

MPC-434

January 1, 2013- December 31, 2013

Project Title:

A Bicycle Network Analysis Tool for Planning Applications in Small Communities

University:

Utah State University

Principal Investigator:

Anthony Chen, Ph.D. (PI)

Professor (Utah State University)

anthony.chen@usu.edu

4110 Old Main Hill

Logan UT 84322-4110

(435) 797-7109

Research Needs:

Non-motorized modes such as bicycles constitute an important part of a small community's transportation system, and they are also vital to the success of transit-oriented-developments (TODs). They were, however, often ignored in transportation planning and travel demand modeling, or at best treated as a byproduct. In addition, many cities have begun to invest and promote cycling as a healthy, environmentally friendly, and economical alternative mode of travel to the motorized vehicles (especially private motorized vehicles). As noted above, the current practice in bicycle planning is inadequate, particularly for small communities with limited resources. Only a few research efforts focus on network analysis for bicycle trips (e.g., Klobucar and Fricker, 2006; Broach et al., 2011; Mekuria et al., 2012). Most assume a bicycle origin-destination (O-D) matrix is available or can be obtained from the four-step travel demand forecasting procedure which requires a large amount of data, travel surveys, and technical staff for operation and maintenance. For large communities, the collection of data and availability of experts are not a big hindrance. For small (and even medium-sized) communities where resources are scarce, the development and maintenance of a traditional four-step travel demand model (i.e., trip generation, trip distribution, modal split, and traffic assignment) is a challenge. To our best knowledge, none of the research efforts address the difficulties faced by small communities in developing bicycle planning tools. Small communities usually do not have sufficient resources to conduct travel surveys or embark on model development and maintenance for carrying out various planning functions. Hence, there is a need to develop network analysis tools that make use of the publicly available data from different sources (e.g., state Department of Transportation (DOT), metropolitan planning organization (MPO), etc.) to estimate bicycle demand (i.e., bicycle O-D trip table) and bicycle volumes on a transportation network (i.e., bicycle traffic assignment).

Research Objectives:

The overall goal of this research is to develop network analysis tools for estimating bicycle trips in small communities with limited resources. Specifically, the objectives include the followings:

1. Collect bicycle data (facility data and field data) from different sources to construct a bicycle network in a geographical information system (GIS) framework.
2. Develop a multi-criteria bicycle traffic assignment model for estimating bicycle volumes on a transportation network.
3. Develop a bicycle origin-destination matrix estimation for estimating bicycle demand in a small community.
4. Conduct a case study using a community in Utah.

Research Methods:

This research proposes to develop network analysis tools for estimating bicycle demand and bicycle volumes on a transportation network. It consists of two main modules: a multi-criteria bicycle traffic assignment module and a bicycle origin-destination (O-D) matrix estimation module. The multi-criteria bicycle traffic assignment module assigns a bicycle O-D matrix (assumed to be given) to the bicycle network to obtain the bicycle traffic flow pattern, while the bicycle O-D matrix estimation module estimates the bicycle demand using the available bicycle field data (e.g., bicycle counts) and other planning data (e.g., conventional travel surveys and census data, non-motorized travel surveys, public bicycle systems if any).

• Develop a multi-criteria bicycle traffic assignment module

In this module, we will develop a multi-criteria bicycle traffic assignment procedure for assigning a bicycle O-D trip table to the bicycle network to obtain the bicycle traffic flow pattern. The core component of the multi-criteria bicycle traffic assignment model is the factors (or criteria) affecting the cyclists' route choice decisions. Most route planners for cyclist consider only a single criterion (e.g., shortest path, safest path, least traffic pollution, least elevation gain, etc.) or a composite criterion by combining several factors (e.g., bicycle level of service (BLOS), bicycle compatibility index (BCI), bicycle stress level (BSL), etc.). In this research, we will explore different factors relevant to cyclists' route choice decisions (e.g., shortest distance, BLOS, BCI, BSL, etc.) to develop a multi-criteria traffic assignment model that explicitly considers each criterion as an objective in the model. We will develop bi-objective traffic assignment model using distance and BLOS as two distinct objectives for cyclists' route choice decisions. The overall procedure for solving the bi-objective bicycle assignment model involves two main steps: (1) determine efficient routes that represent the optimal tradeoffs between distance and BLOS by generating a Pareto set of routes, and (2) determine the flow allocation to each route in the cyclists' route choice set. Step 1 involves developing bi-objective shortest path algorithms to generate the optimal routes, while step 2 will develop different assignment schemes (e.g., equal share assignment, BLOS per unit distance saving assignment, reference point assignment, logit assignment, etc.) to assign the bicycle demand to the optimal routes generated in the first step.

• Develop a bicycle O-D matrix estimation module

In this module, we will develop a path flow estimator (PFE) procedure for estimating bicycle O-D matrix using available field data (e.g., bicycle counts, global position system (GPS) bicycle trajectories) and planning data (e.g., conventional travel surveys and census data, non-motorized travel surveys, public bicycle systems if any). PFE, originally developed by Bell and Shields (1995) and further enhanced by Chen et al. (2005, 2009, 2010), is a network observer capable of estimating path flows and path travel times using only counts from a subset of network links.

The basic idea is to find a set of path flows, hence an O-D trip table by aggregating the path flows for each O-D pair, which can reproduce the observed counts. This task involves modifying the PFE procedure to accept the bicycle counts collected by the counting program (i.e., from some bicycle counting stations) and other relevant bicycle data for estimating a bicycle O-D trip table.

Expected Outcomes:

Results from this research are expected to help small communities that do not have sufficient resources or expertise to develop a bicycle planning model. According to the U.S. Census, over 40 percent of all U.S. communities have populations less than 50,000. In Utah, there are 261 municipalities out of 272 municipalities (or 22 counties out of 29 counties) that have a population less than 50,000 (U.S. Census Bureau). We believe that the end product will be useful to the small communities in Utah, the planning division at the Utah Department of Transportation (UDOT), and the Metropolitan Planning Organizations (MPOs) especially those with limited resources to develop and maintain the bicycle planning model. The bicycle planning tool can help determine how public resources can be best prioritized and allocated to achieve the planning goals of a region.

Relevance to Strategic Goals:

As mentioned above, the estimated bicycle demand and bicycle volumes on a transportation network will assist state DOT and MPO to better plan for a more sustainable transportation system by promoting cycling as a healthy, environmentally friendly, and economical alternative mode of travel to the motorized vehicles. The results of this research project contribute to the following goals: (1) environmental sustainability and (2) livable communities.

Educational Benefits:

Non-motorized transportation planning is an important component of the overall travel demand forecasting process. This research project will provide useful information and real-world data to develop a bicycle transportation planning module for two courses taught by the PI at USU: CEE 5240/6240 Urban and Regional Transportation Planning and CEE 6290 Transportation Network Analysis. Our students will have the opportunity to learn about the actual bicycle transportation planning process conducted by the state DOT and MPOs, and to obtain hands-on experience with using the CUBE software (a transportation planning software tool used by both state and MPO planners in Utah).

Work Plan:

To meet the objectives set out above, we propose to undertake the following tasks in 18 months. Specifically, these tasks are to:

1. Conduct a literature review on non-motorized transportation planning procedure (2 months)
2. Collect bicycle facility data and bicycle counts data (2 months)
3. Code the bicycle network in a geographical information system (2 months)
4. Identify key attributes used in developing a bicycle route choice model (2 months)
5. Develop a multi-criteria bicycle traffic assignment model using the key attributes identified in task 4 (3 months)
6. Develop a bicycle origin-destination estimation model using various field data and planning data (3 months)
7. Conduct a case study using a community in Utah (2 months)

8. Document findings and prepare final report (2 months).

Project Cost:

Total Project Costs: \$100,000

MPC Funds Requested: \$50,000

Matching Funds: \$50,000

Source of Matching Funds: Faculty Salary, Tuition & Fees award for Ph.D. student, Fellowship for a visiting Ph.D. Student from China (See Budget for breakdown)

TRB Keywords:

Bicycle trips; bicycle route choice model; bicycle origin-destination matrix estimation; network analysis.

References:

Bell, M.G.H. and Shield, C.M. A log-linear model for path flow estimation. In Proceedings of the 4th International Conference on the Applications of Advanced Technologies in Transportation Engineering, Carpi, Italy, 1995, pp. 695-699.

Broach, J., Gliebe, J., Dill, J., 2001. Bicycle route choice model developed using revealed preference GPS data. Paper presented at the *90th Annual Meeting of the Transportation Research Board*, January 23-27, 2011, Washington D.C.

Chen, A., Chootinan, P., Recker, W., 2005. Examining the quality of synthetic origin-destination trip table estimated by path flow estimator. *Journal of Transportation Engineering* 131(7), 506-513.

Chen, A., Chootinan, P., Recker, W., 2009. Norm approximation method for handling traffic count inconsistencies in path flow estimator. *Transportation Research Part B* 43(8), 852-872.

Chen, A., Ryu, S., Chootinan, P., 2010. L_{∞} -norm path flow estimator for handling traffic count inconsistencies: Formulation and solution algorithm. *Journal of Transportation Engineering* 136(6), 565-575.

Klobucar, M., Fricker, J., 2006. Feasibility study for bicycle safety: Data assessment and network evaluation. FHWA/IN/JTRP Report, Purdue University.

Mekuria, M., Furth, P., Nixon, H., 2012. Low-stress bicycling and network connectivity. MTI Report 11-19, Mineta Transportation Institute, San Jose, California.