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Quantifying Demand Dynamics for Supporting Optimal Taxi Services Strategies

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Abstract

In recent years, mobility patterns have reasonably attracted scientific interest, especially concerning Mega-Cities. The technological advances, especially concerning sensors, facilitates the collection and access on a massive amount of empirical data capturing in high-resolution urban mobility. The introduction and spread of location tracking devices and services provide the means for collecting reliable real-time data, particularly valuable for industrial as well as for personal applications. In this study, a complex and realistic dataset is monitored and analysed, that provide the real-time occupancy status and Global Positioning System (GPS) location for three taxi fleets during of New Year's Day. The scope of this paper is a preliminary identification of alternative Taxi-Services Strategies by means of dynamic clustering as well as 'heatmap' analysis.

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Keywords: Urban Mobility; Real-Time GPS Information; Taxi-services strategies; dynamic clustering;

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1. Introduction

Through the last decades, cities growth patterns have been undergoing qualitative changes. These changes (from monocentric to polycentric structures) have produced intense changes in mobility patterns in urban structure. Thus contemporary cities organization need to evolve and offer services effectively, efficiently and sustainable in all aspects (Ferreira et al. 2013)

In order to optimize the transportation systems a crucial element stands for the understanding of what drives mobility and its patterns that in turn, is vital for demand and traffic modelling, simulation, forecasting and control (Peng et al. 2012, Veloso, Phithakkitnukoon & Bento 2011). Recent access to a variety of surveillance devices provides research community with an enormous amount of data, requiring new and valid methodological tools in order to take full advantage of these new opportunities. Taxi services stands for a vital demand-responsive transport mode, especially in Mega-Cities.

The remarkable development of the Information and Communication Technology (ICT) provides powerful tools to monitor the time-resolved locations of individuals and makes it possible to understand the basic law of human motion. Although activities can easily appear to be random and unpredictable from the perspective of an observer who is unaware of the activity agenda, rarely perceive any of actions to be anomalous or stochastic. Traditional transportation systems in metropolitan areas often suffer from inefficiencies due to uncoordinated actions as system capacity and traffic demand change. With the pervasive deployment of networked sensors in modern vehicles, large amounts of information regarding traffic demand and system status can be collected in real-time. This information provides opportunities to perform various types of control and coordination for large scale intelligent transportation systems.

Using commercial vehicle fleets as probes may be a cost-effective method for obtaining real-time traffic information. Because the taxi dispatch system automatically records the location of a taxi traveling in an urban network, large quantities of real-time travel data can be obtained at low cost. Although, the reliability of this information, about real-time traffic conditions, has not been investigated. However, Taxi service is an important mode of public transportation in most metropolitan areas since it provides door-to door convenience in the public domain.

The aim of this paper is to identify alternative Taxi-Services Strategies by means of dynamic clustering. Through a complex and realistic dataset, preliminary analysis were done (spatial and temporary data) in order to develop challenging tests for Metropolitan cities. The study of large cities such as the New York City, particularly for the New Year's Day (2010), is a challenge. Due to high demand for taxies that special event day the result was large concentrations and fluctuations through that day.

Spatial data were organized by performing clustering estimation and graphs of origin basis of destination, whereas, the temporal data were organized by performing dynamic analysis, separating the data into five minutes intervals.

The ultimate scope of the paper is the understanding of taxi-services through various experiments, so as to identify the best strategies of taxi services. The strategies that will be close to 'optimal', may be used to create a decision support system that could be used by taxi-services companies.

The paper is structured as follows: after this brief introduction, section 2 follows with a background review on urban mobility based on Global Positioning System-GPS information and taxi data analysis. In section 3 a dataset description is given by analysing the dataset with respect to various considerations. Next, the dataset is being processed and analytically presented, mainly providing GPS-based taxi traces distributed in time, both for pick-up as well as for drop-off locations in 'heatmaps'. Section 4 follows with a clustering estimation, trying to detect and understand strategies followed by taxi drivers. Moreover an analysis of the data produces OD matrices and a brief processes of them is presented. Section 5 gives main conclusions and discusses some future research to improve the current work.

2. Background Review

During the last years researchers has become more and more interested in the statistical analysis and process of transportation and human mobility pattern using the large amount of empirical data from location tracking devices (Castellano, Fortunato & Loreto 2009). Researchers provided evidence on the taxi industry organization, based on dynamic equilibrium assumptions quantified the impact of these policies on medallion prices and on the process that matches passengers with taxicabs in New York City (Lagos 2003). In (Ch, Briones 2006), a graphical approach