Comparison of two simulation methods for testing of algorithms to detect cyclist and pedestrian accidents in naturalistic data

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Comparison of two simulation methods for testing of algorithms to detect cyclist and pedestrian accidents in naturalistic data

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Summary

Naturalistic studies can potentially be used to detect accidents of vulnerable road users and thus overcome the large degree of under-reporting in the official accident records. In this study, simulated cycling and walking accidents were performed by a stuntman and with a crash test dummy to test how they differ from each other and the potential implications of using simulated accidents as an alternative to real accidents. The study consisted of simulations of common accident types for cyclists and pedestrians, such as tripping over a curb or falling of the bike after hitting an obstacle. Motion data in terms of acceleration and rotation as well as the state of the screen (turned on/off) was collected via an Android smartphone to use as indicators for the motion patterns during accidents. The results show that dummy data have a distinct peak at the moment of the fall as a result of not being able to break the fall. As opposed to this, the stuntman arranges himself in a way to reduce the impact when hitting the ground. In real accidents, motion patterns will probably lie in-between these two types.

Background

Only a small percentage of all accidents are recorded by the police (OECD/ITF, 2011). In particular, accidents involving vulnerable road users (pedestrians, cyclists and riders of powered two wheelers) have a low degree of reporting (Agerholm & Andersen, 2015). To increase the amount of registered accidents of vulnerable road users, naturalistic studies can potentially be used to detect them automatically based on motion patterns. As real accidents are rare, simulated accidents can be used as an alternative to accidents when developing and testing algorithms for automatic detection of accidents. This can be done either with a crash test dummy (Candefjord *et al.*, 2014) or by a stuntman (Attal *et al.*, 2014; Watthanawisuth *et al.*, 2012). Falls have also been simulated by volunteers falling onto mattresses and induced during ice-skating; see e.g. Aguiar *et al*. (2014) and Koshmak *et al*. (2013).

Objective

Although simulations are performed to resemble real accidents, they may differ in some aspects, e.g. by the way the crash test dummy or stuntman moves and falls. It is therefore important to assess whether the method of simulating accidents influences the outcome when used to develop and test automatic accident detection systems. In this study two methods of collecting data of simulated accidents are compared. The scope of the study is to assess how the method of accident simulation influences the data and thus the implications of the choice of simulation method when used for automatic detection of accidents in naturalistic data from vulnerable road users.

Method

Accidents were simulated using a crash test dummy and by a stuntman (Figure 1) performing common accident types of pedestrians and cyclists:

1) The bicycle suddenly stops and the cyclist falls forward over the handlebars
2) The cyclist hits an obstacle (e.g. a curb) and falls to the side
3) The pedestrian trips over an obstacle (e.g. a curb) and falls forward or to the side
4) The pedestrian slips on ice and falls backward

Figure 1 – Stuntman (left) and crash test dummy (right)

The stuntman performed twelve different scenarios which consisted of the combination of two fall types (forward, sideways) and three sensor locations (trouser pocket, chest pocket, backpack) for each of the two modes of transportation (cycling, walking). All scenarios were performed three times except for forward cycling falls with the sensor in a backpack, which was only simulated twice as the bicycle broke down. Mattresses were used in all cycling simulations in order to protect the stuntman. The pedestrian falls were performed on a hard mattress or directly on the lawn.

Four of the scenarios were tested using the crash test dummy: sideways cycling falls with two different sensor locations (chest pocket, trouser pocket), forward cycling falls (chest pocket) and forward pedestrian fall (trouser pocket). Additionally, pedestrian falls in backwards direction were carried out with the dummy for two sensor locations (chest and trouser pockets) to simulate falls on slippery surfaces. During simulated cycling accidents the dummy was mounted on a bicycle which was then pushed into an obstacle/a curb with a speed of approx. 15 km/h. For pedestrian accidents, the dummy was carried around and dropped while the researchers simulated to trip over an obstacle.

In addition, normal cycling and walking data from daily commute was collected with various sensor locations.

Motion data was collected from an Android smartphone with an app which was developed specifically for the study. The app recorded acceleration (three axes), rotation (three axes) and the screen state (turned on/off) with a sampling rate of approximately 5 Hz. The latter indicator, i.e. the screen state, was recorded to be able to discard movement from picking up the smartphone and using it. Samsung Galaxy S6 smartphones were used in the accident simulations. A Sony Xperia Z5 Compact was used for collecting normal cycling and walking data.

Results

Figure 2 shows an example of the magnitudes of the acceleration and rotation measured in a simulated accident of a cyclist falling sideways. In the dummy simulation, the dummy was brought up to speed starting from a few seconds before the measurements were initiated. The last part of the acceleration to reach cycling speed is seen, followed by the fall (after 5 s) and the moment after the fall where the dummy is left on the ground. A large peak is seen in both acceleration and rotation where the dummy hit the ground. The acceleration peaks at 35 m/s^2 (not visible).

A similar fall was simulated by the stuntman. The phone was placed in the chest pocket and the stuntman accelerates. After 15 seconds he hits the obstacle and falls onto the mattress, rolls onto his side, stands up and takes the phone out of the pocket to turn off the data collection. This results in a small peak in the end. No peak is observed in the acceleration or rotation at the moment of the fall, but generally, more motion is registered throughout the whole simulation.

A sample of normal data is shown for reference. The patterns are similar in dimension to the stuntman data but with larger fluctuations.

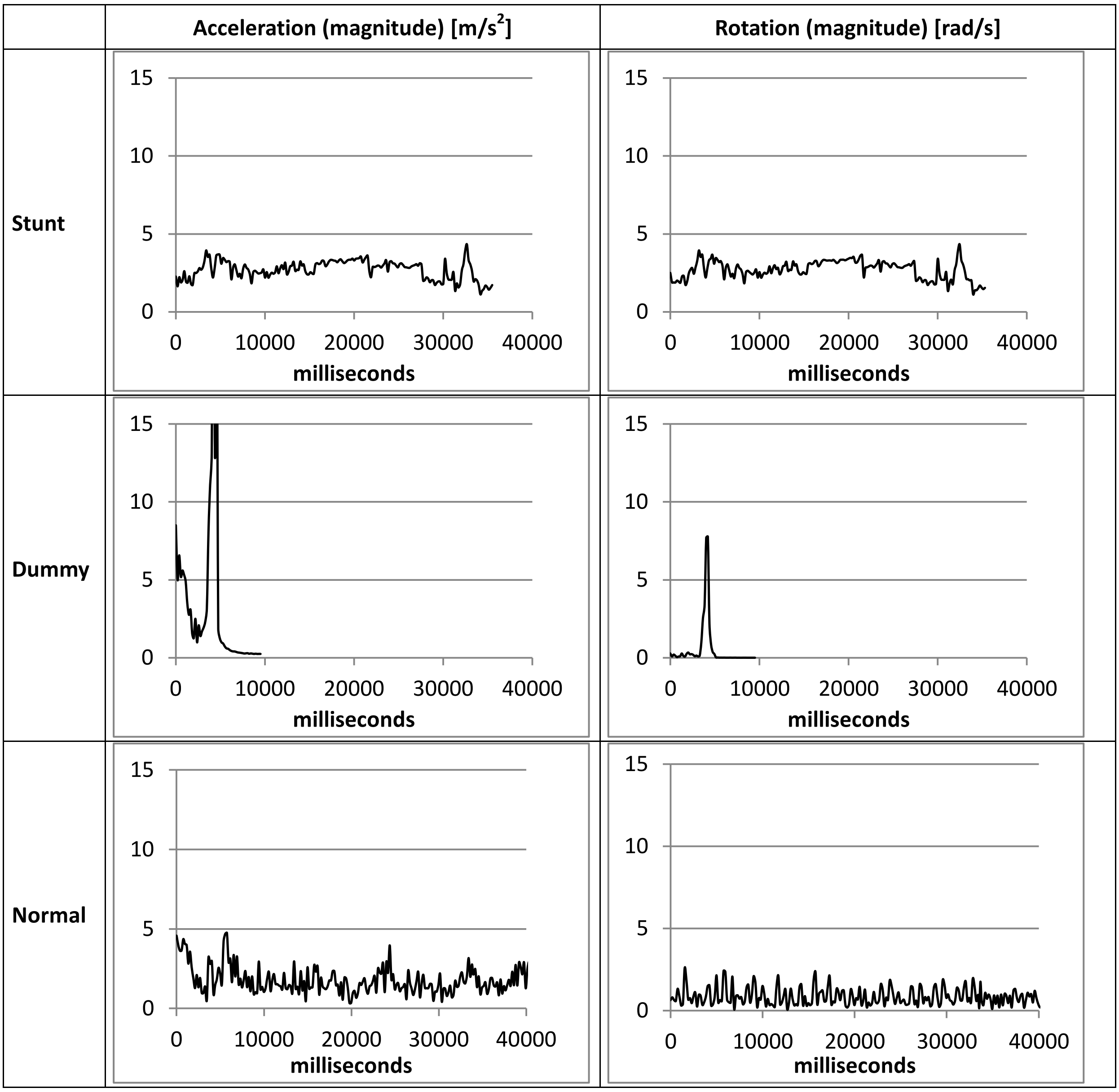

Figure 2 – Example of stunt and dummy accident simulation (sideway cycling fall, phone in chest pocket) compared to normal cycling data (phone in jacket inner chest pocket)

Generally, a peak was seen in all dummy simulations, but with peak values for the acceleration between20 and 70 m/s^2. The motion patterns differed more for the stuntman data, as illustrated in Figure 3. When the same accident was simulated twice, a peak in the acceleration magnitude around the time of the fall occurred in one of the accidents but not in the other.

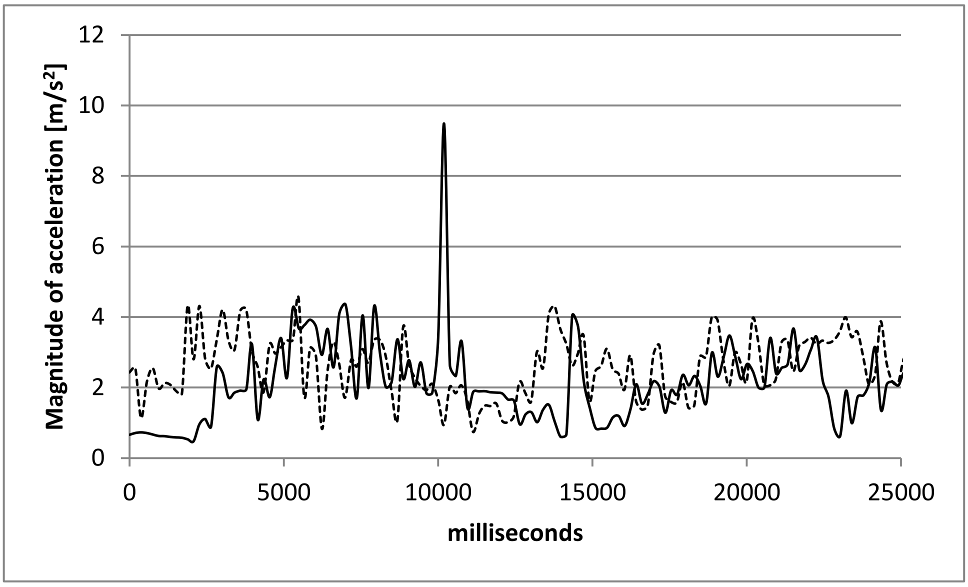

Figure 3 – Two pedestrian fall simulations (stuntman) of falling forward with the phone in the backpack

Discussion

The study shows that motion patterns for simulated accidents performed by a stuntman and with a crash test dummy differs in both values of the motion and in style. Dummy data had a large peak in both acceleration and rotation magnitudes at the time of the fall. As opposed to this, stuntman data showed generally larger motion values when cycling that the dummy. Given that cyclists move their body slightly during cycling, whereas the dummy does not, it is expected that the stuntman data gets closer to actual behaviour in case of walking or cycling normally.

A peak could not always be seen in the stuntman data at the time of the fall and in case that there was a peak, it was smaller than that of the dummy. While the crash test dummy falls to the ground without being able to cushion the fall, the stuntman will, on the other hand, prepare for the fall and do what he can to avoid injuries. The peak in some simulated accidents but not in others may be a result of how the stuntman succeeds in breaking the fall. The impact when hitting the ground will thus most likely be higher in a real accident than shown in the stuntman data but potentially lower than reflected by the dummy data, as the road user will try to break the fall.

Both method have weaknesses and may differ from real accidents. Thus, when using accidents simulated by a dummy, one should take into consideration that the large fluctuations caused by constantly moving the body during walking and cycling is not reflected sufficiently. The result may be that normal behaviour is registered as accidents, for instance when using the phone. On the other hand, stunt data do not necessarily show the peaks in acceleration and/or rotation as would occur during a real accident.

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