a couple to

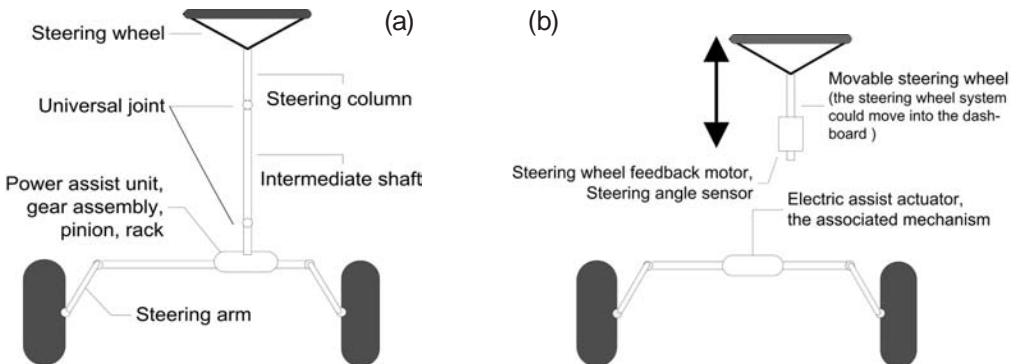


Figure 1. Schematic diagram of power steering system; (a) traditional power steering system; (b) steer-by-wire system with a movable steering wheel

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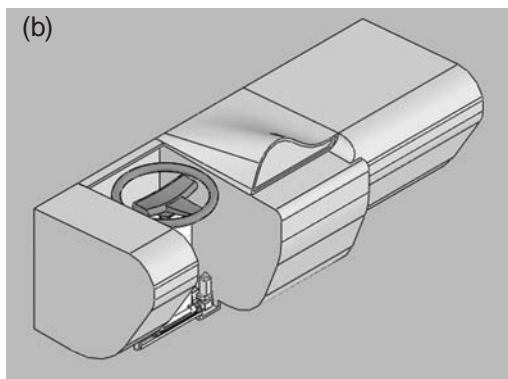
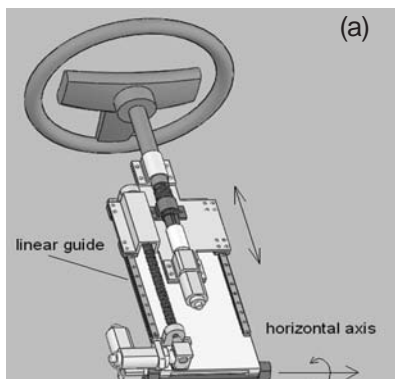


Figure 2. The concept of a movable steering wheel system; (a) movable steering wheel; (b) steering wheel retracted into the dashboard

enjoy the driving experience (Figure 3). The vehicle may also be equipped with an electric auxiliary seat for persons with disabilities who wish to drive the vehicle. In addition, the electric auxiliary seat may function as an independent wheelchair outside the vehicle (Figure 4). Moreover, the acceleration-by-wire and brake-by-wire could also be integrated around the steering wheel or near the dashboard. The total set-up will assist independent mobility in older persons and persons with disabilities.

Except for the rotation of the steering wheel itself, the mechanism of the movable steering wheel system (Figure 2), has two degrees-of-freedom: rotational motion and linear movement. The system design of the movable steering wheel allows drivers to adjust the rotation angle and position of the steering wheel to where they feel comfort-

able to drive. The selection range is wider than the usual steering wheel (Figure 5), and we propose to add a 'driving posture module' (see below) to provide the best suited driving posture for the individual driver.

REQUIRED TECHNOLOGIES

Several key technologies are needed to realize a full-scale geront-vehicle: movable steering wheel, electric auxiliary seat, driving posture module, remote access control, emergency call facility, etc. An assistive module should integrate these technologies. Human factors and ergonomics studies are needed for the combination of the technologies in this module and the car at large, before such a geront-vehicle can be produced. Perhaps someday this car may not only be suitable for older adults or persons with disabilities but will also be considered a favorable alternative for a wider market.

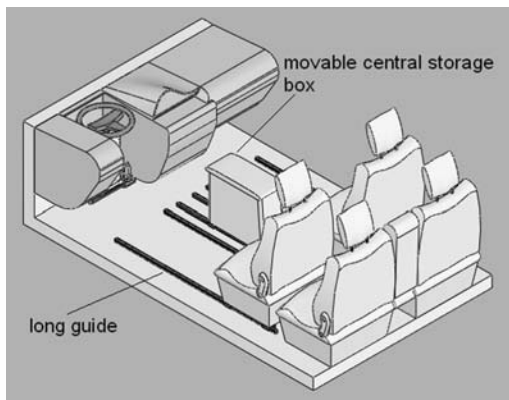


Figure 3. Possible cabin design

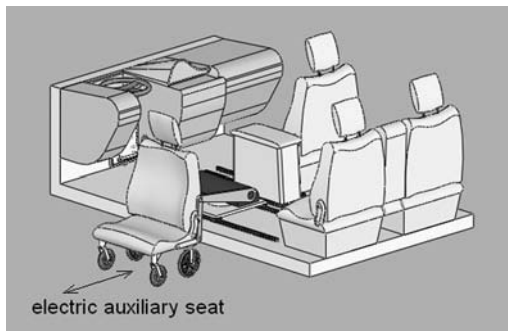


Figure 4. The electric auxiliary seat, which could function as an independent wheelchair outside the vehicle, is placed in the driver seat position

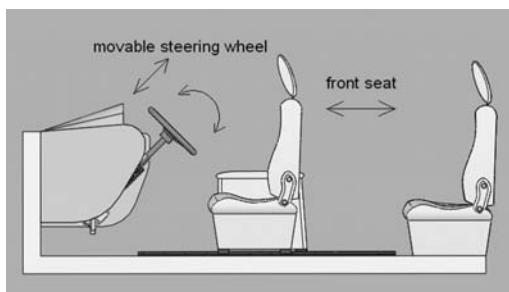


Figure 5. The driving posture module

The movable steering wheel

The movable steering wheel is a key point in the cabin design. It is a mechatronic system that could be accomplished when the steer-by-wire technology is well developed. In fact this concept could be more widely adopted, or perhaps the steering wheel could be exchanged for a revolutionary way of interacting with the automobile.

A driving posture module

Because of the physical aging of older adults, their driving postures may be different from younger people. A 'driving posture module' (Figure 5) is a control unit, which integrates the movable steering wheel system and the electric seat. This module could adjust the movable steering wheel and the electric seat automatically to the position and angle that the user has set. In order to meet automotive electronic specifications, the module needs a CAN-bus architecture^{5,6,13} to access the central computer of the automotive.

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Remote control

The remote control is a convenient and useful function to access the vehicle quickly. This function is integrated in the vehicle security system or the posture module. When the user presses the remote key button to open the vehicle, the geront-driving posture module will execute immediately, and the electric auxiliary seat will move to the destined position and stand by. When the car door is opened, the electric auxiliary seat moves out directly and the total time to board the vehicle is reduced.

Additional

Other by-wire technologies, such as acceleration-by-wire and brake-by-wire, could also be integrated to help physically challenged people drive their cars effortlessly. Due to a person's aging, an emergency call function may be needed. By the application of GPS and telematics technologies¹⁵, the service center of an older person's dwelling is quickly informed of the car's position.

CONCLUSION

We propose a new cabin design for cars in use by older adults with disabilities. It is based on a steer-by-wire system for a steering wheel that can be retracted in the dashboard. It allows for the electric auxiliary seat to function on both the driver and passenger position. Required technologies include both off-the-shelf are still to develop products that are integrated an assistive module to provide better car access and driving for elderly persons and persons with disabilities.

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