지진정보에 기반한 장소 신뢰도 계산 기법

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Method of Calculating Trustness of Location Based on Earthquake Information

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요 약

Recently, location-based services (LBSs) have become popular and essential in many applications such as recommendation systems and disaster warning systems. The main challenge of the LBSs is obtaining the reliability of specified locations. In this paper, we propose an approach to calculate trustness of location based on earthquake events happened. First, we used a JSON web API to automatically obtain the earthquake information from United States Geological Survey (USGS). Second, we propose a method for computing the trustness of a location by using magnitude and location of the earthquake events. Our approach has investigated in making a geo-mapping matrix which describes the impact of earthquakes with the corresponding value of trustness of location. The trustness of location is stored in database servers for further use of applications. To show viability of out approach, we implemented a Java deamon program to collect earthquake information and to calculate trustness of location by using geo-mapping matrix.

1. Introduction

The trustness of location is really important in location-based applications such as friends recommendations in social networks, disaster warning systems and network controllers. It enables the applications to be flexible in diffusing information. For example, if an earthquake warning notification system knows trustness of location around an epicenter, it is able to efficiently deliver the message to recipients who are located in the event area. Another case, when an earthquake event occurs, the networks may get catastrophic impacts such as link failures. In this case, based on trustness of location can help recover network links much switch.

There are several researchers worked on trustworthiness of information. The dynamic source routing (DSR) is modified in [1] so that the path with the highest trust is selected among those leading to the desired destination, instead of selecting the shortest path, to enhance security. To apply for wireless sensor networks [2] focused on the way that trust information is combined with location-based routing protocols. In [3] and [4] proposed the methods by using trust-based and location-based for social recommendation systems which predict the rating for user u on a nonrated item i or to generally recommend some items for the given user u based on the ratings that already exist. [3] presented CoTCoDepth that is a recommender system using limited knowledge and based on explicit user defined social relations with scores are propagated in a P2P manner, while [4] proposed a model SocialMF that is a matrix factorization based approach, learns the latent feature vectors of users and items.

In this paper, we propose a model of trustness calculation which describes the impact of earthquakes using attributes like magnitude and location (latitude and longitude). Our work as described in this paper makes the following contributions:

First, we used a JSON web API to automatically obtain the earthquake information from United States Geological Survey (USGS) in real-time manner. Second, we proposed a model for computing the trustness of a location by using magnitude and location of an earthquake event. This work focus on making a geo-mapping matrix which describes the impact of earthquakes with the corresponding value of trustness of location. The trustness of location is stored in

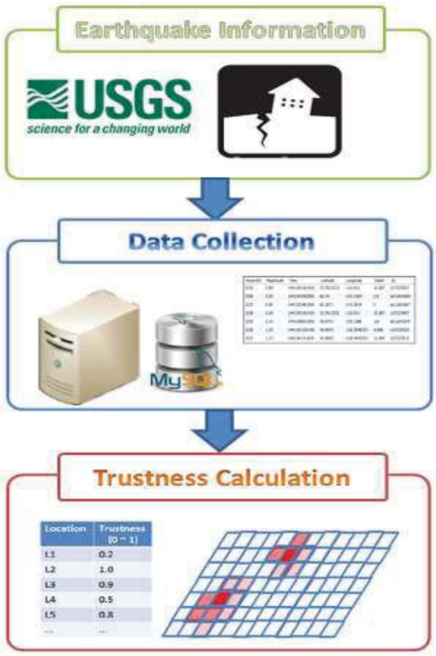

Figure 1: A conceptual view o Calculating Trustness of Location

database servers for further use of applications.

2. Our Approach

In this section, we describe our method for model calculating Trusness of Location. In Section 2.1, we introduce a conceptual view of calculating trustness of location. The collection earthquake information from the USGS is shown in Section 2.2. We give an approach to calculate trustness of location in Section 2.3.

2.1 Overview of Our System

To obtain the values of the trustness of location, we proposed a model as shown in Figure 1. This model consists of two main parts: data collection and trustness calculation. In the data collection, we automatically get earthquake information from a public disaster information center called USGS. There are many disasters information is provided by USGS, but our system only gathers earthquake information. We then selected several particular attributes of an earthquake event that serves for calculating trustness of location later. The all of earthquake information in the world is stored in database server. In the next part, we proposed an algorithm to calculate trustness of location. A matrix is generated that describes the impact of earthquake events in around the epicenter. It also represents the trustness value at these locations. More details, we will present in Section 2.3.

2.2 Collection Earthquake Information

Java-based techniques are able to construct a program to automatically gather the earthquake information from the USGS site. Here, the input to our system is a hyperlink which describes the path storing and updating earthquake information every 5 minutes. The data is stored in JSON format. By using JSON-based we extracted the data of a set of essential information about earthquake include: magnitude, time, longitude, latitude, depth.

In this work, we perform the gathering in automatically by calling procedure *AutoCollection* as in Algorithm 1.

The Algorithm 1, a set of earthquake events are assembled every 5 minutes. In fact, we observed that several events occur with a period more than 5 minutes. Therefore, we only filter out the earthquake events that did not happen before, then store them to the database (line 5-6).

2.3 Calculating Trustness of Location

In this section, we present an approach to computing trustness of location. we give a geo-mapping matrix that is a set of locations L = $[L_{i,j}]_{n\times m}$, where is $L_{i,j}$ is a location that show starting position of each cell on matrix. A cell of this

Algorithm 1 Procedure ***AutoCollection*** is used to gather the earthquake information

Require: A path p is a JSON file that contains earthquake information
Ensure: A set of current earthquake events $E_c(id, m, t, d, lat, lon)$

1: $E_p \leftarrow \emptyset$; /* *a set of earthquake events*/
2: **while** ($true$) **do**
3:     $E_c \leftarrow$ ExtractJSON(p);
4:     **for each** event $e \in E_c$ **do**
5:         **if** $e \notin E_p$ **then**
6:             InsertToDB(e);
7:         **end if**
8:     **end for**
9:     $E_p \leftarrow E_c$;
10:     $E_c \leftarrow \emptyset$;
11:     Sleep(5*60000) /* *sleep 5 minutes*/
12: **end while**

matrix has the size $c \times c$ with c can be a real number describing the length by kilometer. Similarly, we define a trustness matrix T = $[T_{i,j}]_{n\times m}$, which describes the impacting of earthquake events on matrix L, where $T_{i,j}$ denotes the trustness of location for an earthquake event and $T_{i,j}$ is any real number ranging from 0 (no trust) to 1 (full trust). Normally, $T_{i,j}$ = 1.0 when $L_{i,j}$ is the epicenter of the earthquake event and magnitude $M \geq \delta$ with δ is a threshold of magnitude to set trussness value equals 1.0 . The neighbor cells of $T_{i,j}$ may get some value such as 0.8 or 0.9 based on how they are close to the epicenter of the earthquake $L_{i,j}$ and how big the magnitude is.

The impact of earthquake e is described in a trustness matrix T^e = $[T_{i,j}]_{K\times K}$, where in K is the size of the matrix T^e and $T^e \subset T$. In fact, K x K too much smaller than n x m. The size of matrix T^e depends on the magnitude of earthquake. To finding Possible Region Affected (PRA) we used an well-known equation of Wells et al. [5] that shown relationship between moment magnitude and surface rupture length of earthquake as follows

In equation (1), M is the moment magnitude and L_R is the surface rupture length of earthquake. The result in [5] shown that no difference between moment magnitude and magnitude in the range of magnitude 5.7 to 8.0. Therefore, in this paper, we also use M as magnitude value and focus on earthquake events

$$M = 5.08 + 1.16 * \log(L_R) \qquad (1)$$

have M $\geq$ 5.08.

By an equivalent transformation we have equation (2) for

$$L_R = 10^{(0.862069 * M - 4.37931)} \qquad (2)$$

calculating surface rupture length L_R as follows:

Thus, the size of T^e above is K x K, with K is the minimum number of odd integer satisfying $K \geq \frac{L_R}{c}$, excepts the earthquake event happens nearly edge of geo-mapping matrix, the size of T^e is less than **K x K.**

In our approach, the impact of earthquake is linearly decreased with M. Therefore, two adjacent cells get a

$$\triangle = \frac{2M}{\delta * K} \qquad (3)$$

deviation $\triangle$ as follows:

We formulate the influence of an earthquake at each

$$T_i = \begin{cases} \frac{M}{\delta} & \text{if } i = 1 \\ T_{i-1} - \triangle & \text{if } i > 1 \end{cases} \qquad (4)$$

cell on T^e as follows.

where i is a number of integer that shows the distance by cells from epicenter (i=1) to K/2. Thus, the cells have the same distance will get the same trustness value in an initial trustness matrix to T^e.

Using equation (2), (3) and (4) we have the

$$T_i = \begin{cases} \frac{M}{\delta} & \text{if } i = 1 \\ T_{i-1} - \frac{2M^* c}{\delta * K} & \text{if } i > 1 \end{cases} \qquad (5)$$

equation as follows.

The equation (5) calculates the trustness value which describes the impact of an earthquake event based on the magnitude.

The main purpose of this paper is to generate a trustness of location matrix T^k around a cell k with specific location $L_{i,j}$ whenever an earthquake happens. Here, a set of the earthquakes $e = \{e_1, e_2, \ldots, e_n\}$ happened on cell k, where e_1 is the most recent event occurred. The size of trustness value matrix of e_1 is also the size of matrix T^k which should be calculated trustness of location. Our approach based on averaging trustness

$$T_{i,j} = \frac{1}{n} \sum_{e=1}^{n} (T_{i,j})_e \qquad e = \{e_1, e_2, \ldots, e_n\} \qquad (6)$$

value on each cell on matrix T^k as follows.

where $T_{i,j}$ là trustness of location at $L_{i,j}$ after earthquake event e_1 happened.

3. Results and Discussion

In this section, we show an example for calculating the trustness of location and discuss on this study.

Example 1. Suppose we concern an earthquake event (e) happened in Young San, North Korea. This event has magnitude M = 6.5. In this example, we choose a threshold to set full trust value $\delta = 8.0$, the length of a square cell on geo-mapping matrix $c = 5.5$ (approximate 0.05 degree on the earth). Now, we need to the calculating an initial matrix of trustness value (T^e).

By using equation (2), (3) we have L_R = 16.72477 (km), $\triangle$ $\simeq$ 0.27. The size of matrix T^e is 5 x 5. The trustness value of matrix T^e is calculated using equation (5). The result of T^e as follows:

	0.27	0.27	0.27	0.27	0.27	
	0.27	0.54	0.54	0.54	0.27	
	0.27	0.54	0.81	0.54	0.27	
	0.27	0.54	0.54	0.54	0.27	
	0.27	0.27	0.27	0.27	0.27	

Figure 2: An example for matrix of trustness of location

Example 2: A scenario for calculating trustness of location is that we have E = $\{e_1, e_2, \ldots, e_n\}$ is a set of earthquake events in single cell $L_{i,j}$, where n is a integer number. Based on the earthquake information of E we need to compute the trustness of location T around cell $L_{i,j}$. Here, each earthquake event happened in the difference time, magnitude and location, but all inside a single cell $L_{i,j}$. Therefore, we have to maximize the size of trustness matrix T in the result. For example, we consider on two earthquake events, one is e_1 = [20150903190500, 33.3127, 127.1485, 6.5, 25], another is e_2 = [20150901070503, 33.3128, 127.1484, 6.9, 26], where the information in the earthquake corresponds: time, latitude, longitude, magnitude and depth. We have magnitude of e_1 (6.5) is smaller than magnitude of e_2 (6.9). In this case, the size of trustness matrix T^{e_1} is smaller than T^{e_2}, as the illustration in Figure 3.

		0.27	0.27	0.27	0.27	0.27		
		0.27	0.54	0.54	0.54	0.27		
		0.27	0.54	0.81	0.54	0.27		
		0.27	0.54	0.54	0.54	0.27		
		0.27	0.27	0.27	0.27	0.27		

location matrix for earthquake event e_1 with magnitude = 6.5

	0.20	0.20	0.20	0.20	0.20	0.20	0.20	
	0.20	0.42	0.42	0.42	0.42	0.42	0.20	
	0.20	0.42	0.63	0.63	0.63	0.42	0.20	
	0.20	0.42	0.63	[illegible]	0.63	0.42	0.20	
	0.20	0.42	0.63	0.63	0.63	0.42	0.20	
	0.20	0.42	0.42	0.42	0.42	0.42	0.20	
	0.20	0.20	0.20	0.20	0.20	0.20	0.20	

location matrix for earthquake event e_2 with magnitude = 6.9

Figure 3: *Two matrices of trustness of location in a single cell at the difference time.*

We calculated trustness of location for PRA after e_1 happened by using equation (6) above. The result is illustrated as Figure 4.

		0.35	0.35	0.35	0.35	0.35		
		0.35	0.59	0.59	0.59	0.35		
		0.35	0.59	0.83	0.59	0.35		
		0.35	0.59	0.59	0.59	0.35		
		0.35	0.35	0.35	0.35	0.35		

Figure 4: *Averaging trustness of location for a single cell with 2 earthquakes*

Similarly, when earthquake event e_1 happens at a location near to location of e_2 (epicenter is not the same a cell. In this case, trustness of location for PRA after e_1 happens are affected by some cells of e2.

4. Conclusion

Location-based systems has become popular and essential for various applications such as friends recommendations in social networks, disaster warning systems and network controllers. This paper presents an approach to calculate trustness of locations. Through the results of initial implementation, we show the viability of our method.

In the future work, we plan to deeply consider the method for computing the trustness of location more exactly. Besides that, we will find the applications to provide the services and applications based on this study.

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