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GPS Data Analysis For Understanding Urban Transport – A Review of Literature

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Abstract: Travel is a central concept in human behaviour, transport geography, travel demand modelling, public health research, location-based services (LBS) and mobile computing. Each of these disciplines requires a variety of information related to travel, at varied granularities. In urban contexts, different types of travel-related information (e.g., departure times, arrival times, travel routes, durations, modality, company, and trip purposes) are of interest for managing traffic, understanding people's travel demand and preferences and also policy making. The present work deals with a detailed review of papers relating to urban transport modes, theoretical aspects of trajectory data mining and their applications. Finally, a detailed survey of literature related to GPS data analysis relating to urban transport modes has been carried out with the aim to understand the travel behavior of the commuters and travel pattern of various transport modes.

Key Words: Location Based Services, Trajectory data mining, GPS data

1. Introduction:

Travel is a central concept in human behaviour, transport geography, travel demand modelling, public health research, location-based services (LBS) and mobile computing. Each of these disciplines requires a variety of information related to travel, at varied granularities. In urban contexts, different types of travel-related information (e.g., departure times, arrival times, travel routes, durations, modality, company, and trip purposes) are of interest for managing traffic, understanding people's travel demand and preferences and also policy making. Such travel related information, including information on transport modality, is traditionally collected by paper-based or telephone surveys [3]. However, traditional surveys are memory dependent and, thus, suffer from data quality issues. Traditional travel surveys are also limited to low participation rates. In order to overcome such problems, more recently smartphone-based travel surveys have been carried out [1,4] where the participants do not need to memorize the details of their travels. Instead, their movements are recorded as raw trajectories by GPS and other sensors on-board their smartphones. An application accessing these sensors can automatically collect travel data in the background without user intervention. These raw data need to be semantically enriched by algorithms capable of interpreting such data. Only then, spatial database management systems can extract different travel related information from the raw data in order to answer corresponding queries [2].

With the advancement in capturing and computation techniques provided the way to study on trajectory data, which denote the mobility of a diversity of moving objects, like people, vehicles, and animals. Trajectory data mining is an evolving research trend in data mining research to meet with the current availability of trajectory data. analysis techniques leading to prolitable applications. Trajectory data clustering is one of the best techniques to get the knowledge from trajectory data. Internet-enabled mobile devices are primary source for obtaining very large volumes of trajectory data that capture the movements of different types of objects such as people, vehicles, animals and vessels. The increasing pervasiveness of location acquisition technologies has enabled collection of very large trajectory datasets for different types of moving objects. Useful patterns discovered from the movement behaviour of moving objects are terribly valuable and forms a trajectory knowledge base, and far helpful to a type of real-time applications. Ubiquitous amounts of trajectory data sets are being generated continuously with the rapid development of location acquisition technologies. Trajectories of moving objects arc helpful to find information about moving patterns, moving cluster patterns, finding the location of a particular object or service etc. Many global positioning systems (GPS) enabled devices are pervasive [10]. Finding movement patterns in trajectory information is extremely helpful in several time period applications [20]. The source of trajectory data is typically from mobile devices that capture the position of an object at specific time intervals. The encouragement for mining trajectory datasets is that the chance of realizing inherent information, serving to gain the understanding of the elemental phenomena of movement. The knowledge of object movements is helpful in many contexts. Increasing of information and also the variety of ways for utilizing this data is creating trajectory data processing gain ample importance in numerous domains, as well as urban designing, traffic flow management, public health, wildlife protection and location-aware advertising and far additional.

Trajectory Pattern Mining

Another trend of research has considered constraint database models to represent Trajectory Pattern Mining. The main goal of trajectory pattern mining is to find interesting trajectory patterns from trajectory data sets. Close locations oftentimes

visited by a constant cluster of an individual in a given time period are clustered into regions. Scalable algorithms are needed for trajectory data mining.

Applications of Trajectory Data Mining

Potential applications of data mining arc merchandising banking. Master card management. insurance. Telecommunication and human resource management. There exist many applications of similarity search on spatio-temporal trajectories. Some of the useful trajectory data mining applications are path discovery, shortest path discovery. Individual behaviour prediction. Group behaviour prediction, Location prediction, Service prediction and so on.

Research Studies

J. Venkata Subramanian, M. Abdul Karim Sadiq (2014), According to the authors mobile movement estimation is of utmost requirement for proper handoff signals to the nearby mobile towers. The direction in which a mobile would move next has to be predicted so that disruption in the signal during conversation does not occur. They used Artificial Neural Network (ANN) with Back propagation algorithm for predicting the mobile movement. The results are compared with data mining approach. It was concluded that prediction performance of ANN algorithms is higher than that of the data mining approach.

Pascal Pluvineta, Jesus Gonzalez Feliua, (2012), They investigated the contribution of GPS survey techniques for urban goods movement characterization and diagnosis, more precisely the implementation and application issues related to the introduction of real-time data transmission procedures and phone tools with integrated GPS devices. Proposed a GPS-based data collection method for urban freight route characterization using a Smartphone application.

Emilian Necula, (2015), since it has been observed that GPS enabled devices are widely spread between drivers making the collection of GPS data more accessible hence there is an opportunity to infer useful patterns and trends. Here statistical approach has been applied on 10000 vehicle GPS traces, from around 3600 drivers which are mined to extract the outlier traffic pattern to be used further in an Intelligent Transportation System. Urban area into a grid has been divided and road infrastructure as segments has been organized in a graphical pattern. Next at a given time assumptions regarding the congestion level in a specific area has been made taking into account the visits for each vehicle, using the GPS trace data. It is observed that over the time the visited segments will settle into a pattern and vary periodically.

Smita Parijai et.al , used neural network technique to solve location management problem. A multilayer neural model is designed to predict the future prediction of the subscriber based on the past predicted information of the subscriber. This scheme is proposed for locating a mobile terminal in a communication without losing quality maintain a good response. There are various methods of location management schemes for prediction of the mobile user. Based on individual characteristic of the user, prediction based location management can be implemented.

Ruizhi Wu, Guangchun Luo, Junming Shao, Ling Tian, and Chengzong Peng, (2018), used location prediction is the key technique in many location based services including route navigation, dining location recommendations, and traffic planning and control, to mention a few. This survey provides a comprehensive overview of location prediction, including basic definitions and concepts, algorithms, and applications.

Johar Amita, Jain Sukhvir Singh, Garg Pradeep Kumar, (2015), their objective was to apply artificial neural network (ANN) for development of bus travel time prediction model. The bus travel time prediction mode was developed to give real time bus arrival information to the passenger and transit agencies for applying proactive strategies. For development of ANN model, dwell time, delays and distance between the bus stops was taken as input data. Arrivals/departure times, delays, average speed between the bus stop and distance between the bus stops were collected for two urban routes in Delhi.

Arnab Kumar Laha, (2017), concluded that prediction of the destination location at the time of pickup is an important problem with potential for substantial impact on the efficiency of a GPS enabled taxi service. In this paper new solutions in the streaming data set-up has been proposed. Four incremental learning methods using a Damped window model namely, Multivariate multiple regression, Spherical-spherical regression, Randomized spherical K-NN regression and an Ensemble of these methods for their effectiveness in solving the destination prediction problem has been applied.

Ingrid E. Burbey, (2011), predicted people's future locations, and to predict when they will be at given locations. Current location-based applications react to the user‘s current location. The progression from location-awareness to location-prediction can enable the next generation of proactive, context-predicting applications. Existing location-prediction algorithms predict someone‘s next location.

Chunchun Hu and Jean-Claude Thill, (2019), concluded that emerging on-line reservation services and special car services have greatly affected the development of the taxi industry. Surprisingly, taking a taxi is still a significant problem in many large cities. They presented an effective solution based on the Hidden Markov Model to predict the upcoming services of vacant taxis that appear at some fixed locations and at specific times. The model introduces a weighted confusion matrix and a modified Viterbi algorithm, combining the factors of time of day and traffic conditions.

Dorine C. Duives, Guangxing Wang and Jiwon Kim, (2019), concluded that effective crowd management based on the information provided by crowd monitoring systems is difficult as this information comes in at the moment adverse crowd movements are already occurring. Up to this moment, very little forecasting techniques have been developed that predict crowd flows a longer time period ahead. Moreover, most contemporary state estimation methods apply demanding pre-processing steps, such as map-matching. The objective of this paper is to design, train and benchmark a data-driven procedure to forecast crowd movements, which can in real-time predict crowd movement.

Schüssler, Nadine; Axhausen, Kay W., (2009), , compared to classic travel survey methods researchers benefit from more accurate and reliable information. At the same time, the participants' burden is reduced substantially if the GPS data collection is not accompanied by elaborate questioning. Described a post-processing procedure that needs no other input than the most basic GPS raw data: three-dimensional positions and the corresponding time stamps.

*Rahul Deb Das and Stephan Winter, (2016***),** Transport mode information is essential for understanding people's movement behaviour and travel demand estimation. Current approaches extract travel information once the travel is complete. Such approaches are limited in terms of generating just-in-time information for a number of mobility based applications, e.g., real time mode specific patronage estimation. Here a novel hybrid knowledge driven framework is developed by integrating a fuzzy logic and a neural network to complement each other's limitations. Thus the aim of this paper is to automate the tuning process in order to generate an intelligent hybrid model that can perform effectively in near- real time mode detection using GPS trajectory. Tests demonstrate that a hybrid knowledge driven model works better than a purely knowledge driven model and at per the machine learning models in the context of transport mode detection.

Ingrid Burbey, Thomas L. Martin, (2008), implemented the Prediction-by-Partial-Match data compression algorithm as a predictor of future locations. Positioning was done using IEEE 802.11 wireless access logs. Several experiments were run to determine how to divide the data for training and testing and how to best represent the data as a string of symbols.

ZHIYUAN CHEN, 2, BAHRAN SANJABI, DINO ISA, here data mining classification techniques are analyzed on trajectory dataset and Performance of these techniques is evaluated with recall, precision, kappa and accuracy.

Dominic Kohler , (2018), , Predicting future locations of mobile users is beneficial for various applications. A rich selection of hybrid features, extracted from the users' history movement data, is used to predict users' future places. To solve the prediction task, various machine learning algorithms, both individual and ensemble methods have been used. For the users with a low number of total visits and homogeneous movement pattern an average accuracy of 86.7% is achieved. For users with a heterogeneous movement pattern and a low number of total visits, the average accuracy is 65.41%.

Eelco Herder, Patrick Siehndel and Ricardo Kawase , (2014), , it shows how daily and weekly routines can be modelled with basic prediction techniques. The methods based on their performance, entropy and correlation measures have been compared. Further, it was discussed how location prediction for everyday activities can be used for personalization techniques, such as timely or delayed recommendations.

Shuming Sun, Juan Chen and Jian Sun, (2019), Since speed sensors are not as widely used as GPS devices, the traffic congestion level is predicted based on processed GPS trajectory data in this article. Hidden Markov model is used to match GPS trajectory data to road network and the average speed of road sections can be estimated by adjacent GPS trajectory data. Four deep learning models including convolutional neural network, recurrent neural network, long short-term memory, and gated recurrent unit and three conventional machine learning models including autoregressive integrated moving average model, support vector regression, and ridge regression are used to perform congestion level prediction. According to the experimental results, deep learning models obtain higher accuracy in traffic congestion prediction compared with conventional machine learning models.

Jean Damascène Mazimpaka and Sabine Timpf , (2016), , showed that increasing use of location-aware devices has led to an increasing availability of trajectory data. As a result, they devoted their efforts to developing analysis methods including different data mining methods for trajectories. Here generic methods of trajectory mining and the relationships between them has been discussed. Trajectory-mining application problems under major problem groups based on how they are related has been discussed This classification of problems can guide researchers in identifying new application problems.

2. Conclusion

Travel behaviour has been studied for decades to guide transportation development and management, with the support of traditional data collected by travel surveys. Recently, with the development of information and communication technologies (ICT), we have entered an era of big data, and many sources of novel data, including mobile phone data, have emerged and been applied to travel behaviour research. Compared with traditional travel data, GPS data have many unique features and advantages, which attract scholars in various fields to apply them to travel behaviour research, and a certain amount of progress has been made to date. However, this is only the beginning, and GPS data still have great potential that needs to be exploited to

further advance human mobility studies. This paper provides a review of existing literature relating to travel behaviour studies that have applied GPS data, and presents the progress that has been achieved to date, and then discusses the potential of these data in advancing travel behaviour research and raises some challenges that need to be dealt with in this process.

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