Technologies for Safe & Efficient Transportation

THE NATIONAL USDOT UNIVERSITY TRANSPORTATION CENTER FOR SAFETY

Carnegie Mellon University | UNIVERSITY of PENNSYLVANIA

Project 22 - Building an accessible, low-stress, safe, and sustainable, bicycle infrastructure network for the City of Pittsburgh

Final Research Report

PI: Zhen (Sean) Qian, Assistant Professor

Research Assistants: Wei Ma, Allan Khariton, James Crnkovich

Department of Civil and Environmental Engineering

Carnegie Mellon University

Disclaimer

Problem Statement

Sustainable mobility is one of the key challenges for smart cities. Being a critical component of the multi-modal transportation system, bicycle infrastructure supports short- and medium-distance trips for residents, commuters and visitors. Cycling allows people to travel with minimum impact from/to roadway congestion. It offers a healthy lifestyle and reduces fuel use. The goal of this research is to build an accessible, low-stress, safe, and sustainable bicycle infrastructure network for the City of Pittsburgh.

Pittsburgh is quickly emerging as one of the nation's most progressive bike-friendly cities. Pittsburgh already has 67 miles of designated bike lanes, and has built protected bike lanes on three streets, Penn Ave., Saline St. and Schenley Park. However, cyclists still have a hard time finding low-stress bike routes to commute and navigate from neighborhood to neighborhood that are safe to bicycle, pedestrian and motorized vehicular traffic. The long-term sustainability of bicycle infrastructure networks call for systematic design and planning of bicycle infrastructure that takes into consideration the presence of pedestrians, bicycles, and other vehicles. In this research, we utilize massive multi-source mobility data in the existing multi-modal transportation systems to establish bikability score for each road segment in the City of Pittsburgh, facilitate decision making on expanding infrastructure networks, as well as to provide bike-friendly route information to cyclists.

The current bike riding information is unclear and insufficient to cyclists. Every day, a mix of pedestrians and cyclists use the streets and sidewalks. In order to plan their routes, many people use mapping applications such as Google Maps or Bing Maps. These programs provide users a bike/walk route to their destination based primarily on shortest distance. However, this distance-based algorithm does not take into account factors that affect bikes, such as the availability of bike infrastructure, safety, and physical riding difficulty.

In particular, cyclists must account for factors that are usually not considered for automobiles, such as: the slope of a road due to the increased effort required to navigate hills, safety concerns due to the limited protection offered by a bicycle, the existence or absence of designated bike lanes, the availability of shared bike infrastructure, and mobility concerns with the transit coverage. In order to address such concerns, this research create a metric system that rates bikeability for each segment based on those factors, and develops an application that fuses multi-modal data sources to assess bike safety/mobility, and allows cyclists to customize the weights of attributes such as safety or the slope of roads. In addition, the customizable bikeability score would serve as the base for users to choose routes based on safety and personal preferences.

Approach

We gain access to massive data for the Pittsburgh region which include, but are not limited to, crash data, incident data, traffic volume/speed data, transit data, and geographic elevation

data. We then apply statistical models to establish the relationship between cyclist crash risk and various explanatory variables. The data are specified as follows:

1. Bike data. We collect GIS data of the existing bike infrastructure, which include sidewalk, trails, bike lanes, on-street bike routes, cautionary on-street bike routes, and bike sharing stations (Healthy Ride).
2. Roadway safety. We geocode all reported traffic incidents from the County 911 call-for-service data, and estimate the crash risk for each road segment using statistical safety models.
3. Traffic flow. We have hourly traffic volume data from PennDOT and SPC at selected arterials and 5-min traffic speed data from INRIX. The traffic flow data is used to estimate potential crash risk for bike rides.
4. Ride difficulty. We use high-resolution elevation data to compute the slope of each road segment for each direction.
5. Interaction with transit services. We can associate bus service with any road segment, since Pittsburgh buses are equipped with a front-mounted bike rack that holds two bicycles.

We will then deploy an online web application in Pittsburgh to present those road-cycling scores and recommend routes. Recommendations can be made based on customized user weighting of each variable, so that each cyclist can plan according to his or her own priorities and be more knowledgeable about the safety of the chosen route.

In addition, we build a web-GIS application to provide best routes for shared bike (Healthy Ride) users. The best routes would navigate users from their origins of their choice, to pick up a bike from an existing shared bike dock, drop off the bike to a destination dock, and finally get to their destinations.

Outcomes

We developed the web-based application. A screenshot is in Figure 1. The application provides a bikability score for each main road segment in the City of Pittsburgh. The score is based on the users' preferences on weights of each of the five factors: traffic speed, elevation slop, crash frequency, injury frequency and bus coverage. The scores are scaled from 0 to 100, 100 being the most bike friendly and 0 being almost not bikable. The scores are then color coded on the map. Users can view those scores interactively. Figure 1 shows the bikability score on the Fifth Ave is 58.59/100, likely above average, while Figure 2 shows the bikability score on the Forbes Ave is 69.73/100.

In addition, users, if planning to use Healthy Ride shared bikes, can enter an origin point and a destination point. The application would recommend a route for Healthy Ride users based on pick-up/drop-off of rental bikes and bikeability scores of their preferences, as shown in Figure 3.

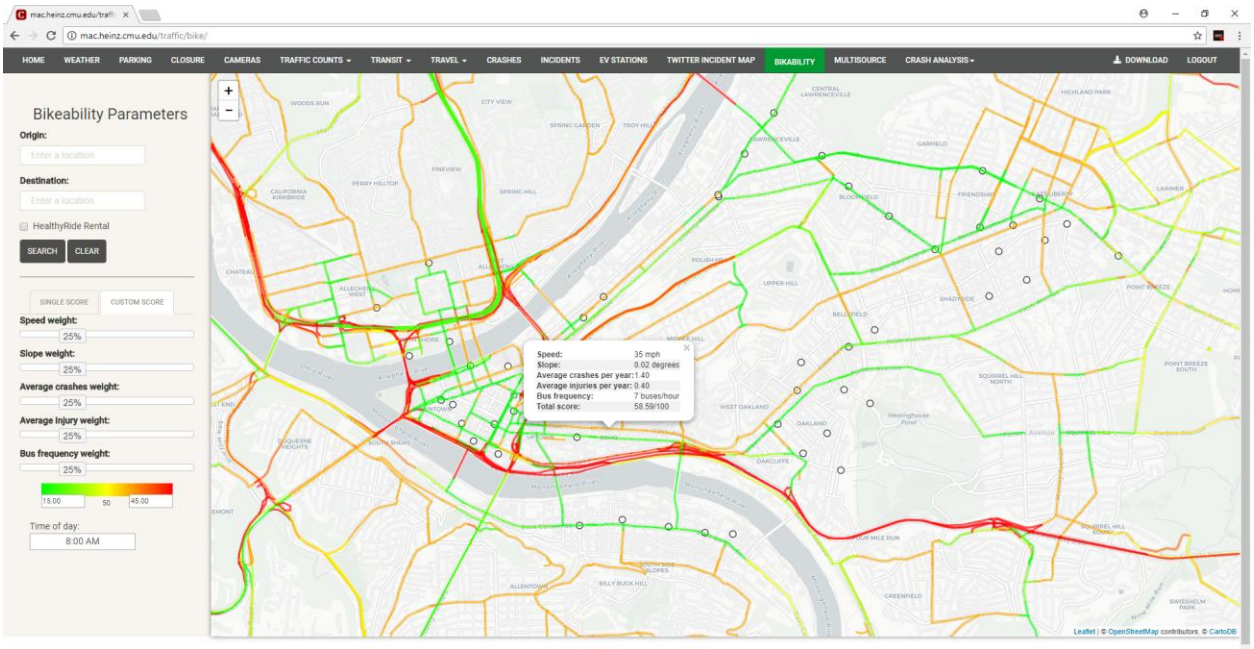

Figure 1. A screen shot of bikability web-based GIS application.

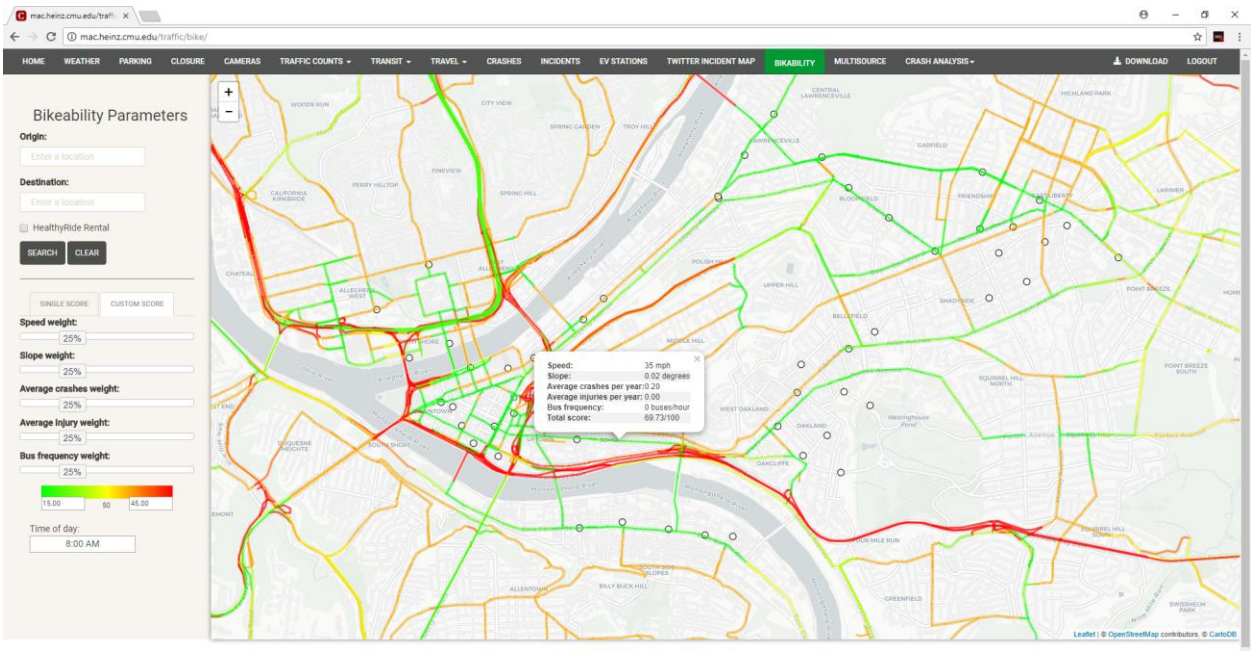

Figure 2. A second screen shot of bikability web-based GIS application.

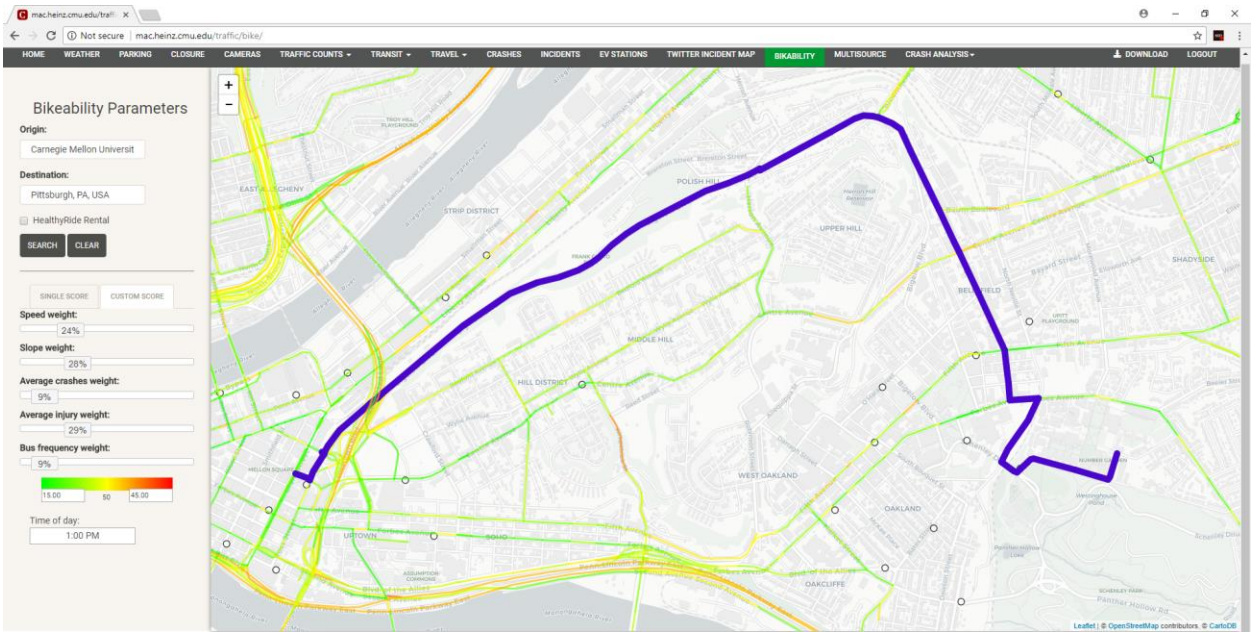

Figure 3. Recommending a route for Healthy Ride users based on pick-up/drop-off of rental bikes and bikeability scores of their preferences.

Conclusions

Bike has demonstrated an increasing role in Pittsburgh's multi-modal transportation network. Although bicycling is gaining in popularity and Pittsburgh's bicycling infrastructure is growing, improving online route-finding and making the network more equitable offer opportunities to accelerate this growth.

Market-dominant route-providing services like Google Maps and city-specific trail maps like BikePGH's provide a barebone approach to route-finding and lack critical functionality for cyclists. Because safe cycling is more sensitive to route slope, crash frequency, multimodal congestion, and traffic speed than cars, greater nuance must be applied to determining an optimal bike route which matches user preferences.

This research offers a holistic framework to implement a user-driven route-finding web application. An application was developed allowing users to weight routes by combinations of the speed, slope, average crashes, average injuries, and bus frequency along a route, and furthermore offers the most comprehensive and user-sensitive routing available in Pittsburgh.