

Development of Handle Type Electric Wheelchair Simulator

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ABSTRACT

Enhancing the understanding of traffic rules and the ability to anticipate the potential dangers in mixed traffic of pedestrians, bicycles, motorcycles, automobiles, and the like, would be an effective way of helping to prevent accidents for the electric wheelchair users. A handle type electric wheelchair simulator was accordingly developed to enable people to safely experience those potential dangers.

The simulator was given two configurations. The actual wheelchair type combines an actual wheelchair with a personal computer and large-screen display. The widespread use type has a steering handle unit and a notebook computer. The simulator screens are set up to be easy to follow and easy to operate for the elderly user, and the narration employs a frequency range that is easier to hear. A module that enables test subjects to check their own physical functionality and judgment capability was also included. The traffic scenario experience module was configured with several scenarios for situations that could easily turn dangerous, based on the particulars from a number of accidents.

This enables not only electric wheelchair users but also people who have never operated an electric wheelchair to have a driving experience by means of a simulator. It also enables traffic safety lectures to be held with a simulator experience included as part of the program.

1. Background

Recent years have seen the use of handle type electric wheelchairs as a means of transportation for many people who find walking difficult. The Japanese Industrial Standards classify these as the joystick standard type and the handle type. The handle type comes in three-wheel and four-wheel versions.

Ownership of electric wheelchairs⁽¹⁾ is increasing, and the demand for handle type models is high (Fig. 1).

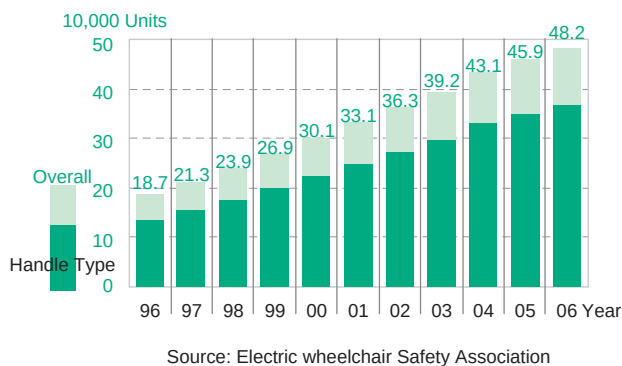


Fig. 1 Number of electric wheelchairs owned

The aging of society is bringing developments in the legal system (the Transportation Accessibility Improvement Law of 2000) and infrastructure. The use of electric wheelchairs is expected to increase accordingly. However, the growing number of users is paralleled by a rise in the number of electric wheelchairs involved in traffic accidents (Fig. 2).

Approximately 70% of electric wheelchair users who encounter accidents are aged 65 or over. Accidents

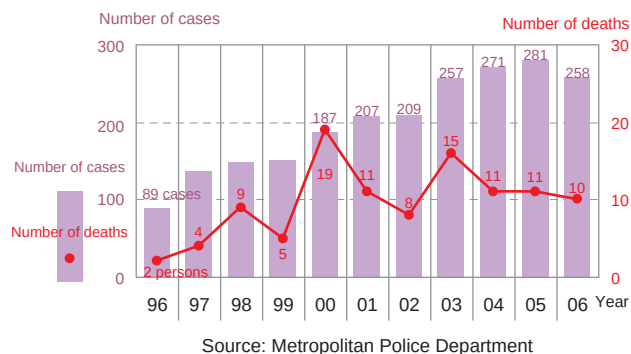


Fig. 2 Electric wheelchair transition of the number of traffic incidents and deaths

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involving contact with a motor vehicle while crossing a street are the most common (Fig. 3). In addition, many of the people who operate electric wheelchairs have not had automobile driver's licenses, amounting to 48.2% (reported at International Association of Traffic and Safety Sciences in 2002).

Electric wheelchair users need to be aware of the distinctive characteristic of electric wheelchair accidents enumerated below:

- (1) Electric wheelchair riders are positioned relatively low to the ground, making them less visible for automobile and other drivers.
- (2) The top speed of electric wheelchairs is fixed by law at 6 km/h, so that they require time to take evasive action.
- (3) Electric wheelchairs may enter the roadway when sidewalks are blocked by steps or obstacles.

As a manufacturer of motorcycles and automobiles, Honda has long proclaimed the concept of "safety coexistence," which seeks the safety of all people who live together in the mobility society. Honda is therefore engaging in safety initiatives by both technological (meaning hardware-based) and educational (meaning software-based) approaches.

In terms of vehicle-related measures, Honda considered the heightening of visibility for automobile drivers. Measures were taken on the number and placement of

lamps and lights on the Monpal ML200^{(2),(3)} with the adoption of Honda's ASV-3 LONG design. This raised the likelihood that automobile drivers could judge the distance to an ML200 by approximately 10%, compared to the first generation ML100.

On the other hand, approaches from the "soft" side include the provision of safety guidance at the time electric wheelchairs are purchased. Electric wheelchairs are conveyances that the Road Trucking Vehicle Law classifies as pedestrians, and a driver's license is not required. Honda has therefore been training wheelchair operation instructors and providing guidance in methods of operation and traffic rules, from the time the Monpal ML100 went on sale in 1999. (Fig. 4)

2. Development Purpose and Goals

Honda also seeks to provide users of these wheelchairs with a better understanding of traffic safety. In addition to guidance in wheelchair operation given at the time of purchase, Honda employs simulators that allow users to safely experience the kinds of incidents that can occur in actual operation on the streets. Honda has established a record with motorcycle and automobile simulators.^{(4),(5)} That experience was put to use in planning the development of a handle type electric wheelchair simulator with a focus on the potential users of electric wheelchairs and their family members.

The following development objectives were determined:

- (1) Ease of use by the elderly
- (2) Size and configuration to allow use at locations where potential users gather
- (3) Capability for objective assessment of electric wheelchair operating ability and judgment capability

Since many users are elderly, a method of development based on user interaction was adopted.

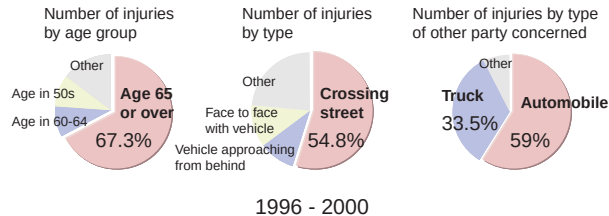
3. Simulator Construction and Content

3.1. Simulator Construction

3.1.1. Widespread-use type simulator

A simple simulator using the steering handle unit from an actual wheelchair together with a notebook computer was first made in order to collect customer comments and impressions. This simulator was taken to welfare equipment exhibitions, traffic safety lectures, and other such events, and people's comments were collected. That data was organized systematically, the corresponding technologies were applied, and the resulting simulator would then be tried out by test subjects. This process was repeated in order to pursue ease of use (Fig. 5).

The steering handle unit was equipped with a screw clamp to make it more convenient to mount on ordinary desks and tables. In order to reproduce the direct forward motion experienced in actual operation, the unit was



Source: International Association of Traffic and Safety Sciences 2002

Fig. 3 Current breakdown of handle type electric wheelchair injuries



Fig. 4 Guidance by the safety instructor

equipped with a return spring that brings the steering handle back to a neutral position (Fig. 6).

Wheelchair users were observed using these simulators from their own wheelchairs. Given this observation,



(a) At a driving school



(b) At a safety promotion event

Fig. 5 User interaction type development technique

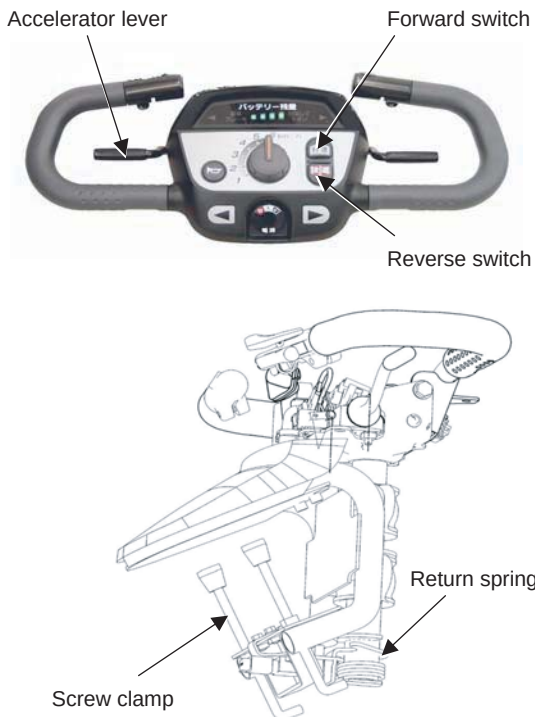


Fig. 6 Appearance of version for widespread use

together with the ease of installation and maneuverability of the simulators, it was confirmed that they could be used to provide simulated experience to larger numbers of people (Fig. 7).

3.1.2. Actual wheelchair type simulator

This simulator was envisioned for use at gatherings with large numbers of people so that beginners coming into contact with electric wheelchairs for the first time could have a more realistic simulated experience of actually riding in a wheelchair. The simulator was therefore made by combining an actual wheelchair with a large wide-screen display (Fig. 8).

The Monpal ML200 implements controller area network (CAN) communications between the motor drive unit ECU and control panel unit ECU in order to realize advanced fault diagnostics and reduce the number of harnesses. Sensor values from the drive lever are converted to digital data by a circuit board in the control panel and transmitted by CAN.

That communications data was used in this simulator in order to simplify the system. Moreover, connection to the diagnostic computer interface on the Monpal ML200



Fig. 7 Simulator operation by a wheelchair user



Fig. 8 Simulator configuration

enables simple setup and helps eliminate the need for dedicated simulator equipment. This system is therefore made easy to introduce at dealers that have actual wheelchairs on hand (Fig. 9).

3.2. Simulator content

3.2.1. Screen easy to see and narration easy to hear

Various measures were also devised in terms of content to help potential users who are considering use of an electric wheelchair gain a better understanding of traffic manners and rules.

The display was designed for ease of operation and a sense of security, removing the tension and apprehension that might be felt by the user when faced with a personal computer.

The menu is composed of folders that contain material under the three main categories of “Learning Operation,” “Learning How to Drive on the Street,” and “Other.” The menus within those folders are indexed so that users can easily look over their overall contents (Fig. 10).

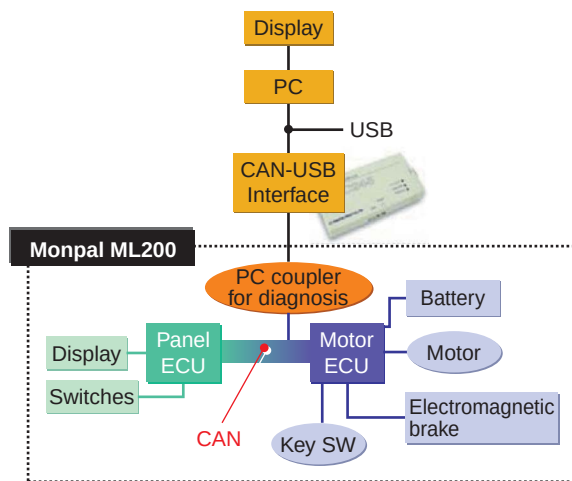


Fig. 9 Diagram of CAN-USB system



Fig. 10 Indexed menu

The simulator displays text using large, high-contrast characters that make the screens more easily visible.

The narration was also made easier to hear for the elderly by boosting the sound pressure in the 250-1000 Hz low-frequency band, based on the average hearing threshold level by age group⁽⁶⁾ (Fig. 11).

3.2.2. Practicing basic operation and checking physical functionality (visual acuity, delay in movement)

There were requests to make the simulators usable for objectively checking the physical capability of customers in their operation of electric wheelchairs (their reaction speed, grip strength, and so on) as well as their judgment capability where the wheelchairs are sold, and to make them useful in providing safety guidance. Among people interested in using electric wheelchairs, and their family members, a need was also felt for information on which to base decisions on whether they are suited to operating these wheelchairs.

The menu has an “Other” folder that provides access to functions for practicing basic operation as well as for measuring physical reaction speed, visual acuity and judgment capability.

Practicing basic operation involves becoming accustomed to how the wheelchair comes to a stop when the accelerator is released, which is a distinctive feature of electric scooters. There are driving practice courses where customers can learn this maneuver and the actions of going forward, turning, and stopping.

The screen for measuring delay in reaction movement works by having a traffic signal up ahead turn red while the test subject is driving and measuring how long the test subject takes to release the drive lever (to come to a stop). That time is displayed at the bottom of the screen (Fig. 12).

The screen for measuring visual acuity and judgment capability displays a message board with a brief written instruction. As the user drives, this gradually becomes larger. The user's approximate visual acuity can be extrapolated from the size of the text at the point when

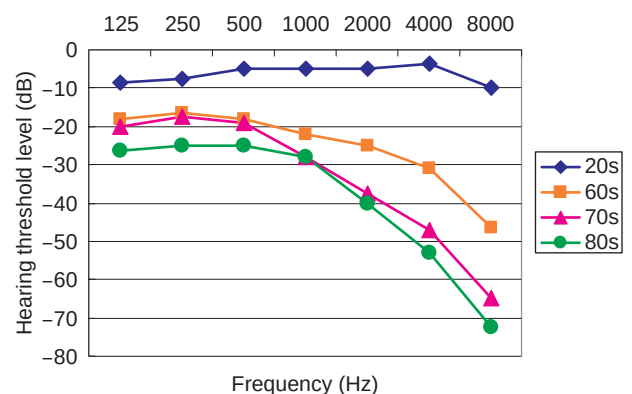


Fig. 11 Average hearing threshold level by age group

the user reads the instruction and carries out the indicated action. The visual acuity measurement is displayed at the bottom of the screen (Fig. 13).

These functions allow the test subjects to understand their physical and judgment capabilities for themselves. The flowcharts for these functions are shown in Fig. 14.

3.2.3. Setup of traffic scenarios

Analysis was made of actual accident particulars obtained from electric wheelchair accident statistics and from surveys of dealers and customers. The following traffic scenarios were selected for simulation:

- (1) Obstacle on the roadway
- (2) Intersection with traffic signal
- (3) Going over a railroad crossing
- (4) Pedestrian crossing without traffic signal
- (5) Vehicle crossing the sidewalk
- (6) Intersection with poor visibility
- (7) In crowds of people
- (8) Vehicles backing up
- (9) Face to face on a farm road
- (10) Going through automatic doors
- (11) Using an elevator



Fig. 12 Measuring delay in reaction movement

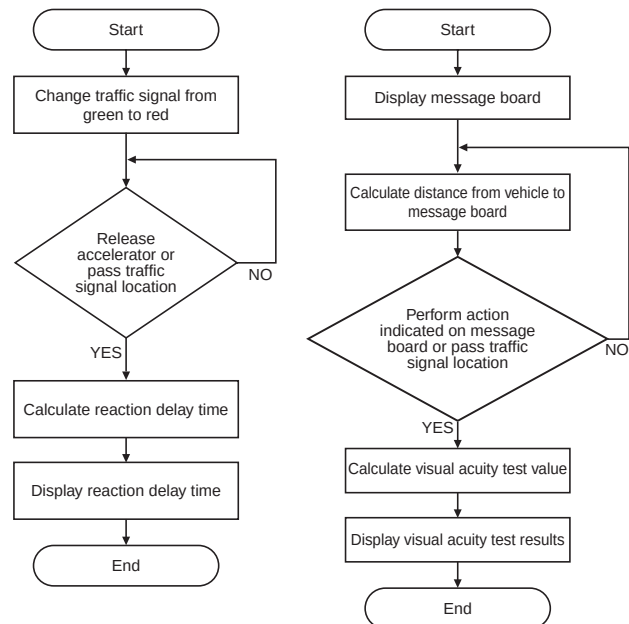


Fig. 13 Vision test

Scenarios can be combined to match the test subject's skills and learning objectives. The period of the virtual driving experience in these scenarios was shortened to approximately three minutes. This measure was devised so that test subjects would remain interested in the simulation, and so that more people would be able to experience the simulator when it is used at traffic safety lectures and other such events where learning times are limited (Fig. 15).

3.2.4. Ride simulation using imagery of actual scenes

A system that uses imagery of actual scenes rather than imagery generated by computer graphics was also made. A video camera was installed on a Monpal ML200, which was then operated on city streets and in parks. That video imagery was edited and the simulator was set up so that manipulating the Monpal simulator controls would cause



(a) Delay in reaction movement

(b) Vision test

Fig. 14 Flow chart



Fig. 15 Scene across a railroad crossing



Fig. 16 Scene of a junction

the video image to move. This system possesses the following functions:

- (1) Moving and stopping: Pressing down on the drive lever causes the video to play back, and releasing the drive lever pauses the video.
- (2) Speed control: The video plays back in slow motion according to the indicated speed.
- (3) Moving forward and moving in reverse: During forward movement the video plays back as normal, and during reverse movement the video plays back in reverse.
- (4) Branch in the road: At predetermined junctions, turning the handle causes the video to switch to imagery of the branch the wheelchair is moving into (Fig. 16).
- (5) Riding locations can be selected from the menu.

This system does not enable as much freedom of movement as in screens generated by computer graphics, but it enables users to experience something of the sensation of riding in actual urban settings and was devised to make people want to go out in their electric wheelchairs. Video imagery of local urban scenes in the user's community can also be utilized to make the simulator feel more familiar and approachable.

3.3. Comments from users

The simulator has been used to date by approximately 30 test subjects. The comments that have been received, based on their experiences, included the following:

"It gave me a sense of security to be able to train on the simulator before riding on an electric wheelchair."

"Its compactness and transportability are good."

"We would like to have the use of these at traffic safety lectures and senior citizens clubs."

The intention for the future is to evolve the system to provide greater educational effect, including methods of operation.

4. Conclusion

A handle type electric wheelchair simulator was developed for the purpose of providing training in traffic rules and manners to the elderly people who drive such

wheelchairs, as well as enhancing their ability to anticipate danger. This handle type electric wheelchair simulator possesses functions and characteristics as follows:

- (1) There are two simulator types, one using an actual wheelchair and one for widespread use, which can be selected to suit the size and purpose of the safety lecture;
- (2) The operating menu is simple and easy to use for elderly people;
- (3) The simulator can be used for learning basic operations (learning before riding an actual wheelchair);
- (4) It can be used to check physical capabilities; and
- (5) It enables experience of potentially dangerous situations in mixed traffic.

This has enabled not only electric wheelchairs users but also people who have never operated an electric wheelchair to have a driving experience by means of a simulator. It has also enabled traffic safety lectures to be held with a simulator experience included as part of the program.

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