Context-Based Traffic Recommendation System

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Abstract. In this paper, we propose a new traffic system recommendation based on support real-time flows in highly unpredictable sensor network environments. The approach system is real-time recommendation system which meet various demands of users. The proposed algorithm include two phases. First phase is proposed to deal with the real-time problem. By this way, the drivers are able to transfer on the way with the shortest-time. For second phase, a research algorithm based on Depth First Search (DFS) algorithm will recommend the paths which meet demands of drivers based their context such as the paths with include the famous landscapes or the paths where they can find out good restaurants for their break while driving.

Keywords: Recommendation system · Sensor network · DFS algorithm

1 Introduction

With growth rate of world population, vehicular traffic is also increasing tremendously, especially in urban areas. This result affects directly to economies, human health, and environment because of huge traffic congestion. An effective solution is necessary to deal with this vehicular traffic problem. Wireless sensor network (WSN) based intelligent transportation systems (ITS) have emerged as an effective technology for management vehicular traffic since their low cost, flexibility of deployment and ease to maintains. There have been many studies on WSN technology to improve the circulation of vehicles. In [1], it has provided an innovative Wireless Sensor Network for traffic safety measurements. Liang [2] has used WSN to detect traffic flow. The simulation shows that the sensor nodes provide average detection rate of above 90 percent. On other hands, some papers focus on using sensor to monitor vehicular traffic. In [3], Li, X. et al. indicate that Vehicle-based sensor can be used for traffic monitoring. The performance evaluation shows that traffic congestion will be reduced.

Recommendation System is proposed as one of the effective solutions for traffic management. Recommendation systems are a subclass of information filtering system that seek to predict the 'rating' or 'preference' that a user would give to an item [4]. It has become extremely common in recent years, and are

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applied in a variety of applications. The most popular ones are probably movies, music, news, books, research articles, search queries, social tags, and products in general... In [5], Phanich et al. introduced a Food Recommendation System (FRS) which recommend the proper substituted foods in the context of nutrition and food characteristic. For the music application, Soo-Hyun et al. in [6] proposed a new recommendation system for public places based on sensor network, the system will play a music which best matches the current situation such as the number of people, season, weather and time in public places. Otherwise, there have been some studies using recommendation system to deal with traffic problem. Wang, H. et al. in [7] developed a real-time route recommendation system. They indicated that using route recommendation system can not help control traffic jam since it always recommend the same route for users while traffic flow are always changing. Recommendation Systems are designed broadly in tourism. Long, L. et al. in [8] is also proposed a novel recommendation system to provide self-drive tourist with real-time personalized route recommendation. Meehan et al. in [9] proposed context-aware intelligent recommendation system for tourism, their system is a hybrid based recommendation approach made up of collaborative filtering, content based recommendation and demographic profiling. Otherwise, Patcharee and Anongnart in [10] presented the personalized recommendation system for e-tourism by using statistic technique base on Bayes Theorem to analyze user behaviors and recommend trips to specific users.

In this paper, we propose a traffic recommendation system based on wireless sensor network for users who want to find out a suitable path to theirs destination. There have been some studies using recommendation system for traffic traveling problem, but they do not focus on traffic congestion. In this paper, the approach system is a real-time system, this thing not only recommend for users the paths to save their time but also meet theirs demand at that time since drivers are not always want to find a short-path, sometimes they want to enjoy theirs travel during driving. The proposed recommendation system works based on contexts of vehicular traffic. In this paper, we assume the context that the drivers on the road network usually prefer to transfer on the paths with the shortest-time, famous landscapes and good restaurants... The approach system will recommend the paths which include the most place names with taking as little time as possible for users.

The main contributions of this paper include: (1) The proposed system based on wireless sensor network which are flexible deployment and ease to management. (2) Since the proposed system is a real-time system, it is able to control traffic jam as well as recommend for users the best routes. (3) The proposed system is not only provide for users the shortest-time paths to save their time but also recommend for them the suitable paths to make their routes become more interesting based on their favorite. The remaining parts of this paper are organized as follows. In Sect. 2, The system architecture of the proposed system is presented. The detailed algorithms of the approach system are proposed in Sect. 3. We make a discussion by give out an example to evaluate the effectiveness of our system in Sect. 4. Finally, we conclude this paper as well as point out some problems for future work in the last section.

2 System Architecture

This section describes the architecture of proposed traffic recommendation system based on wireless sensor network. The architecture of system is shown in the Fig. 1. As shown in the figure, the proposed system includes Road Network which created by many nodes and edges between nodes in the map, a Host Server analysis information and recommend lists for users. The process of proposed system works as follows: User will send request to Host Server, and then Host Server collects information from the request of user and data of Road Map to analysis and return back a suitable recommendation list to user.

Road Network consists sensor nodes which located in cars and sensor nodes which located fixedly in the public places where people coming and going frequently. As shown in Fig. 2, Road Network consists nodes which presented as sensor nodes and edges which are distance between two nodes. The sensor nodes can be located in public places which up to the specification geography of each areas, they may be located in popular places such as place names or famous restaurants... and they all are managed by Host Server. When user send request, sensor node which located in car transmit sensed information (the destination, the latitude and longitude of the car..), sink node collects and transmit sensed information to Host Server. By this way, Host Server collects all sensed information to find out the suitable paths by proposed recommendation algorithms.

The proposed algorithm is real-time recommendation system, it can be solved the problem which finding the shortest path between nodes. Since traffic flow is always changed every time, the shortest distance sometimes is not the shortest time, it is up to the traffic congestion at that time. The system will recommend the shortest time for user based on their speed and distance from source to

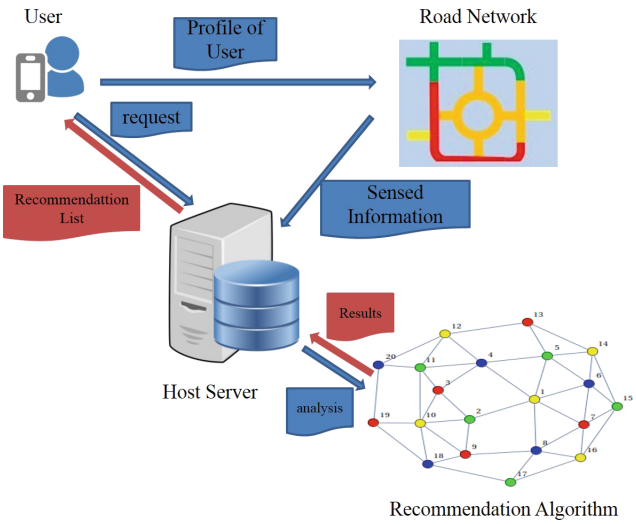

Fig. 1. System architecture

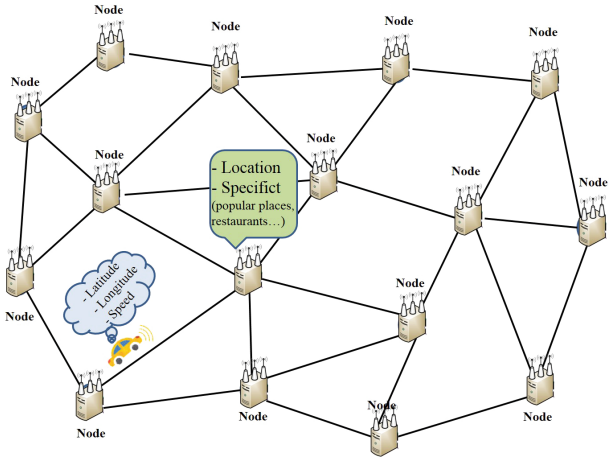

Fig. 2. Road network

destination of user. Moreover, drivers sometimes do not want to the shortest time paths. In some cases, they like to drive on the path which include famous landscapes or they want to enjoy their meal in a good restaurant for their break during driving. The proposed algorithm will recommend the suitable path based on the context of traffic network. Since the road network is developed based on sensor network, we can see the sensor network structure as the graph structure which the vertexes are nodes, the edges are the links of two neighboring nodes. By this way, the recommendation algorithm is transform to graph coloring algorithm. Detail of the proposed algorithm will be introduced in next section.

3 The Proposed Algorithm for Context-Based Traffic Recommendation System

To solve with the approach problem, the proposed system is divided into two phases. First phase is proposed to estimate the time to drive between two nodes to deal with real-time problem. Second phase is the recommendation algorithm to recommend the paths from source to destination which meet user's demands based on their context.

3.1 Phase 1: Estimate the Time Between Two Nodes

Since traffic flow is always changing, the shortest distance is not mean we can reach the destination with shortest time. By this way, in first phase, we estimate the time to transfer between nodes. The time to move from node A to node B (in case there is an edge between Node A and Node B) can be calculated as:

$$t_{A,B} = \frac{s_{A,B}}{v_{A,B}} \tag{1}$$

in Eq. (1), s is the distance between node A and node B, v is the average speed of vehicular traffic transferring on the way from node A to node B at that time. Thus, we are able to estimate the total time that the drivers need to take from source to destination for their route. It is noticeable that if the traffic flow is high, the average speed of vehicles will be low, so it takes more time to transfer from node A to node B.

3.2 Phase 2: Recommendation Algorithm

In this phase, we propose the algorithm to recommend the suitable paths for users. The outputs are different based on the contexts of vehicular traffic on the road network.

```
Data: Source S; Destination D, Adjacency Matrix A, Set of Node N.
Result: Set of Paths P from S to D
initialization;
if S==D then
    Print Path (P[S]); // Print out the path from S to D
else
    marked S; // marked the Node S we already passed
    for each U of set N do
        if U ∈ A_S then
            if U is not marked then
                marked U;
                Put U in P; //get node U in the path
                Recall DFS(U,A,D); // recursion method
                Unmarked U; //unmarked for Node U
                Put U out P;
            end
        end
    end
end
```

Algorithm 1. Search Algorithm

The process of the proposed algorithm is given as follows: (1) first, we transform the system model into undirected graph G(N,E) with N is set of Nodes and E is set of Edges between neighboring nodes. The weigh of edge between two neighboring nodes is the time that we computed in Eq. (1). (2) in second step, we based on Depth-First Search (DFS) algorithm to find out the paths from Source S to Destination D as shown in Algorithm 1, A is Adjacency Matrix of network which are computed based on sensed information from sensor nodes. (3) the system will collect and analysis information from results of Phase 1 and Algorithm 1 to compute and synthesize the paths as much as possible from Source to Destination of user (detail in Algorithm 2). (4) Based on context of users, the system will return back the recommendation list of paths for user (Algorithm 3).

Data: Set of Paths P from S to D
Set of Time T between 2 node
R, L the set of specific of Nodes
Result: List Data of Paths P
initialization;
Rr[]; Ll[];
for *each p of P* **do**
  for *each V of p* **do**
    Totaltime = TV + TV+1 ; **if** $V \in R$ **then**
      put $V \in Rr$;
    else
      if $V \in L$ **then**
        Put $V \in Ll$;
      end
    end
  end
end

Algorithm 2. The data of paths from Source to Destination

Data: Set of Paths P from S to D
Set of Time T between 2 node
t,r,l are contexts of users
Result: List Data of Paths P
initialization;
for *each path p of paths P* **do**
  if $p \in t$ **then**
    if $p \in r$ **then**
      if $p \in l$ **then**
        print(p);
      end
    end
  end
end

Algorithm 3. Recommendation algorithms

4 Discussion

To estimate the effectiveness of the proposed system, we give an example for our recommendation system. The system parameters are shown in Fig. 3. For instance, the distance between Node 1 and Node 2 is 7 km, and the car transfers on this way with speed 40 km/h at that time. To estimate correctly, we assume at least one taxi driving between nodes at that time (in case more taxi driving in the same route, we will compute by their averaged speed).

By get information from taxi driving reports,we are able to compute the time to transfer among nodes (1,2,3,4....11) based on their speed and distance between nodes as shown in Fig. 4. Notice that these traffic information has few minutes delay, we treat these information as the approximate real-time traffic condition.

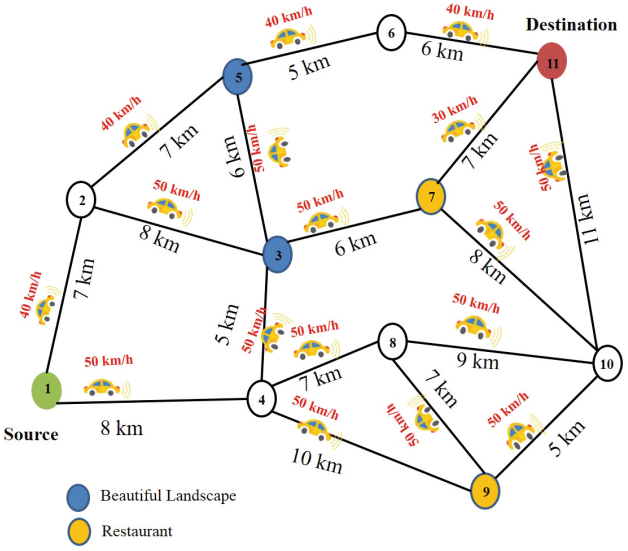

Fig. 3. System model for example

Node	1	2	3	4	5	6	7	8	9	10	11
1	0	0.18	0	0.16	0	0	0	0	0	0	0
2	0.18	0	0,18	0	0,16	0	0	0	0	0	0
3	0	0.16	0	0.1	0.18	0	0.12	0	0	0	0
4	0	0	0.1	0	0	0	0	0.14	0.2	0	0
5	0,16	0.18	0	0	0	0.13	0	0	0	0	0
6	0	0	0.12	0	0.13	0	0	0	0	0	0.15
7	0	0	0.12	0	0	0	0	0	0	0.16	0.2
8	0	0	0	0.14	0	0	0	0	0.14	0.18	0
9	0	0	0	0.2	0	0	0	0.14	0	0.1	0
10	0	0	0	0	0	0	0.16	0.18	0.1	0	0.22
11	0	0	0	0	0	0.15	0.2	0	0	0.22	0

Fig. 4. Example: estimate the time (h) between neighboring nodes

After using phase 1, search algorithm will find out as much as possible the paths from source to destination as well as their data as shown in Table 1. It is up to the context of users, the Recommendation List shows the suitable paths to recommend for users. In this paper, we assume the contexts of users are the shortest-time driving, the famous landscapes and the restaurants.

Table 1. Example: the data of paths from source to destination

Path	Total time	Famous Landscapes	Restaurants
1-2-3-4-8-9-10-7-11	1.2086	3	7;9
1-2-3-4-8-9-10-11	1.035	3	7
1-2-3-4-8-10-7-11	1.128	3	7
1-2-3-4-9-8-10-7-11	1.108	3	7;9
1-2-3-4-9-10-7-11	0.935	3	7;9
1-2-3-5-6-11	0.73	3;5	
1-2-3-7-10-11	0.835	3	7
1-2-3-7-11	0.688	3	7
1-2-5-3-4-8-9-10-7-11	1.343	3;5	7;9
1-2-5-3-4-8-9-10-11	1.17	3	9
1-2-5-3-4-8-10-7-11	1.238	3	7
1-2-5-3-4-9-8-10-7-11	1.483	3;5	7;9
1-2-5-3-4-9-10-7-11	1.263	3;5	7;9
1-2-5-3-4-9-10-11	1.09	3;5	9
1-2-5-3-7-10-11	0.97	3;5	7
1-2-5-3-7-11	0.823	3;5	7
1-2-5-6-11	0.625	5	
1-4-3-2-5-6-11	0.87	3;5	
1-4-3-5-6-11	0.655	3;5	
1-4-3-7-10-11	0.76	3	7
1-4-3-7-11	0.613	3	7
1-4-8-9-10-7-3-2-5-6-11	1.43	3;5	7;9
1-4-8-9-10-7-3-5-6-11	1.195	3;5	7;9
1-4-8-9-10-7-11	0.933		7;9
1-4-8-9-10-11	0.76		4;9
1-4-8-9-10-11	0.76		4;9
1-4-8-10-7-3-2-5-6-11	1.37	3;5	7
1-4-8-10-7-3-5-6-11	1.155	3;5	7;9
1-4-8-10-7-11	0.873		7
1-4-8-10-11	0.7		
1-4-9-8-10-7-3-2-5-6-11	1.57	3;5	7;9
1-4-9-8-10-7-3-5-6-11	1.355	3;5	7;9
1-4-9-8-10-7-11	0.993		7;9
1-4-9-8-10-11	0.82		9
1-4-9-10-7-3-2-5-6-11	1.35	3;5	7;9
1-4-9-10-7-3-5-6-11	1.135	3;5	7;9
1-4-9-10-7-11	0.853		7;9
1-4-9-10-11	0.68		9

Table 2. Example: recommendation list for user

Route	Path	Total time (h)	Distance (km)
1	1-4-3-7-11	0.613	26
2	1-2-5-6-11	0.625	25
3	1-4-3-5-6-11	0.655	30
4	1-4-9-10-11	0.68	34
5	1-4-9-10-7-11	0.853	38

As result which is showed in Table 2, the system will recommend a list of paths which based on the context of users transferring in the road network. For instance, the routes are the path with the shortest-time, the paths obtain place names such as landscapes and restaurants with short-time driving, respectively.

5 Conclusion and Future Work

Recent years, the flow traffic problem become more serious because of the potential growth of vehicles. In this paper, we introduce a context-based traffic real-time recommendation system based on wireless sensor network. First, we estimates the real-time of user which is able to take for their route. Then, we recommend for user the recommend list paths which suitable for their demands by using graph coloring algorithm. This system will bring more benefit for user since it is not only recommend the paths which saving their time, but also introduce the paths which meets their specific preferences.

In this study, we give an example to estimate the effective of the proposed system. The implementation as an experiment environment and evaluated through real participants are considered as future work. Moreover, the context of users could be added more information such as weather, period to recommend more effective to users.

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