Building Bicycle Safety performance Functions (SPFs) for Pacific Northwest Cities in the U.S. by Using Crowdsourcing Data

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1 INTRODUCTION

There were 726 people lost their lives in bicycle crashes in 2014 and the percentage of total fatalities has been increased from 2005 to 2014 [1]. Figure 1 demonstrates the fatalities rate for bicyclist per year in the U.S. has increased since 2005. The number of bicyclists has been growing dramatically and the trips made by bicycle in the U.S. grow from 1.7 billion to 4 billion in 2009 according to National Household Travel Survey. Portland, with 408% percentage growth rate, is leading the increase of bicycle commuter share in the U.S.[2].

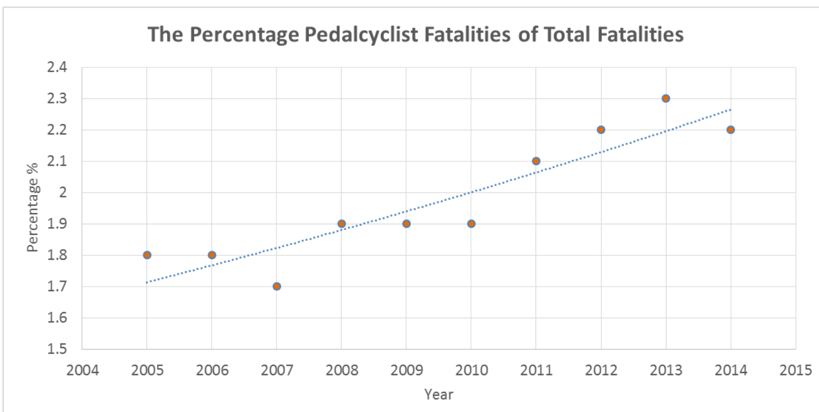

Figure 1, percentage bicycle fatalities of total traffic fatalities.

Certainly, the dramatic increase of bicycle trip is the main reason of the growing pedal-cyclist crashes, but it is the indication that engineer and city planners need to shift more attention from traffic to bicycle safety. Traffic safety has been widely studied since the vehicles joined into daily life, and there are plenty of useful safety evaluation tools from traffic researches can be adopted to ensure bicycle safety. Safety Performance Functions (SPFs) are one of them. SPFs are equation-based crash prediction tools to assess the safety of road sites including ramps, segments, and intersections. There are mathematical equations predicting the number of crash of various sites. Those equations can also be applied in assessing the effect of treatments, screening network safety, determining the safety impact of changing designs, etc.[3]. Combining data from crash report, traffic volume, and geometric information, SPFs can provide a statistical relation between expected yearly crash count and roadway features [4].

However, there are three significant gaps in building bicycle SPFs in the U.S. including: 1) there is not enough reliable bicycle count data for jurisdictions to build SPFs; 2) existing bicycle SPFs are still not sophisticated enough to predict accurate crash frequency and severity[5]; 3) jurisdiction don't have their own specific bicycle

SPFs. Therefore, in order to fill those gaps, in this research engineers are using crowdsourcing bicycle data to establish SPFs for intersections in Pacific Northwest cities in the U.S. The highlights of this study include:

- Crowdsourcing bicycle data is verified by comparing with yearly bicycle data form permanent count stations;
- Three different kinds of cities (state capital city, university city, metropolitan) are chosen to increase the ability of models' representation;
- SPFs are built for Pacific Northwest cities in the U.S. where there is no bicycle SPF existing;
- Systematic sampling process is applied to address the cluster correlation issue;
- Geometric data, land use data are integrated with volume data to build SPFs instead of building Crash Modification Factors (CMFs).

2 METHODOLOTY

After comprehensively reviewing existing literatures, engineers decided to use Negative Binomial Regression (NB), Zero-inflated Poisson Regression, Zero-inflated Negative Binomial Regression to build SPFs. Those three regressions will be compared and the best regression, regarding data characteristics and distributions, will be selected to create final SPFs for intersections.

Based on previous study [6], the NB SPFs for intersections in this research can be written as:

$$c_i = e^{\varepsilon}(AADT_1 + AADT_2)^{\beta 1}(CBV_1 + CBV_2)^{\beta 2}(X_i)^{Bi}$$

Where: c_i represents the crash frequency happened per year; $AADT_1$is the annual average daily traffic for major road at intersection whereas $AADT_2$ is for minor road at intersection; CBV_1 represents crowdsourcing bicycle volume for major road at intersection whereas CBV_2 is for minor road; X_i is geometric or land use data, and Bi is the corresponding parameters for data type i.

3 RESULTS AND CONCLUSION

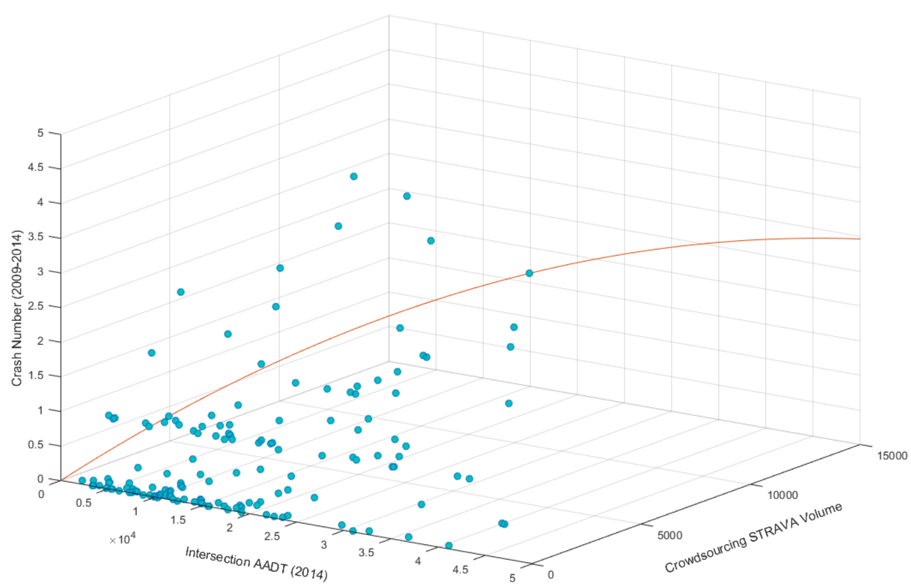

Figure 2, crash number (2009-2014) for different AADT and crowdsourcing STRAVA® bicycle volume

The final model will be built based on more than 300 sites. Due to the large number of samples and long data collection process, engineers decided to divide the whole process to two stage. Stage 1 was completed in which 150 samples has been collected for testing different models. Engineers will adopt the data collection based on the interim results. Figure 2 demonstrates the preliminary result from the first 150 sample from three cites: Portland, Eugene, and Salem, OR. Results shows the crash number increases with the AADT and crowdsourcing bicycle volume increase; however, the line slope decreasing indicates the crash rate drops down when volume is high. At the first stage, NB regression was applied on first 150 samples and Table 1 shows the results. For the basic SPFs, only volume data are included in independent variable. Land use and geometric data will be integrated in model next step.

Table 1, Basic SPFs for intersection using Negative Binomial Regression

Variable	***Estimate***	***SD***	***P-value***	***Significance***
Intercept	*-1.566e+00*	*2.507e-01*	*4.23e-10*	***
STRAVA	*5.096e-05*	*9.136e-06*	*2.44e-08*	***
AADT	*1.050e-04*	*3.815e-05*	*0.00592*	**

*Significant Code: 0 '***'; 0.001 '**'; 0.01 '*'; 0.05 '.'; 0.1 ''.*

This research will be finished at end of May, 2017. The final SPFs will be built for the three different cities with more than 300 data sites based on traffic volume, bicycle volume, land use and geometric data. Engineers and city planner can use this tool systematically screening bicycle network and identify the intersections with high probability of bicycle crash. Exact numbers of bicycle volume will be provided to help engineers design safer infrastructure for bicyclists. This research can be also used as a guide for using crowdsourcing data to build bicycle SPFs, then jurisdictions can establish bicycle SPFs with relatively lower cost.

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