

Development of Bicycle Simulator for Safety Riding Education

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ABSTRACT

Lifelong Education of Traffic Safety necessitates educating not only motorcycle and automobile drivers but also giving traffic safety education to bicycle users who may not have driving licenses. A “Bicycle Simulator” was developed for teaching safe riding to a wide age range, with effective functions to teach traffic rules and manners and enhance the student’s ability to predict risks.

1. Introduction

People of a wide age range use bicycles in Japan for all types of reasons, including everyday transportation and leisure. According to the Japan Bicycle Promotion Institute (JBPI), the number of bicycles owned increases year by year⁽¹⁾ (Fig. 1). In addition, the fact that bicycles create little environmental burden as a means of transportation is expected to further promote their use.

However, a look at accident statistics from the Institute for Traffic Accident Research and Data Analysis (ITARDA) shows that accidents increase proportionately with increases in bicycle users, and there has been a rapid increase in accidents involving pedestrians in particular⁽²⁾ (Fig. 2). Moreover, because no license is required to operate a bicycle, there is little sense of the bicycle as a light vehicle under traffic law, with the accompanying obligation of bicycle riders to obey traffic laws as they ride. For that reason, the fact that some riders violate rules and manners is widely seen as a social issue. Under the circumstances,

creating a healthy transportation society necessitates preparing a road infrastructure, offering administrative guidance and providing further traffic safety education for bicycle operators.

The Bicycle Simulator gives users a way to safely experience the risks involved in mixed traffic situations, which would be difficult in actual transportation settings. By this means, the user can objectively review, understand and grasp his or her own operations. Honda has developed motorcycle and automobile simulators that can be used as part of the curriculum at driving schools, as well as a “Riding Trainer”⁽³⁾ that lets users learn safe bicycle operation at nearby motorcycle shops. To take advantage of that experience, and to help achieve lifelong education of traffic safety as part of its obligation as a mobility enterprise, Honda has developed the “Bicycle Simulator,” which can be used effectively by a wide age range of users.

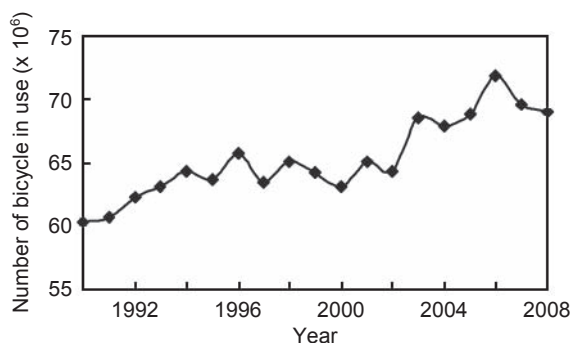


Fig. 1 Number of bicycles in Japan

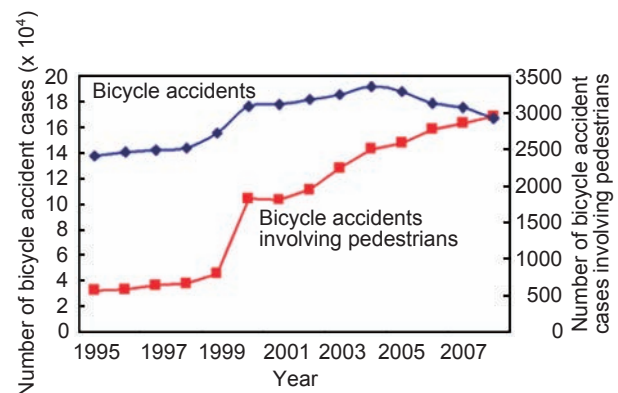


Fig. 2 Number of bicycle accidents and those involving pedestrians

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2. Traffic Accident Situation and the Current State of Bicycle Training

As the bicycle accident factors in ITARDA's accident statistics indicate, violations of safe driving obligation, violations of intersection safety traffic obligation, stop sign violations, etc., have a rather high percentage, and about 70% of bicycle operators commit some kind of legal violation⁽⁴⁾ (Fig. 3). Additionally, a look at bicycle-related traffic accidents by age group indicates that, while those involved comprise a wide age range, from children to senior citizens, the highest percentage is among operators aged 19 and younger, who account for about 30% of accidents⁽⁴⁾ (Fig. 4). This suggests that an effective way to help reduce bicycle accidents is to provide traffic rules education and risk prediction training starting in childhood, when bicycle operators are just beginning to experience road traffic⁽⁵⁾.

There already are many examples of bicycle safety education, including bicycle clinics given by police departments, general learning time at schools, club activities, and as part of the local activities provided by driving schools and automobile dealers. According to documents of the National Police Agency⁽⁶⁾, bicycle clinics are being given more frequently. In 2005, 2.53 million people attended about 22,000 such events. Typical educational techniques include classroom learning,

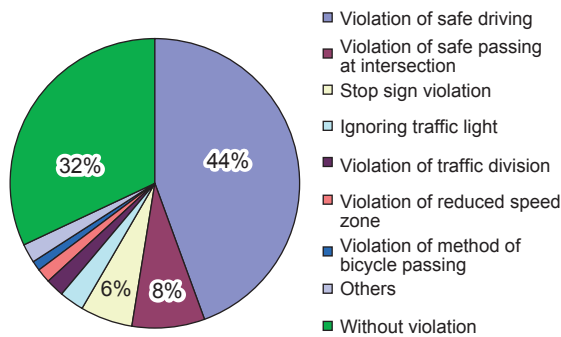


Fig. 3 Bicycle accident factors (2008)

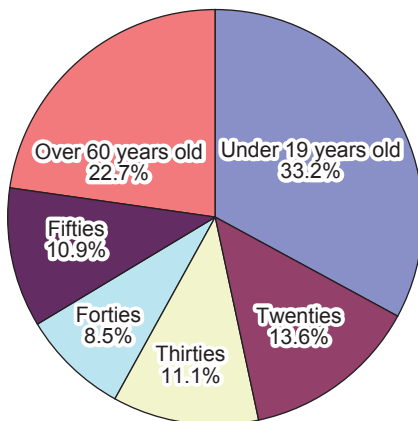


Fig. 4 Ratio of traffic accidents related to bicycles according to age group

simulations of road conditions in open-air spaces, and checking safety when passing through intersections, during takeoff and in places with poor visibility. Increasingly, traffic safety education is being given not only to young children and students, but also in bicycle clinics for senior citizens and events that mix three generations (children, parents and senior citizens). However, it has been said that bicycle safety training is not yet sufficient for all ages, and that in general "there is no sign of the participating children and students being self-directed"⁽⁷⁾. It is desirable that new initiatives be taken that provide highly effective training and create interest among the participants.

3. Configuration of Simulator

The Bicycle Simulator developed by Honda is shown in Fig. 5. The simulator consists of a front monitor, monitor stand, controlling PC, main body and rear view monitor. It is designed for easy mobility, dismantling and reassembly for transportation, in order to conform to the circumstances in which bicycle clinics are given. The main body, just like an actual bicycle, has an operating system with a handlebar, brake levers and pedals.

Because both children and adults use them, the handlebar and seat can be moved up and down, and the adjustment direction of the handlebar has also been taken

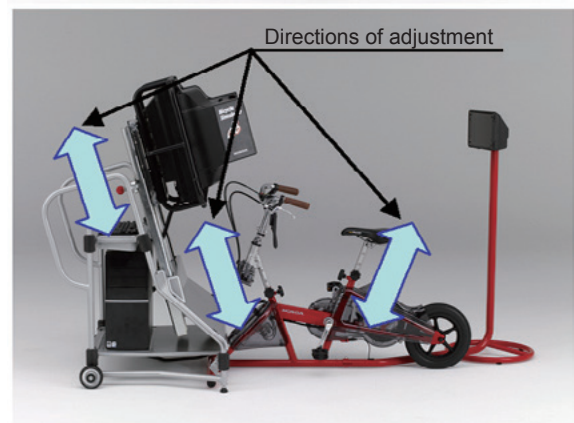
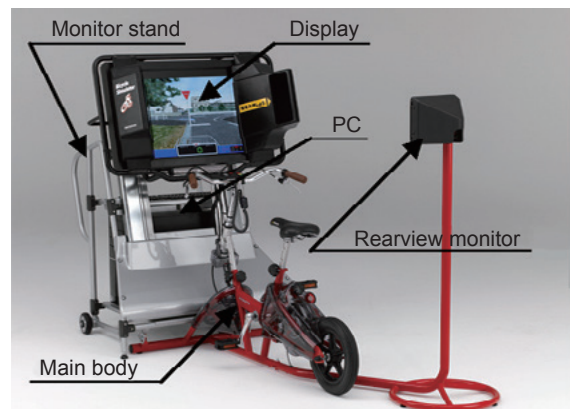


Fig. 5 Bicycle Simulator

into account. The front monitor height adjuster uses a mechanism that combines a gas damper and slide rail so the monitor can be moved up and down without too much force, making it easy to adjust to a height suitable to the user's line of vision. Handlebar operation and pedals put an appropriate burden on users so that their experience is true to that of actual road riding.

The Bicycle Simulator is designed for riders as young as five-year-old children, about the age when people start riding bicycles. To confirm whether children can actually have safe experiences with the simulator, Honda did field tests at kindergartens. The tests looked at whether any part of the simulator could cause injury or whether mischief could lead to concerns, and Honda incorporated these issues into the specifications.

To keep the simulator affordable and save space, a single PC was used to operate the controller, including video and audio. The part ridden by the user and the PC were designed to interface by USB.

The simulator was also equipped with "Mirror Boxes" for checking safety to the sides, a "Rear View Monitor" for the same check to the rear, and a "Step Sensor" so that the user could act as if walking and pushing the bicycle. Together, these mechanisms let the rider master the vital act of checking for safety as a function conforming to the content of bicycle clinics. Device details are given in the next chapter.

4. Characteristics and Functions of the Simulator

4.1. Side Safety Check Function

To help the user develop a habit of checking for safety to the sides at intersections with poor visibility and in alleys, it is necessary that the simulator have a function that makes the user perform side safety checks. This function has been realized in the simulator by a combination of screen partitions and Mirror Boxes. The monitor screen is partitioned into four parts: a central field that displays the front view, left and right fields that give smaller displays of the left and right views, and a rear field that displays the rear view (Fig. 6). The smaller views displayed by the left and right fields are magnified by Fresnel lenses, and there is a mechanism built into the Mirror Box to change the angle of view by 90° using mirrors (Fig. 7). As a result, in order to check safety to the side, the user has to move his or her upper body forward to look into the Mirror Box, encouraging the user to develop the habit of using his or her body when checking side safety. This also helps reduce cost and space, since a single monitor can provide the same functionality as if monitors had also been placed on the left and right.

Because the central, left, right and rear fields are all displayed on the front monitor, a projector can be connected to show the same video on a screen, allowing observers other than the user to see the same riding status

as the user. This makes the simulator easy to use in group teaching.

4.2. Rear Safety Check Function

Just as in the case of checking side safety, it is necessary to have repeated actual practice in checking rear safety to make this a habit during takeoff or when changing line of travel, so a Rear View Monitor (8" screen with USB connectivity) is provided. The video of the rear field as shown on the front monitor is cut out by software and shown on the Rear View Monitor, where the rear traffic situation is shown (Fig. 8). When the simulated bicycle is stopped, this monitor shows a number superimposed on

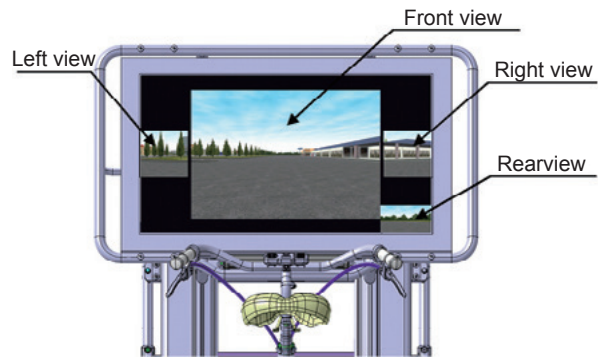


Fig. 6 Screen image

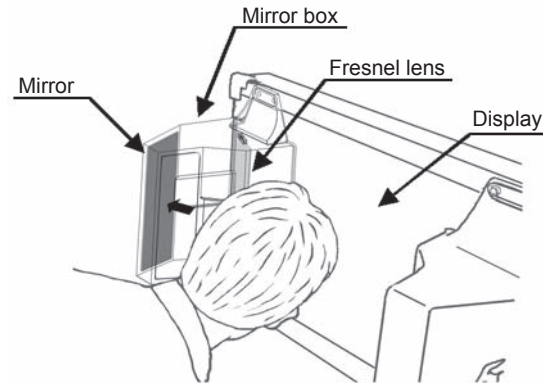


Fig. 7 Structure of "Mirror Box"



Fig. 8 Photo of "Rearview Monitor"

the rear video. The user looks back to check the number, then presses the number button of the “Handle Switch” that is on the handle (Fig. 9). If the number of the button pressed matches the number displayed on the screen, the simulator makes an affirming sound that indicates the user made the rear check correctly. If the numbers do not match, a buzzer sounds, or if the user takes off without checking and pressing a button, the simulator gives a warning encouraging him or her to check, thereby developing the habit of checking to the rear during takeoff.

During the early stages of development, developers did the same thing using only a three-color LED display device⁽⁸⁾; with this mechanism, however, evaluations of field tests indicated that the user could not make decisions in keeping with circumstances because he or she did not understand the rear traffic conditions when turning to the rear. Based on these results, the current monitor specifications were adopted allowing display of rear traffic conditions.

4.3. Walking and Pushing Function

Articles 17 and 63 of the Road Traffic Law (Japan) state that when operating a bicycle, the rider must dismount and walk and push the bicycle on pedestrian-only walkways and in crowds of people, or any time that the bicycle would be an obstacle to pedestrians, such as in pedestrian crossings, but in general these rules are not well known. In order to teach these points, a function was added to simulate walking and pushing the bicycle. A specially designed Step Sensor is used to detect this walking and pushing action (Fig. 10). Inside the Step Sensor is a semiconductor-type three-axis acceleration sensor. The user dismounts from the bicycle, puts the Step Sensor on his or her waist and walks in place, which allows the sensor to detect hip acceleration.



Fig. 9 Photo of “Handle Switch”

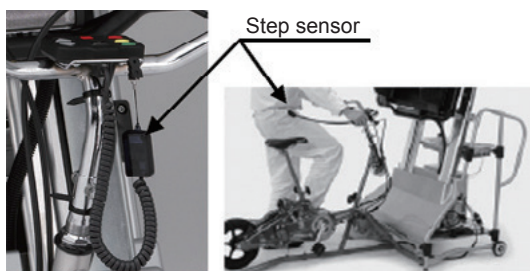


Fig. 10 Photo of “Step Sensor”

The simulator calculates walking speed based on this acceleration, and is set up so that the video moves forward in the direction the handlebar is being held.

4.4. Acceleration/Deceleration Calculation

A typical technique (in exercise machines, for example) for calculating cruising speed is to detect the rotating speed of the bicycle's rear wheel driven by the pedals and taking the result, as is, as the cruising speed⁽⁹⁾. However, unless a load and inertial mass equivalent to actual situations is attributed to the rear wheel, it is difficult to reproduce realistic acceleration/deceleration operation, necessitating a large, heavy flywheel and making the entire Bicycle Simulator larger and heavier. The simulator uses a small flywheel rotated and driven by pedals and chain, as well as a pickup that detects rotating speed (Fig. 11). It uses a newly devised speed calculation algorithm to reproduce cruising speed with a compact, lightweight system. The rotating speed signal detected by the pickup is multiplied by a coefficient described below, and this is considered the acceleration expected by the operator. Deceleration, found from the amount of brake application, the grade of the road and rolling resistance, is reflected in this acceleration to determine the total acceleration/deceleration. This acceleration/deceleration is integrated to calculate cruising speed. The coefficient that is multiplied by the rotating speed signal is larger when starting to pedal and smaller after starting to cruise. The video's movement, as a result, shows that speed rises directly in relation to the user's stepping on the pedals when first pedaling, but after starting to cruise, the motion accelerates rather moderately, thus creating a sense of acceleration/deceleration closer to that of an actual bicycle (Fig. 12).

4.5. Teaching Function

In addition to the experiential function that simulates the unique motions of bicycles, the simulator has a function as a teaching device, as described below.

The courses provided include the “Practice Course” (to learn the basic actions of cruising, turning and stopping), the “Easy Course” (to learn about the law while experiencing road cruising), the “Difficult Course” (to experience road

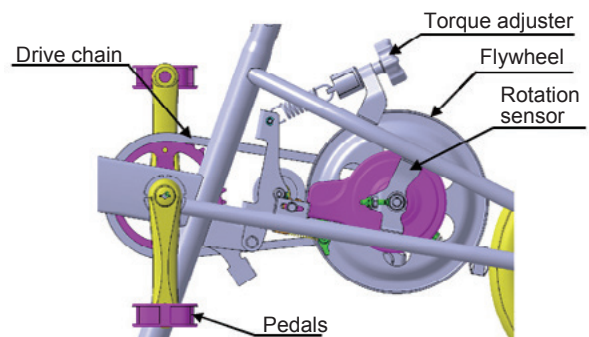


Fig. 11 Structure of drive parts

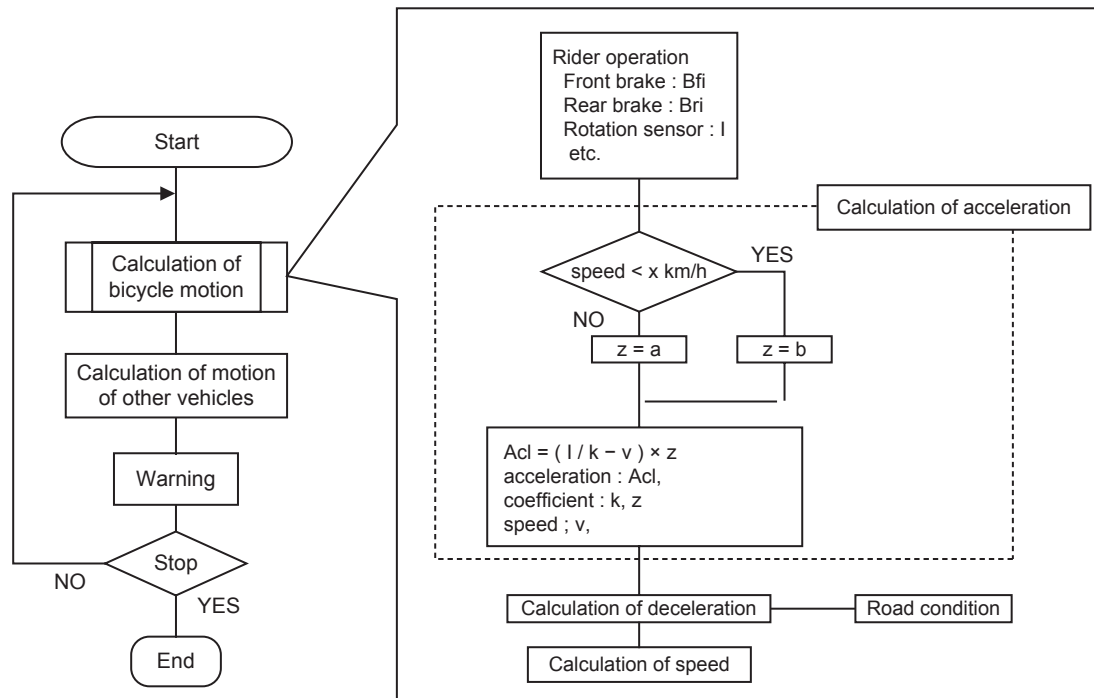


Fig. 12 Control flow of bicycle motion

risks and to learn to predict them), the “Quiz Course” (to learn about traffic signs and markings, rules and manners in a question format), and the “Case Study Course” (to help the user experience, in a short period of time, certain points anticipated about road cruising, such as cautions when crossing pedestrian crossings and the importance of stopping and checking for safety when going through intersections).

Riding simulators used at driving schools⁽¹⁰⁾ assume that the rider is old enough to get a driving license, and consist of systems that let them function as teaching tools. The Bicycle Simulator, however, is also targeted at children who do not yet know the traffic rules, so effort was put into making learning fun and interesting. “ASIMO” is used as a character to explain points and give advice, by animation and voice. While earlier simulators compiled and evaluated results after cruising was finished, the new simulator considers the wide age range of learners, especially how lesson effectiveness diminishes as a young person’s memory of how he or she operated the bicycle fades. So in addition to the general evaluation after cruising, the simulator reads riding position, collision type and the setting of encountered risks in real time and gives appropriate spoken explanations and advice instantly as the user operates the simulator.

The user is asked to select his or her age before starting to cruise, which enables changing what is in the field of vision (according to appropriate eye level for his or her physique) as well as cruising performance (maximum speed, acceleration/deceleration, etc.), the explanations and expressions used for the level of understanding of the age group, and traffic scene settings reflecting differences in

applicable laws. This lets the simulator provide education in safe bicycle usage for a wide range of ages.

Aside from giving advice each time at the moment an unsafe situation occurs, if an accident happens while cruising on a course, immediately afterwards it is automatically replayed with a bird’s eye view, so that the user can reflect on what happened and why, as soon as it happens. On the accident playback screen, the speed is shown numerically, and the amount of braking applied in front and back is displayed by bar graph. Because the simulator knows how the user was operating the left and right brakes, the system can provide instruction on brake operation (Fig. 13).

Finally, Fig. 14 shows the simulator in use in an actual traffic safety clinic.



Fig. 13 Screen image of replay after riding



Fig. 14 Bicycle simulator in actual training

5. Conclusion

Honda has developed a Bicycle Simulator that is fun and interesting for everyone from children to senior citizens to learn traffic rules and manners and enhance their ability to predict risks. The Bicycle Simulator has the following functions.

- A function to learn the action of checking for side and rear safety
- A function that corresponds to walking and pushing the bicycle to learn the correct way to ride in conformity with the Road Traffic Law (Japan)
- A function to give training content and advice appropriate for each age group
- A function to experience risky situations that can be encountered in mixed traffic situations

6. Afterword

After trials with a prototype at numerous elementary, middle and high schools, senior citizen bicycle clinics, events and exhibitions, Honda received many comments saying that even children not yet able to ride a bicycle were able to learn safe operation and found it fun and interesting. The simulator was released as a product in October 2009 and went into mass production in February 2010. Honda hopes that as the Bicycle Simulator becomes widely disseminated and used, it will help to achieve a healthy traffic society.

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