A Study of the Two-Wheeled Bicycle Stability at Low Speeds

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Abstract

Many studies of the stability of two-wheel bicycles have been published. But the evaluations of stability are often limited to a high-speed state. Stability in low-speed could be a critical requirement. Its speed is the useful speed range at the aging society. In addition, decreasing of the instability at starting and stopping is the important factor for all bicycles. At the static state, many studies have been applied to increase stability using another power source without human power, for example, inverted pendulum. However, that system is not able to use to easy in bicycle, due to limitations of the size and the weight the power supplies and equipment. Instability of the bicycle has not been well understood yet. How to stabilize the bicycle is considered in many ways. This study organizes some effective parameters of each component of the bicycle in many situations for the stability, which it gives an indication of the design of the bicycle for elderly people to use in safe. It can also use to low-volume production by adapting individual body shape, strength, sense, and the purpose of use. This study proposes that a bicycle is produced for the elderly by using the parameters obtained in the experiment, and it is evaluated the stability at low velocity.

1. Introduction

It becomes the aging society, a bicycle is in demand for elderly people health. According to the traffic accident statistics in Japan[1] the accident of a bicycle occupied 16.7% of the whole (Table 1). By age group, a fatal accident aged 65 and over was about 60% of the bicycle accident (Fig. 1). We have to make more safety bicycle for elderly people in this situations. They need a stable bicycle at the low speeds. However we do not have enough studies about it at low speeds. If we could make a stable bicycle in this speed range, it will be decreased the fatal accident of the aging society.

Table 1 Number of casualties by state(End of December each year)

by state	year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Percentage of total
Bicycle	Casualty	177,811	180,573	184,206	190,251	185,532	175,453	171,923	162,967	156,308	151,631	143,738	16.7
	Fatality rate	0.56	0.55	0.53	0.45	0.46	0.46	0.43	0.44	0.44	0.43	0.44	―

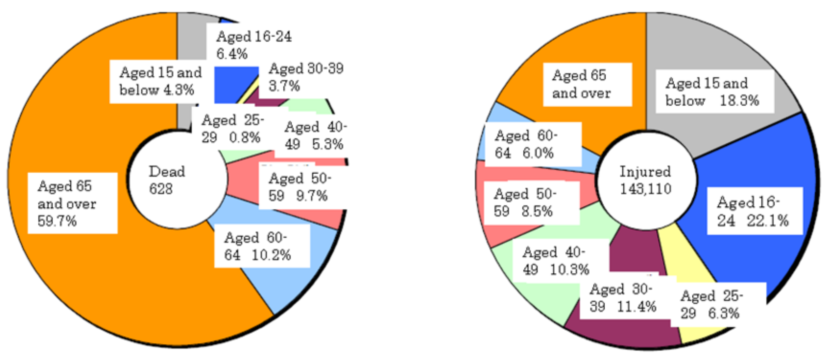

Fig.1 The number of dead and injured while driving by age group of bicycle (April 2010-2011)

2. Targets and conditions

This study is a stability of the two- wheeled bicycle, not three or more. It is because a two wheeled bicycle can be parked in a small space and the elderly people also have to support a sense of proportion. The target of this study is that a bicycle is not easy to fall over, and a rider does not feel uneasiness to control it.

3. The definition of stability

In general, a bicycle has intrinsic stability by its dimensions that are caster angle, trail, wheel base, and so on. A bicycle has two contact points on the road. A rider mass is about 60 kg that is about three times or more of a bicycle mass. A center of gravity of the both of a bicycle and a rider is the height about 1 meter from the road. We use the definition of a certain paper[2] here. We consider an triangle that is made from this two contact points and a center of gravity. This triangle has a face. The resultant vector of the attraction from the earth and the centrifugal force starts at this center of gravity. When this resultant vector are on this triangle face, we think that is in stable (Fig. 2). We evaluate a stability by width of the swing trajectory of of a front wheel which it begins to run from the state that a bicycle has stopped.

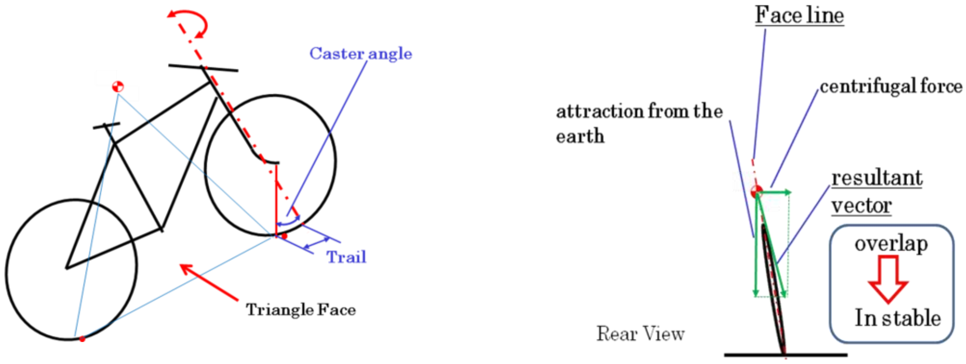

Fig. 2 Triangle face and The resultant vector

4. How to get the stability -some ideas-

a. Gyro effect

Stabilization by the gyro wheel drive by external or pedaling energy >> Weight is increased. It is not suit for elderly people.

b. Inverted pendulum

The height of a center-of-gravity position is adjusted and a response is changed. >> It cannot move to a moment. However this may be using when changing a speed range.

c. Variable mechanism of dimensions

A caster angle, a trail, a wheel base, and a center-of-gravity position of a front wheel system are changed by mechanical system automatically. >> We should change a parameter effective in attaining the purpose (Fig. 3). We want to move the contact point of front tire and the road, but it cannot move because of frictional force. In fact, a frame is moved to the counter direction which turned the steering. When a caster angle is removed, even if a rider sways a steering right and left gradually, there is no movement of the center of gravity and it is stabilized.

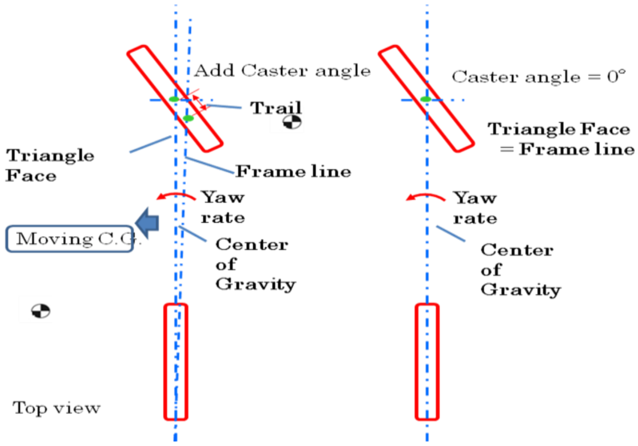

Fig. 3 When the steering, movement of the center of gravity

5. Experiment

There are a lot of papers of a bicycle dynamics, however we have to get data behavior of the dynamics at a slow speed. We have a experiment data by using a popular bicycle that has 26 inches wheels in Japan. The measurement system is shown in Fig. 4. Measurement and adjustment items as follows:

a. Measurement values

Speed, Steering angle, Steering rate, Steering torque, Pedaling angle, Pedaling torque, Role rate, Yaw rate

b. Adjusting parameters

Caster angle, Trail, Position of center of gravity, Weight value

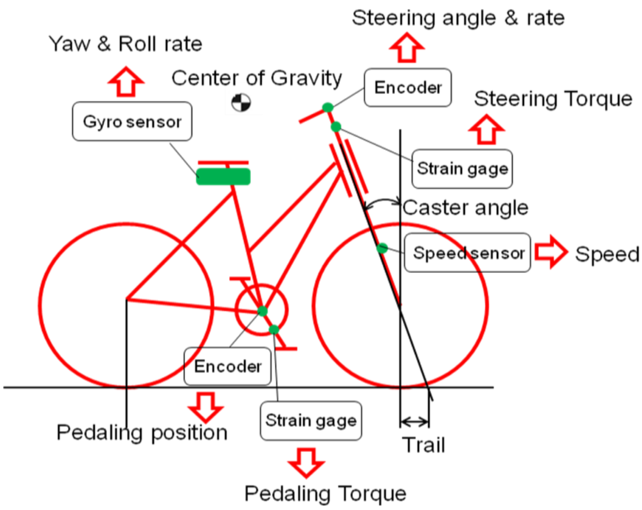

Fig. 4　The measurement system

6. Progress

We are just making the experimental equipments. We should have been able to organize the data before conference.

7. Reference

[1] Traffic accident statistics (the end of April 2012)
http://www.e-stat.go.jp/SG1/estat/List.do?lid=000001088968

[2] Tsujii, E., Kimura, T., Andou, Y., "Motorcycle steering system development (evaluation of motorcycle stability at low speeds)." Yamaha Motor Technical Review 47 (2011): 67-73