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A Comprehensive Survey on Providing Efficient Driving Directions Using GPS and Driver's Ability

G. Sivaiah[1*] and P Krishna Rao[2]

[1&,2]Department of Computer Science and Engineering, CMR Institute of Technology, Hyderabad, A.P.

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***Abstract*: ---** Global positioning system (GPS) data can provide us valuable knowledge to understand the user. It also enables context-aware computing based on user's present transportation mode and design of an innovative user interface for Web users. GPS-equipped taxis are employed as mobile sensors probing the traffic rhythm of a city and taxi drivers' intelligence in choosing driving directions in the physical world. Here we mine smart driving directions from the historical GPS trajectories of a large number of taxis, and provide a user with the practically fastest route to a given destination at a given departure time. There are many problems we need to address with regard to driving directions such as finding nearest distance route between source and destination, traffic lights on route, direction turns on route, and checking weather conditions. Hence, a survey is conducted through which we can focus on the most important issue is finding efficient route driving directions.

***Index Terms*: ---** GPS, Driving Directions, Data mining, Spatial databases and GIS, Time-dependent fast route, Taxi trajectories, Road network

I. INTRODUCTION

In recent years, on the World Wide Web, geographic information has enabled an explosion of applications in which locality and mobility usually connect to one another closely. Web-based mapping applications like Google Maps, Yahoo Maps and Live Maps as well as mobile/local search engines have attracted considerable interest among Web users and developers. Meanwhile, with the increasing prevalence of GPS devices, as never before, many communities that engaged in geographically related activities have been established. However, Finding efficient driving directions has become a daily activity and been implemented as a key feature in many map services like Google and Bing Maps. A fast driving route saves not only the time of a driver but also energy consumption. Therefore, this service is important for both end users and governments aiming to ease traffic problems and protect environment. To mine smart driving directions from a large number of real-world historical GPS trajectories of taxis. As shown in Figure 1, taxi trajectories are aggregated and mined in the Cloud to answer queries from ordinary drivers or Internet users. Given a start point and destination, our method can suggest the practically fastest route to a user according to his/her departure time and based on the intelligence mined from the historical taxi trajectories. As the taxi trajectories are constantly updated in the Cloud, the suggested routes are state-of-the-art.

Corresponding Author: *G. Sivaiah*

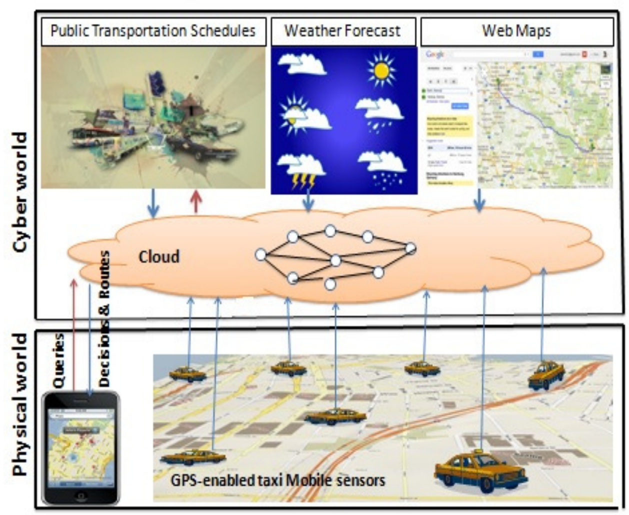

Fig.1 Architecture for cloud-based driving directions service.

As shown in the left part of Figure 1, this process is comprised of five steps. 1) A user submits a query, consisting of a start point , a destination , a departure time and a custom factor , from a GPS-enabled mobile phone. Here, can be a future time and is a vector, which represents how fast the user typically drives on different landmark edges. is set by a default value at the very beginning and is gradually updated in later services. 2) Using our time-dependent routing algorithm, the *Cloud* computes the fastest driving route for the user according to the received query. This routing algorithm uses the traffic condition at the time when the road was actually driven. This future condition is constantly computed in the online inference. 3) The *Cloud* sends the

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computed driving route along with the distributions of travel times on each landmark edge contained in the driving route to the user's mobile phone. 4) The GPS-phone records a GPS trajectory when the user really traverses the route. 5) The user's phone computes a new based on the recorded trajectory and the travel time distributions sent from the cloud.

Challenges and Contributions:

The time that a driver traverses a route depends on the following three aspects: 1) the physical feature of a route, such as distance, capacity (lanes), and the number of traffic lights as well as direction turns; 2) the time dependent traffic flow on the route; and 3) A user's driving behavior. 4) Heterogeneous traffic patterns: the traffic patterns on roads vary across days of a week and hours of a day. Different road segments have often distinct time-variant traffic patterns. It is difficult to use one model to detect outliers across the road network at different time periods. 5) Data sparseness and distribution skewness: even though we could have a large number of sensors (taxis) probing the traffic on roads, there are many roads that have only a small number of samples given a large size of road networks in a major city. Moreover, a few road segments are traveled by thousands of vehicles in a few hours, while some segments may be only driven on a few times in a day. These 4 and 5 properties together result in unique challenges in detecting outliers from traffic data. 6) Causality among outliers: we not only need to discover outliers from the traffic, but also infer causal relationships and interactions among them, especially given the large number of outliers that could be identified. So a challenge is how to detect the appearance, growth, disappearance and transformation of outliers by time (e.g., propagation of a traffic jam).

This survey is design to several steps to address the above challenges and propose solutions to the problem of finding efficient driving directions. A time-dependent landmark graph to model the dynamic traffic pattern as well as the intelligence of experienced drivers so as to provide a user with the practically fastest route to a given destination at a given departure time. Then, a Variance-Entropy-Based Clustering approach is devised to estimate the distribution of travel time between two landmarks in different time slots. Based on this graph, we design a two-stage routing algorithm to compute the practically fastest and customized route for end users.

The organization of the remainder of the paper is as follows. Section II presents the literature survey on existing research work. Section III explains the conclusions and future work.

II. Literature survey

1. Sivan Toledo et. al [1] proposed VTrack: Accurate, Energy-aware Road Traffic Delay Estimation Using Mobile Phones. VTrack, a system for travel time estimation using this sensor data that addresses two key challenges: energy consumption and sensor unreliability. While GPS provides highly accurate location estimates, it has several limitations: some phones don't have GPS at all, the GPS sensor doesn't work in "urban canyons" (tall buildings and tunnels) or when the phone is inside a pocket, and the GPS on many phones is power-hungry and drains the battery quickly. In these cases, VTrack can use alternative,less energy hungry but noisier sensors like Wi-Fi to estimate both a user's trajectory and travel time along the route. VTrack uses a hidden Markov model (HMM) based map matching scheme and travel time estimation method that interpolates sparse data to identify the most probable road segments driven by the user and to attribute travel times to those segments. They presented experimental results from real drive data and Wi-Fi access point sightings gathered from a deployment on several cars. They had shown that VTrack would tolerate significant noise and outages in these location estimates, and still successfully identify delay-prone segments, and provide accurate enough delays for delay-aware routing algorithms.

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VTrack, a system for using mobile phones to accurately estimate road travel times using a sequence of inaccurate position samples, and evaluates it on route planning and hotspot detection. This method addressed two key challenges: 1) Reducing energy consumption using inaccurate position sensors (Wi-Fi rather than GPS), and 2) Obtaining accurate travel time estimates from these inaccurate positions. VTrack uses an HMM-based map matching scheme, with a way to interpolate sparse data to identify the most probable road segments driven by the user and to attribute travel times to those segments. They presented a series of results that showed tolerate significant noise and outages in these estimates, and still successfully identify highly delayed segments, and provide accurate enough travel time estimates for accurate route planning.

2. Corrado de Fabritiis et. al [2] proposed Traffic Estimation And Prediction Based On Real Time Floating Car. The knowledge of the actual current state of the road traffic and its short-term evolution for the entire road network is a basic component of ATIS (Advanced Traveler Information Systems) and ATMS (Advanced Traffic Management System) applications. In this view the use of real-time Floating-Car Data (FCD), based on traces of GPS positions, is emerging as a reliable and cost-effective way to gather accurate travel times/speeds in a road network and to improve short-term predictions of travel conditions. They presented a large-scale working application of FCD-system, developed and operated by OCTOTelematics, delivering real-time traffic speed information throughout the Italian motorway network and along some important arterial streets located in major Italian metropolitan areas. Traffic speed estimates are deduced at an interval of 3 minutes from GPS traces transmitted in real-time from a large number (and still growing) of privately owned cars equipped with a specific device covering a range of insurance-related applications.

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They also proposed two algorithms, respectively based on Artificial Neural Networks and Pattern-Matching, designed to on-line perform short-term (15 to 30 minutes) predictions of link travel speeds by using current and near-past link average speeds estimated by the OCTOTelematics FCD system. The Rome ring road (GRA-Grande Raccordo Anulare) was used for testing the feasibility of the two algorithms. Testing results showed that the proposed approaches for short-term predictions are very promising and effective.

3. Yu Zheng et. al [3] proposed Learning Transportation Mode from Raw GPS Data for Geographic Applications on the Web. Geographic information has spawned many novel Web applications where global positioning system (GPS) plays important roles in bridging the applications and end users. Learning knowledge from users' raw GPS data can provide rich context information for both geographic and mobile applications. However, so far, raw GPS data are still used directly without much understanding. This was an approach based on supervised learning is proposed to automatically infer transportation mode from raw GPS data. The transportation mode, such as walking, driving, etc., implied in a user's GPS data can provide us valuable knowledge to understand the user. It also enables context-aware computing based on user's present transportation mode and design of an innovative user interface for Web users.

This method consists of three parts: 1) A change point-based segmentation method. 2) An inference model and 3) A post-processing algorithm based on conditional probability. The change point-based segmentation method was compared with two baselines including uniform duration based and uniform length based methods. Meanwhile, four different inference models including Decision Tree, Bayesian Net, Support Vector Machine (SVM) and Conditional Random Field (CRF) are studied in the experiments. They evaluated the method using the GPS data collected by 45 users over six months period. As a result, beyond other two segmentation methods, the change point based method achieved a higher degree of accuracy in predicting transportation modes and detecting transitions between them. Decision Tree outperformed other inference models over the change point based segmentation method.

4. Jing Yuan et. al [4] proposed An Interactive-Voting Based Map Matching Algorithm. Matching a raw GPS trajectory to roads on a digital map is often referred to as the Map Matching problem. However, the occurrence of the low-sampling-rate trajectories (e.g. one point per 2 minutes) has brought lots of challenges to existing map matching algorithms. To address this problem, They proposed an Interactive Voting-based Map Matching (IVMM) algorithm based on the following three insights: 1) The position context of a GPS point as well as the topological information of road networks, 2) the mutual influence between GPS points (i.e., the matching result of a point references the positions of its neighbors; in turn, when matching its neighbors, the position of this point will also be referenced), and 3) the strength of the mutual influence weighted by the distance between GPS points(i.e., the farther distance is the weaker influence exists). In this method, they did not only consider the spatial and temporal information of a GPS trajectory but also devise a voting-based strategy to model the weighted mutual influences between GPS points. They evaluated IVMM algorithm based on a user labeled real trajectory dataset. As a result, the IVMM algorithm outperforms the related method (ST-Matching algorithm).

They investigated the problem of map matching for low-sampling-rate GPS trajectories. A novel algorithm termed IVMM is proposed and analyzed. This algorithm employs a voting-based approach to reflect the mutual influence of the sampling points. They defined a distance weight function to evaluate the impact of distance to the matching positions. Extensive experiments are conducted with real GPS tracking data. Both for low-sampling-rate data and high-sampling-rate data, the correct matching percentage of IVMM algorithm is higher than ST-Matching algorithm. In particular, when the sampling interval ranges from 2 to 6 minutes, the accuracy rate of IVMM algorithm always has a more than 10% improvement over the ST-Matching algorithm. The results demonstrate that IVMM algorithm significantly outperforms ST-Matching algorithm which is so far the only approach aimed at low sampling-rate GPS data in terms of matching quality. The distance weight function which plays an important role in IVMM algorithm is intriguing. They note that the weighted influence of the sampling points is not only related with the distance but also with the topology of the road networks. Typically, the influence of two sampling points in a dense road network is much less than that of a sparse one. That was because the more the number of possible paths traversing two points is, the less weighted influence they might brought on each other.

5. Yin Lou et. al [5] proposed Map-Matching for Low-Sampling-Rate GPS Trajectories. Map-matching is the process of aligning a sequence of observed user positions with the road network on a digital map. It is a fundamental pre-processing step for many applications, such as moving object management, traffic flow analysis, and driving directions. In practice there exists huge amount of low-sampling rate (e.g., one point every 2-5 minutes) GPS trajectories. Unfortunately, most current map-matching approaches only deal with high-sampling-rate (typically one point every 10-30s) GPS data, and become less effective for low-sampling-rate points as the uncertainty in data increases. In this method, they proposed a novel global map-matching algorithm called ST-Matching for low sampling-rate GPS trajectories. ST-Matching considers (1) The spatial geometric and topological structures of the road network and (2) The temporal/speed constraints of the trajectories. Based on patio-temporal analysis, a candidate graph is constructed from which the best matching path sequence is identified. We compare ST-Matching with the incremental algorithm and Average-Freshet-Distance (AFD) based global map-matching

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algorithm. The experiments are performed both on synthetic and real dataset. The results show that our ST-matching algorithm significantly outperform incremental algorithm in terms of matching accuracy for low-sampling trajectories. Meanwhile, when compared with AFD-based global algorithm, ST-Matching also improves accuracy as well as running time.

They proposed a new global map-matching algorithm called ST-Matching to match low-sampling-rate GPS data onto a digital map. The algorithm employs spatial and temporal analysis to generate a candidate graph, from which a sequence of matched results with highest sum of score is identified as the matching result. The experiment results demonstrate that our ST-matching algorithm significantly outperforms incremental algorithm in terms of matching accuracy for low-sampling trajectories. Meanwhile, when compared with ADF-based global algorithm, ST-Matching also improves accuracy as well as running time. In our future work, They planed to build a full-fledged map-matching system based on ST-Matching algorithm. The first application of such system will be taxi trajectory matching that can help in driving directions based on taxi-driver's knowledge.

6. Guangzhong Sun,et. al [6] proposed T-Drive: Driving Directions Based on Taxi Trajectories. GPS-equipped taxis can be regarded as mobile sensors probing trace owes on road surfaces, and taxi drivers are usually experienced in ending the fastest (quickest) route to a destination based on their knowledge. This method mind smart driving directions from the historical GPS trajectory rise of a large number of taxis, and provide a user with the practically fastest route to a given destination at a given departure time. In our approach, we propose a time-dependent landmark graph, where a node (landmark) is a road segment frequently traversed by taxis, to model the intelligence of taxi drivers and the properties of dynamic road networks. Then, a Variance-Entropy-Based Clustering approach is devised to estimate the distribution of travel time between two landmarks in die rent time slots. Based on this graph, they design a two-stage routing algorithm to compute the practically fastest route. They were build a system based on a real world trajectory dataset generated by over 33,000 taxis in a period of 3 months, and evaluate the system by conducting both synthetic experiments and in the led evaluations. As a result, 60{70% of the routes suggested by a method ware faster than the competing methods, and 20% of the routes share the same results. On average, 50% of resulted routes were at least 20% faster than the competing approaches.

This system presented a method that nods out the practically fastest route to a destination at a given departure time in terms of taxi drivers' intelligence learned from a large number of historical taxi trajectories. In this method, wrest construct a time-dependent landmark graph, and then perform a two-stage routing algorithm based on this graph to and the fastest route.

III. Conclusions and Future Work

In this paper, we presented the literature survey that we carried out on computing fastest paths over road networks with traffic speed patterns. The presented survey reveals various aspects of research work that is already carried out in the same problem. Finding efficient route is not possible in one step but it requires consideration of many facets of the problem. We study the applicability of existing algorithms for computation of time-dependent shortest path in real-world large spatial networks with time-varying edge travel-times. In all these papers we studied, we observed a pessimistic approach to the same problem. We can propose the best system for of time-dependent shortest path in real-world large spatial networks with time-varying edge travel-times.

Our future work is to implement a method to construct a time-dependent landmark graph, and then perform a two-stage routing algorithm based on route graph to find the fastest route. We build a real system with real world GPS trajectories and evaluate the system with extensive experiments and in-the-field evaluations. The results show that our method significantly outperforms both the speed-constraint-based and the real-time-traffic-based method in the aspects of effectiveness and efficiency.

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G. Sivaiah had B.Tech in Computer Science and Engineering from Intellectual Institute of Technology,Anantapur,Andhra Pradesh . He is an M.Tech. Student in CSE Department of CMR Institute of Technology, Hyderabad. She is currently working for her M.Tech. Research project work under the guidance of P.Krishna Rao. His areas of interest include Network Security, Computer Networks, and Programming languages.

P. KrishnaRao had his B.Tech from G.PullaReddy Engg. College, Kurnool, and he had M.Tech from School of Information Technology(SIT) , JNTU, Hyderabad. He is currently working as Assistant Professor in CSE Department of CMR Institute of Technology, Hyderabad. His areas of interest are Software Quality Assurance and Testing, Network Security, Data Mining, Image Processing, and various fields.