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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 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 nonmovement 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 selfreported travel surveys be collected for at least a fraction of the households. The selfreported 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).

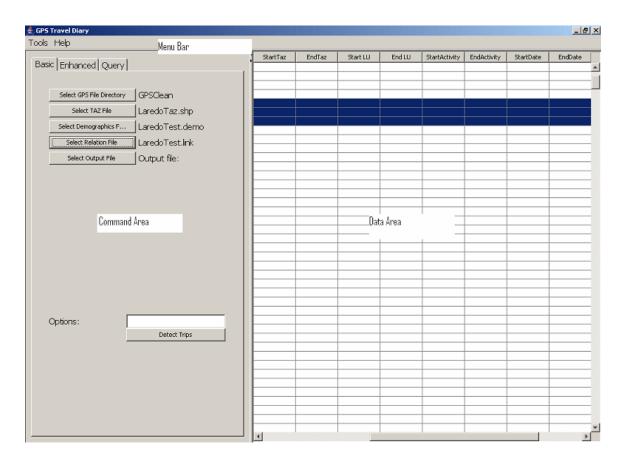


Figure 1: Basic structure of the software screen identifying the command area, the data area, and the menu bar

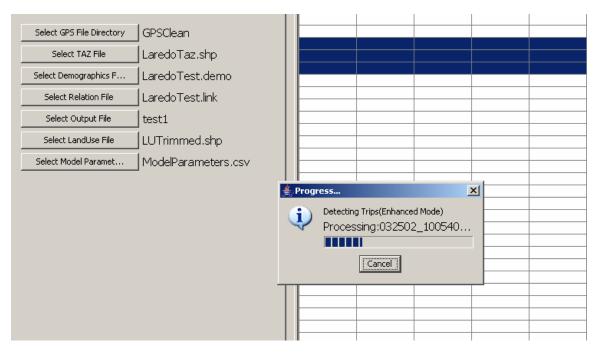


Figure 2: View of software screen during processing

	Vehid	DriverId	OriginalTripNo	TrinNo	TripDuration	StartTaz	EndTaz	Start LU	End LU	Start
lasic Enhanced Query	10049871	10049872	1	1	355	172	177	Unzoned	Unzoned	Home
asic Enhanced Galery	1 10049871	10049872	2	2	147	175	162	LDR	Unzoned	Scho
	10049871	10049872	3	3	158	162	159	Unzoned	Unzoned	Serve
	10049871	10049872	4	4	232	160	148	Unzoned	RETAIL/OFFI	Perso
Select GPS GPSClean1	10049871	10049872	6	5	389	148	163	Unzoned	Unzoned	Pers
Select TAZ LaredoTaz.shp	10049871	10049872	7	6	376	163	177	Unzoned	Unzoned	Groo
	10049871	10049872	8	7	283	177	173	Unzoned	LDR	Scho
Select Dem Laredo.demo	10049871	10049872	9	8	225	162	147	Unzoned	Unzoned	Serv
	10049871	10049872	10	9	180	148	20	Unzoned	RETAIL/OFFI	Serv
Select Relati Laredo.link	10049871	10049872	11	10	209	23	68		Unzoned	Serv
Select Outp	10049871	10049872	14	11	360	173	177	Unzoned	RETAIL/OFFI	Eat_
Select Outp LaredoE	10058081	10058081	3	1	285	159	124	Unzoned	Unzoned	Hom
Select Land	10058081	10058081	6	2	528	137	178	Unzoned	Unzoned	Serv
	10058081	10058081	8	3	405	177	159	Unzoned	Unzoned	Serv
Select Mode ModelParam	10058081	10058081	9	4	168	159	137	Unzoned	Unzoned	Serv
	10058081	10058081	13	5	281	148	28	Unzoned	Unzoned	Serv
	10058081	10058081	17	6	326	22	158	Unzoned	Unzoned	Serv
	10058081	10058081	19	7	334	159	125	LDR	Unzoned	Pers
	10058081	10058081	20	8	289	125	109	Unzoned	RETAIL/OFFI	Serv
	10058081	10058081	21	9	620	109	103	RETAIL/OFFI	RETAIL/OFFI	Othe
	10058081	10058081	22	10	647	103	136	RETAIL/OFFI	Unzoned	Groo
	10091221	10091221	1	1	479	134	124	MDR	Unzoned	Horr
	10091221	10091221	2	2	122	125	195	RETAIL/OFFI	Unzoned	Sch
	10091221	10091221	3	3	491	134	124	Unzoned	Unzoned	Serv
	10091221	10091221	4	4	394	126	134	Unzoned	MDR	Wor
	10016171	10016171	1	1	471	102	95	Unzoned	INSTITUTION	Horr
	10016171	10016171	2	2	692	95	102	INSTITUTION	LDR	Wor
	10029442	10029442	1	1	531	94	189	LDR	RETAIL/OFFI	Horr
	10029442	10029442	2	2	298	189	99	RETAIL/OFFI	RETAIL/OFFI	Sch
	10029442	10029442	2	3	582	99	93	RETAIL/OFFI	RETAIL/OFFI	Serv
Options:	10029442	10029442	2	4	184	93	94	RETAIL/OFFI	Unzoned	Soc
Detect Trips	10056352	10056355	1	1	555	61	95	Unzoned	INSTITUTION	Hom
- Dated inpo	10056352	10056355	2	2	756	95	92	INSTITUTION	INSTITUTION	Wor
	10056352	10056355	3	3	1091	92	97	INSTITUTION	RETAIL/OFFI	Serv
	10056352	10056355	4	4	342	97	61	Unzoned	Unzoned	Pers
	10101431	10101431	1	1	679	93	95	RETAIL/OFFI		Hom
	10101431	10101431	2	2	294	95	190	Unzoned	LDR	Serv
	10101431	10101431	4	3	412	95	190	RETAIL/OFFI		Wor
	10101431	10101431	5	4	357	190	95	Unzoned	INSTITUTION	Pers
	10101431	10101431	7	5	419	93	97	LDR	RETAIL/OFFI	Serv
	40404404	40404494	0	le .	2002	00	loc	INCTITUTION	1.1	Dave

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

	StartTaz	EndTaz	Count	Average Trip Length	Average Trip Duration	Average Trip Speed
Basic Enhanced Query	21	136	1	2.77432301712726	644.0	22.252079
	1 22	158	1	2.15466224982879	326.0	26.29194
Query Options	23	68	1	2.85676831402093	209.0	57.079906
	55	101	1	2.49853956603812	405.0	32.48414
Select Trip File	61	95	1	4.80286888811832	555.0	34.67584
	62	93	1	4.64076013237672	573.0	32.147343
User-Defined	62	123	1	1.41801446011944	223.0	26.03924
	68	181	1	10.3731091005627	1197.0	34.154705
Aggregate By	92	97	1	6.5155352066497	1091.0	25.785334
	93	61	1	4.95313494859039	582.0	32.416042
By starting Taz	93	94	2	1.39560107152198	227.5	23.4550635
E Deservice Tes	93	95	1	3.0371175575096	679.0	23.538986
🗹 By ending Taz	93	97	1	2.7196143490956	419.0	26.075714
By startActivity	93	190	1	2.04379746803984	402.0	24.63446
	94	93	1	1.74000207679819	202.0	31.611193
By endActivity	94	189	1	4.63839652715252	531.0	41.01365
	95	92	1	3.90873433707156	756.0	25.832924
	95	102	1	3.0010574426297	692.0	20.472836
	95	190	3	2.04892349834196	286.0	32.9286606666667
User-Defined Pre-Defined	96	103	1	2.54285658382615	439.0	24.32755
1	96	112	1	1.60901651331656	257.0	29.974678
Select By Value	97	61	1	2.56149307316689	342.0	30.954605
ocider by value	98	95	1	1.34522266642205	282.0	18.71976
By starti	99	54	1	6.81996813315727	951.0	37.340816
	99	93	1	6.48132445208864	582.0	41.26021
	99	103	1	3.00312895943983	619.0	23.711596
By endin	100	188	1	4.33139156349605	461.0	35.43866
and the second se	101	99	1	4.14610943618653	551.0	31.989567
By startT 07:00	102	95	1	2.57693324616565	471.0	22.052256
	102	190	1	5.32086838517548	739.0	31.199999
By endTi 07:00	103	95	1	2.66701559341714	428.0	27.576942
	103	100	1	2.84179540749557	849.0	22.54616
By startA All	103	136	1	3.76362013556552	647.0	23.631378
	103	190	1	3.80567088470827	449.0	34.108353
By endA All	106	112	1	1.30034608243147	300.0	27.570625
	109	103	1	2.9335117658703	620.0	19.631927
	112	103	1	1.57984880184946	187.0	31.078993
	112	106	1	1.31855864011841	269.0	23.9123
Execute Query	123	117	1	2.08609978628254	492.0	16.796875
	125	109	1	1.7647074305303	289.0	23.292028
					10.5.5.5	

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)

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Your Involvement Is Welcome!

Disclaimer

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