ANALYSIS OF REAL MOBILITY RECORDS IN URBAN AND SUBURBAN ENVIRONMENTS

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Abstract

The long-term motion of vehicles and people is of great interest for many sectors of our society, such as urban planning, traffic forecasting, medicine, retail economy and public transport.
This paper analyzes the parameters of multiple mobility data sets obtained from real-field measurement campaigns. The mobility records show how the target vehicles use the street network in different geographical areas (old city center, suburban areas and highways). The records are obtained from Global Navigation Satellite System receivers mounted on the targets.
This study is useful for smart city scenarios for assessing the feasibility and the performance of metropolitan transport networks.

Keywords: traffic planning; urban transport; mobility records; GNSS; vehicle mobility

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1. Introduction

Nowadays, the notion of Intelligent Transportation System is of great interest because of the advances in transport technology and due to the major increase in the mobility of people and goods [1]. The current global economic and social growth is leading to an increase in the use of existing transport networks. Considerable effort is spent in the direction of maximizing the capacity of road systems, both in busy urban areas and in rural regions. The way forward is given by the capability of correctly forecasting the traffic volume and the changes in mobility patterns. This capability is very useful for local and central authorities, because it permits an adequate road maintenance and investment policy and the avoidance of periodic traffic jams.

Global Navigation Satellite Systems (GNSS) are an enabler of several applications in road transportation. Navigation is the most widespread application of Satellite Navigation. Another application is represented by satellite road traffic monitoring services that collect floating car location data from vehicles and process traffic information. GNSS also permits easy fleet management solutions that enable transport operators to monitor the logistics activities performance. Another application is illustrated by insurance telematics services that rely on GNSS to increase transparency for insurers/subscribers. Satellite navigation permits Cooperative /Connected Vehicles to enhance road safety and comfort for the driver.

In intelligent road networks a great importance is given to the area of vehicles to vehicles communication for a more efficient and safer road traffic. In this domain, many papers proposed several procedures to design and develop new Vehicular ad-hoc networks (VANET) [2,3,4]. These theoretical concepts have undertaken simulation and testing stages, in order to prove their practicability and fidelity.

The testing algorithms need to simulate as good as possible the aspects of real-life traffic like road works, meteorological conditions, changes in the behavior of traffic participants, road hazards and incidents. All these requirements are very difficult to obtain, without the use of real-life observations on vehicular mobility. The existing literature in the domain [4] compares the behavior of the algorithms with real mobility statistics collected in large metropolis, such as San Francisco and Shenzen [5,6].

This paper is a work in progress and presents the initial findings on the mobility parameters obtained from data sets from real-field measurement campaigns. The mobility records show how the target vehicles use the street network in different geographical areas of the city of Rome, Italy. This metropolis presents a complex road network with different traffic patterns, in areas like the old city center, suburban areas and highways. The records are obtained from Global Navigation Satellite System receivers mounted on the targets. The vehicles are represented by a fleet of around 400 taxis from Rome.

This work is intended to be valuable for the analysis of the performances of simulators for Intelligent Transport Networks, because it offers mobility parameters derived from real-world measurements. These results characterize actual traffic with a medium duration, over medium distances in a large city and contain many real-life aspects that are very difficult to simulate, such as traffic lights, weather, accidents and incidental congestions. This is considered the novel input of this work.

The paper is structured as follows. In the beginning of section 2 is presented how the measurement sets were undertaken and archived. Next the measured parameters are explained. Section 3 presents how the post-processing is done and what mobility parameters are obtained. Next is illustrated the variation of the mobility parameters over a time period of three days, for five taxi vehicles from the measurement set. Parameters such as horizontal speed, distance covered and attitude are shown. The last section draws the conclusions from the measurement results and proposes the way forward.

2. The measurement sets

The measurement sets were obtained from the Universita di Roma “Tor Vergata”, from Rome, Italy [7]. The measurement data files have been shared with the academic community through the “Community Resource for Archiving Wireless Data At Dartmouth” Project, developed by the Dartmouth College, USA. The measurements were done continuously on a fleet of 370 taxi cars working in the city of Rome, over a period of six months. Each car is tracked with an on-board GNSS receiver, only when the car is in service. When the engine is turned off and the car is locked (eg. when the driver is off-duty) no measurements are taken, because the tracker device is not under power. Thus these recordings characterize the track of the car during its working time. A message from every car containing its time-stamped position is sent wirelessly every 15 seconds to a central server, where it is recorded consecutively.
Each message contains:

- the unique code of the car,
- the calendar date,
- the time with a 5 digit precision for the seconds,
- the instantaneous latitude and longitude of the car.

3. Results obtained from post-processing

For this paper, the measurement sets were processed in Mathworks Matlab in order to obtain the time variations of specific mobility parameters for a car, such as horizontal speed, travelled distance between each recording and heading. By analyzing the values of the speed for each car, we derived also a statistic of the idle times, when the car is stopped, with the tracking device under power. The car is considered to be stopped and idle when its recorded speed is approximately zero (eg. less than one km/h). This approximation is necessary because of inherent positioning errors. This can happen during normal traffic (e.g. in intersections, at traffic lights) or when the taxi is stopped, eg. while waiting for a customer. Figures 1 (a) and 2 (a) illustrate the apparition and duration of idle times for taxis number 2 and 191 during the analyzed duration of recordings. The vertical axis represents the duration of the idle time in minutes. Figures 1 (b) and 2 (b) show the histograms of these idle times.

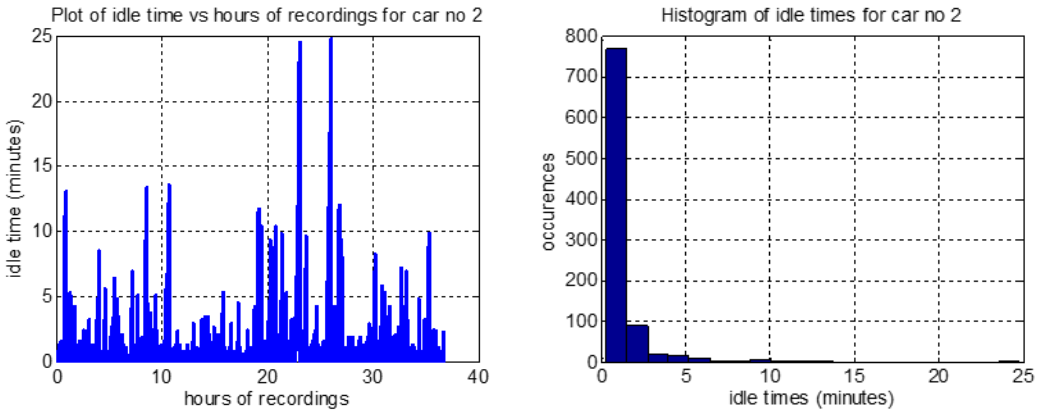

Fig. 1. (a) Occurrence and duration of idle times for taxi number 2; (b) histograms of idle times for taxi number 2

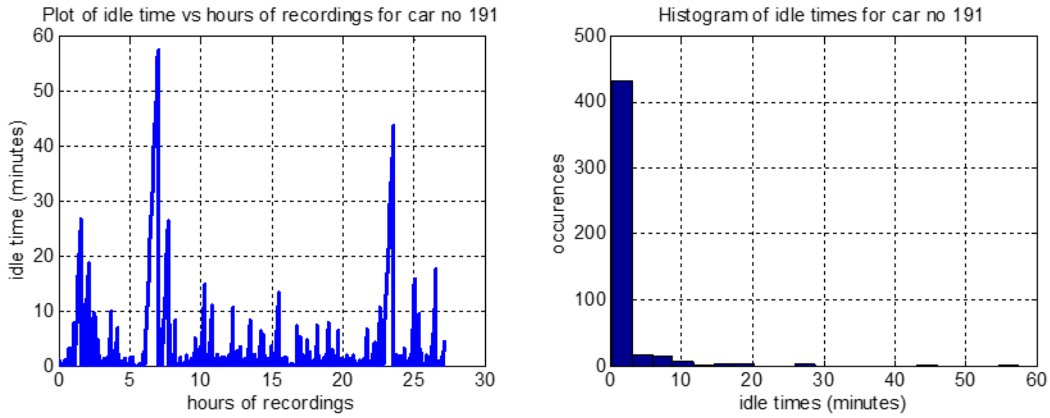

Fig. 2. (a) Occurrence and duration of idle times for taxi number 191; (b) histograms of idle times for taxi number 191

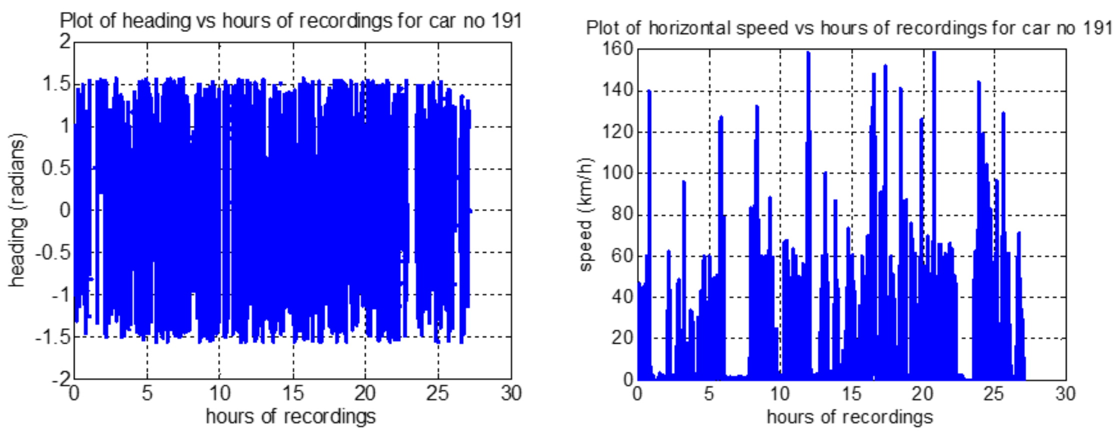

Fig. 3. (a) Variation in time of the heading of taxi number 191; (b) variation in time of the horizontal speed of taxi number 191

Figure 3 (a) illustrates the variation in time of the heading (eg. bearing) of taxi number 191 during the analyzed duration of recordings. Figure 3 (b) shows the variation in time of the horizontal speed of taxi number 191 during the analyzed duration of recordings. The correlation with figure 2 (a) is clearly seen, because the horizontal speed tends to zero during the idle times of the taxi, particularly in the 2nd, 7th and 24th hours of recordings.

Figure 4 (a) illustrates the track in (x,y) horizontal coordinates for taxi number 191 during the analyzed duration of recordings. The origin of the coordinates is chosen arbitrarily. Figure 4 (b) shows the activity status of taxi number 191 during the days when the recordings were taken. This three-day interval is much longer than the duration of the recordings previously analyzed because the taxi has been active only during a small part of each day. The activity periods are graphically represented by vertical stems. The rest of the time the taxi is off-duty. It can be observed that this particular taxi is active each evening, approximately during 5 PM-1 AM.

Figure 5 (a) presents the variation in time of the covered distance by taxi number 191 between two consecutive recordings (15 seconds), during the analyzed duration. Figure 5 (b) shows the variation in time of the horizontal speed of taxi number 2 during the analyzed duration of recordings. A correlation with figure 1 (a) can be made, because the horizontal speed tends to zero during the idle times of the taxi, particularly in the 23nd and 24th hours of recordings.

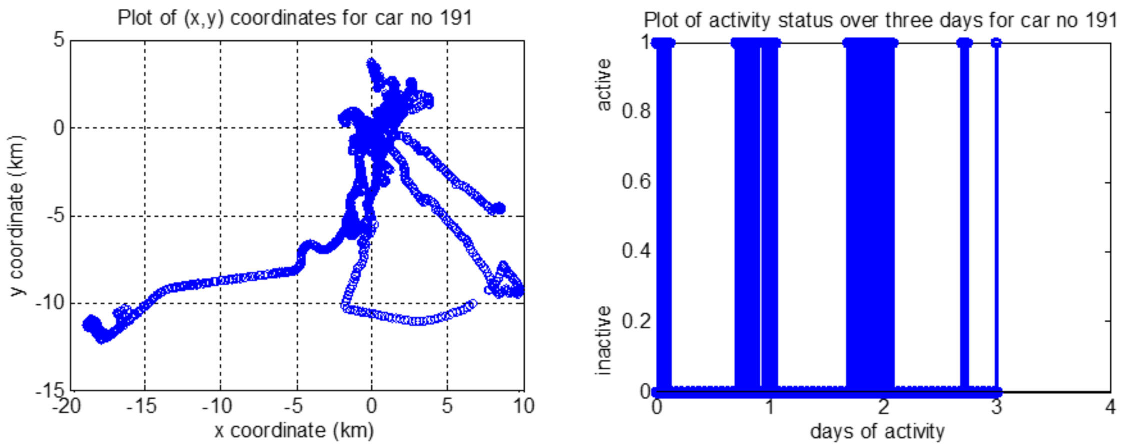

Fig. 4. (a) Track in (x,y) horizontal coordinates for taxi number 191; (b) the activity status of taxi number 191 during three days

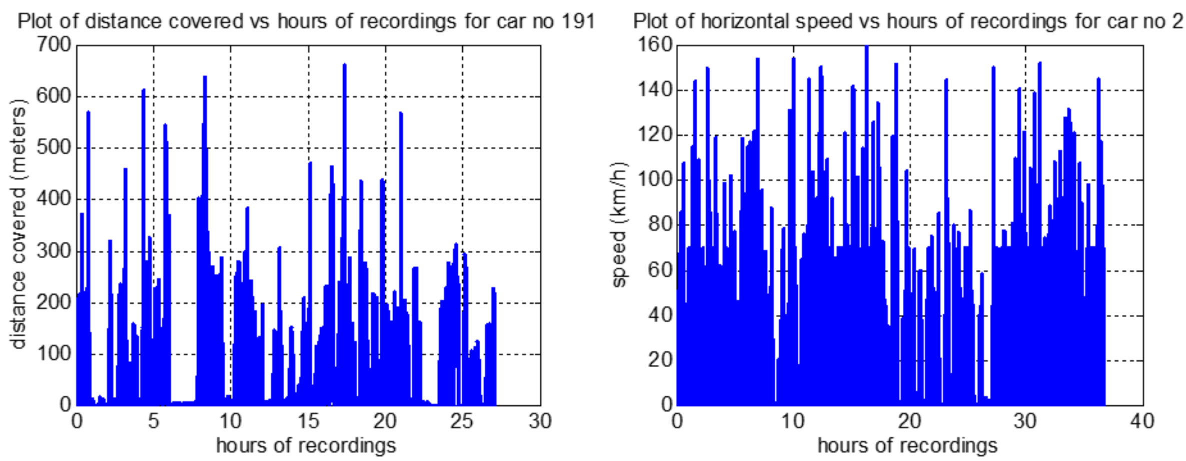

Fig. 5.(a) Variation in time of the covered distance by taxi number 191 between two consecutive recordings; (b) variation in time of the horizontal speed of taxi number 2

This variation is linked with the idle time presented in figure 2 (a) and the speed illustrated in figure 3 (b), because the taxi is not covering any distance when its speed is almost zero (eg. it is idle).

Table 1 illustrates statistics of idle times for five taxis, chosen arbitrarily from the monitored fleet. For further work, we propose to analyze the statistics of the whole fleet. The following parameters are noted: total idle time in hours; percent of total active period when the taxi is idle; total number of stops longer than 90 seconds (eg. when the taxi is waiting for a customer) occurred during the analyzed duration of recordings.

Taxi number	2	343	191	156	79
Total idle time in hours	17.79	11.24	13.52	12.27	9.74
Total idle time in percents	51.74	37.13	53.16	48.84	42.59
Number of parking stops	155	90	110	103	74

Table 1. Mobility statistics

4. Conclusions and further work

Considerable effort is spent in the direction of maximizing the capacity of road systems, both in busy urban areas and in rural regions. The way forward is given by the capability of correctly forecasting the traffic volume and the changes in mobility patterns. For this paper, real-field measurement sets were processed in order to obtain the time variations of specific mobility parameters for a car, such as horizontal speed, travelled distance between each recording and heading. By analyzing the values of the speed for each car, we derived also a statistic of the idle times, when the car is stopped, with the tracking device under power.

The results underline that, during the idle times of the taxi, the horizontal speed of the car tends to zero and that it is not covering any distance, particularly in the 2nd, 7th and 24th hours of recordings. The statistic shown in Table 1 concludes that a taxi spends as much as 53% of its active time idling (e.g. in intersections, at traffic lights or while waiting for a customer), which is of interest for an urban mobility model. Also it can be seen that a taxi parks for about three-four times per hour, on average. The taxis with the most parking stops show the largest idle time in percents. Another conclusion is that high driving speeds (over 100km/h) are possible on urban roads with highway status, as recorded in figure 3 (b). The histograms of idle times conclude that the vast majority of idle times last less than three minutes, but some can be as long as 45 minutes. The track of the taxi shows that most of its activity is done in a relatively small area, of about 4 by 4 km and that trips of more than 10 km are rare.

This work is intended to be valuable for the analysis of the performances of simulators for Intelligent Transport Networks, because it offers mobility parameters derived from real-world measurements. These results characterize actual traffic with a medium duration, over medium distances in a large city and contain many real-life aspects that are very difficult to simulate, such as traffic lights, weather, accidents and incidental congestions. This is considered the novel input of this work.

For the future, we propose to analyze the previously mentioned mobility parameters for at least a hundred cars, in order to obtain their statistical distribution over the whole fleet. Also we intend to determine the probability that a car returns to certain point and the probability with which two cars meet on the same road.

5. References

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