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Fuzzy ontology-based sentiment analysis of transportation and city feature reviews for safe traveling [☆]

Farman Ali ^a, Daehan Kwak ^b, Pervez Khan ^c, S.M. Riazul Islam ^a, Kye Hyun Kim ^a, K.S. Kwak ^{a,*}^a Inha University, South Korea^b Rutgers University, USA^c Incheon National University, South Korea

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ABSTRACT

Traffic congestion is rapidly increasing in urban areas, particularly in mega cities. To date, there exist a few sensor network based systems to address this problem. However, these techniques are not suitable enough in terms of monitoring an entire transportation system and delivering emergency services when needed. These techniques require real-time data and intelligent ways to quickly determine traffic activity from useful information. In addition, these existing systems and websites on city transportation and travel rely on rating scores for different factors (e.g., safety, low crime rate, cleanliness, etc.). These rating scores are not efficient enough to deliver precise information, whereas reviews or tweets are significant, because they help travelers and transportation administrators to know about each aspect of the city. However, it is difficult for travelers to read, and for transportation systems to process, all reviews and tweets to obtain expressive sentiments regarding the needs of the city. The optimum solution for this kind of problem is analyzing the information available on social network platforms and performing sentiment analysis. On the other hand, crisp ontology-based frameworks cannot extract blurred information from tweets and reviews; therefore, they produce inadequate results. In this regard, this paper proposes fuzzy ontology-based sentiment analysis and semantic web rule language (SWRL) rule-based decision-making to monitor transportation activities (accidents, vehicles, street conditions, traffic volume, etc.) and to make a city-feature polarity map for travelers. This system retrieves reviews and tweets related to city features and transportation activities. The feature opinions are extracted from these retrieved data, and then fuzzy ontology is used to determine the transportation and city-feature polarity. A fuzzy ontology and an intelligent system prototype are developed by using Protégé web ontology language (OWL) and Java, respectively. The experimental results show satisfactory improvement in tweet and review analysis and opinion mining.

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* Corresponding author.

E-mail addresses: farmankanju@gmail.com (F. Ali), kwakno1@cs.rutgers.edu (D. Kwak), pervaizkanju@hotmail.com (P. Khan), riaz@inha.ac.kr (S.M.R. Islam), khyehyun@inha.ac.kr (K.H. Kim), kskwak@inha.ac.kr (K.S. Kwak).

1. Introduction

Traffic monitoring and transportation facilities are two major concerns of intelligent transportation systems (ITSs). At present, sensor network based transportation systems are employed to monitor the entire traffic network and to provide emergency services in response to associated activities occurring on the roads. In addition, people use various devices in vehicles, such as small-scale collision radars, global positioning systems, radio transceivers, and sensing devices to retrieve real-time information in order to travel safely. Most of these systems are designed for short-range communications and are unable to collect all traffic-related data. They also fail to notify drivers before entering risk zones, resulting in wasted time and consumption of extra fuel. As a solution, precise information is needed that can be utilized to rapidly identify risky spots and activities. However, because of the wonderful trends in interpersonal organization during the most recent decade, network platforms, like the various community blogs, Facebook, Twitter, and online forums have turned into the richest sources of real-time data (Liu et al., 2005; Cao et al., 2014; Kim and Hovy, 2006).

Currently, people utilize social media sites to share their opinions on different issues associated with transportation (e.g., traffic collisions, traffic jams, and landslides or rockslides). New clients come across the reviews of others and react to them regarding the same subject (e.g., roads or city streets jammed, street-side organizations, and associations). Conversely, a large volume of tweets or reviews can puzzle web surfers trying to determine immediate and safe routes. In most cases, people give their assessments about transportation in terms of features like “the information of the traffic police officer was extremely definite and helpful”; or “at least three hurt in a two-vehicle mishap close to the downtown”; or “Victoria downtown has a ton of offices, yet the street is jammed”. Opinion reviews are concealed in forums and blogs, making it difficult for the user to extract meaningful information. Sentiment-analysis or opinion mining is the process of extracting valuable information from public tweets and reviews about a specific topic using text analysis methods and natural language processing (Ali et al., 2015a,b). Therefore, sentiment analysis can help ITSs to improve traffic monitoring and transportation facilities.

Most of the present systems are not good enough to categorize the correct positive and negative sentiment words and to recognize terms for the degree of feature polarity. It is critical to determine whether a tweet or review represents a strongly positive, positive, neutral, negative, or strongly negative polarity. In addition, data extraction frameworks primarily take classic ontologies into account. The classic ontology addresses only crisp data, and cannot recover alluring results from the cloudy wellspring of social network data. Different systems and sites on transportation and travel give a rating score to a city, taking rates of various variables into account, for example, green space, cleanliness, tourism offices (restaurants, hotels, parks, and so on.), safety, peacefulness, low crime rates, and so on (Gilboa et al., 2015). These rating scores do not convey precise information, in spite of the fact that tweets or reviews are significant because they offer some assistance to the transportation administrators and travelers so they will know about all positive and negative points of each feature. However, it is troublesome for ITSs and travelers to peruse every tweet and review and come to an important conclusion in regards to their necessities from city factors. For the most part, people shroud their feelings about a city, rather examining it in terms of city-features; for instance, “the marvelous foggy weather of our excellent Manhattan” (Bertrand et al., 2013). Therefore, it is critical to locate the individual city-feature polarity, and thereafter, the overall city polarity. On that, this paper presents fuzzy ontology-based sentiment analysis and semantic web rule language (SWRL) rule based decision-making knowledge that will help ITSs and travelers. Below are the main contributions of this research.

- The proposed system effectively retrieves reviews and tweets related to city features (e.g., bus and train stations, bridges, parks, restaurants, airports, medical centers, and hotels) and transportation activities (e.g., collisions, roadsides, congestions, and traffic jams).
- An unsupervised linear method is used to automatically extract related sentiments from online consumer tweets and reviews.
- Fuzzy ontology-based semantic knowledge is developed to extract individual transportation activities and city features with the opinion words. Then, fuzzy ontology is used to compute the polarity of transportation activities, city features and the overall city from the degrees of the terms (strongly negative, negative, neutral, positive, and strongly positive).
- SWRL rule based decision-making knowledge is proposed to find the major causes of traffic congestion and negative polarity.
- An opinion map of the city features and city transportation activities is automatically designed by using semantic knowledge and sentiment analysis results, which enrich the performance of ITSs by determining the traffic problems and providing safe routes for travelers.

The remainder of this paper is organized as follows. Section 2 provides the state-of-the-art work in this area. Section 3 illustrates the basic concept of the proposed system architecture. Fuzzy ontology based semantic knowledge is explained in Section 4. Section 5 briefly explains the overall scenario and internal process of the sentiment analysis and polarity computation. Section 6 presents the experimental results.

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