Streamlining Instrumented Bicycle Data Analysis: A Unified Approach with Practical Tools and Interfaces

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Abstract

Naturalistic data collection methods play an important role in facilitating safe and reliable bicycle infrastructure development. Bicycles, instrumented with sensors like GPS, accelerometer, power meter, cadence sensor, heart rate monitor, and LIDAR, can provide traffic researchers with infrastructure-specific and behavioral data. The raw sensor data is often collected unprocessed and unstructured; and requires a framework for further usability. Proper data streamlining manifests the ability to the researchers to access the data efficiently. However, the streamlining process encompasses various types of implementations. Some implementations require complicated functionalities, which may be difficult to maintain after implementation. A critical step is that the framework must support continuous updates of new data, and any modification of data will not impair the original functionalities. In this master's thesis, conducted under the Chair of Bicycle Traffic of Bergische Universität Wuppertal, a streamlining approach of bicycle sensor data was underscored, which was designed specifically for the cycling behavior research. To develop the cycling infrastructure in a high and varying altitude region, the chair collected riders' behavioral data within a predefined cycling track by developing instrumented bicycles incorporating GPS, power meter, cadence sensor, heart rate monitor, and speed sensors. Primary goal of this thesis was to streamline these sensor data through preprocessing and visualizing. This master's thesis also emphasized major research and scientific literature related to instrumented bicycles, methodologies, and sensor types relevant to bicycle infrastructure research. The streamlining process includes organizing and correcting bicycle computer and sensor data, exploring statistical attributes of the data, and developing a visualization interface of the processed data. The data visualization tools must have the compatibility to continuous update of new data. Additionally, the sensor data of each rider can be compared to each other and againstnthe aggregate trend. With the sensor data, an attempt was undertaken to classify different cycling modes along the cycling path. Map matching technique was employed to correct GPS points. On the other side, PostgreSQL, and Apache Superset were utilized as tools for database creation, sensor data visualization, and reporting purposes.