Chapter 11
Human Mobility Patterns

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ABSTRACT

It is well accepted that the physical world itself, including communication networks, humans, and objects, is becoming a type of information system. Thus, to improve the experience of individuals, communities, organizations, and societies within such systems, a thorough comprehension of collective intelligence processes responsible for generating, handling, and controlling data is fundamental. One of the major aspects in this context and also the focus of this chapter is the development of novel methods to model human mobility patterns, which have myriad uses in crucial fields (e.g. mobile communication, urban planning, etc.). The chapter highlights the state of the art and provides a comprehensive investigation of current research efforts in this field. It classifies mobility models into synthetic, trace-based, and community-based models, and also provides insight into each category. That is, well-known approaches are presented, discussed, and qualitatively compared with each other.

1. INTRODUCTION

Ubiquitous access to information anywhere, anytime and anyhow is one of the main features of future communication networks which experience a tremendous development including a wide variety of new services and broadband applications. The Internet itself emerges towards what is today known as “the Internet of things”, which assumes that each object is embedded with sensors and is able to communicate (Ovidiu et al., 2009). In other words, the physical world itself including communication networks, humans and objects is becoming a type of an information system. Thus, to improve the experience of individuals, communities, organizations and societies within such systems, a thorough comprehension of collective intelligence processes responsible

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of generating, handling and controlling those data is fundamental. One of the major aspects in this context is the development of novel methods to model human mobility patterns, which have myriad uses in crucial fields, e.g. mobile communication research, urban planning, ecology, epidemiology, etc. The authors in (Gonzalez, Hidalgo & Barabasi, 2008) state that human mobility patterns are far from being random. They show a high degree of temporal and spatial regularity, thus, follow simple reproducible patterns. So, faithfully reproduction of the movements of real people significantly helps in answering crucial questions necessary to improve the experience of individuals, organizations, etc. For instance, an accurate reproduction of how people move around a city can help to evaluate if the installation of a specific sensing application on mobile devices would be able to reach the desired coverage, see (Isaacman et al., 2012).

The modeling of how large as well as small populations move within small, medium and metropolitan areas is the goal that various human mobility modeling techniques tried to achieve. Many studies have shown that individuals tend to spend the majority of their time at few places, e.g. work offices, homes, etc., see (Gonzalez et al., 2008), (Isaacman et al., 2011) and (Song, Qu, Blumm & Barabási 2010). Keep in mind that the reproduction of human density over time at various geographic scales helps in addressing essential societal issues like the environmental impact of home-to-work commutes for instance. Furthermore, different geographic distributions of communities, commercial centers, companies, etc. heavily affect human mobility patterns, which are affected by, and also must be reflected in, various factors such as transportation infrastructures, plans for cities growth, etc. Previous efforts have reported significant differences between cities in terms of metrics such as commute distances, for instance, see (Isaacman et al., 2011a), (Isaacman et al., 2010) and (Noulas, Scellato, Lambiotte, Pontil & Mascolo, 2012).

Models of human mobility patterns are categorized into three categories, namely synthetic, trace-based and community-based models, see (Musolesi & Mascolo, 2009), (Camp, Boleng & Davies, 2002) and (Ranjan Roy, 2011). Synthetic models are mathematical ones trying to capture the patterns of human movements by means of a set of equations. The key idea of trace-based models is the exploitation of available measurements and traces achieved in deployed systems to reproduce synthetic traces characterized by the same statistical properties of real traces. Community-based modeling of human movements depends on the fact stating that mobile devices are usually carried by humans, which implies that movement patterns of such devices are necessarily related to human decisions and socialization behaviors. So, human movement routines heavily affect the overall movement patterns resulting, e.g. people move daily morning from their houses to their offices and come back at the afternoon for instance. One of the major contributions in this context is the application of the social network theory to generate more realistic human movement patterns, see (Musolesi & Mascolo, 2009).

The chapter highlights the state of art and provides a comprehensive investigation of current research efforts in the field of human movement patterns. It is organized as follows: section 2 discusses synthetic mobility models. It overviews well-known approaches and summarizes with a qualitative comparison. The trace-based modeling of human movement patterns is handled in section 3. Section 4 discusses the third category of mobility models, namely the community-based. Following that, the chapter concludes in section 5 with the main results.

2. SYNTHETIC MODELING OF HUMAN MOBILITY PATTERNS

Synthetic models are largely preferred and widely applied to simulate mobile communication net-