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16. Abstract

This research project developed prototype software called GPS-TDG to automate the processing of raw GPS data and to generate outputs of activity-travel patterns in the conventional travel-diary format. The software identifies trips and characterizes them by several attributes, including trip-end locations, trip purpose, time of day, distance, and speed. The software is also capable of aggregating the trip diaries into inter-zonal highway performance measures.

This summary report briefly documents the entire research performed. Also included is a brief description of the findings and recommendations of the research team.

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Project Summary Report 0-5176-S

CONVERSION OF VOLUNTEER-COLLECTED GPS DIARY DATA INTO TRAVEL TIME PERFORMANCE MEASURES

INTRODUCTION

For nearly fifty years, household travel surveys have been used to document the travel behavior of regional households as part of long-range transportation planning efforts. The survey data are used for general planning and policy analysis, as well as to serve as the foundation for regional travel demand models. Technology advancements have resulted in changes in household travel survey data collection procedures, the most recent being the introduction of Global Positioning Systems (GPS) to record travel patterns. The GPS technology shows promise to minimize costs, while maximizing the volume of travel data collected. However, the data recorded by GPS devices do not directly yield travel information; rather, the outputs from these devices are in the form of navigational streams that have to be processed to derive travel information. Therefore, the success of this new technology as a travel survey instrument depends on the ability of the analyst to derive meaningful trip information from the navigational data streams of GPS devices.

In the State of Texas, GPS-based travel surveys have been conducted in Austin (1997-98), Laredo (2002), and Tyler/Longview (2003) establishing Texas as one of the leaders in the nation in the use of GPS technology for travel-data collection. In an effort to fully realize the strengths of this new approach, and to efficiently generate the required data for travel modeling, Texas Department of Transportation (TxDOT) contracted with The University of Texas at Austin's Center for Transportation Research to develop automated procedures for processing GPS streams. Specifically, the objectives of this project were to develop prototype software that (1) automates the process of converting navigational data streams collected passively from in-vehicle GPS devices into an electronic travel diary (i.e., a sequence of vehicle trips identified from the GPS streams, with each trip characterized in terms of attributes such as trip-end location, trip purpose,

time of day, duration, distance, and speed) , and (2) aggregates the derived trip diaries to produce inter-zonal vehicle trip tables and network performance measures.

WHAT WE DID

Development of Travel-Diary Extraction Algorithm

The travel diary extraction algorithm developed comprises three major components. In the first component, potential trips-ends or stops are detected in the GPS streams by identifying time-gaps between GPS recordings as well as based on non-movement for extended periods of time. In the next component, the attributes of the potential trips identified are determined. These attributes include trip timing, trip-end locations (TAZs), distance, speed, and activity purpose at trip-end. The activity-purpose at trip ends can be determined both at an aggregate level (i.e., home, work, and other) and at a disaggregate level (such as shopping, social, and drop-off at school). For the latter, a probabilistic procedure has been developed in which the disaggregate activity purpose is determined based on trip characteristics, traveler characteristics, and the land-use of the trip-end location. In the final component of the travel-diary extraction algorithm, the potential trips are examined for reasonableness in terms of their attributes such as trip duration. Those that fail this check are discarded as "false" trips and the rest are classified as "true" trips.

Software Implementation

A software package called the "GPS-Based Travel Diary Generator" (GPS-TDG) that implements the travel-diary extraction algorithm has been developed in the Java programming language using ArcGIS 9.0 as the platform for GIS processing. The software has been designed to operate either in a basic analysis mode or in an enhanced analysis mode. The basic mode converts the GPS data into a simple trip file that distinguishes among home-based work, home-based other, and non-home-based trips. The enhanced mode utilizes additional land-use data and pre-estimated model parameters to derive more refined trip purpose classification taxonomy.

The algorithm implemented within the GPS-TDG software is controlled by several parameters (such as the dwell-time thresholds) which can be easily modified by the analyst. Thus, the software can be calibrated for any specific study region. Default values for all these parameters have also been developed.

Finally, the software is also capable of aggregating the derived trip diaries to produce inter-zonal vehicle trip tables, network performance measures (average trip speed, distance, and travel time), and other summary measures (such as average trip lengths, distance, and speeds by trip-end activity purpose). These measures can be generated in the overall or for specific trip purposes or for specific times-of-the-day.

WHAT WE FOUND

This research project resulted in the development of a prototype software tool labeled the "GPS-Based Travel Diary Generator" (GPS-TDG) that automates the process of converting navigational data streams collected passively from in-vehicle GPS devices into an electronic travel diary. This exercise demonstrates the feasibility of developing and automating procedures for systematically identifying travel patterns from GPS streams. Almost all the attributes reported in CATI surveys can be derived purely from the GPS streams (a caveat here is that since we have focused on in-vehicle GPS devices, we infer the vehicles' travel patterns and not the person-level travel patterns as is recorded by CATI surveys). Further, it is possible to compute travel attributes such as trip distances and speeds which are not collected in conventional travel surveys. The GPS streams, however, do not provide information on activity purpose and vehicle occupancy.

We also find that it is possible to augment the trip-diary derived from GPS streams using supplemental data often available with the analysts. Specifically, this research highlights the use of land-use data for the determination of disaggregate trip purpose. Further, the use of detailed roadway network data can be explored to improve trip-detection (i.e., to better distinguish between signal delays and short-duration stops).

THE RESEARCHERS RECOMMEND

Recommendations based on this research fall into two main categories: implementation and further research.

Implementation

The researchers recommend applying GPS-TDG for processing data generated from future GPS-based travel surveys. The implementation would require that self-reported travel surveys be collected for at least a fraction of the households. The self-reported and passively recorded data from these households can be used to calibrate the software (i.e., determine the best algorithm parameters) before application to the entire study. A second possible application of the software is to develop correction factors for under-reporting by using the recorded and reported trip-rates. It is important to note here that prior to any large-scale applications, it would be useful to optimize the software for performance both in terms of memory and speed.

Further Research

The research team prescribes the conduct of extensive validation as an important area of further research. Such an exercise will help determine better default parameters as well as to enhance the travel-diary extraction algorithm in the overall.

Rigorous validation requires CATI data where the extent of under-reporting is known to be minimal and hence it is possible to match all (or most of) detected trips to corresponding reported trips. In this context, it is useful to point out that GPS-TDG is a useful tool for conducting such rigorous tests. This is because the algorithm parameters can be varied using the GUI and the derived trip-diaries can be aggregated to generate summary measures using the GPS-TDG's querying capabilities.

The validation exercise will also substantially benefit with additional data collection. Specifically, well-designed test runs can be performed aimed at (1) fine-tuning procedures for handling signal-loss situations because of travel through urban canyons, (2) identifying GPS stream patterns that may help distinguish between short duration stops without engine off and signal delay, (3) developing algorithms for determining the trip timing more accurately (accounting for signal acquisition times), and (4) evaluating trip-distance and trip speed computation procedures using odometer readings and self-recorded times. (Note that the trip distances and speeds are not collected in travel surveys).

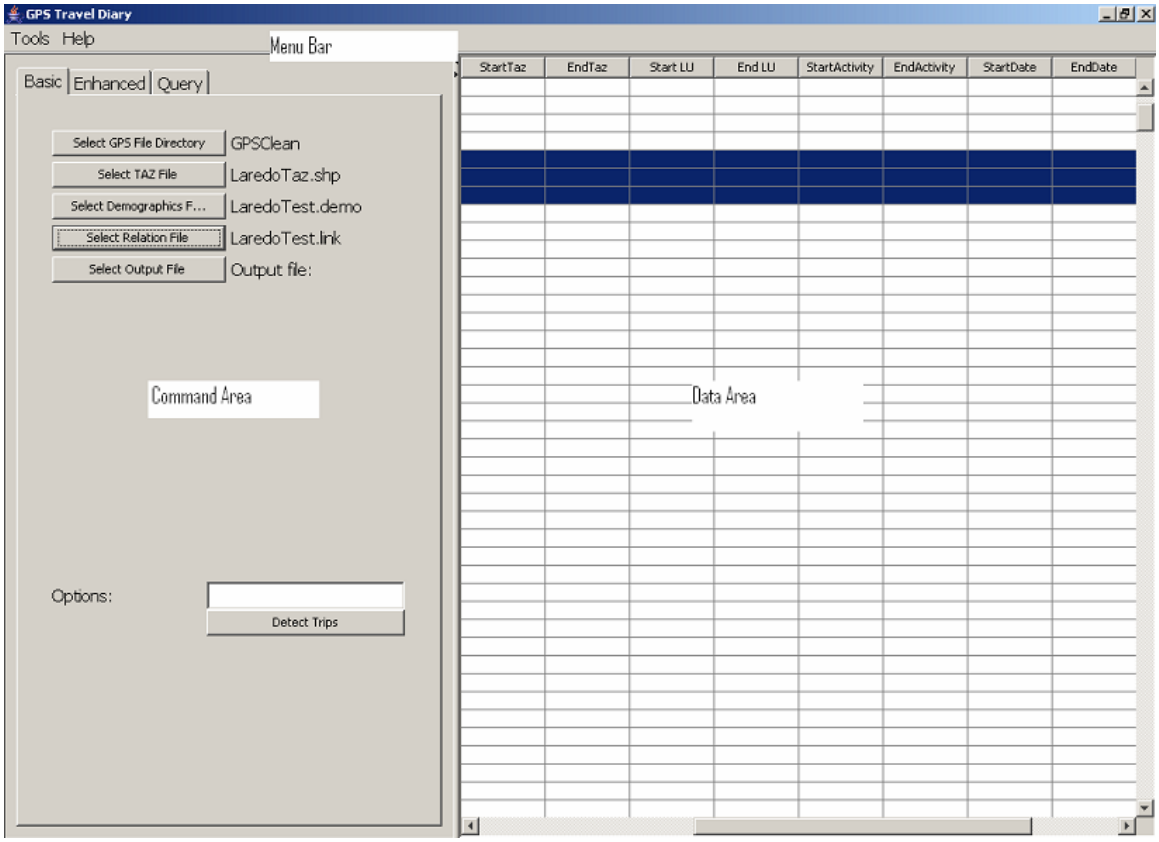

Figure 1: Basic structure of the software screen identifying the command area, the data area, and the menu bar

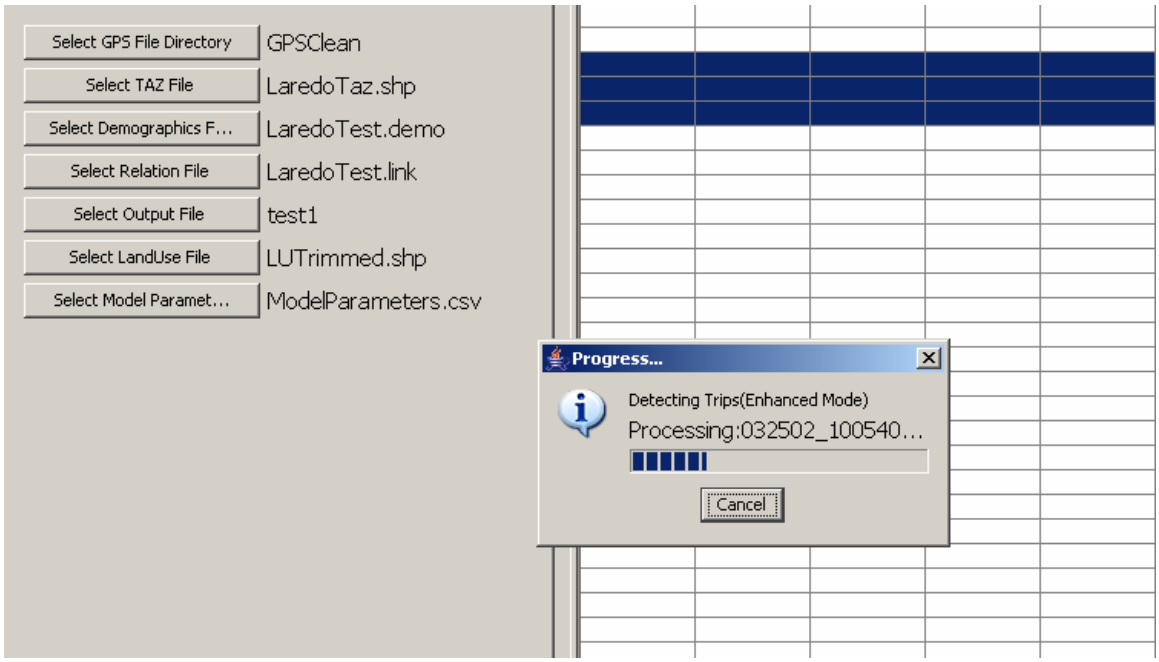

Figure 2: View of software screen during processing

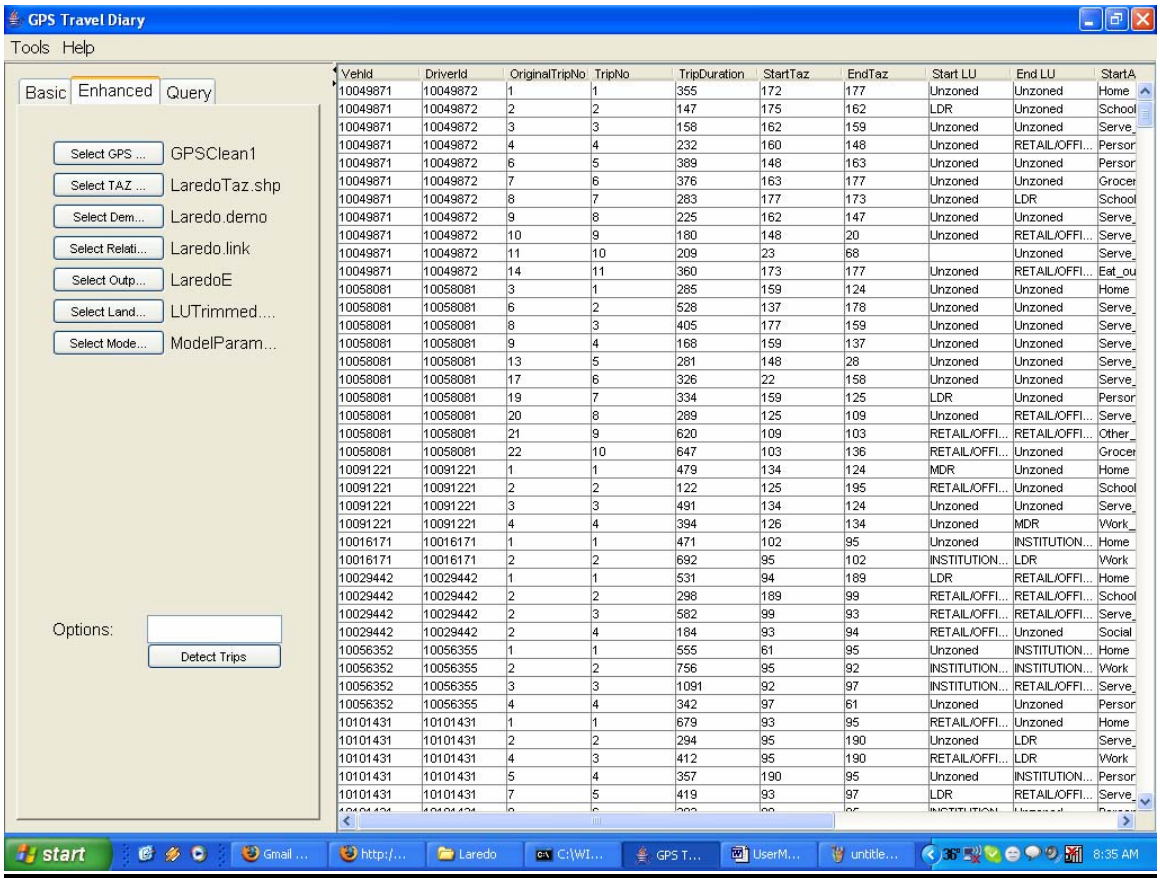

Figure 3: Software screen with input file names and derived travel patters

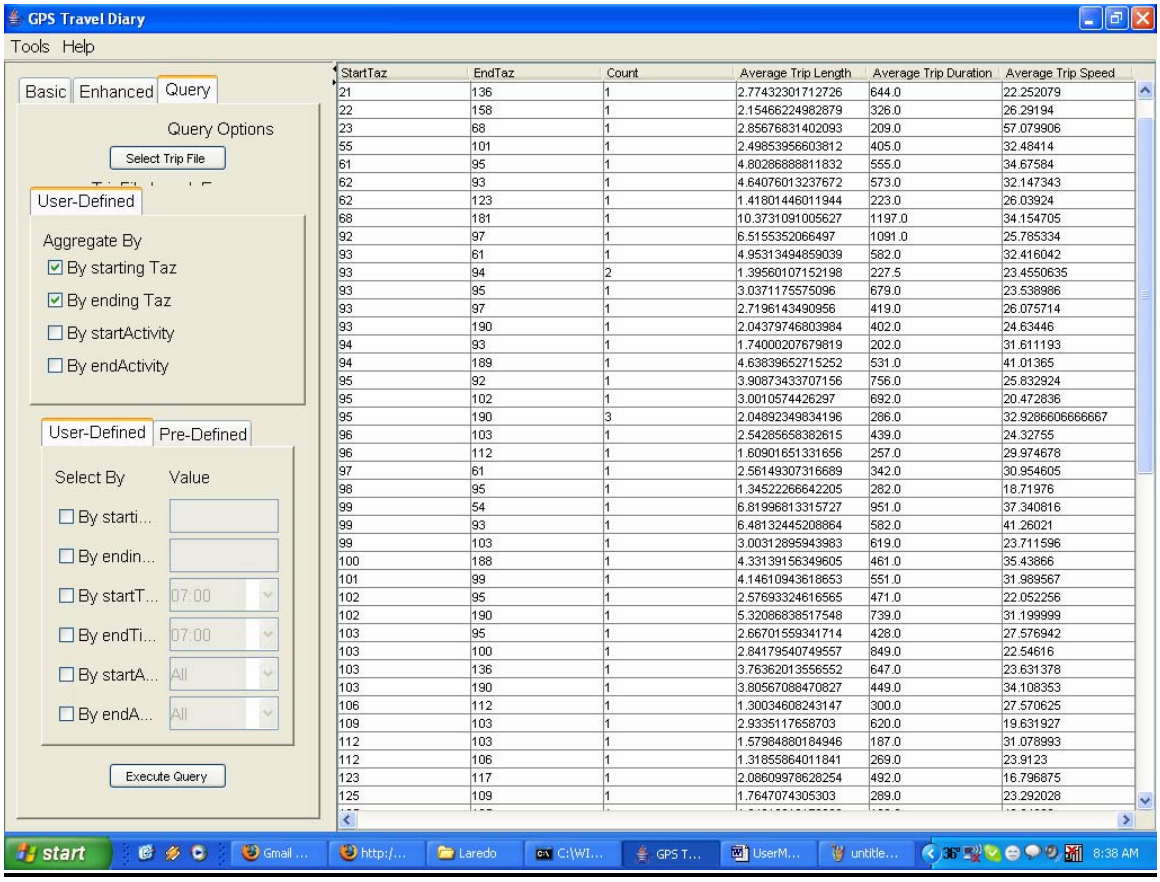

Figure 4: Software screen with inter-zonal trip counts and highway performance measures obtained by aggregating the derived trip file

For More Details…

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The research is documented in the following reports:

0-5176-1 Conversion of Volunteer-collected GPS Diary Data into Travel Time Performance Measures: Literature Review, Data Requirements, and Data Acquisition Efforts (December 2004)

0-5176-2 Conversion of Volunteer-Collected GPS Diary Data into Travel Time Performance Measures: Algorithm for Extracting Travel-Diary Data from GPS Streams and GPS-TDG Software Design (August 2005)

0-5176-3 Conversion of Volunteer-Collected GPS Diary Data into Travel Time Performance Measures: Final Report (February 2006)

To obtain copies of the report contact the CTR Library, Center for Transportation Research, at (512) 232-3126 or ctrlib@uts.cc.utexas.edu.

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Your Involvement Is Welcome!
