International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 20 (2017) pp. 9997-10001

Real-time Path Prediction and Grid-based Path Modeling Method Using GPS

Seongwon Min *, Jong-Yong Lee and Kye-Dong Jung ****

** Department of Information System, Kwangwoon University Graduate School of Information Contents, 20 Kwangwoon-ro, Nowon-gu, Seoul 01897, Korea*

*** Ingenium College of liberal arts, KwangWoon University, 20 Kwangwoon-ro, Nowon-gu, Seoul 01897, Korea*

**Corresponding author: Kye-Dong Jung*

Abstract

In this paper, we propose a real-time path prediction and a grid based path modeling method using GPS. path prediction method estimates the next location by applying the RLS algorithm to the GPS. This enables near-real-time path prediction for the un-modeled path. and Grid based path modeling method divides the collected path into the cell and transforms the path in the cell into an equation. It provides the same role as the existing personal path model. However, individual cells can be used for path prediction of other pedestrians. Also, the path transformed into the equation can eliminate the coordinates error caused by the GPS update delay.

Keywords: V2P, GPS, RLS, Pedestrian Path Prediction, Prediction of Pedestrian Trajectories

INTRODUCTION

According to OECD, the risk of traffic accidents has increased as the number of vehicles increases each year. to reduce this problem, the automotive industry is spreading the AEB system that detects and brakes ahead objects. However, the AEB system based on cameras and infrared sensors is not efficient of the night and blind spot. Recently, research is underway to improve the characteristics of cameras and infrared sensors [1-3].

V2X (Vehicle to Everything) is a communication technology that exchanges information with vehicles and infrastructure where IoT network is built. Among them, V2P (Vehicle to Pedestrian) is that focuses on pedestrians and a nearby vehicle and a pedestrian perceive each other through a wireless communication network and exchange information. Recently, studies are underway to improve the disadvantages of AEB system by applying pedestrian path prediction technique to V2P [4,5].

Existing pedestrian path prediction method used the path model to predict the final destination. The path model pre-collects data such as a starting point, a destination, a moving path, and environment variable(time, date, etc) to a specific person. Although there have been many studies to infer pedestrians' destinations by applying various algorithms to them, there is a problem that it is difficult to apply them to unspecified persons because it is a personal model. It also does not support predictions for un-modeled paths. This method is not suitable for V2P.

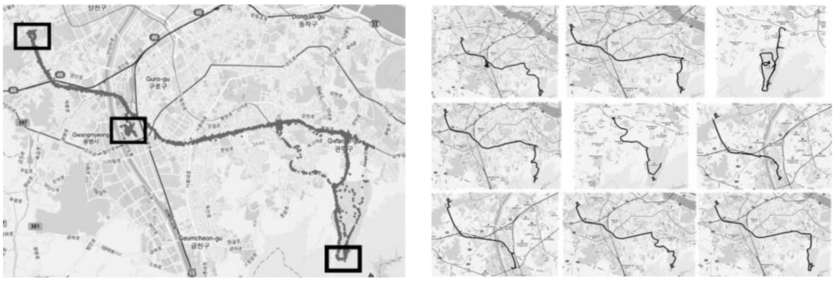
In this paper, we propose a real-time path prediction and grid-based path modeling method using GPS which is a improve of the existing path prediction method to V2P. The proposed method collects the GPS of the pedestrian in real time and predicts the path within about 2 seconds. We used the RLS (Recursive least squares) algorithm, which is one of the adaptive algorithms, to predict the path. The grid based path modeling method divides the collected path into the grid and transforms the path of each cell into an equation.

The composition of this paper is as follows. Section 2 describes the existing model-based pedestrian path prediction, and Section 3 describes the proposed method. In Section 4, conclusions and future research issues are explained.

Pedestrian Path Prediction

Recently, as the penetration rate of smart phones has increased, studies are being conducted to predict the pedestrian path using sensors built into smart phones. The pedestrian path prediction method is a field of personalization services that is being studied under the precondition that most people spend a repetitive routine.

The existing method predicts the route through the following process. First, we analyze the collected data to find the pattern and create the model. And we apply this to the current state to predict the destination. Figure 1 shows the Action Logger developed by MDS, which was collected the path on the period of time and generated the model based on this path



(a) (b)

Figure 1. The path collected via GPS and the modeled major path

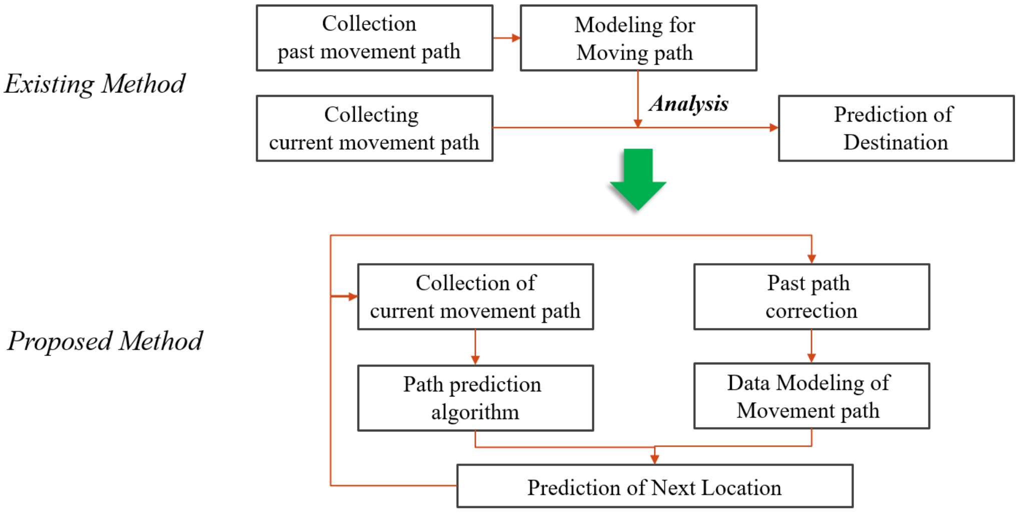


Figure 2. Flow chart of the path prediction method which improves the existing method

The collected path includes not only GPS data but also various environment variables (day, date, time, direction, etc.), and various path models are created based on the environment variables. The collected path by Figure 1-(a) includes not only GPS data but also various environment variables which day, time, date, etc.

The model that is generated based on the collected paths includes environment variables and paths. The generated model is used to predict the route of the pedestrian. It can select different destinations by environment variables, even if you move the same path.

PEDESTRIAN PATH PREDICTION AND GRID-BASED PATH LEARNING USING GPS

Existing path prediction method focus on predicting destinations using path models. This method is not suitable for predicting paths to unspecified persons. Below is a problem with the existing method.

(A). Difficult to predict for un-modeled paths

(B). A model of personality that cannot be applied to unspecified persons.

In this paper, we propose 'Pedestrian Path Prediction and Grid - based Path Modeling Method' to improve existing problems.

Path Prediction Using RLS(Recursive least squares)

The RLS algorithm is a kind of adaptive filter algorithm that can perform 'forward prediction' that predicts future data with historical data. In particular, it can be advantageously used to predict a path in a linear form. We applied this algorithm to GPS providing simple latitude and longitude. These coordinates contain various information such as the speed and direction of the pedestrian's movement. The basic RLS algorithm used in this paper is as follows.

$$datas = \{(x,\ y)|(x_i,\ y_i),\ (x_{i+1},\ y_{i+1}),\ \cdots,(x_{n-1},\ y_{n-1}),(x_n,\ y_n)\}$$

$$f(x_{n+1}) = y_{n+1} = \alpha x_{n+1} + \beta \quad (1)$$

$$\alpha = \frac{n\sum_i^n x_i y_i - \sum_i^n x_i \sum_i^n y_i}{n\sum_i^n x_i^2 - \left(\sum_i^n x_i\right)^2} x_{n+1} \quad (2)$$

$$\beta = \frac{\sum_i^n y_i - \alpha\sum_i^n x_i}{x_{n+1}} \quad (3)$$

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 12, Number 20 (2017) pp. 9997-10001

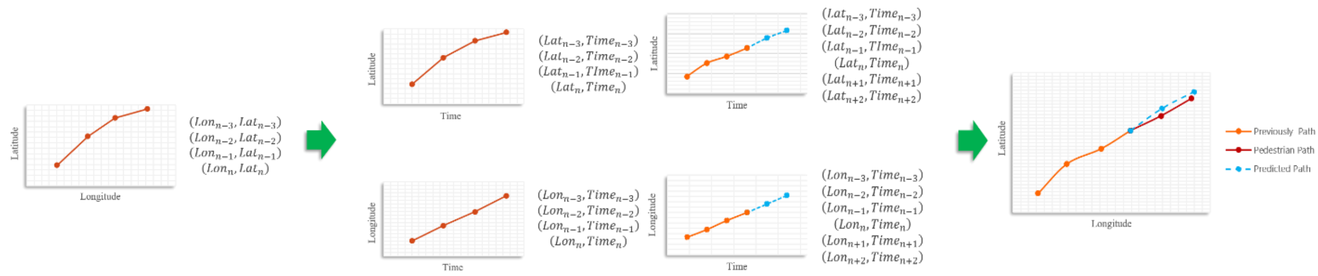
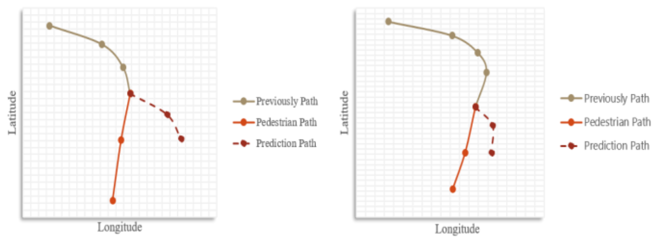


Figure 3. The Cartesian coordinate for latitude and longitude expressed in the time axis

We apply the RLS algorithm to the GPS of the pedestrians collected in real time to predict the path. GPS provides latitude and longitude, and in order to predict the path, it needs to be changed to information about time. Figure 3 shows the process of separating collected latitude and longitude with respect to time.

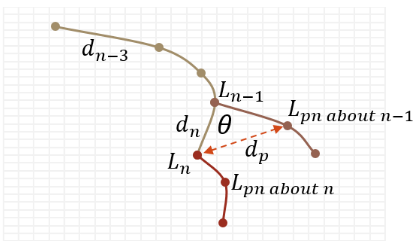
As shown in Fig. 3, it can be seen that the path calculated from the actual pedestrian path and the predicted path are similar. This means that the linear prediction of the RLS algorithm is suitable for the path of the pedestrian. Figure 4 shows the predicted path in the curve section.



(a) (b)

Figure 4. Error of curve section

It can be seen that the error rate is significantly higher than that of Fig. This is an error that occurs when the GPS used in predicting the measured GPS and pedestrian path has different directions when the pedestrian switches direction. (A), it is difficult to improve the path of the pedestrian because it can not predict the direction change of the pedestrian. However, (b) is the error caused by the linear prediction of RLS. We applied the following algorithm to improve this problem.



.

$$d_n = distance(L_n,\ L_{n-1})$$

$$d_p = distance(L_n,\ L_{pn\ about\ n-1})$$

$$d_{avg} = \frac{d_n + d_{n-1} + d_{n-2} + d_{n-3}}{4}$$

$$\theta = \operatorname{atan}((L_{pn\ about\ n-1\rightarrow lat} - L_{n-1\rightarrow lat})/(L_{pn\ about\ n-1\rightarrow lon} - L_{n-1\rightarrow lon})) - \operatorname{atan}((L_{n\rightarrow lat} - L_{n-1\rightarrow lat})/(L_{n\rightarrow lon} - L_{n-1\rightarrow lon}))$$

$$If\ \ d_{avg} * 0.9 > d_p \ \text{ or } \ d_{avg} * 1.1 < d_p \qquad (4)$$

$$\begin{pmatrix} L'_{pn\ about\ n\rightarrow lon} \\ L'_{pn\ about\ n\rightarrow lat} \end{pmatrix} = \begin{pmatrix} \cos\theta & -sin\theta \\ sin\theta & cos\theta \end{pmatrix} \begin{pmatrix} L_{pn\ about\ n\rightarrow lon} \\ L_{pn\ about\ n\rightarrow lat} \end{pmatrix} \qquad (5)$$

When $L_{pn\ about\ n}$ is predicted by $\{L_{n-3,} \cdots, L_n\}$, if Eq. (4) is satisfied, $L_{pn\ about\ n}$ is corrected by using Eq. (5). When $L_{pn\ about\ n}$ is corrected, the $L_{pn+1\ about\ n}$ is also automatically corrected by the RLS algorithm. Figure 6 shows the coordinates before correction and after correction

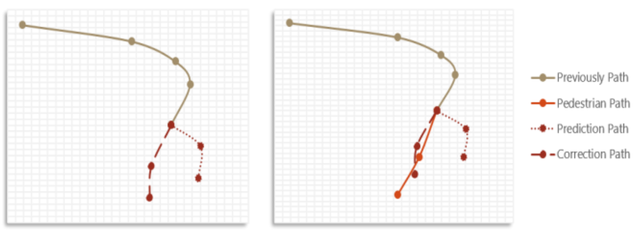


Figure 5. The predicted path corrected by Equation (5)

Figure 6. Actual and Predicted Paths

Table 1. Measured path information

Number of GPS markers	Total Distance	Moving Time
132	210 m	2min 3sec

Table 2. Comparison of actual and predicted paths

	Minimum Error	Maximum Error	Average
Prediction Path: T+1	0.05 m	2.3 m	0.52 m
Prediction Path: T+2	0.22 m	4.2 m	1.1 m

3.2. Grid-based Path Modeling Method

Grid-based path learning is an improved method that can apply the existing model method to an unspecified person. We applied the grid to the conventional method of modeling the path to the destination and added the path modeling for each cell. The grid modeling method divides the collected path into cells as shown in Figure 7 and models the path for each cell.

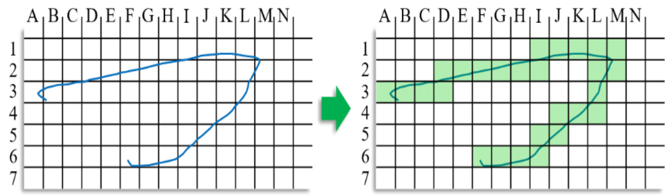


Figure 7. Grid-based pedestrian path modeling

The modeling process of a cell goes through processes such as path expression using equations, environmental variables such as time and day of the week, and the relationship of cells. The path expression using the equation is a process of converting a path into an equation using a plurality of GPS located in a cell. The path is expressed by the maximum N ((the number of GPS in the cell) -1) equation from the first order equation, and the equation with the correlation coefficient (R) closest to 1 is used.

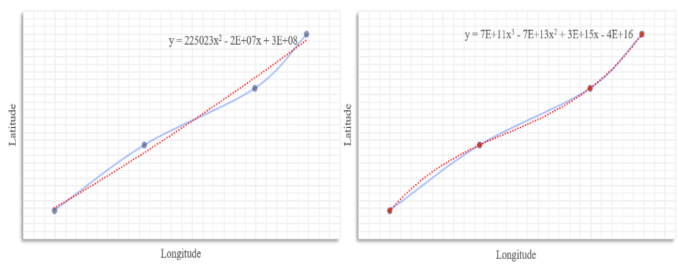


Figure 8. Path represented by the equation

Environment variables are used for path reasoning, and cell relationships are defined as the cell-to-cell movement.

3.2. Grid-based Path Modeling Method

We predict the path of the pedestrian using the methods presented above. Using RLS, we predict the short path of a pedestrian in real time and use a grid-based model to predict a path a little further than the previous one. Figure 9 shows the method of predicting the route of the current pedestrian in the accumulated model by the method proposed in this study.

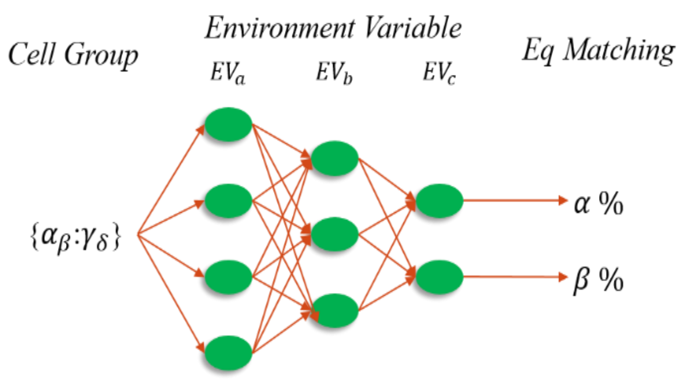


Figure 9. Path Prediction Method

'Cell Group' is a set of cell codes used when searching for a model with the same path. It consists of one or more cell codes. The model searched through the cell group undergoes an additional classification process according to each environment variable. The final classified model through the environmental variables is compared with the path equation of the cell group, and the pedestrian path is predicted using the model with the high matching rate.

CONCLUSION

In this paper, we proposed a real-time path prediction and grid - based path modeling method using GPS. In the proposed method, it is possible to predict in real time by applying the RLS algorithm to a path that has not yet generated a model. In addition, the grid-based path modeling method maintains the characteristics of the existing path model, and the subdivided model into cells can be used in unspecified persons. And we eliminated the error caused by the GPS delay by expressing the path as an equation. Table 1 compares the conventional path prediction model with the proposed path prediction model.

Table 3. Compare with Existing Method and Proposed Method

	Existing Method	Proposed Method
Purpose	Estimate destination	Estimate the movement path after
Process	(1). Pre-Collect Path (2). Pre-Create Model (3). Predict Destination	(1). Collect Path (2). Predict Path & Create the Previous Path Model (3). Predict After Path
Characteristic	Personalized path model	Universal path model
Unspecified person	Not shown	Prediction of the path using the grid method.
Without Constructed Path model	Using near path model	Real-time prediction for a short distance

The proposed method can be applied to the V2P environment where the path of the unspecified person should be predicted. In future, it plans to carry out research to reduce the risk of pedestrians' traffic accidents by combining with short-range wireless communication such as Bluetooth and Zigbee.

REFERENCES

[1] PYYKÖNEN, P., et al. IoT for intelligent traffic system. In: *Intelligent Computer Communication and Processing (ICCP), 2013 IEEE International Conference on*. IEEE, 2013. p. 175-179.

[2] DIEWALD, Stefan, et al. Mobile Device Integration and Interaction with V2X Communication. In: *World Congress on Intelligent Transport Systems: 22/10/2012-26/10/2012*. 2012.

[3] DIEWALD, Stefan, et al. DriveAssist: a V2X-based driver assistance system for Android. In: *Konferenz Mensch & Computer: 09/09/2012-12/09/2012*. Oldenburg Wissenschaftsverlag, 2012. p. 373-380.

[4] BAGHERI, Mehrdad; SIEKKINEN, Matti; NURMINEN, Jukka K. Cellular-based vehicle to pedestrian (v2p) adaptive communication for collision avoidance. In: *Connected Vehicles and Expo (ICCVE), 2014 International Conference on*. IEEE, 2014. p. 450-456.

[5] LEWANDOWSKI, Andreas, et al. Design and performance analysis of an IEEE 802.15. 4 V2P pedestrian protection system. In: *Wireless Vehicular Communications (WiVeC), 2013 IEEE 5th International Symposium on*. IEEE, 2013. p. 1-6.

[6] Yunhyoung Hwang, Yousic Lee, Seonggeun Shin, Hyuckkee Lee, Daeryong Ahn. Pedestrian Trajectory Estimation for the Collision Threat Assessment. The Korean Society of Automotive Engineers, 2015. p. 643-645.

[7] KIM, Je-Min; BACK, Hea-Jung; PARK, Young-Tack. GPS based Smartphone Users' Personal Route Model Learning and Moving Route Prediction. *Journal of KIISE: Software and Applications*, 2012, 39.1: 56-65.

[8] SCHNEIDER, Nicolas; GAVRILA, Dariu M. Pedestrian path prediction with recursive Bayesian filters: A comparative study. In: *German Conference on Pattern Recognition*. Springer, Berlin, Heidelberg, 2013. p. 174-183.

[9] KELLER, Christoph G.; GAVRILA, Dariu M. Will the pedestrian cross? A study on pedestrian path prediction. *IEEE Transactions on Intelligent Transportation Systems*, 2014, 15.2: 494-506.

[10] KOOIJ, Julian Francisco Pieter, et al. Context-based pedestrian path prediction. In: *European Conference on Computer Vision*. Springer, Cham, 2014. p. 618-633.

[11] BROGAN, David C.; JOHNSON, Nicholas L. Realistic human walking paths. In: *Computer Animation and Social Agents, 2003. 16th International Conference on*. IEEE, 2003. p. 94-101.

[12] MØGELMOSE, Andreas; TRIVEDI, Mohan M.; MOESLUND, Thomas B. Trajectory analysis and prediction for improved pedestrian safety: Integrated framework and evaluations. In: *Intelligent Vehicles Symposium (IV), 2015 IEEE*. IEEE, 2015. p. 330-335.

[13] DATTA, Trisha; JAIN, Shubham; GRUTESER, Marco. Towards city-scale smartphone sensing of potentially unsafe pedestrian movements. In: *Mobile Ad Hoc and Sensor Systems (MASS), 2014 IEEE 11th International Conference on*. IEEE, 2014. p. 663-667.