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ANALYSIS OF DRIVER BEHAVIOR IN CAR USING CLUSTERING

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Abstract— **Identifying car following behavior of the driver is essential when the mode of transportation is by car as driving is a daily routine for people every time drivers hit the road they face many threats and it is essential to provide a safety and efficient driving.It is proposed to focus on traffic safety and efficiency which is very important for the driver to drive the car in safe and comfortable manner. Driver behavior is vital to model vehicle dynamics in a traffic simulation environment. A new sequential clustering algorithm is developed to find out the driving behaviors and incorporate the comfort interface of the driver which will help to analyze driving pattern also. The clustering is based on different variables such as speed, trip identifier, time, heading, gas pedal position, light intensity; break on off, turn signal state etc. that will help to improve the efficiency of car-following behavior as well as driver pattern.**

I. INTRODUCTION

A driver's behavior is the way a driver responds to his/her existing systems (e.g. speed, distance, accelerate or steer). His/her behavior can, therefore, be formally defined as the function that maps traffic states to a driver's actions. Typically, driver behavior studies collect data that encompass both states and actions and attempts to develop a more accurate mapping between them. These efforts do not usually include many influencing factors of human behavior, such as emotion, personality, hunger, or thirst [18].

The driver's internal factors are important in impacting traffic safety in addition to vehicle road environment. The driver's internal factors include the driver psychological characteristics. The differences of driver's age, gender, driving experience and individuality result in different psychological characteristics and the different psychological characteristics are reflected as driving tendencies. The system of driving tendency recognition plays an important role in improving the applicability and accuracy of vehicle active safety systems (collision avoidance as warning system) [16].
The proposed system is structured such that a known state can be linked to multiple actions thus accounting for the effects of developing a new driving state. A sequential clustering algorithm is developed and used for the clustering of driving behaviors. It is proposed to use sequential clustering algorithm which will segment and cluster a car following behaviors based on different variables such as speed, trip identifier, time, heading, gas pedal position, light intensity; break on off, turn signal state etc. The objective of this system is to find a perspective set of driving state.

II. CAR-FOLLOWING BEHAVIOR

In recent years, modeling and recognizing driver behavior have become crucial to understanding intelligent transport system, human vehicle systems, and intelligent vehicle system (ITS)[5].In the field of transportation and engineering many research and field experiments to study car-following behavior have been conducted on test tracks and roadways, and then modeled to represent driver's behavior [17].A car the following model was first proposed by Reachel(1950)and Pipes(1953) and was greatly extended by Herman(1959~1967) and has been continuously refined up to present with various approaches to describing relationships between the leader and the following vehicles. Most of the research into clustering has occurred outside of the field transportation engineering. Largely, there have been two kinds of data collection methods for car-following experiments, using either video recording (or aerial film) to capture many anonymous vehicles, or wire-linked test vehicles on a test track or a roadway [19]. In the first case, it should note that this type of data collection is very difficult and tedious work. One advantage is that real drivers are being observed; who are unaware that the experiment is taking place, thus, their behavior is as "natural" as can be expected.

A. *Data Collection Method*

Car-Following studies typically collect vehicle trajectory data through various factors, including naturalistic, simulator and video data collection methods. It also considers the different lane, weather factor, road construction, types of vehicle and traffic flow to analyze it. Data collection mainly observed the drivers physical actions as well as steering movement. The following table gives the description about the different data type and their advantages and flaws including driver's reaction into a different environment. It captures the data and analyzes that data.

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Table I

Data Type	Description	Strengths	Weaknesses
Naturalistic	An instrumental vehicle is driven in normal driving routines	-The driver is in the natural environment. -Multiple trajectories are observed for each driver.	Drivers know they are being observed

B. Data Clustering

There are several clustering techniques are available within each group, but for the application car-following behavior, the time-series clustering is more suitable.

III. METHODOLOGY

Sequential clustering technique is used to capture the full range of state–action clusters for car drivers. First, observed the naturalistic database, followed by extract car-following periods from the huge amount of data. Next, the data is divided into different states to finding a cluster. A car-following period is defined as a period during which one vehicle is reacting to a leading vehicle in the same direction of the car. The behavior is the link between the data set and the action variables that the driver expresses (acceleration, deceleration, lane change, turning). The segmentation process divides each car-following period into multiple segments, and each segment will be defined as a new data set. The sequential clustering process group's similar segments into a single cluster for the new dataset will generate. Thus, a cluster gives the grouping of a certain behavior. Fig 1 shows data collection for recognition of driving pattern.

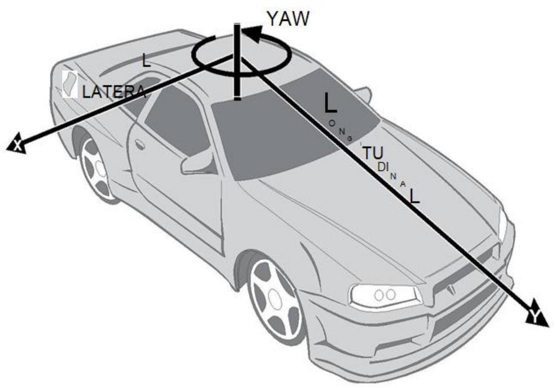

Figure 1. Coordinate System

A. Naturalistic Driving Data

Naturalistic driving data refer to the data collected from drivers in their natural environment. This is taken by different vehicles with specialized sensors and "vehicle network" recording equipment's, then allowing the drivers to drive the vehicles as they feel comfortable. The equipment records a large number of variables (e.g., speed, acceleration, and steering wheel positions, lane markings), and of particular interest to car following, a radar system positioned at the front of the vehicle records the differences in the position of the car and the speed between the target and leading vehicles. The equipment also includes cameras that record what the driver sees from the front as well as from the two side mirrors, the driver's face, and what the driver is doing inside the vehicle. The naturalistic data used in this system were collected by VTTI. These data were collected from 100 cars that were used by multiple drivers. The 100 Car Naturalistic Driving Study was an instrumented vehicle study conducted in the Northern Virginia / Washington, D.C. area over a two year period.

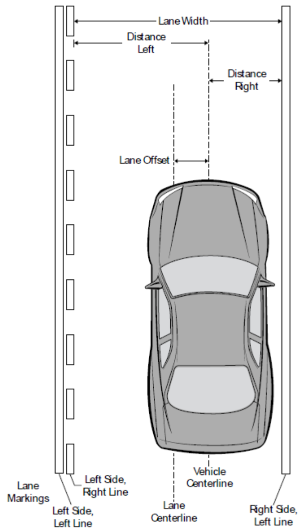

Figure 2. Machine-vision-based Lane Tracker Variable Names and Dimensions

Fig 1.1: System Architecture

B. Data variables

There are different variables used for deriving driver pattern. The variables record will be taken for each individual driver and analyze it. Table shows the different variables used this variables will help to take a record of driver reacting with those variables. List of Dictionary Fields – A description of the components or fields described in the dictionary for each variable entry. List of Variables – A list of the entries (variables) in the dictionary which can be used as a table of contents to locate specific variables in the document.

Conversions, Coordinate System and Formulas – A catalog of unit conversions, sign conventions and formulas which may be of value to researchers working with these data.

Data Dictionary Entries – The dictionary entries themselves, one for each variable included in the data set.

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List of Variables in proposed system

The following variables are included in the text files.

Var	Name
1	Trip Identifier
2	Sync
3	Time
4	Gas pedal position
5	Speed, vehicle composite
6	Speed, GPS horizontal
7	Yaw rate
8	Heading, GPS
9	Lateral acceleration
10	Longitudinal acceleration
11	Lane Markings, Continuity, Left Side Left Line
12	Lane Markings, Continuity, Left Side Right Line
13	Lane Markings, Continuity, Right Side, Left Line
14	Lane Markings, Continuity, Right Side, Right Line
15	Lane Markings, distance left
16	Lane Markings, distance right
17	Lane Markings, type left
18	Lane Markings, type right
19	Lane markings, probability left
20	Lane markings, probability right
21	Radar, forward, ID
22	Radar, rearward, ID
23	Radar, forward, range
24	Radar, rearward, range
25	Radar, forward, range rate
26	Radar, rearward, range rate
27	Radar, forward azimuth
28	Radar, rearward azimuth
29	Light intensity
30	Brake on off
31	Turn signal state

C. Sequential Clustering

The second part of this methodology clusters the segments, which were found by the segmentation algorithm, in order to find similar segments or behaviors in the car-following data. Clustering the segments shows how certain behaviors repeat throughout the data within and between drivers.

Algorithm

Let d(x, C) denote the distance between data vector x and a cluster C. Furthermore, q is the allowed threshold of dissimilarity. [9]

Let m=1

$C_m = X_1$

For i=2 to N,

Find C_k:$d(x_i, C_k) = \min_{i<=j<=m} d(X_i, C_j)$

If (d $(x_i, C_k) > \varnothing$) AND (m<q),

m=m+1

$C_m = x_i$

Else,

$C_k = C_k U x_i$

Where necessary, update representatives

end

end

Sequential Clustering Algorithm

Parameters

k: Maximum number of clusters.

x: Distance threshold used to form new clusters.

C: Distance threshold used to merge clusters.

m: Batch length (patterns processed between lumping stages).

The algorithm begins choosing the first cluster center among all the pattern samples arbitrarily. Then, it processes the remaining the patterns sequentially. It computes the distance from the actual pattern to its nearest cluster center. If it is smaller than or equal to x, the pattern is assigned to its nearer cluster. If not, a new cluster is formed with the actual pattern. Every m patterns, clusters are merged using a distance criterion (two clusters are combined into one if the distance between their centroids is below C). If there are still more than k clusters, clusters are lumped together using a size criterion (clusters with less than patterns are merged with their nearest clusters). If we still have too many clusters, the nearest pairs of clusters are merged until there are exactly k clusters left.

When C is represented by a single vector m_C

$d(x, C) = d(x, m_C)$

If the mean vector is used as a representative, the updating may take place in an iterative fashion, that is,

$$m_{C_k}^{NEW} = \frac{(n_{C_k}^{NEW} - 1) m_{C_K}^{OLD} + x}{n_{C_K}^{NEW}}$$

where $n_{C_k}^{NEW}$ is the cardinality of C_k after the assignment of x to it.

IV. CONCLUSION

It is proposed to find a prescriptive set of state-action clusters that can be used to characterized possible driving patterns of car driver as well as it will help to improve efficiency and safety of driver.

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