Predicting Bicycle Ride Quality from Dynamic Measurements and Pavement Roughness Index

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ABSTRACT

To date, bicycle paths or lanes have not been actively prioritized using traditional pavement systems analysis. Most cities rely on route preferences (e.g. a common route to school) or visual checks to identify needed pavement improvements for bicycles. Ride quality is affected by pavement surface defects such as cracks, uplifting, and potholes [1]. In order to prioritize and compete within standard pavement rating systems, it is necessary to develop a quantitative evaluation system for bike ride quality.

This research presents exploratory method for bike ride quality prediction. We combined bicycle dynamics indices with a new bicycle path roughness index inspired by the traditional pavement roughness measurement method for vehicle travel lanes. The bicycle dynamics indices include acceleration in lateral, longitudinal, and vertical directions, which measure the vibrations in those directions (Figure 1) [2]. We also measured the pavement roughness with a distance sensor under bicycle shaft (Figure 2). The idea of this measurement generates from the International Roughness Index (IRI), which is a traditional index evaluating longitudinal road profiles. This new index can significantly detect defects on bike pavements, which can cause handling difficulties for cyclists (Figure 3). We set a distance range to filter out points caused by pavement defects and used these data to calculate the new roughness index.

This new bicycle pavement roughness index is calculated as:

$$Roughness\ index = \frac{1}{n}\sum_{1}^{n} d_i \tag{1}$$

where n is the number of points outside distance range (as shown in Figure 3) and d_i is the distance measured by the sensor.

Based on the pavement surface conditions, bike path sections were chosen as the representative samples to collect acceleration data and roughness index data. Cyclists were also recruited to complete a post-ride survey on ride quality. We then constructed a model to predict ride quality (Equation 2).

$$Ride\ Quality = Constant + a_1 \times Roughness\ index\ + a_2 \times Acceleration\ data \tag{2}$$

where a_1 and a_2 are the coefficients for the variables in the linear model.

Our results can help to shape the framework for a new bike pavement management system that is to grade bike ride quality using acceleration and a new bicycle pavement roughness index.

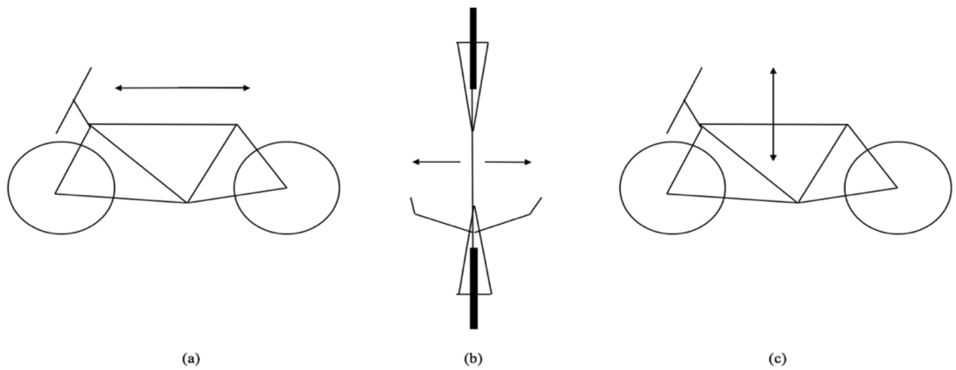

Figure 1: Acceleration in three directions: (a) longitudinal direction; (b) lateral direction; (c) vertical direction

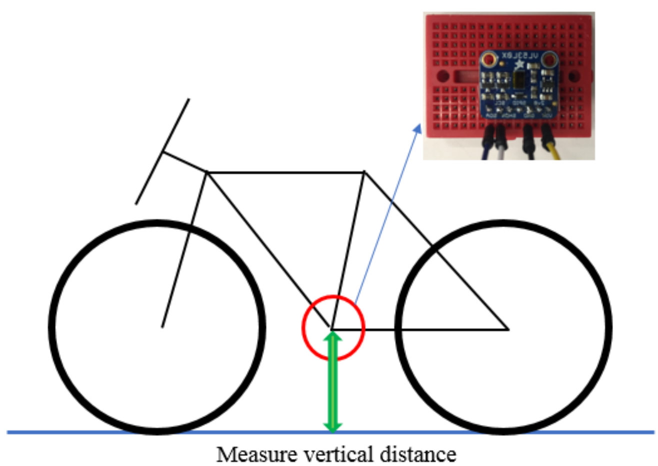

Figure 2: A sensor measuring vertical distance from bicycle shaft bottom to ground

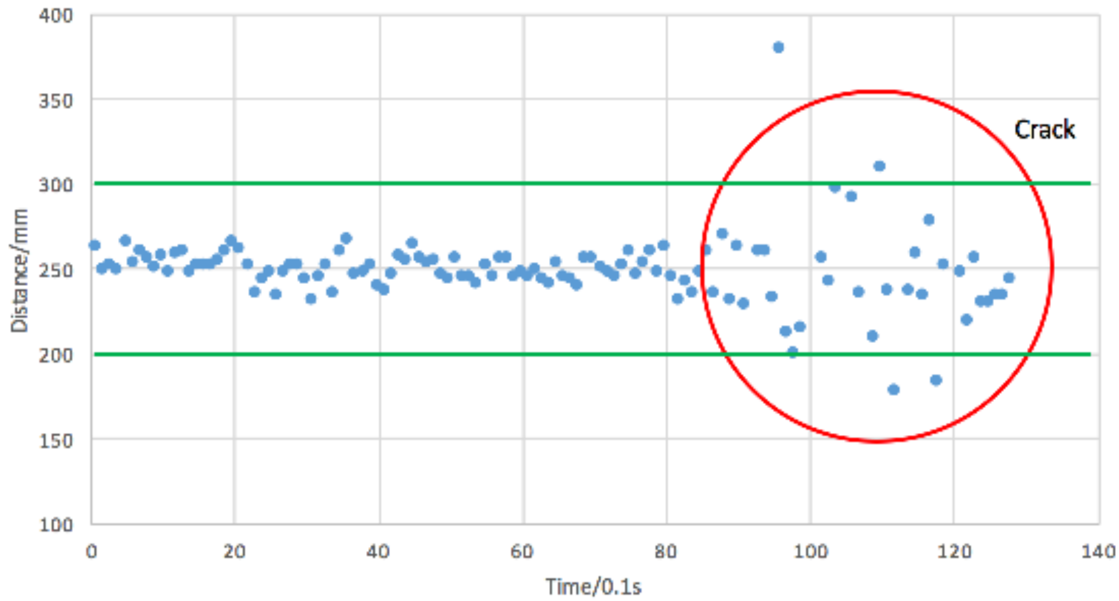

Figure 3: A sample of distance data from one rough bicycle pavement section

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