**Driving profile generated with data from NHTS**

The charging behaviors of batteries in electric vehicles depends on the driving profiles of these EVs, which determines how much energy is consumed by the vehicles and when the batteries are available to be charged. In our study, a set of driving profiles is constructed using data from the 2009 National Household Travel Survey (NHTS) [1]. One single driving profile for each vehicle consists of two parts, *i.e.*, its traveling speed and location throughout a day, which are derived using two functions, *‘FUNC\_speed.m’* and *‘FUNC\_location.m’,* respectively.

**1 Abstract useful data from original database**

The NHTS is conducted by the Federal Highway Administration of United States by interviewing persons in 70,000 households in US about their travelling behaviors in certain days. The results are organized into four different data files [2], among which the day trip file containing “data about each trip the person made on the households randomly assigned travel day” is applicable for our research. We take 6 variables that are applicable for our research from the total over one hundred ones in the NHTS’s day trip file. The names and the explanations as well as the meanings of the values of the variables are listed in Table 1 [3].

Table 1. Variables selected in the data sets

|  |  |  |
| --- | --- | --- |
| Name | Explanation | Values ranges and their meanings |
| HOUSEID | HH eight-digit ID number |  |
| PERSONID | Person ID number |  |
| ENDTIME | Trip END time in military | 0000-2359, corresponding to time in a day 00:00-23:59 |
| TRVL\_MIN | Trip time - minutes | 0-1230 |
| WHYTO | Travel day purpose of trip | 1. Home   10-14 Work related  20-24 School related  30- Medical/dental services  40-43 Shopping related  50-55 Social related  60-65 Family related  other: other reasons |
| TRPMILES | Calculated Trip distance converted into miles | 0-9000 |

Considering the size of data profiles and the physical scale of a power grid,

only households in Texas state are included in our data sets.

The data is selected and imported into MATLAB using the command lines in *‘gen\_Matlab\_data.m’*.

**2 Speed profile of the EVs**

The speed profile of a EV gives information about the speed of the given EV at each time point in the day. This information is necessary when we attempt to obtain the discharging rate and energy consumption of the batteries. To derive these speed profiles, we construct the *‘FUNC\_speed.m’* function.

The time step is 1 minute in our study, which is corresponded in other functions. We firstly generate a subtable containing 'ENDTIME', 'TRVL\_MIN' and 'TRPMILES' of trips conducted by the first person in the given housed:

% Select the row for a given houseid

% Only select the first member of the household whose PERSONID == 1

rows = table.HOUSEID==houseid & table.PERSONID==1;

subtable= table(rows, {'ENDTIME', 'TRVL\_MIN', 'TRPMILES'});

Only one person is taken into consideration because the household member may share one vehicle in their trips and, as a result, two trips conducted by two persons in one household may be actually the same trip on the vehicle aspect. Each row of the subtable represents a single trip. We define the speed during the travel period as constant and thus can be calculated as:

The travel distance and time are directly obtained from variable 'TRPMILES' and 'TRVL\_MIN', while the travel period shall be derived by taking 'ENDTIME'-'TRVL\_MIN' as starting point and 'ENDTIME' as end point. It is noticeable that 'ENDTIME'-'TRVL\_MIN' as starting point might go zero or negative sometimes which means the trip started before midnight. In these cases, we just define start point to be 1 as our time scope is only one day from 1 to 1440 minutes. These implementations are realized by:

for i=1:height(subtable)

t\_start=subtable.ENDTIME(i)- subtable.TRVL\_MIN(i);

if t\_start<1

t\_start=1;

end

t\_range= t\_start:(subtable.ENDTIME(i) - 1);

speed(t\_range)= subtable.TRPMILES(i)/subtable.TRVL\_MIN(i);

end

The final output of this function is a one-demission vector where each element is the speed value at each minute in the day and the index of elements is corresponding to the time with minute as the unit.

**3 Location profile of the EVs**

The location profile of a EV shows where the EV is during a day. Three values are to be assigned at each time point, which are respectively representing: ‘1’ as “at home”, ‘-1’ as “on road”, ‘0’as “at other places”. These definitions are determined corresponding to the state of charging of the batteries, *i.e.,* batteries are available to be charged at home (represented as ‘1’), and are discharged on road (represented as ‘-1’) while they would not be charged or discharged so stay constant at other places (represented as ‘0’). The *‘FUNC\_location.m’* function is constructed to get the location profiles.

Similar to the process of speed function, we create a subtable containing 'ENDTIME', 'TRVL\_MIN', 'TRPMILES' and a new variable ‘WHYTO’ of trips of the given person:

%Selcet data for the given houseid

%only select the first person, which means PERSONID=1

rows = table.HOUSEID==houseid & table.PERSONID==1;

subtable= table(rows, {'ENDTIME','AWAYHOME', 'TRVL\_MIN', 'WHYTO' });

For each trip, we first nominate the period of time when the trip is being taken place, *i.e.,* the vehicle is on road. We define the location value during these period is ‘-1’ as explained previously. Since we have the information of ‘WHYTO’, we know the location of the vehicle after this trip. Therefore, from the next minute after the trip to the last minute before next trip (or the last minute of the day), we can assign value to the location according to the value of ‘WHYTO’, which is achieved as following:

period= subtable.ENDTIME(i)- subtable.TRVL\_MIN(i): subtable.ENDTIME(i)-1;

for t=period(period>0)

location(t)=-1;

end

% consider the cases when the vehicle is not moving

% change the location

t=t+1;

if t<1

t=t+1;

end

while (speed(t)==0) && (t<=(60\*24-1))

if subtable.WHYTO(i)==1

location(t)=1;

else

location(t)=0;

end

t=t+1;

end

To point out, such a method does not cope with the location before the first trip, so we initialize the location values as ‘1’, assuming every vehicle stays at home before any trips are conducted:

%Initialization

location=ones(1,60\*24);

The final output of this function is a one-demission vector where each element is the location value at each minute (‘1’- “at home”, ‘-1’- “on road”, ‘0’- “at other places”) in the day and the index of elements is corresponding to the time with minute as the unit.

[1] U.S. DoT, National Household Travel Survey, http://nhts.ornl.gov/download .shtml (2009).

[2] U.S. DoT, 2001 National Household Travel Survey: User’s Guide, http:// nhts.ornl.gov/publications.shtml#usersGuide (2009).

[3] U.S. DoT, 2001 National Household Travel Survey: User’s Guide, http:// nhts.ornl.gov/publications.shtml#coodbook (2009).