Literature Search 616: Designing and Implementing Maintainable Pedestrian Safety Countermeasures
Friday, June 26, 2020

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Resources searched: TRID, Pooledfund.org

Summary: Results are compiled from the databases named above. Links are provided for full-text, if applicable, or to the full record citation. I completed my searches using the following terminology: bike, biking, bicycle, pedestrian, walk, count, traffic, planning, smartphone data, mobile data, cellular data, GPS data. Results are divided into more and least relevant categories below.

Most Relevant Results

Pogodzinska, Sylwia; Kiec, Mariusz; Dâ€™Agostino, Carmelo. Bicycle Traffic Volume Estimation Based on GPS Data. Transportation Research Procedia, Volume 45, Issue 0, 2020, pp 874-881
https://trid.trb.org/view/1695217

Abstract: All the analytic methods for assessing the safety or comfort of bicyclists in urban area have as a common factor the number of bicycles that enter the system in a certain time interval or an estimate of that. The estimation of the average bicycle volume based on manual and automatic measurements is time-consuming and often require the use of expensive technology. The paper presents a method of estimation based on global positioning system (GPS) data from a bike sharing system as a low-cost option for data collection. The analysis was made for the city of Krakow (Poland), using the daily volume of bicycles from 5 automatic counter loops and GPS data from a bike sharing system called Wavelo. Based on the two-factor analysis of variance (ANOVA) and the Tukey post-hoc test, the influence of "localization" and "day of the week" factors on the share of Wavelo bicycles in the entire bicycle flow was estimated. It was shown that examined share is not significantly different between individual days of the week, but changes significantly between analyzed locations. Developed models are characterized by high R² coefficients (exceeding 0.90) and the average error of estimation up to 11.5%. The results of the studies show that bicycle volume can be estimated based on GPS data from bike sharing system. However, it is necessary to carry out control measurements to verify developed models and their possible application in other locations.

Huber, Stefan; Lißner, Sven. Disaggregation of aggregate GPS-based cycling data â€“ How to enrich commercial cycling data sets for detailed cycling behaviour analysis. Transportation Research Interdisciplinary Perspectives, Volume 2, Issue 0, 2019
https://trid.trb.org/view/1661172

Abstract: In order to investigate cycling behaviour, planners and researchers are increasingly using disaggregate data such as global positioning system (GPS) data. However, disaggregate data on cycling behaviour is not available for most cities. At first sight, the data collected by (sport) app providers like Strava could help fill the data gap, as they are available for most cities around the globe. Due to data privacy reasons however, this data is usually aggregated before it is sold commercially by data providers. To use the data for detailed analysis, this article presents a multi-step disaggregation approach to synthesise single routes from aggregate data sets. The approach requires aggregate origin-destination data of cycling demand as the primary input. A double-constrained routing algorithm is subsequently used to derive single bicycle routes from this data. This disaggregate route data can then be enriched with further attribute data
and can thereafter be used to estimate bicycle route choice models. This article presents the approach developed as well as a proof of concept using a case study. It further illustrates how the results can estimate a route choice model for a case study area in Germany. The overall results show that the presented approach could easily be used to disaggregate available aggregate cycling data to investigate cycling behaviour.

Clarry, Andrew; Faghih Imani, Ahmadreza; Miller, Eric J. Where We Ride Faster? Examining Cycling Speed using Smartphone GPS Data. Sustainable Cities and Society, Volume 49, Issue 0, 2019
https://trid.trb.org/view/1627022
Abstract: Research in cyclist behavior has until now avoided complex models for cyclist speed, instead preferring simple average speeds aggregated from multiple cyclists travelling on different terrain. This paper applies methods from recent research to create a detailed linear model for cyclist speeds, which varies according to road characteristics. This model is estimated using GPS point data for Toronto bicycle trips, generated by a smartphone app published by the City of Toronto. The model results indicate that the negative effect of cycling uphill on speed is stronger than the positive effect of travelling downhill. Further, the results demonstrate that bicycle infrastructure such as bike paths and bike lanes significantly increases cycling speed. The findings are useful for planners and decision makers who want to propose guidelines to increase cycling speed in order to attract more people toward cycling.

Lue, Gregory; Miller, Eric J. Estimating a Toronto pedestrian route choice model using smartphone GPS data. Travel Behaviour and Society, Volume 14, Issue 0, 2019, pp 34-42
https://trid.trb.org/view/1564800
Abstract: This study examines the feasibility of using revealed preference GPS data collected through a smartphone-based travel survey and discrete choice modeling techniques to determine pedestrians’ preferences towards street infrastructure, built environment, and land use. Smartphone GPS points were collected after 50 m of travel and had a horizontal spatial accuracy of 30 m or less. A path size logit model with stochastic route choice generation choice set was used for this model. The results of the model showed that distance, the number of turns, the number of signalized intersections, and distance along links with sidewalks on both sides of the street were significant variables in the route choice model. Turns are found to be equivalent to an additional 32 m, signalized intersections are equivalent to a reduction of 34 m, and travel along streets with sidewalks on both sides of the road is evaluated as 33% shorter than streets with other sidewalk conditions. While the dataset used for this study was relatively small (776 trip observations), these results are consistent with other pedestrian route choice studies which support the viability of using smartphone GPS data for future pedestrian route choice studies.

Chen, Xiaoxuan; Wan, Xia; Ding, Fan; Li, Qing; McCarthy, Charlie; Cheng, Yang; Ran, Bin. Data-Driven Prediction System of Dynamic People Flow in Large Urban Network Using Cellular Probe Data. Transportation Research Board 98th Annual Meeting, Transportation Research Board, 2019, 25p
https://trid.trb.org/view/1573227
Abstract: Cellular probe data, which is collected by cellular network operators, has emerged as a critical data source for human-trace inference in large-scale urban areas. However, because cellular probe data of individual mobile phone users is temporally and spatially sparse (unlike GPS data), few studies predicted people-flow using cellular probe data in real-time. In addition, it is hard to validate the prediction method at a large scale. This paper proposed a data-driven method for dynamic people-flow prediction, which contains four models. The first model is a cellular-probe data preprocessing module, which removes the inaccurate and duplicated records of cellular data. The second module is a grid-based data transformation and data integration module, which is proposed to integrate multiple data sources, including transportation network data, point-of-interest data, and people movement inferred from real-time cellular probe data. The third module is a trip-chain based human-daily-trajectory generation module, which provides the base dataset for data-driven model validation. The fourth module is for dynamic people-flow prediction, which is developed based on an
online inferring machine-learning model (Random Forest). The feasibility of dynamic people-flow prediction using real-time cellular probe data is investigated. The experimental result shows that the proposed people-flow prediction system could provide prediction precision of 76.8% and 70% for outbound and inbound people, respectively. This is much higher than the single feature model, which provides prediction precision around 50%.


Description: Data-driven approaches play a critical role in developing safety improvement investment decisions. However, for non-motorized travel, exposure to risk has often been the missing piece of the puzzle. Safety analysts have been struggling with the lack of availability of exposure data, making it difficult to discern a trend in crash rates and identify high-risk locations for pedestrians and bicyclists. While short-term counts cannot be considered policy relevant (until they are scaled to a long-term representative value), continuous monitoring of non-motorized traffic using automatic sensors are often not cost effective. Moreover, every sensor has some limitations in terms of coverage, accuracy, and reliability. In the era of big data, global positioning system (GPS) data, cell phone tracking apps, fitness tracking devices or bike sharing systems hold great potential to observe travel activity but they include a range of biases related to representation. Recognizing these limitations and benefiting from the advancements in technologies, this project aims to develop effective methodologies to fuse together different data sources to develop accurate and reliable exposure estimates for safety analysis. The proposed framework will bring together traditional and emerging data sources, and will be developed in such a way that it can be up- or down-scaled based on the available data sources of a study area. The exposure estimation output will then be used for crash assessment tailored to the needs of the study area. The proposed approach will increase the quality and representativeness of data and help safety analysts to effectively derive benefits from potential sources in their decision making.

Burmester, Benjamin; LaMondia, Jeffrey J. Cyclists' Preferences for Bicycle Lanes Versus Road-Adjacent Shared-Use Paths Using a Year-long Bike Share GPS Dataset. Transportation Research Board 97th Annual Meeting, 2018, 5p [Link](https://trid.trb.org/view/1494591)

Abstract: The presence of bicycle infrastructure has been shown to influence cycling levels and mode choice. To reach more potential users and increase ridership, much effort has been done to improve cycling facilities with recent emphasis on providing protected bicycle facilities separated from vehicular traffic. It has been hypothesized that less confident cyclists prefer protected or off-street facilities compared to traditional bicycle lanes that only separate motor vehicle traffic and cyclists with striping. It has also been documented through national design guidance that off-street shared-use paths do not substitute for the need for on-street bicycle facilities. This study uses one full year of global positioning system (GPS) route data from the Auburn University’s bike share program to model facility choice between an ideal on-street bicycle lane and off-street shared-use path. By selecting a site where both bicycle facility types are present, the analysis found that slightly more than half of the almost 900 trips were taken on the bicycle lane. A binary logic regression model was run using calculated user demographics, annual travel patterns and trip characteristics to determine what variables influence the facility choice. The modeling and analysis validates the difference in bicycle users where confident, regular cyclists overall prefer direct, on-street bicycle facilities while less confident and less experienced cyclists would rather ride on a protected facility away from traffic even if it requires sharing the path with pedestrians and is a slightly less direct route.

Abstract: This study examines the feasibility of using revealed preference global positioning system (GPS) data collected through a smartphone-based travel survey and discrete choice modeling techniques to determine pedestrians’ preferences towards street infrastructure, built environment, and land use. A path size logit model with stochastic route choice generation choice set was used for this model. The results of the model showed that distance, the number of turns, the number of signalized intersections, and distance along links with sidewalks on both sides of the street were significant variables in the route choice model. Turns are found to be equivalent to an additional 32m, signalized intersections are equivalent to a reduction of 34m, and travel along streets with sidewalks on both sides of the road is evaluated as 33% shorter than streets with other sidewalk conditions. These results are consistent with other pedestrian route choice studies which support the viability of using smartphone GPS data for future pedestrian route choice studies.


https://trid.trb.org/view/1487855

Abstract: Very little is known about cyclist speeds and delays at the disaggregate level of each road segment and intersection in an entire city network. Speeds and delays serve as vital information for planning, navigation and routing purposes including how they differ for different times of the day and across road and bicycle facility types, after controlling for other factors. In this work, the authors explore the use of recent global positioning system (GPS) cyclist trip data, from the Mon RésoVélo Smartphone application, to identify different performance measures such as travel time, speed and delay at the level of the entire network of roads and intersections on the island of Montreal. Also, a linear regression model is formulated to identify the geometric design and built environment characteristics affecting cyclist speeds on road segments. Among other results, on average, segment speeds are greater along arterials than on local streets and greater along segments with bicycle infrastructure than those without. Incorporating different measures of cyclist personality in the models revealed that the following characteristics all affect cyclist speeds along segments, each cyclist’s average speed on uphill, downhill and level segments as well as geometric design and built environment characteristics. The model results also identify that the factors that increase cyclist speeds along segments include, segments which have cyclists biking for work or school related purposes, segments used during morning peak and segments which do not have signalized intersections at either end.


https://trid.trb.org/view/1465698

Abstract: The increasing popularity of global positioning systems (GPSs) has prompted transportation researchers to develop methods that can automatically extract and classify episodes from GPS data. This paper presents a transferable and efficient method of extracting and classifying activity episodes from GPS data, without additional information. The proposed method, developed using Python®, introduces the use of the multinomial logit (MNL) model in classifying extracted episodes into different types: stop, car, walk, bus, and other (travel) episodes. The proposed method is demonstrated using a GPS dataset from the Space-Time Activity Research project in Halifax, Canada. The GPS data consisted of 5127 person-days (about 47 million points). With input requirements directly derived from GPS data and the efficiency provided by the MNL model, the proposed method looks promising as a transferable and efficient method of extracting activity and travel episodes from GPS data.

Abstract: Concerned by the nuisances of motorized travel on urban life, policy makers are faced with the challenge of making cycling a more attractive alternative for everyday transportation. Route choice models can help achieve this objective by gaining insights into the trade-offs cyclists make when choosing their routes and by allowing the effect of infrastructure improvements to be analyzed. The authors estimate a link-based bike route choice model from a sample of global positioning system (GPS) observations in the city of Eugene on a network comprising over 40,000 links. The so-called recursive logit (RL) model (Fosgerau et al., 2013) does not require to sample any choice set of paths. The authors show the advantages of this approach in the context of prediction by focusing on two applications of the model: link flows and accessibility measures. Compared to the path-based approach which requires to generate choice sets, the RL model proves to make significant gains in computational time and to avoid paradoxical accessibility measure results discussed in previous works, e.g. Nassir et al. (2014).

Ton, Danique; Cats, Oded; Duives, Dorine ; Hoogendoorn, Serge. How Do People Cycle in Amsterdam, Netherlands? Estimating Cyclistsâ€™ Route Choice Determinants with GPS Data from an Urban Area. Transportation Research Record: Journal of the Transportation Research Board, Issue 2662, 2017, pp 75–82

Abstract: Nowadays, the bicycle is seen as a sustainable and healthy substitute for the car in urban environments. The Netherlands is the leading country in bicycle use, especially in urban environments. Yet route choice models featuring inner-city travel that includes cyclists are lacking. This study estimated a cyclistsâ€™ route choice model for the inner city of Amsterdam, Netherlands, on the basis of 3,045 trips collected with GPS data. The main contribution of this study was the construction of the choice set with an empirical approach, which used only the observed trips in the data set to compose the choice alternatives. The findings suggested that cyclists were insensitive to separate cycle paths in Amsterdam, a city characterized by a dense cycle path network in which cycling was the most prominent mode of travel. In addition, cyclists were found to minimize travel distance and the number of intersections per kilometer. The impact of distance on route choice increased during the morning peak when schedule constraints were more prevalent. Furthermore, overlapping routes were more likely to be chosen by cyclists, everything else being the same.


Abstract: Bikeshare systems with docking stations have gained popularity in cities throughout the United States and have increased from six programs with 2,300 bikes in 2010 to 74 systems with 32,200 bikes in 2016. Even though bikeshare systems generate a wealth of data about bicycle checkout and check-in locations and times at docking stations, virtually nothing is known about routes and activities undertaken between checkout and check-in. Such information could greatly enhance expansion of bikeshare systems, placement of new docking stations, and location of new bike lanes and paths. In pursuit of such information, the District Department of Transportation, Washington, D.C., placed GPS trackers on 94 Capital Bikeshare (CaBi) bikes in the spring of 2015. On the basis of these data, this geographic information system analysis distinguished riders by type of CaBi membership, identified popular routes, analyzed bicycle infrastructure use, and examined stops and dwelling times at places of interest. Results showed strong differences in trip attributes between types of membership. Trips taken by short-term users were longer in distance, slower than long-term usersâ€™ trips, and concentrated in and around the National Mall, whereas long-term usersâ€™ trips were concentrated in mixed-use neighborhoods. Short-term users rode 12% of their miles on dedicated bicycle infrastructure, 61% in parks, and 27% on roadways with motorized traffic, whereas for long-term members the percentages were 33%, 17%, and 50%, respectively. On the basis of the routes taken in this study, potential locations were recommended for bicycle infrastructure improvements and new bikeshare stations.
Zimmerman, M; Mai, T; Frejinger, E. *Bike route choice modeling using GPS data without choice set of paths.* Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT), 2016, 23p [https://trid.trb.org/view/1435840](https://trid.trb.org/view/1435840)

Abstract: Concerned by the nuisances of motorized travel on urban life, policy makers are faced with the challenge of making cycling a more attractive alternative for everyday transportation. Route choice models can help achieve this objective by gaining insights into the trade-offs cyclists make when choosing their routes and by allowing the effect of infrastructure improvements to be analyzed. We estimate a link-based *bike* route choice model from a sample of GPS observations in the city of Eugene on a network comprising over 40,000 links. The so-called recursive logit (RL) model does not require to sample any choice set of paths. We show the advantages of this approach in the context of prediction by focusing on two applications of the model: link flows and accessibility measures. Compared to the path-based approach which requires to generate choice sets, the RL model proves to make significant gains in computational time and to avoid paradoxical accessibility measure results discussed in previous works.


Abstract: *Big Data* has begun to create significant impacts in urban and transport planning. This paper covers the explosion in data-driven research on cycling, most of which has occurred in the last ten years. The authors review the techniques, objectives and findings of a growing number of studies the authors have classified into three groups according to the nature of the data they are based on: *GPS data* (spatio-temporal data collected using the global positioning system (GPS)), live point data and journey data. The authors discuss the movement from small-scale GPS studies to the â€”Big GPSâ€” data sets held by fitness and leisure apps or specific cycling initiatives, the impact of *Bike Share Programmes* (BSP) on the availability of timely point data and the potential of historical journey data for trend analysis and pattern recognition. The authors conclude by pointing towards the possible new insights through combining these data sets with each other â€” and with more conventional health, socio-demographic or transport data.

Watkins, Kari; Ammanamanchi, Rohit; LaMondia, Jeff; Le Dantec, Christopher A.. *Comparison of Smartphone-based Cyclist GPS Data Sources.* Transportation Research Board 95th Annual Meeting, Transportation Research Board, 2016, 16p [https://trid.trb.org/view/1393960](https://trid.trb.org/view/1393960)

Abstract: It is important for planning agencies to have data on cyclist travel patterns, routes, volumes, and speeds, but access to such data is currently limited and often expensive to obtain. Many regions are looking toward the use of *GPS data* collected using smartphones to track cyclist trips, both via apps deployed by the agencies and, more recently, fitness-based apps providing anonymized user data by roadway segment. As regions begin to collect and purchase GPS-based data, there are many questions about potential uses in transportation planning, including the representativeness of the data. This paper provides a comparison of the data obtained from two smartphone-based apps, Cycle Atlanta and Strava, to begin to understand how *GPS data* can be used to map cyclist movements in an urban area. Analysis includes user demographic data and overall trip statistics, time-of-day, and geographic trips by segment comparisons. Differences between the two populations were found in terms of gender, age, percent commute trips, trip lengths, and preference for *bike* paths. Cycle Atlanta data was also compared to a set of manual *bike counts* and it was found that only about 3% of the cyclists counted had recorded their trip in Cycle Atlanta. The usage of GPS-based smartphone cycling app data is a promising new data source for transportation planning and design analysis, but should carefully take into account the likely bias from the self-selected users of such apps. These apps can supplement, but not replace large-scale *count programs* to establish system-wide cyclist volumes.
Strauss, Jillian; Miranda-Moreno, Luis F; Morency, Patrick. **Mapping Cyclist Activity and Injury Risk in a Network Combining Smartphone GPS Data and Bicycle Counts.** Transportation Research Board 94th Annual Meeting, Transportation Research Board, 2015, 17p

https://trid.trb.org/view/1338780

Abstract: In recent years, research has been carried to identify risk factors and map injury risk for cyclists. This task requires three main sources of data: geocoded injury data, geometric design and built environment characteristics as well as exposure measures, also referred to as motor-vehicle and bicycle flows, volumes or activity. Among these three elements, bicycle flow on each facility and network element is an essential component in the calculation of injury rates which can be used in many planning tasks such as the identification of the most dangerous routes and of corridors with high bicycle activity where infrastructure can be justified. The main objectives of this work are to estimate and map bicycle volumes followed by injury risk throughout the entire Montreal network of road segments and intersections, combining smartphone global positioning system (GPS) traces and manual and automatic, short-term and long-term counts, and to validate the use of GPS data as a reliable source of obtaining cyclist exposure data. Bayesian methods are applied to the GPS data to map injuries and risk for each and every element of the road and intersection network for the island of Montreal. Among other results, cyclist risk is greatest outside the central neighbourhoods and where bicycle infrastructure is not present and much greater at intersections than along segments. This work validates the use of GPS data as a reliable source of bicycle flow to be used in a variety of safety analyses.

Yeboah, Godwin. **Understanding Urban Cycling Behaviours in Space and Time.** Northumbria University, 2014, 318p

https://trid.trb.org/view/1689982

Abstract: The aim of this research thesis was to understand how the urban built environment interacts with utility cycling behaviours in space and time. Using mixed methods entrenched in the philosophy of pragmatism, the research contributed to an as yet under-developed research evidence-base within the British context by addressing the gap in knowledge relating to: the usability of space- time and action space theories within visual analytics context in facilitating the knowledge discovery process from spatio-temporal datasets; empirical evidence on perceived and actual movement behaviour of urban utility cyclists; methodological advancement in collecting, refining, analysing and visualising detailed utility cycling behaviours in a British urban environment. Findings suggest that 57.4% of cyclists’ bike trips were found on the cycle network and with 42.6% of cyclists still cycling outside the designated cycle network; it is therefore imperative that policy initiatives aimed towards strategic investment in cycling behavioural research and infrastructure. The findings also showed a higher concentration of cycling uptake around the south-eastern part of Newcastle upon Tyne suggesting this area may need more investment than other areas in Tyne and Wear. Systematic comparison of GPS data and travel diary data suggest 8.4% under reporting of the former. The null hypothesis that urban transport network restrictions do not have any significant influence on movement of commuter cyclists was rejected upon examination and it was found that observed routes tend to be significantly longer than their shortest path counterparts. Profiling activity spaces of utility cyclists utilising different geographies was found to be useful in the examination of cycling behaviours for the purpose of providing visual aid for planners and policy makers to identify areas for improvement and informed investment in support of sustainable transport. Several efforts were being made to enhance data availability to inform policy strategies, and facilitation of feasible solutions for improving the urban cycling infrastructure and encouraging more people to cycle as part of their daily commute, for which this research aimed to contribute by providing evidence on the use of the area’s cycling infrastructure by utility cyclists and spatial variability of cycling in space and time.

Park, H Joon; Kim, Patrick H; Marsico, Michael; Rasheed, Naim. **Data Mining Strategies for Real-time Control in New York City.** Procedia Computer Science, Volume 32, Issue 0, 2014, pp 109-116

https://trid.trb.org/view/1317761

Abstract: The Data Mining System (DMS) at New York City Department of Transportation (NYCDOT) mainly consists of four database systems for traffic and pedestrian/bicycle volumes, crash data, and signal timing plans as well as the Midtown in Motion (MIM) systems which are used as part of the NYCDOT Intelligent Transportation System (ITS)
infrastructure. These database and control systems are operated by different units at NYCDOT as an independent database or operation system. New York City experiences heavy traffic volumes, **pedestrians** and cyclists in each Central Business District (CBD) area and along key arterial systems. There are consistent and urgent needs in New York City for real-time control to improve mobility and safety for all users of the street networks, and to provide a timely response and management of random incidents. Therefore, it is necessary to develop an integrated DMS for effective real-time control and active transportation management (ATM) in New York City. This paper will present new strategies for New York City suggesting the development of efficient and cost-effective DMS, involving: 1) use of new technology applications such as tablets and smartphone with Global Positioning System (GPS) and wireless communication features for data collection and reduction; 2) interface development among existing database and control systems; and 3) integrated DMS deployment with macroscopic and mesoscopic simulation models in Manhattan. This study paper also suggests a complete data mining process for real-time control with traditional static data, current real timing data from loop detectors, microwave sensors, and video cameras, and new real-time data using the GPS data. GPS data, including using taxi and bus GPS information, and smartphone applications can be obtained in all weather conditions and during anytime of the day. GPS data and smartphone application in NYCDOT DMS is discussed herein as a new concept.


Abstract: Identifying the transportation mode can offer several advantages in different fields of transportation engineering such as transportation planning and intelligent transportation systems which lead to a broad range of environmental and safety applications. Support vector machine, as a supervised learning method, is adopted in this paper to develop a multi-class classifier to distinguish between different transportation modes including driving a car, riding a **bicycle**, taking a bus, walking, and running. Data from different mobile phone sensors were trained and tested to evaluate the model. Sensors from which the data were obtained include accelerometer, gyroscope, rotation vector, and Global Positioning System (GPS). A Gaussian kernel was applied as part of the classifier and unlike some ambiguity seen in the literature, a complete model selection is conducted. A small window size of one second was considered, so the model can be useful in a broader range of applications. For the first time, the data from gyroscope and rotation vector sensors were used in experiments based on individual sensor data. The study showed that such data can contribute to high detection rates. It was found that including attributes that have similar behavior among different modes can negatively impacts the detection rates. When using multiple sensors, high average overall accuracies of 98.86% and 97.89% were achieved with and without using the GPS data, respectively. These results offer improvements compared to what is reported in the literature. The bus mode was the most difficult mode to differentiate due to some similarities to the car and the **bike** mode data.

Hood, Jeffrey; Sall, Elizabeth; Charlton, Billy. **A GPS-Based Bicycle Route Choice Model for San Francisco, California.** Transportation Letters: The International Journal of Transportation Research, Volume 3, Issue 1, 2011, pp 63-75 [https://trid.trb.org/view/1097265](https://trid.trb.org/view/1097265)

Abstract: Recognizing the environmental and health benefits of cycling, cities around the world are promoting use of the **bicycle** for everyday transportation, but with limited information about the preferences of cyclists and the effectiveness of investments in **bicycle** infrastructure. To better understand the decision-making of cyclists, the authors estimated a route choice model with GPS data collected from smartphone users in San Francisco. Traces were automatically filtered for activities and mode transfers, and matched to a network model. Alternatives were extracted using repeated shortest path searches in which both link attributes and generalized cost coefficients were randomized. The prior distribution for the coefficients was calibrated automatically using only the network. A Path Size Multinomial Logit model revealed that **bicycle** lanes were preferred to other facility types, especially by infrequent cyclists. Steep slopes were disfavored, especially by women and during commutes. Other negative attributes included length and turns. Traffic volume, traffic
speed, number of lanes, crime rates, and nightfall had no effect. Marginal rates of substitution imply a user benefit of bike lanes of $0.61 USD per km per trip. Coefficients were applied to a trip assignment model that will be used to evaluate prospective investments in bicycle infrastructure in San Francisco.

Casello, Jeffrey; Nour, Akram Omar; Rewa, Kyrylo Cyril; Hill, John. Analysis of Stated-Preference and GPS Data for Bicycle Travel Forecasting. Transportation Research Board 90th Annual Meeting, Transportation Research Board, 2011, 18p
https://trid.trb.org/view/1093054
Abstract: In this paper, we present preliminary results from an ongoing study of cyclists and cycling in the Region of Waterloo, Ontario Canada. The paper describes two data collection efforts. The first is an on-line survey that provides information on cyclists’ demographics as well as their household composition. The survey also gathers data on respondents’ motivation for and obstacles to cycling. The second activity collects data on actual cycling trips using GPS units. We describe these units and the steps taken to validate the data. We use the GPS data to produce trip generation and attraction rates for cycling as a function of land use. We also generate a histogram of observed cycling trip lengths that can be used to calibrate a gravity-type model of trip distribution. We then explore the methods by which the survey and GPS data may be combined to develop multi-class and multi-trip purpose generalized cost functions. These formulations may be applied to prioritizing infrastructure investments, as well as for mode and path choice models. We conclude with a discussion of ongoing research work.

Harvey, Francis; Krizek, Kevin J; Collins, Reuben. Using GPS Data to Assess Bicycle Commuter Route Choice. Transportation Research Board 87th Annual Meeting, Transportation Research Board, 2008, 20p
https://trid.trb.org/view/848852
Abstract: This research analyzes bicycle commuter behavior that relies on the innovative use of Global Positioning System (GPS)-based data collection. The study examines the commute travel distances using data collected from GPS receivers and self-reported values. Analysis compares cyclists’ preferred routes with the shortest-network paths to determine the additional distances cyclists are willing to travel; multivariate regression models identify route and participant attributes affecting route choice. The analysis results suggest that as cyclists become more comfortable riding in heavy traffic conditions, they are less likely to travel additional distance beyond the shortest network path. In spite of accuracy concerns and complex data processing issues, we further conclude that GPS technology has great potential to be used in studies of bicycle commuting.

Krizek, Kevin J; El-Geneidy, Ahmed; Iacono, Michael; Horning, Jessica. Access to Destinations: Refining Methods for Calculating Non-Auto Travel Times. University of Minnesota, Twin Cities; Minnesota Department of Transportation, 2007, 144p
https://trid.trb.org/view/813707
Abstract: The functioning of the system of land use and travel networks in a region can be encapsulated into measures of the ease of reaching destinations from various locations, often referred to as accessibility measures. Regardless of the form used to specify accessibility, all measures require as inputs travel times between the zones of a region. For most transportation planning purposes, these travel time calculations are limited to motorized modes (auto and public transit), since these modes carry the bulk of all urban travel. In this research study, attention is focused on developing methods for calculating travel times by non-auto modes, including walking, bicycling and public transit. Unique networks for each mode are developed, accounting for the presence of special facilities such as pedestrian or bicycle trails and on-street bike lanes. A statistical model is estimated to identify the influence of special bicycle facilities on travel speeds, using GPS data collected from bicyclists in a real-world setting. These methods are demonstrated with an application to a section of the Twin Cities metropolitan region encompassing parts of the cities of Minneapolis, St. Paul and Bloomington. The output of the application of these methods are a set of maps depicting travel sheds from various
locations within the study area. The data are displayed for three points in time: 1995, 2000 and 2005. Changes to these travel sheds over time are demonstrated with maps that show the difference in travel time between each set of origins and destinations for each pair of years. The research concludes with some suggestions about the uses of the travel time data, such as the calculation of multimodal, multipurpose measures of accessibility.

Least Relevant Results

https://trid.trb.org/view/1637872
Abstract: Over the past decade, interest has grown in using Global Positioning System (GPS) data to augment or even to replace traditional travel survey or activity diaries. If the full potential of this new class of data is to be realized, processing techniques will need to be standardized and automated to some degree. This paper develops a multinomial logit (MNL) model to impute travel mode from GPS and hip-mounted accelerometer data. The MNL model is the workhorse of travel demand modeling, but it has rarely been applied to GPS data processing. A web-based recall survey provided over 900 trips for estimation and 500 plus trips for validation from a larger multi-day GPS travel survey in Portland, Oregon. Special attention is given to the imputation of bicycle travel, the identification of which has been given little attention in the North American context. The authors also apply two existing non-MNL mode imputation models to their Portland data and to compare and test the broader transferability of specific techniques. They find that the MNL model as specified performs well overall, generally outperforming competing model forms on the Portland GPS data. Transit network data and accelerometer data significantly improve model fit for specific modes. Accelerometer data is found in particular to aid model fit for bicycling; however, external validation results were less clear. No benefit is found to segmenting models by traveler age, although not all age groups were covered by the sample. The MNL model shows strong potential for automated GPS processing and, as a commonly used transportation modeling technique, should be relatively easy to implement elsewhere.

https://trid.trb.org/view/1573460
Abstract: Bicyclists often deviate from the shortest possible routes and take detours in search of more pleasant riding conditions. The extent of detours and the factors affecting bicyclists to ride excess distances have not yet been fully explored. This study aims to measure and analyze the detour extent of utilitarian bicycle trips and their relationships with the route-level environmental components using data collected from individual bicyclists' smartphone GPS in Columbus, Ohio. Comparing the chosen routes with their shortest counterparts, the authors calculate two detour indices (a distance-based index and an area-based index) and provide a comparative analysis of built environment attributes for low, moderate, and high levels of detours. They then estimate multilevel mixed-effect generalized linear regression models to identify the contribution of built-environment characteristics to such detours while accounting for individual heterogeneity. The authors find that most bicycle trips (91.1%) include a detour and are 13.5% longer on average than their shortest alternatives with large variations. Detour degrees are higher for long-distance trips and for peak-period trips. They find that bicyclists choose routes with smaller shares of commercial and single-family land-uses and low levels of land-use diversity. Longer detours are positively associated with street greenery. The authors find that sparse bicycle facilities and high-speed limits are strong contributors to bicyclists' detour decisions, while multilevel mixed-effect linear regression models further present significant heterogeneity in bicyclists' responses to some environmental attributes. The area-based detour index performs better in explaining the relationships between land-use features and detour degrees.
Fickas, Stephen. V2X: Bringing Bikes Into The Mix. University of Oregon, Eugene; National Institute for Transportation and Communities; Office of the Assistant Secretary for Research and Technology, 2019, 37p

https://trid.trb.org/view/1601582

Abstract: This project demonstrates how an inexpensive system (hardware and software) can add new functionality to existing signal controllers, giving bicyclists an efficient way to cross a controlled intersection. The system integrates three components: (1) a Bike Connect box that resides near the signal-controller and is connected to it, (2) an application that runs on a Bike Connect device (currently an iPhone) and requests a green light at the correct approach-distance, and (3) a cloud-based publish/subscribe (pub/sub) component that handles cellular-communication between phone app and box. One stumbling block for the project was a means to obtain reliable GPS data to compute distance while walking, biking and standing still (being idle). The authors report on their evaluation of 4 methods: raw GPS, averaged GPS, line of best fit and speed. The authors found that a combination of methods was most effective and describe that combination and its results. The final system was put into place and tested with 120 separate rides. The authors report on the results and potential future paths to take the research.

Liu, Xiaoyue Cathy; Taylor, Jeffrey; Porter, Richard J.; Wei, Ran. Using trajectory data to explore roadway characterization for bikeshare network. Journal of Intelligent Transportation Systems, Volume 22, Issue 6, 2018, pp 530-546

https://trid.trb.org/view/1570843

Abstract: The rapid expansion of bikeshare programs nationwide provides opportunities to gain insights on the optimal development of multimodal networks and bike-friendly environments. The profusion of trajectory-level data produced by bikeshare systems allows for information extraction on users' route preferences and, if modeled properly, will lead to a greater understanding of road characteristics that are appealing to bikeshare users. Leveraging Global Positioning System (GPS) data obtained from the GREEN bike program, this study proposes a method to characterize roadways (e.g. collector, peripheral road, attractive road, and local road) on the basis of a variety of network centrality functions. The methodology is able to uncover the structure of the underlying transportation network and identify locations of critical bicycle infrastructures. A series of centrality measures, including degree, shortest-path betweenness, and random-walk betweenness centrality are implemented to determine the roadway classifications. Their suitability and usability for this purpose is then explored and discussed at length through a sensitivity analysis. The method can be applied to any bikeshare system that has access to trajectory-level (i.e. GPS, crowdsourcing) data for identifying road attributes that are appealing to bike users. Results can effectively guide future investment choices.


https://trid.trb.org/view/1530306

Abstract: A new generation of bike-sharing services without docking stations is currently revolutionizing the traditional bike-sharing market as it dramatically expands around the world. This study aims at understanding the usage of new dockless bike-sharing services through the lens of Singapore’s prevalent service. The authors collected the global positioning system (GPS) data of all dockless bikes from one of the largest bike sharing operators in Singapore for nine consecutive days, for a total of over 14 million records. The authors adopted spatial autoregressive models to analyze the spatiotemporal patterns of bike usage during the study period. The models explored the impact of bike fleet size, surrounding built environment, access to public transportation, bicycle infrastructure, and weather conditions on the usage of dockless bikes. Larger bike fleet is associated with higher usage but with diminishing marginal impact. In addition, high land use mixtures, easy access to public transportation, more supportive cycling facilities, and free-ride promotions positively impact the usage of dockless bikes. The negative influence of rainfall and high temperatures on bike utilization is also exhibited. The study also offered some guidance to urban planners, policy makers, and transportation practitioners who wish to promote bike-sharing service while ensuring its sustainability.
Lu, Wei; Scott, Darren M; Dalumpines, Ron. **Understanding bike share cyclist route choice using GPS data: Comparing dominant routes and shortest paths.** Journal of Transport Geography, Volume 71, Issue 0, 2018, pp 172-181

https://trid.trb.org/view/1531657

Abstract: This paper investigates cyclist route choices using global positioning system (GPS) data collected from 750 bicycles in Hamilton, Ontario's bike share system â€” SoBi (Social Bicycles) Hamilton. A dataset containing 161,426 GPS trajectories describing observed routes of cyclists using SoBi bikes over a 12-month period (April 1, 2015 to March 31, 2016) is used for analysis. This study groups trips by origin-destination hub pairs and uses a GIS (geographic information system)-based map-matching algorithm to generate routes along with attributes such as length, number of intersections, number of turns, and unique road segments. Unique routes and their use frequencies are extracted from all the hub-to-hub trips using a GIS-based link signature extraction tool developed for this research. The most popular routes between hubs taken by cyclists are then identified as dominant routes and their attributes are compared to those of corresponding shortest path routes derived by minimizing distance traveled. The comparison finds significant differences in multiple attributes, and demonstrates that dominant routes are significantly longer than their shortest distance counterparts, suggesting that cyclists are willing to detour for routes characterized by positive features such as bicycle facilities and low traffic volumes. Detouring does, however, come at a cost â€” increases in number of turns and number of intersections. This research not only enhances our understanding of cyclist route preferences within a bike share system, it also presents a GIS-based approach for identifying potential locations for future bike facilities based on such preferences.

Wang, Bao; Gao, Linjie; Juan, Zhicai. **Travel Mode Detection Using GPS Data and Socioeconomic Attributes Based on a Random Forest Classifier.** IEEE Transactions on Intelligent Transportation Systems, Volume 19, Issue 5, 2018, pp 1547-1558

https://trid.trb.org/view/1511238

Abstract: The past few years have witnessed the rapid growth in the collection of large-scale GPS data via smartphone-based travel surveys around the world, following which transportation modes detection received significant attention. A mass of methods varying from Criteria-based rules to Machine Learning technology were employed to recognize the travel modes. However, the limited sample size, deficient feature selection and the less emphasis on addressing confusion modes, which leave room for improvement. This paper therefore sought to develop and evaluate a Random Forest classifier combined with a rule-based method to detect six travel modes (subway, walking, bicycle, e-bike, bus and car). Seven GPS-related variables are selected as feature set from the initial list of 22 variables. Consequently, more than 98% subway trips were correctly identified and the overall accuracy of the rest five modes classification is obtained as high as 93.11%. More than 85% trips were successfully identified for each mode except for the bus. More importantly, results show that socioeconomic attributes data could significantly improve the prediction of e-bike and address the confusion between bus and car modes. The employment of ROC curve provides a statistical proof to the excellent classification capacity of Random Forest in this study. Besides, the comparison with two representative classifiers demonstrates the applicability of Random Forest classifier for travel modes detection incorporating multi-source attributes.

Mäenpää, Heikki; Lobov, Andrei; Martinez Lastra, Jose L. **Travel mode estimation for multi-modal journey planner.** Transportation Research Part C: Emerging Technologies, Volume 82, 2017, pp 273-289

https://trid.trb.org/view/1478065

Abstract: For route planning and tracking, it is sometimes necessary to know if the user is walking or using some other mode of transport. In most cases, the global positioning system (GPS) data can be acquired from the user device. It is possible to estimate userâ€™s transportation mode based on a GPS trace at a sampling rate of once per minute. There has been little prior work on the selection of a set of features from a large number of proposed features, especially for
sparse GPS data. This article considers characteristics of distribution, auto- and cross-correlations, and spectral features of speed and acceleration as possible features, and presents an approach to selecting the most significant, non-correlating features from among those. Both speed and acceleration are inferred from changes in location and time between data points. Using GPS traces of buses in the city of Tampere, and of walking, biking and driving from the OpenStreetMap and Microsoft GeoLife projects, spectral bins were found to be among the most significant non-correlating features for differentiating between walking, bicycle, bus and driving, and were used to train classifiers with a fair accuracy. Auto- and cross-correlations, kurtoses and skewnesses were found to be of no use in the classification task. Useful features were found to have a fairly large (>0.4) correlation with each other.

https://trid.trb.org/view/1493304
Abstract: This study examines the effects of built environment features, including factors of land use and road network, on bicyclists' route preferences using the data from the city of Seattle. The bicycle dataset collected from a smartphone application named âCycleTracks.â The route choice set is generated using the labeling route approach, and the cost functions of route alternatives are based on principal component analyses. Then, two mixed logit models, focusing on random parameters and alternative-specific coefficients, respectively, are estimated to examine bicyclists' route choice. The major findings of this study are as follows: (1) the bicycle route choice involves the joint consideration of convenience, safety, and leisure; (2) most bicyclists prefer to cycle on shorter, flat, and well-planned bicycle facilities with slow road traffic; (3) some bicyclists prefer routes surrounded by mixed land use; (4) some bicyclists favor routes which are planted with street trees or installed with street lights; and (5) some bicyclists prefer routes along with city features. This analysis provides valuable insights into how well-planned land use and road network can facilitate efficient, safe, and enjoyable bicycling.

https://trid.trb.org/view/1472481
Abstract: With cooperative intelligent transportation systems, vulnerable road users (VRU) safety can be enhanced by multiple means. On the one hand, perception systems are based on embedded sensors to protect VRUs. However, such systems may fail due to the sensors' visibility conditions and imprecision. On the other hand, vehicle-to-pedestrian (V2P) communication can contribute to the VRU safety by allowing vehicles and pedestrians to exchange information. This solution is, however, largely affected by the reliability of the exchanged information, which most generally is the GPS data. Since perception and communication have complementary features, the authors can expect that a fusion between these two approaches can be a solution to the VRU safety. In this paper, the authors propose a cooperative system that combines the outputs of communication and perception. After introducing theoretical models of both individual approaches, the authors develop a probabilistic association between perception and V2P communication information by means of multi-hypothesis tracking. Experimental studies are conducted to demonstrate the applicability of this approach in real-world environments. Their results show that the cooperative VRU protection system can benefit of the redundancy coming from the perception and communication technologies both in line-of-sight (LOS) and non-LOS conditions. The authors establish that the performances of this system are influenced by the classification performances of the perception system and by the accuracy of the GPS positioning transmitted by the communication system.

Abstract: Rapidly-evolving geo-referenced information and communication technologies have improved the feasibility of collecting individualized high-fidelity and fine-resolution GPS data. Such GPS data is used by transportation practitioners to calibrate and validate various travel and traffic models, and to create transportation system performance measures in compliance with programs such as the Congestion Management Process (CMP) and Moving Ahead for Progress in the 21st century (MAP-21). Research on developing a systematic and practical model to best use this GPS data, however, is rather limited. This research extends and expands this line of inquiry, introducing a comprehensive procedure containing a series of four models to measure regional transportation network performance with high-frequency GPS data. The series consists of a mode detection model, a map-matching model with sub-models of a network expansion and a shortest path model, an activity filtering model, and a link-performance measure update model. With 56.9 million GPS points collected over a 15-month period in Tucson, Arizona, the procedure generated transportation performance measures including free-flow speed, average speed, and delay. The outcome of this study provides transportation practitioners with a comprehensive and practical solution to the development of transportation network performance measures using high-frequency GPS data.

Fitch, Dillon T; Thigpen, Calvin; Cruz, Antonio; Handy, Susan. Bicyclist Behavior in San Francisco: A Before-and-After Study of the Impact of Infrastructure Investments. National Center for Sustainable Transportation; University of California, Davis; California Department of Transportation; Office of the Assistant Secretary for Research and Technology, 2016, 97p

Abstract: This study explores bicyclist behavior in San Francisco using data collected before and after major bike infrastructure investments. From early 2011 to December 2013, investments of $3.3 million correlated with a 14% increase in counts of bicyclists, part of a 96% increase in bicyclist counts from 2006 to 2013 (San Francisco Municipal Transportation Agency, 2013a). To better understand the relationship between these investments and changes in bicycling behavior, the authors build on the successful GPS travel survey conducted in 2010 by the San Francisco County Transportation Authority (SFCTA) (Hood et al., 2011). The authors used data from the smartphone based GPS data collection method (the CycleTracks application developed by SFCTA) which records bicyclists’ routes. In addition, they administered a detailed web-based survey to CycleTracks users in order to better characterize the factors associated with their bicycling behavior. The authors examine the relationship between bicycle infrastructure and behavior of bicyclists so as to assess the effectiveness of existing investments, and to provide guidance on efforts that are effective at increasing bicycling.

Strauss, Jillian; Miranda-Moreno, Luis F; Morency, Patrick. Speed, Travel Time, and Delay for Intersections and Road Segments in Montreal Using Cyclist Smartphone GPS Data. Transportation Research Board 95th Annual Meeting, Transportation Research Board, 2016, 19p

Abstract: Until now, very little has been known about cyclist speeds and delays at the disaggregate level of each road segment and intersection. Speeds and delays serve as vital information for navigation and routing purposes since they can identify speeds and delays during different times of the day and how they differ across roads and bicycle facilities. In this work, the authors explore the use of recent GPS cyclist trip data, from the Mon RÃ©soVélo smartphone application, for identifying different level-of-service measures such as travel time, speed and delay at the level of the entire road and intersection network for the island of Montreal. Also, a linear regression model is formulated to identify the geometric design and built environment characteristics affecting cyclist speeds on segments. Among other results, on average, segment speeds are greater along arterials than on local streets and greater along segments with bicycle infrastructure than those without. Modeling cyclist speed revealed that the variable representing the cyclists’ average speed on uphill, downhill and level segments, cyclists’ average speed on arterials as well as geometric design, built environment affect segment speeds. The model results identify that segments which have cyclists biking for
work or school related purposes, segments used during morning peak, segments with bicycle infrastructure and segments which do not have signalized intersections at either end, tend to have cyclists riding at greater speeds. Also, cyclists travel faster when the temperature is between 10° and 20° and travel slower late at night or early morning.

Abstract: This study presents a pedestrian route choice model estimated from revealed preference Global Positioning System (GPS) data. The authors extend existing pedestrian route preference work by treating the choice of which path to take as a single, utility maximizing decision from a discrete set of alternatives. The authors find that this traditional travel demand modeling method can be usefully applied to walk travel. Predicted routes could be used as inputs in more precise measurements of pedestrian accessibility. Such measures should be more adept at accounting for individual projects in planning scenarios. In addition to the model’s applications, some interesting findings about pedestrian route preferences are revealed. The authors find that pedestrians are sensitive to attributes of the walking network, intersection crossing aids, and elements of the street and block face environment along urban routes. People walking are willing to go out of their way to use more attractive facilities, but their tolerance for detours is limited, perhaps more so than for cyclists. Crossing aids must be densely placed along major streets to be useful. Neighborhood-scale commercial streets might serve as both attractive destinations and walking routes. Alleyways and unpaved streets do not seem to be useful to pedestrians, who only will use them if the distance saved is large. Terrain is perceived as a barrier only when very steep, and then only in the uphill direction. Finally, the authors find that joint travelers may prefer more direct routes than solo travelers. The authors find no significant differences in route preferences for female pedestrians.

Nour, Akram; Casello, Jeffrey; Hellinga, Bruce. Developing and Optimizing a Transportation Mode Inference Model Utilizing Data from GPS Embedded Smartphones. Transportation Research Board 94th Annual Meeting, Transportation Research Board, 2015, 16p https://trid.trb.org/view/1338992
Abstract: Advances in wireless communications and technologies provide the opportunity to collect detailed information on travel trajectory using smart-phones equipped with GPS and accelerometers. These types of smart-phones are ubiquitous and, as such, present an opportunity to conveniently collect spatial and temporal data at regular time intervals. This can be useful to utilize as a method to document travel behavior’s origin, destination, departure time, route choice, trip purpose, and mode choice. One of the challenges that has been addressed in the literature is how to identify the transportation mode of travel. This paper presents a data-driven classification model to infer transportation mode choice from data collected with GPS equipped smart phones. Rather than making a priori assumptions, the authors instead employ an optimization method to objectively produce the following classifier components and methods: a ranked feature vector based on the power of differentiation between different modes; the classification technique between the range of candidate classifiers; the number of ranked attributes to include in the feature vector; data formatting; and optimal model parameters. The model is trained and tested using known transportation mode segments’ limits of travel by a given mode. The calibrated model is evaluated by testing its ability to classify travel mode correctly for GPS data at a different level of disaggregation than the one used in the model training step. The model provides an accuracy of approximately 86% at the disaggregated level (e.g. Walk, Bike, Transit, and Private Automobile) and approximately 94% at aggregated level (e.g. Non-Motorized and Motorized.)

Abstract: Existing regional travel forecasting systems are not typically set up to forecast usage of bicycle infrastructure and are insensitive to bicyclists’ route preferences in general. To remedy this, we collected revealed preference, GPS data on 162 bicyclists over the course of several days and coded the resulting trips to a highly detailed bicycle network model. We then use these data to estimate bicyclist route choice models. As part of this research, we developed a sophisticated choice set generation algorithm based on multiple permutations of labeled path attributes, which seems to out-perform comparable implementations of other route choice set generation algorithms. The model was formulated as a Path-Size Logit model to account for overlapping route alternatives. The estimation results show compelling intuitive elasticities for route choice attributes, including the effects of distance and delay; avoiding high-volumes of vehicular traffic, stops and turns, and elevation gain; and preferences for certain bike infrastructure types, particularly at bridge crossings and off-street paths. Estimation results also support segmentation by commute versus non-commute trip types, but are less clear when it comes to gender. The final model will be implemented as part of the regional travel forecasting system for Portland, Oregon, U.S.A.

Broach, Joseph; Gliebe, John P; Dill, Jennifer. Bicycle Route Choice Model Developed from Revealed-Preference GPS Data. Transportation Research Board 90th Annual Meeting, Transportation Research Board, 2011, 14p
https://trid.trb.org/view/1093304

Abstract: To better understand bicyclists’ preferences, we used bicycle-mounted GPS units to observe the behavior of 162 bicyclists for several days each. Trip purpose and several other trip-level variables were recorded by the cyclists, and the resulting trips were coded to a highly detailed bicycle network. We then used the 1,449 valid non-exercise trips to estimate a bicycle route choice model. As part of this research, we developed a choice set generation algorithm based on multiple permutations of labeled path attributes, which seemed to out-perform comparable implementations of other route choice set generation algorithms. The choice model was formulated as a Path-Size Logit model to account for overlapping route alternatives. Estimation results are intuitive and suggest that cyclists are sensitive to the effects of distance, turn frequency, slope, intersection control, and traffic volumes. In addition, cyclists appear to place relatively high value on off-street bike paths, enhanced neighborhood bikeways (bicycle boulevards), and bridge facilities. Finally, estimation results support segmentation by commute versus non-commute trip types. The route choice model presented in this paper is currently being implemented as part of the regional travel forecasting system for Portland, Oregon, U.S.A.