Single-actor bicycle crash classification guide

Benjamín González
B.GonzalezToledo@tudelft.nl

March 24, 2025

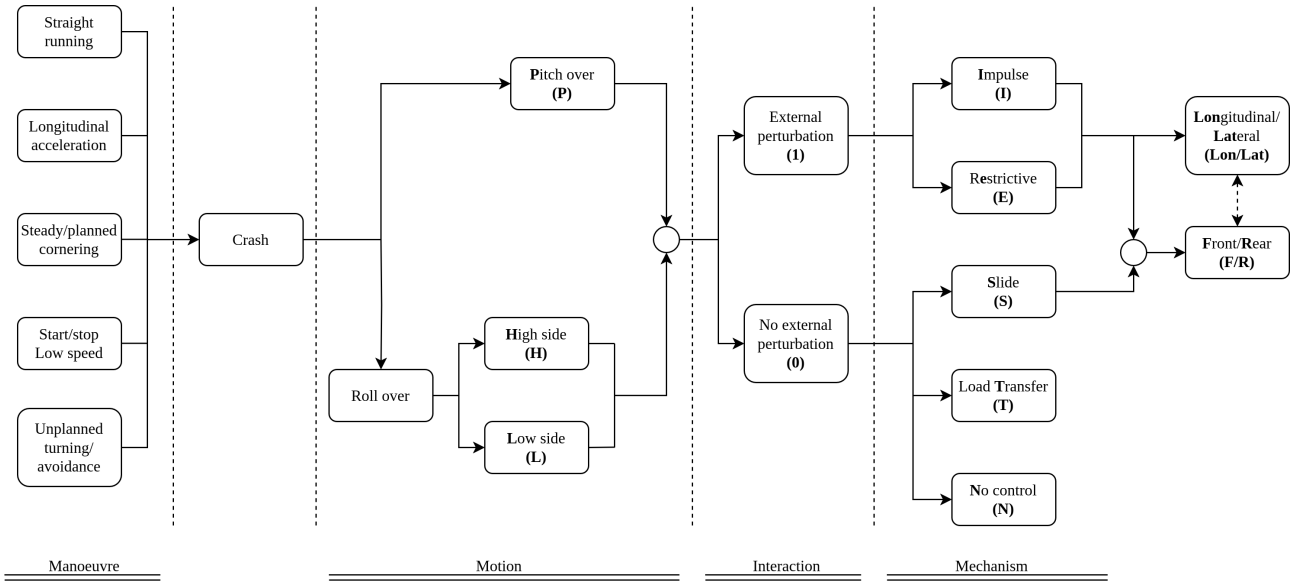

Figure 1: Flowchart of bicycle crash classification.

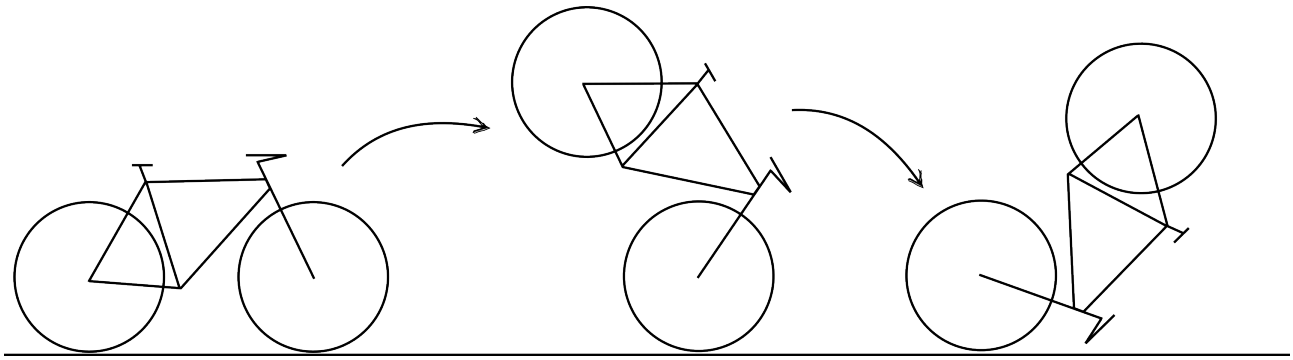

Figure 2: Simple diagram of pitch-over motion.

1 Introduction

This document aims to guide you to understand the proposed classification [1] of single-actor bicycle-crashes and label the samples sent to you.

1.1 What is a Single-actor bicycle crash?

A single-actor bicycle-crash is an event where the normal riding of the bicycle is disrupted and ends in a crash with no other road users involved.

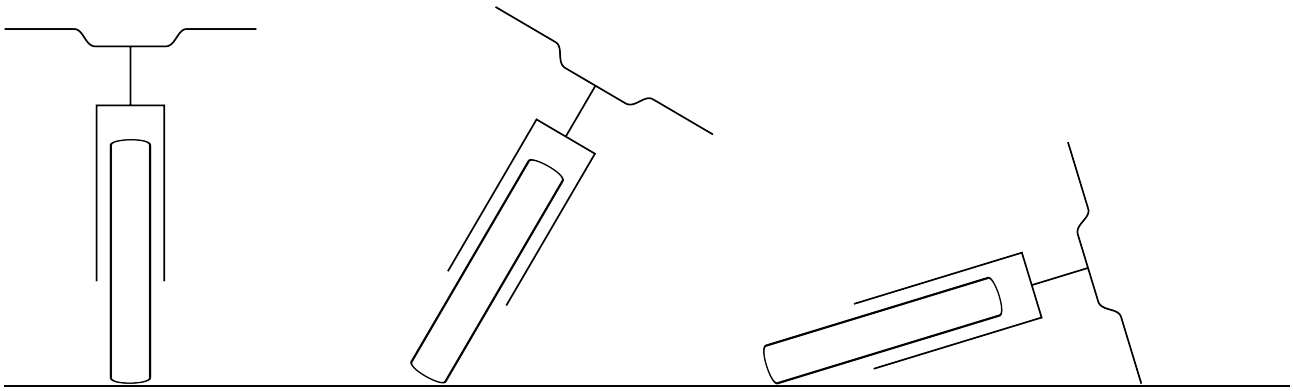

Figure 3: Simple diagram of roll-over motion.

2 Bicycle dynamics-oriented classification

The proposed workflow to classify the crash according to the observed characteristics is composed by three sub-categories: motion, interaction and mechanism (see Figure 3).

2.1 Motion of the bicycle

This is related to the main motion of the rear frame of the bicycle while the crash is occuring. Due to the dynamics of the bicycle, and following the common simplification to its analysis, we find two main motions related to the degrees of freedom: pitch-over and roll-over. Additionally, the roll-over motion includes its own sub-classification according to the direction of rotation with respect to the initial motion. Please visit `https://youtube.com/shorts/_etyqSpH10c?feature=shared` to watch an example of a crash where the final rotation is in the opposite direction of the initial motion. This is particularly challenging to represent in a normal drawing so the visual explanation is on the make.

- **Pitch-over (P):** The main characteristic of this motion is one of the wheels lifting from the ground and following a trajectory that finishes with the front wheel behind the rear wheel.
- **High-side (H):** Characterised for a sudden deceleration of the wheel while in lateral motion, which leads to a violent roll motion in the opposite direction of the initial motion.
- **Low-side (L):** The human-bicycle system follows an excessive roll motion in the same direction as at the beginning.

3 Interaction with the environment

This category refers to the forces excerted on the human-bicycle system, where we find external perturbation or no external perturbation.

- **External perturbation (1):** This makes reference to any force excerted on the bicycle different to the required ones to make the system work.
- **No external perturbation (0):** This refers to internal forces in the human-bicycle system, or changes in the required forces to make the system work (e.g. friction between tyres and road surface).

4 Mechanism of crash

The mechanisms of crashes are closely related to the interaction with the environment. For this reason, we include two sub-categories for external perturbations and three for non-external perturbations.

External perturbations

- **Impulse (I):** Any excerted perturbation with a duration equal or under 0.5 [ms]. This is because the average response time for a proprioceptive is [ms]. Therefore, the human is not capable of perform a controlled action to maintain the balance.

- **Rstrictive (E):** Excerted perturbations that are cyclical of continuous in time, where the human is capable of perferming a response but this is unsucessful. This type of perturbation generate the loss of one of the degrees of freedom of the system, usually making it uncontrollable.

Non-external perturbations

- **Slide (S):** Directly related to the tyre-ground interaction, makes reference to the event where friction is less than required and the wheel exhibits a motion mostly perpendicular to its orientation.
- **Load transfer (T):** Changes in the system occured by load transfer. Usually, this destabilises the system in the longitudinal axis.
- **No control (N):** This makes reference to the situaitons where the rider is unable to maintain the balance in scenarios that are within normal riding conditions.

Finally, together with the mechanisms, for external perturbations we can identify the direction where they act: longitudinal or lateral. The nature of the direction is related to the motion generated on the bicycle, i.e. a longitudinal perturbation in the handlebar is analogous to a lateral perturbation in the front wheel, since both create a rotation of the steering. In line manner, these perturbations and slide mechanisms can be differentiated according to the region of occurence within the system: front or rear.

5 Example

Let's do an example using the following video `https://youtube.com/shorts/VZibdrdhdgM?feature=shared`.

First, it is observed that the main motion of the bicycle in the crash is related to roll angle. Additionally, it is in the same direction of the beginning of the motion. Therefore, this corresponds to the category low-side (L).

Second, there are no visible perturbations that fit into the classification. For this reason, we classify it as non-externally perturbed (0).

Third, the mechanisms that best fits into the scenario is slide (S). After a detailed examination, it is reasonable to assume that the event started from the front wheel slide (F).

Finally, the classification of this crash would be **L0-SF**, front slide low side.

References

[1] Elin K. Jacob (2004): Classification and Categorization: A Difference that makes a Difference. Graduate School of Library and Information Science. University of Illinois at Urbana-Champaign. `http://hdl.handle.net/2142/1686`