An Open-Source Data Logger for Field Cycling Collection: Design and Evaluation

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Keywords: naturalistic data, pedelec, bicycle stability.

1 INTRODUCTION

The collection of naturalistic and field data from bicycles is increasingly common and promises groundbreaking discoveries in cycling safety. As examples, naturalistic cycling studies have already cast new light on rider behavior [1], accident causation [2], and rider conflicts with other road users [3]. Field studies, on the other hand, have been able to compare stability and performance across riders and bicycle type [4], measure the interaction between cyclists and drivers [5], and test the effect of new technologies in cycling performance [6].

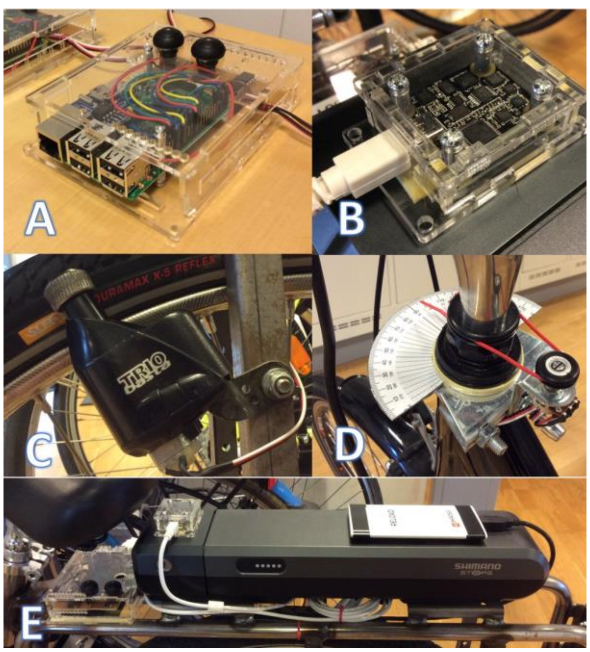

Figure 1: A: Logger, B: Inertial measurement unit (IMU), C: Speed sensor, D: Angle sensor, E: Logger, IMU, and power bank installation.

Today we are lacking standard tools to collect comparable data across real-world studies. So far, naturalistic and field studies have been using data loggers developed ad hoc, whose designs differ greatly across studies [7]. While different studies with different research questions may indeed require different data, it should not be necessary to develop each logger from scratch for each study. To promote synergies across past and future real-world studies, this abstract presents an open-source data logger for field and naturalistic data collection. To validate this new logger, we ran an experiment to compare the stability and maneuverability of pedelec bicycles and traditional bicycles in a field study, which was greatly inspired by Kovácsová et al.'s 2016 work [8].

2 METHODS

2.1 Logger Design

The core of the logger was a Raspberry PI 3 (Model B, 1.2 GHz quad-core CPU and 1 GB RAM) with the Raspbian Jessie operating system, which ran the C code[1] to enable collection from an inertial measurement unit (IMU), an

[1] Logger software repository: https://github.com/feuerblitz7/cycle-data-logger

angle sensor, and a speed sensor (Fig 1: Table 1). The angle sensor used a potentiometer to record the steering angle. The speed sensor was made of a DC motor housed in an old dynamo. Sensor resolutions, reported in Table 1, satisfy all requirements from previous studies such as Kovácsová et al. 2016 [8]. A standard power bank (5 V at 1 A with 5600 mAh) powered the logger. Speed and steering angle sensors were calibrated with static and dynamic trials. A 10-bit analog-digital converter (MCP 3008) digitized the data from the speed and steering angle sensors. The logger had two buttons for operation and automatic data download. Data was saved in CSV format and time stamped with a real-time clock (Adafruit DS 1307) on the Raspberry PI.

Table 1: Sensor characteristics.

Sensor	Maker and Part number	Resolution
Inertial Measurement Unit	PhidgetSpatial 3/3/3 1044	Acceleration 76.3 µg Angle rate: 0.02 deg/s
Angle sensor (potentiometer)	BI TECHNOLOGIES TT ELECTRONICS P160KNP-0QC20B25K	0.1 deg
Speed (DC motor)	MULTICOMP MM10	0.1 km/h

2.2 Logger Evaluation

Seventeen cyclists rode a pedelec and a traditional bicycle in different conditions, and the data were collected with the logging installation described above. Their mean age was 29 years, mean height 180 cm, and mean weight 76 kg. Cyclists were rewarded with a cinema ticket for their participation. Most of the riding conditions resembled the ones presented in Kovácsová et al. (2016) [8] and included accelerating, traveling at steady speed, braking, and maneuvering the bicycle.

Speed and steering angle data were collected at 125 Hz. Signal integrity was verified with time and frequency analyses. Several parameters such as mean speed, mean steering angle, mean steering rate, and mean roll rate were computed to compare rider kinematics across bicycle type.

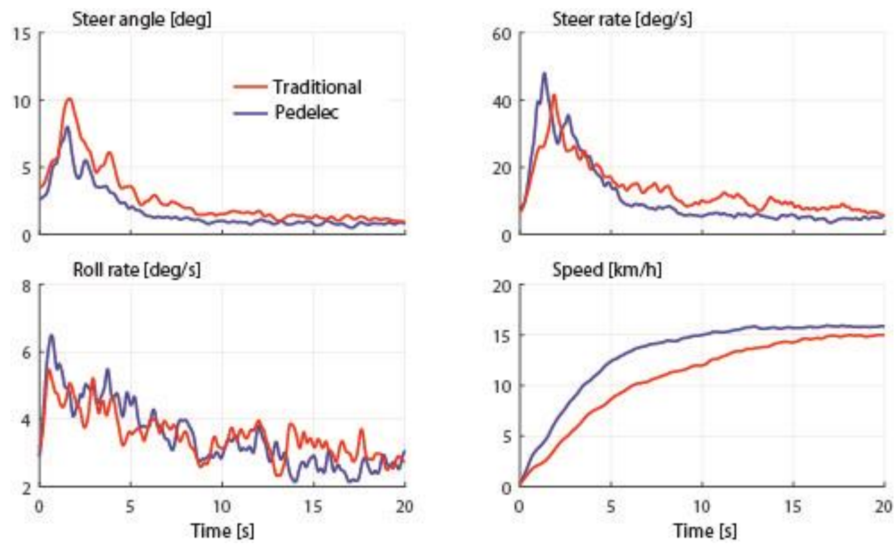

Figure 2: Mean of steering angle, steering rate, roll rate and speed from the logger validation experiment.

3 RESULTS

The averages of some key signals for a representative accelerative maneuver are presented in Figure 2. Data collection was successful every time the analyst remembered to start the logger. The signals passed all quality checks, delivering the expected resolutions, and the logger recorded for 14 hours before needing a newly charged power bank. When riding traditional bicycles, cyclists took twice as long (20 s vs 10 s) to reach 15 km/h. Depending on the conditions, several other measures differed across bicycle type.

4 DISCUSSION AND CONCLUSIONS

This abstract presented an open-source data logger and described a field experiment comparing a pedelec and a traditional bicycle which validated the logger. The logger cost approximately 2,000 SEK (the IMU alone was 1,250 SEK) and used an open source hardware platform; its code has been made available by the authors as open source. The availability of this logging solution may save significant time and effort in future studies, since researchers can now focus on improving the platform. Further improvements might include waterproofing the logger and interfacing it to a camera. Further, the logger does not start and stop by itself, and the software doesn't exploit the logger's wireless capability. Finally, a more economical IMU, such as a Microchip (MM7150), could be interfaced to the logger to provide better performance at lower cost than the current PhidgetSpatial 3/3/3 provides.

ACKNOWLEDGEMENTS

This study was sponsored by Chalmers, the Transport Area of Advance, SAFER, and Cycleurope AB.

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