Scientific Journal of Impact Factor (SJIF): 5.71

e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 02, February -2018

Mobile Movement Prediction Using Statistical Methods – A Review

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Abstract - *Today, most of Communications between person to person or person to device or device to person are based on mobile phones in the modern world. Because, communications are very much important. In this paper, we present the comparison of some of the statistical methods used for predicting the future location of mobile phone in the personal communication systems and their performance are analyzed.*

Keywords *– Prediction, statistical, movements, comparison, location*

I. INTRODUCTION

In personal communication system, the entire network has been logically divided the hexagonal cells. Each and every cell acts as a small geographical area of the total communication network. If a person phone moving along with his mobile phone across the cells of the total communication area, His on-going call should not disturbed by the movement or roaming. So, for getting the better signal performance and quality of service, the prediction of the future location of the mobile is needed. If predicted the future location, then the user can get uninterrupted service through service provider.

Statistical methods are playing a vital role in the prediction analysis. There are many statistical techniques available for prediction. The following statistical techniques were analysed as follows,

II. COMPARISON OF VARIOUS STATISTICAL METHODS

The Order-k Markov Predictor:
The order –k markov predictor predicts using the history and current state. For getting the transition probability matrix, movement history was considered.

Lempel – Ziv Predictor :
This predictor based on popular incremental parsing algorithm used for text compression. Here the LZ parsing algorithm is used to predict in each node.

Grid based techniques & Cluster based techniques :

The authors [2] were discussed the following techniques, the one is Grid based technique and the other is cluster based technique. In grid based techniques, the entire environment is considered as a grid. The grid consists of many grid cells the transition of the mobile between the grid cells used for prediction. Whereas In the cluster based techniques, moving trajectories were observed and similar trajectories recorded and used for prediction.

The authors used cluster based technique which having learning algorithm and estimation algorithm. In the learning algorithm, moving trajectories were found from the moving objects. Based on the trajectories calculate the future movement busing Gaussian probability estimation. For implementation, they used Agglomerative Complete-Link Hierarchical Clustering (CL) [15] and Deterministic Annealing Pair wise Clustering techniques with the help of expectation maximization algorithm, the simulated data used for Gaussian distribution .

Markov Predictors :

Markov predictor family is more appropriate to request and predict the location in a smart network . Using markov chains, the authors[3] were tried to predict location (in fixed length / variable length) with the following techniques.

Prediction by Partial Match Scheme :

In this scheme, the model assumes a sequence with a length of k. And further subsequences with a constant length of 1, upto k+1. The predictor can estimate from the multiple passes in the sequences with required statistical info.

Lempel-Ziv-78 Scheme :

This online scheme is used for predicting the variable length sequences. But infinite length. This scheme is an enhanced version of old LZ78 scheme.

Probabilistic Suffix Tree Scheme:

This tree scheme is also online scheme and consists of five nos. of administratively set parameters, namely maximum context length, minimum normalized appearance count, difference between the prediction capability at hand and its father node and finally, significance threshold. Using the above parameters the predictor calculates the length of the trie.

Context tree weighting scheme:

This Context tree weighting assumes a pre-determined maximum order. Here the node manages two different counters namely as and bs they used for counting ones and zeros respectively, using Krichevsky-Trofimov estimator, the Context tree weighting predictor predicts with the help of hypothesis.

The authors were qualitatively compared the above four predictive models, the Prediction by partial match scheme specifically used for fixed length and high complexity. The Lmpel-ZIV-78 Scheme may missed few patterns in the sequences. But it is an online scheme. The probabilistic suffix Tree scheme gave emphasis for parameterization. And the Context tree weighting scheme, particularly binary in nature.

Among the four different schemes, the Prediction by Partial Match scheme and Mempel-Ziv 78 schemes produces the results with highest accuracy precisions.

Kalman filter and Bayesian decision theory:

The authors [4] followed the following four steps, they are estimation, filtering, prediction and fusion. They combined the kalman filter and Bayesian decisions. Using Predicted and corrected location estimation algorithm, prediction and fusion results were found by the authors. Timestamp is used as recursive step in the k- filter. The results found in the way of prediction and correction rules to calculate the accurate location.

Classification and decision trees Approach:

The authors [5] found the next place prediction using mobile data, they used Mobile data Challenge Data set provided by Nokia that was dedicated to the mobile computing and statistical calculations.

Here the data has been segregated in to two namely training data and testing data. Among the visits of the uses from home, workplace and etc., every visits were recorded and used as data for prediction of future move. Based on the classification approach the decision tree has been drawn by the classification. Finally they measured the accuracy with three different tools.

Directional and / or Temporal Statistical Approach

The statistical approaches of directional and temporal considered by the authors [6]in the above paper. Based on the mobility of the users, two different approaches followed, they are directional modeling and time based modeling based on cell permanence time.

In the directional mobility prediction, the network partitioned cell entry of the mobile user at time 0, the mobility matrix model has been created with hand-in directions as rows and hand-out directions as columns. The mobility generated by C4R simulator and the Mobility matrix model which are statistically distributed.

On the other hand, in the concept of time based mobility prediction, there are the following two terms were considered the one is Cell Permanence Time (CPT) and the other is Call Holding time (CHT). CPT allows the assessment of how long a user will stay in a cell during its Call Holding Time (CHT) and how many cells probably the user will visit. This can be useful in resource reservations, for future prediction, where node mobility is supported. With the help of CPT samples, they are distributed statistically and used Gaussian approximation for the results.

The above two different approaches were compared in-terms of utilization, the authors found the time based mobility prediction used less utilization than directional mobility prediction. Also with the minimum prediction error.

Trajectory similarity base location prediction method :

The authors [7] used MIT reality mining real time data set used. The personal mobility model generated from Second order Markov chain model. The authors[7] introduced a social contagion theory based approach for location prediction used to design system architecture.

The powerful huge MIT data set contains around 9 months movements of 106 no of mobile users and more than 32,000 BTS were involved with 26 lakhs of GSM Traces. With the performance evaluated and produces better accuracy.

Exponential weights forecaster :

In this work[8] the authors, diverted to different view, ie., most of the authors only concentrated to predict the next movement of the user in fixed length or some time variable length with their regular movements but the authors[8] used the view of movements of roaming user such as tourists from other country that they are travelling across the country, but with short data history in the geometrical coverage area network. So the prediction is so much difficult when compare to the regular users.

They also used real time data set from Vodafone – Italia which contains the dataset of around 10 million roaming people moving across the European countries.

The performance compared with EW forcaster and Markov Chain but, EW forecaster produces high accuracy.

Bidirectional Adaptive Space Division Method :

The authors [9] used the novel separation of the coverage area in to small cells for better coverage and administration of small area. They used sparse dataset to predict the trajectories with the available data. They considered about the changes of distances from the sampling location to the end of the trajectory instead of predicting using novel methods.

The authors motivated tourists to get the un interrupted signals while their travelling. The evaluated with the help of the dataset having some movement of taxies in the town of china. They found and compared the efficiency and accuracy with gradient descent and markov transition model.

Table – 1, Mobile Movement Prediction Methods Comparison

Sl.No.	Authors and Year	Approach / Methods Used	Training Dataset Used
1.	Christine Cheng, Ravi Jain & Eric Van den Berg 2002	Order-k Predictor, Lempel-Ziv Predictor	Few movements only from handoffs.
2.	Dizan Vasquez & Thierry Fraichard Inria Rhône-Alpes & Lab. Gravir, Grenoble 2004	Grid based techniques & Cluster based techniques	Movements of the users recorded at pedestrian tracking system in Inria Entry Hall, France
3.	Dimitrios Katsaros & Yannis Manolopoulos 2009	Markov Predictors : Prediction by Partial Match Scheme, Lempel-Ziv-78 Scheme, Probabilistic Suffix Tree Scheme & Context tree weighting scheme	---
4.	Muhammad Alam, Mazliham Muhammad Suud, Patrice Boursier,Shahrulniza Musa & Jawahir Che Mustapha Yusuf 2010	Kalman filter and Bayesian decision theory	Small geographical area
5.	Le-Hung Tran, Michele Catasta, Luke K. McDowell & Karl Aberer 2012	Classification and decision trees Approach	Nokia Mobile Phone Data set collected 24/7 basis about 14 months

6.	Peppino Fazio, Mauro Tropea, Salvatore Marano & Cesare Sottile 2013	Directional and / or Temporal Statistical Approach	Rome City in radius of 250metre of each cell
7.	Zelei Liu, Liang Hu, Chunyi Wu, Yan Ding & Jia Zhao 2016	Trajectory similarity base location prediction method	MIT Data set consists of 106 mobile users with more than 26 lakhs of GSM Traces
8.	Bartosz Hawelka, Izabela Sitko, Pavlos Kazakopoulos & Euro Beinat 2017	Exponential weights forecaster	Vodafone Italia dataset having more than 10 million people of European countries
9.	Liang wang, Zhiwen yu, bin guo, Tao ku & fei yi 2017	Bidirectional Adaptive Space Division Method	GPS trajectories of taxies about 10 days in town of China

III. CONCLUSION

Here we have analyzed various statistical methods and approaches. Almost all the above authors, tried to predict the next movement of the mobile users to provide better quality of service and uninterrupted services to their customers. The prediction accuracy and efficiency of algorithms were also compared. Many authors used real time data sets. Now this emerging research topic considered in many European and asian countries with their own contributions. So the combinations of algorithms would favor to get more accurate and best services.

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