A Network based-Referent Tracking for Infectious Disease using GPS Sensor Data

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Abstract

Due to the dynamic nature of complex interactions and the mobility of people, it is challenging to construct a contact network and detect the possible spread of an infectious disease. For the purpose of disease surveillance and control, much attention has been paid to recording/estimating dynamic contact networks at the individual level. The use of rich data set (i.e., GPS sensor data) holds the key to estimate such dynamic network (Bansal, Read, Pourbohloul, & Meyers, 2010; Bian & Liebner, 2007). In addition, referent tracking (RT) as a paradigm that helps to keep track of the ways individuals navigate through the health care system was developed. All individuals are given unique IDs (called IUIs - Instance Unique Identifiers) that describes explicitly the templates of a given reality (Ceusters & Smith, 2006). Combining both ways of representing dynamic reality, we propose a dynamic network based referent tracking that improves the ways of disease surveillance and control by detecting possible spread of infectious disease through time.

From the perspective of Basic Formal Ontology (BFO), we distinguish universals (i.e., classes, types) from particulars (i.e., individuals, instances), the former being entities such as person, and the latter entities such as Jeon-Young. Additionally, BFO has a dichotomy between continuants (i.e., object) and occurrents (i.e., phenomena). Derived from BFO, we describe whole process of an infectious disease in the following ways: (1) all continuant particulars (i.e., individuals) are participated in the three processes of moving around, interacting with others, and getting an infectious disease (e.g., influenza), (2) all individuals take roles such as vector and/or host, which are changeable over time. Additionally, all individuals take states as their quality. States are individual’s situation at any phenomena, which are represented by tuple. For instance, a GPS data (latitude, longitude, time) can depict a trajectory of an individual at a given time.

In detail, the observation of infections among people could arise in three non-exclusive levels (1) individuals in a certain set of state of processes, such as (IUI, latitude, longitude, time, SEIR), (2) the population through an infectious disease spread. The population as a whole has states (number of population, free of infections and/or increasing/decreasing/static rate of infection, and time), and (3) subsets of the population, formed as contact networks, such as (number of network members, rate of infection, location, and time). These observations would thus describe patterns of human’s connection and disease spread.

Unfortunately, existing ontology of infectious disease (Infectious Disease Ontology, IDO) does not fully cooperate with GPS sensor data. It is designed as interoperable ontologies of the infectious disease domain to provide a fine knowledge of diseases (Cowell & Smith, 2010). However, it is still challenging to apply the concept of a near real-time based dynamic contact network for describing states of infectious disease of the individual particulars.

In this paper, we propose a conceptual framework to capture the possible spread of infectious disease cases using GPS sensor data. Firstly, we specify a near real-time contact network and logically possible states of infectious diseases based on SEIR model. Secondly, we implement an algebraic specification of the dynamic network and the states of SEIR model using

\( SEIR \) refers to model of infection process where every individual undergoes four general states: Susceptible – Exposed – Infectious – Recovered.
Haskell. Finally, the effectiveness of proposed methodology is evaluated using a synthetic GPS data.

**Reference**


