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Detecting change in road environment via analysis of marked point processes associated with traffic signs

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Abstract

In the paper, logs of traffic signs – possibly recognized and recorded by an automatic traffic sign recognition system – are analyzed to detect change in some aspect of the road environment along a route and to locate the change point – also along the route – between the different environments. The logs considered here keep a record of the locations and types of the traffic signs installed and detected along a route. The traffic sign logs are seen as realizations of marked binomial processes and the minimal description length (MDL) approach is used for detecting change in the road environment along a route. In particular, the change detection problem associated with driving from one topographical area to another is addressed here as a simple illustrative example. In order to cater for an efficient solution of this task – and also for that of other road-environment change detection tasks – the on-the-fly minimization method used in the Page-Hinkley change detector has been adopted. Simulation results in respect of traffic sign data generated for test purposes corroborate the expected behavior of the detector. In respect of real traffic sign data, a good qualitative agreement was found between the GPS-based altitude-profile of the data collection trip – thresholded at some manually or automatically selected altitude after the trip – and the MDL-based topographical segmentation of the route. For this segmentation, the traffic sign locations, more precisely the path-lengths corresponding to these locations measured from the starting point of the route along the route, and the corresponding traffic sign types were used as input.

Keywords: Detection of road environment; Change detection; Advanced driving assistance systems; Marked point processes; Minimal description length approach; Page-Hinkley detector.

1. Introduction

Roads are planned for, constructed, operated, maintained and used within their environments. The environment of a road could refer to its natural environment, covering the geological, the geographical, the meteorological and the biological aspects, and to its human environment, covering the social, the political, the legal, the economic, and the socio-cultural issues. When driving a car, one must take into consideration the type, the geometry and the quality of the road used, the weather conditions around it, and also the actual and expected traffic over it, and many other

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conditions and circumstances. Some of these conditions are determined by the country one is driving in (e.g., hand of traffic, speed-limits), some depend on the socio-cultural environment, while others depend on the natural environment of the road.

Usually, car drivers are assisted in many ways in recognizing, perceiving and understanding the conditions and circumstances of driving. The best engineering practices used in assisting drivers – driving their cars on different kinds of roads and in different viewing and traffic conditions – with regards to the above tasks are covered by Edquist et al. (2009). The means of assistance include e.g., road signs, traffic signs, information and directional signs, printed and electronic maps, navigational devices, various on-board sensors and nowadays also community-based information services, see e.g., Dennis et al. (2015). In case of driving a smart car, the driver is further helped by the car's various advanced driving assistance systems (ADAS), e.g., its anti-lock braking (ABS), lane-departure warning (LDW) and traffic sign recognition (TSR) systems, see Nikoliċ (2014). From this list, our paper will focus on the traffic signs, but the TSR systems will be also touched upon.

Undoubtedly, it is very important to perceive, to register, to understand and to obey each and every relevant traffic sign that one drives by, but perhaps it is of similar importance to register the natural/human/socio-economic environment of the road, understand its implied dangers (e.g., large number of pedestrians in a busy downtown area) and rules, and behave and drive in accordance with these. Presently, however, neither the TSR systems, nor any other common on-board camera-based systems assist the car drivers in this respect. Perhaps, in the not very distant days of even-smarter cars, a new type of ADAS will appear in the automotive market: the environment recognition systems (ERS). Again, the various environmental aspects mentioned above can be considered in this respect.

Hereinafter, a statistical inference approach – applied to traffic sign data – that could be utilized in the envisaged ERS is presented in the form of a simple instructive example. Consider therefore a log of geographical locations of traffic signs with the types of the traffic signs being also noted in it. Furthermore, it is assumed that the log is recorded along a loopless route taken by a car. Using statistical inference in the context of environment recognition is motivated by the expectation that certain traffic signs appear more frequently in some environments than they do in others. In town centers, signs indicating railway/bus station, restaurant, hotel/motel, cafeteria/refreshments, museum/historic building, parking places, particularly parking places against fee in the vicinity, and the ones warning the drivers of pedestrian traffic are likely to appear. Other traffic signs are installed more frequently in suburbs (e.g., traffic signs indicating industrial area, goods harbor, airport, low-flying aircraft/sudden aircraft noise) and still others in rural areas (e.g., traffic signs warning of cattle/wild animals, and falling rock).

In conjunction with the topographical environment of the road, one expects that the bend to left/right, the double bend and the steep ascent/descent traffic signs are installed in considerably bigger numbers in hilly areas than by the roads running over a flatland. In Fig. 1, a road segment – in the hilly area of the Mátra Mountains – that is marked with a bend to right traffic sign is shown as an example that supports this expectation.

Referring to the above environment detection examples, it is not claimed here that using statistical inference in respect of traffic sign logs is the best way to determine a particular environmental aspect of the road, e.g., whether

Fig. 1. A bending road in the Mátra Mountains. The drivers are forewarned of the sharp turn of the road by the bend to right traffic sign. In the inset, the two distant traffic signs appear enlarged.