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Measuring of Driving and Impact Dynamics of Cyclists

Zuzana Radová[a]*, Luboš Nouzovský[b]

Faculty of Transportation Sciences, Horská 3, Prague 2, 128 03, the Czech Republic

[a]radova@fd.cvut.cz, [b]nouzolub@fd.cvut.cz

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Abstract: The contribution is aimed at detection of cyclists' dynamics in standard and non-standard situations. From forensic experts point of view there are significant both, ie. riding dynamics of cyclist and also post-crash motion in case of collision with passenger car.

To determine the riding trajectory, it is necessary to devise a measuring apparatus and devise methods for measuring and processing of the collected data. Measuring involves combination of several procedures such as accelerometric measuring, photogrammetry and GPS use.

In the term of post-crash motion the paper deals with the biomechanical analysis of load exerted on the child cyclist in configuration typical for cyclists (sudden enter the road or the case of non-giving way; the car front vs. the left side of the cyclists).

Introduction

In case of riding dynamics, trajectory of a bicycle-rider system has, even when moving straight forward, a sine pattern – a sinusoidal waveform. The amplitude of this "macrowave", as well as the amplitude of a "microwave" generated by the swaying of a bicycle along the macrowave, is influenced by many factors. The magnitude of the macrowave can be directly affected by riders themselves – by their own volition and concentration on riding. This does not apply to the microwave.

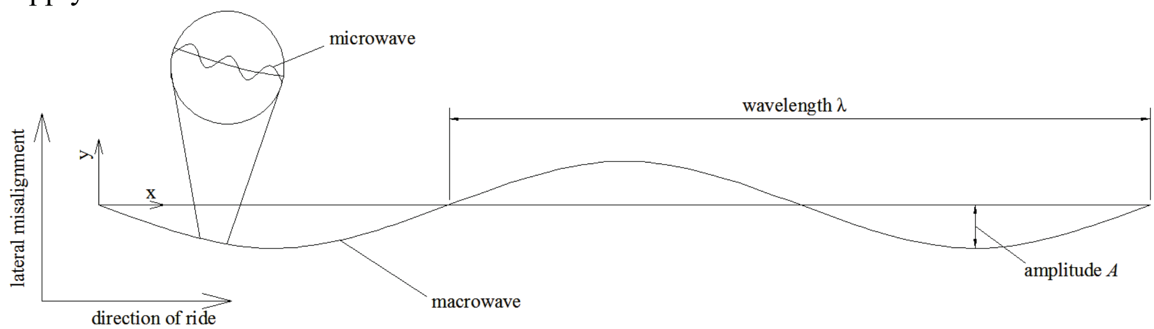

Fig. 1: Illustration of linear motion

During collision with a passenger car, the cyclist moves along a trajectory which depends on the collision speed, the shape of the front vehicle structure and its rigidity and pedestrian´s or cyclist´s initial position towards the vehicle. Because of number of factors affecting the course of impact, it is a process with a high degree of variability.

Material and method

For the riding dynamics trajectory detection the test bike was fitted with multifunctional accelerometric device, GNSS receiver, field computer. This measuring apparatus enabled to collect data essential for the description of the cyclist's motion such as acceleration, angular velocity and position-time data.

Fig. 2: Image sequence of two tests: the same configuration - with/without bicycle helmet

Performed passive safety tests were focused on vehicle front part, which is usually tested by impactors with respect to certified methodology 78/2009 ECE. In terms of boundary conditions the limit case of conflict of the child cyclist (height 117 cm, weight 22 kg) with a passenger car was tested. Two tests were performed in the same configuration and nominal collision speed, the first one with a bicycle helmet and the second one without the helmet.

Additional third test was performed in following configuration vehicle front part – back of cyclist (insufficient breaking, uncontrolled avoidance manoeuvre…) Using the accelerometers in the head, chest, pelvis and knee of the dummy acceleration fields were detected, which is the cyclist exposed during the primary (contact with the vehicle) and secondary collision (contact with the vehicle road surface).

Results

From the results of the test of riding dynamics measurements (man, 25 years, intermediate experienced rider, sunny weather and no wind, road without grade) can be preliminarily said that the width of the riding corridor is a significantly wider, when the start of the motion is captured. When start is included, the corridor width is about 70 cm. Conversely, the continuous driving corridor size (as a sum of the greatest opposite amplitudes) is approximately 20 cm. It is important to note that captured curve represents only the trajectory of a point through space – the measuring apparatus. It is therefore necessary to add the width of bicycle-rider system.

For the evaluation of performed dynamic tests were chosen biomechanical criteria that are frequently used for classification of biomechanical load in passive safety tests, for example for the head load evaluation the Head Performance Criterion was used, where the input value are accelerations measured at the head centre of gravity. The resulting HPC value should not be greater than 1000.

Tab. 1: HPC values for performed tests in the first configuration

Test No.	Contact with the vehicle		Contact with the road surface	
	HPC_{15}		HPC_{15}	
	[-]	limit	[-]	limit
102 – without helmet	**47.9**	1000	**1325.0**	1000
202 – with helmet	**30.7**	1000	**104.7**	1000

Conclusion

Aim of the presented method of measuring and processing of cyclist's riding data is classification and quantification of particular factors, which affects the movement. This information should be used not only for forensic experts, but also for the general public.

Results of passive safety tests were interpreted by values of biomechanical load and severity of potential injuries, as well as a documentation of final positions. In addition, the positive impact of bicycle helmets has been demonstrated to the general public within an awareness campaign.