

Space-Time Analytics of Big Data to Discover Patterns of Life

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Big Data are often characterized as high volume, high velocity, high variety, high variability, and high complexity. Almost everything digital can be considered as data, and continuing waves of data from social media, RSS feeds, sensor networks, online repositories, and crowd sourcing applications have stimulated many novel studies on large-scale, timely human dynamics that would be data- and resource-prohibited before. Common approaches to Big Data analytics include analyses of frequencies, clusters, and associations to reveal themes, trends or hot spots. The position paper advocates for the needs to develop space-time analytics methods that can go beyond findings from the common approaches to reveal patterns of life.

Why Patterns of Life

“Pattern of Life” is a loose term used in psychology, sociology, ecology, anthropology, geography, and perhaps other disciplines as well. Its general concept relates to rhythmic activities taken by a population or an individual. Recently, the term is associated with activity-based intelligence in surveillance. However, the association shall not deter its intellectual rich ground for understanding human dynamics. The underlying patterns of life for an individual, a population, or a place serve the basis to anticipated activities and events, detect anomalies, predict futures, as well as respond and adapt potential changes.

What Patterns of Life

Patterns of life may exhibit in an individual, a population, and a place. Everyone has daily, weekly, monthly, and seasonal routines that carry out activities with some degree of regularity. A population exercises cultural practices with weekly, seasonal, and annual events. Spatial and temporal dimensions of these activities and events give rhythms that characterize a place, such that traffic jams at I-35 and Main Street 7-9am on weekdays, farmer markets open on Robinson Crossing every Wednesdays or Jazz in June in Central Park first weekend of June every year.

Patterns of life from individuals, populations, and places are interrelated into a complex system. On one hand, individual's life patterns are influenced by the population to which the individual belongs and the place where the individual resides. On the other hand, patterns of life for a population and a place cannot be maintained without sustained activities from their constituted individuals. The interrelationships drive the dynamics of the complex system in which patterns of life evolve through constraints of the population (including subcultural groups) and place to individuals and through support of individuals to the patterns of life for the population and place.

Big Data and Patterns of Life

Patterns of life constitute activities and events with emphases on what they are as well as where, when, and how often they take place. Furthermore, patterns of life are rhythmic; that is, there are sequential transitions among the activities and events. Hence, Big Data support for discovery of patterns of life must start with identifying activities and events and proceed with determining their locations and times as well as spatial and temporal relationships.

In natural languages, activities and events are noted by verbs (e.g. walk) or action nouns (e.g. demonstration). In imagery or videos, activities and events are recognized by changes in properties (i.e. difference) or location (i.e. movement). In sensor observations, activities and events are inferred from significant variations in measurements.

Once activities and events have been detected, they need to be contextualized in space and time to recognize the environmental and situational affordance (e.g. the spatial and temporal conditions and connections to other activities and events). Conceptual frameworks are important to guide recognition of activities and events from big data, patterns of life, and the corresponding complex system of life patterns among individuals, populations, and places.

A Simple Demonstrative Case

Space-Time Analytics of Big Data to discover patterns of life can be demonstrated in a simple case of using dense GPS points of individuals to recognize routine activities. The demonstrative case is being developed with Dr. Atsushi Nara in a project sponsored by the National Institute of Justice. Highly intensive GPS data on individuals were recorded every 15 minutes when in motion or every hour when at rest. We developed a suite of space-time analytics algorithms and geospatial contextualization to discover patterns of life for each individual. The simple case illustrates the strategy used to develop a conceptual framework to meet the analytics needs and findings to reveal the space-time rhythms of the individuals. Approaches taken by the simple case are extendable to cases beyond GPS data. We will explore opportunities to extract activities and events from social media or web resources and how the extracted activities and events can contribute to discovering patterns of life and how the discovery can help enhance our understanding of human dynamics.