A Framework on New Travel Demand Model Based on Potential Travelers and Surrounding Land Uses for Rapid Transit

Z. Abal Abas

Centre for Advanced Computing Technology (C-ACT),
Faculty of Information and Communication Technology,
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya,
76100 Durian Tunggal, Melaka, Malaysia.

Email: zuraidaa@utem.edu.my

Abstract—**One of the public transports is rapid transit, which provides the highest performance mode of urban transportation. Currently, existing rapid transit travel demand analysis from the service provider is based on ticketing data that contain information such as time travel, origin and destination; which is using trip based method. This method has its limitation such as the demand is for trip making rather than for activities as well as having spatial, temporal and demographic aggregation errors. It also failed to predict the travel demand when there is future development or growth in the surrounding area. Therefore, new method for modeling travel demand is needed. This paper proposes a framework of new model and analytics for travel demands of rapid transits based on big data of potential travelers and surrounding land uses. Land uses and transportation are interdependent. With this proposed concept, the accurate travel demand for rapid transit in the future will be met. Therefore, the rapid transit service will have excellence operation, which includes optimum frequency, punctuality and reliable service.**

Index Terms—**Rapid Transit, Travel Demand Model, Traveler and Land Uses.**

Article history: Manuscript received 25 February 2017; received in revised form 18 November 2017; Accepted 4 October 2017.

I. INTRODUCTION

"A developed country is not a place where the poor have cars. It is where the rich use public transportation", quotes by Gustavo Petro, who gains a lot of attention from various countries and inspired many people around the world. Gustavo also stated that developed countries should be focusing more on sustainability and enhancing the efficiency where the heart of transportation must be beneficial for public community in the country. In fact, public transportation provides the easiest, fastest, inexpensive, environmentally friendly and a great way to obtain an aerial view of places. Moreover, public transportation service offers convenient and economical advantages to the people of the country especially the poor. Hence the need to an efficient and connected public transport system is seen as more urgent than ever. This is obvious particularly when improving the Urban Public Transport (UPT) is selected as one of the key areas in Malaysian National Key Resource Agenda (NKRA).

Interestingly, [1]–[4], highlights that in order to understand cities, the flow and the network must be understand to demonstrate the relationships between people and places. However, the flow and the travel demand have not been widely analyzed from a network perspective. A study conducted by [5] investigated the travel demand in a city using millions of origin-destination trips. The work introduced complex network-driven approach as a way to understand and characterize the urban travel demand, complementary to the existing advanced activity and agent based model developed by [6], [7] as well as the trip based method [5], [8], [9].

One of the urban public transports is rapid transit, which provides the highest performance mode of urban transportation [10]–[12]. It must be highlighted here that the existing rapid transit travel demand model from the service provider is based on ticketing data which captured travel information such as time travel, origin and destination rapid transit station. In specific, the service provider is using trip-based method. This method has its limitation such as the demand is for trip making rather than for activities as well as having spatial, temporal and demographic aggregation errors [5]. The method also failed to predict the travel demand when there is future development or growth in the surrounding area.

As a matter of facts, the starting point and the destination of the traveling is not only from the rapid transit station. Travelers may travel from their homes, offices, recreation parks and others and then continue their journey with rapid transit and finally continue back to the destination places. There are also times where events are held at certain places which some of the participants may use rapid transit to travel back and forth [13]. At the same time, some surrounding areas or places has future development and growth [14]. It should be noted that analysis based on ticketing data only or specifically trip-based method is not comprehensive for predicting rapid transit travel demand. With the current technology that surround us and massive data that can be gathered through multiple social media as well as surrounding land uses data, predicting travel demand could be more comprehensive and accurate. A variety of land uses include residential, commercial, institutional, industrial, parks and etc. Therefore, new approach of rapid transit demand model is urgently needed and highly significant in order to provide holistic and comprehensive insight towards reliable and optimum operation for rapid transit. However, since this is a new approach of proposed solution, how to construct the parameters based on leveraging the big data sources and formulate it into new model for predicting the rapid transit travel demand remain an open question.

This paper will present the framework for the new travel demand model based on potential travelers and surrounding land uses for rapid transit. The idea lies on the fundamental of graph theory [15][16], classification concept [17] and optimization [18].

METHODOLOGY

Problem formulation using mathematical approach is used in order to obtain a clear insight [19]–[24]. For this model, the data collection will be from variety of big data sources such as census collection districts (CCD), GPS, variety of land uses, social network and etc. Once the data has been collected, the infrastructure of the urban public transports specifically the rapid transit is carefully analyzed. This is associated with the current methods and techniques in travel demand prediction model. At the same time, big data sources on potential travelers and surrounding land uses are analyzed. Finally, all of the relevant data are analyzed on how to map it to the concept of graph theory.

Methodology used to develop the conceptual model is divided into two phases. The first phase construct new parameters for the number of travelers based on big data of potential travelers and surrounding land uses. Second phase is to formulate the rapid transit demand model based on the constructed parameters in network representation for demand prediction.

RESULT AND DISCUSSION

Phase 1: Construct new parameters for the number of travelers based on big data of potential travelers and surrounding land uses

Fig. 1. illustrates the variety of land uses and rapid transit stations at the areas. Travelers from variety of land uses will use the nearest public transport in order to travel to their destination.

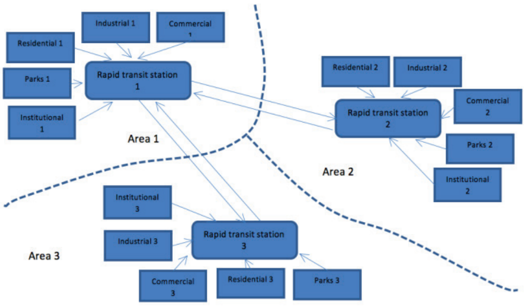

Fig. 1. Rapid transit stations and land uses.

Based on all the big data sources of potential travelers and a variety of surrounding land uses, among the related entities that are translated and formulated into parameters are:

x_{11} : The number of potential travelers from land uses 1 in area 1

x_{12} : The number of potential travelers from land uses 2 in area 1

⋮

x_{ki} : The number of potential travelers from land uses k in area i

where $i = 1, 2, 3, \ldots n$ and n is total maximum areas $k = 1, 2, 3, \ldots m$ and m is total maximum type of land uses.

A graph, $G = (V, E)$ that represents the network of urban rapid transit is constructed. It consists of two components:

(1) Set $V = \{v_i\}$ of nodes for i= 1, 2, 3,…n.
(2) Set $E = \{e_{ij}\}$ of m edges connecting the nodes for $i, j = 1, 2, 3, \ldots n$.

In the above graph representation, the nodes denote rapid transit station in area i. The second component, which is the edge, can be written in a more detail that is $e_{ij} = \{v_i, v_j\}$ where v_i denotes an initial rapid transit station (origin) and v_j denotes a terminal rapid transit station (destination).

Phase 2: Formulate the rapid transit demand model based on the constructed parameters in network representation for demand prediction

At each edge, a number of weights will be assigned as illustrated in Fig. 2.

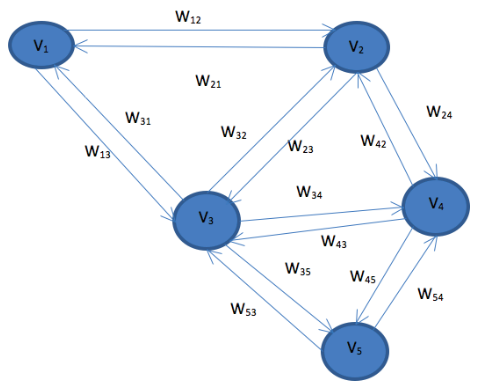

Fig. 2. The edges and weights in the network representation of rapid transit

The weights represent the number of passengers traveling from a link connecting the initial rapid transit station (origin) to destination rapid transit station (destination). The weight will be model as follows:

$$w_{12} = a_{11}x_{11} + a_{12}x_{12} + a_{13}x_{13} + \ldots. + a_{1m}x_{1m} = \sum_{k=1}^{m} a_{1k}x_{1k}$$

⋮

$$w_{ij} = a_{i1}x_{i1} + a_{i2}x_{i2} + a_{i3}x_{i3} + \ldots. + a_{im}x_{im} = \sum_{k=1}^{m} a_{ik}x_{ik}$$

The coefficient a_{ik} denotes the rates or proportion of potential travelers from land use k at area i. It must be noted that the weight is the travel demand for rapid transit from potential travelers and a variety of surrounding land uses. The rapid transit demand prediction will be based on the network representation.

CONCLUSION

This paper presented a new framework for the new travel demand model based on potential travelers and surrounding land uses for rapid transit. This framework has potential application in urban public transport specifically for determining rapid transit travel demand. Once the accurate prediction of the rapid transit travel demand is established, an optimum operational and decision-making in transportation industry will be achieved.

ACKNOWLEDGMENT

Sincere thanks to Universiti Teknikal Malaysia Melaka (UTeM) for granting permission to publish the report.

REFERENCES

[1] M. Betty, The new science of cities. MIT Press, Cambridge, 2013.

[2] Z. A. Abas, L. Ee-Theng, A. F. N. A. Rahman, Z. Z. Abidin, and A. S. Shibghatullah, "Enhanced scheduling traffic light model using Discrete Event Simulation for improved signal timing analysis," ARPN J. Eng. Appl. Sci., vol. 10, no. 18, pp. 8135–8140, 2015.

[3] J. Holmgren, "An analysis of the determinants of local public transport demand focusing the effects of income changes," Eur. Transp. Res. Rev., vol. 5, no. 2, pp. 101–107, 2013.

[4] V. R. Vuchic, "Urban Public Transportation Systems," Transp. Eng. Plan., vol. I, p. 26, 1981.

[5] M. Saberi, H. S. Mahmassani, D. Brockmann, and A. Hosseini, "A complex network perspective for characterizing urban travel demand patterns: graph theoretical analysis of large-scale origin-destination demand networks," Transportation (Amst)., pp. 1–20, 2016.

[6] M. . Gonzalez, H. C.A, and B. A.L, "Understanding individual human mobility pattern," Nature, vol. 453, 2008.

[7] C. M. Schneider, V. Belik, C. T., S. Z., and M. C. Gonza´lez, "Unravelling daily human mobility motifs," J. R. Soc. Interface, vol. 10, 2013.

[8] IBM, "Big data and analytics in travel and transportation," 2013.

[9] "London ′ s Rapid Transit Initiative," 2014.

[10] L. Zhang and D. Levinson, "Agent-Based Approach to Travel Demand Modeling: Exploratory Analysis," Transp. Res. Rec., vol. 1898, no. 1, pp. 28–36, 2004.

[11] N. Huynh, V. L. Cao, R. Wickramasuriya, M. Berryman, P. Perez, and J. Barthelemy, "An Agent Based Model for the Simulation of Road Traffic and Transport Demand in A Sydney Metropolitan Area," Eighth Int. Work. Agents Traffic Transp. , no. 2005, pp. 1–7, 2014.

[12] M. C. Beutel, S. Addicks, B. S. Zaunbrecher, S. Himmel, K. H. Krempels, and M. Ziefle, "Agent-based transportation demand management: Demand effects of reserved parking space and priority lanes in comparison and combination," SMARTGREENS 2015 - 4th Int. Conf. Smart Cities Green ICT Syst. Proc., pp. 317–323, 2015.

[13] N. F. Mansor, Z. Abal Abas, A. F. N. Abdul Rahman, A. S. Shibghatullah, and S. Safiah, "An analysis of the parameter modifications in varieties of harmony search algorithm," Int. Rev. Comput. Softw., vol. 9, no. 10, pp. 1736–1749, 2014.

[14] A. Morimoto, Transportation and Land Use Planning. 2014.

[15] S. Salleh and Z. Abal Abas, Simulation for Applied Graph Theory Using Visual C++. Boca Raton: CRC Press Taylor & Francis Group, 2016.

[16] Z. Abal Abas, S. Salleh, and Z. Manan, "Extended Advancing Front Technique for the Initial Triangular Mesh Construction on a Single Coil for Radiative Heat Transfer," Arab. J. Sci. Eng., vol. 38, no. 9, pp. 2245–2262, 2013.

[17] S. F. Abdullah, A. F. N. A. Rahman, and Z. A. Abas, "CLASSIFICATION OF GENDER BY USING FINGERPRINT RIDGE DENSITY IN NORTHERN PART OF MALAYSIA," ARPN J. Eng. Appl. Sci., vol. 10, no. 22, pp. 10722–10726, 2015.

[18] N. F. Mansor, Z. A. Abas, A. F. N. A. Rahman, A. S. Shibghatullah, and S. Sidek, "AN OPTIMIZATION SOLUTION USING A HARMONY SEARCH ALGORITHM," in International Symposium on Research in Innovation and Sustainability 2014, 2014, vol. 2014, no. October, pp. 1745–1749.

[19] Z. A. Abas, S. Salleh, A. F. N. A. Rahman, H. Basiron, A. S. Hassan Basari, and N. Hassim, "Improvement of Element Creation Procedure for Generating Initial Triangular Unstructured Mesh for Radiative Heat Transfer Modelling," Int. Rev. Model. Simulations, vol. 6, no. 5, pp. 1649–1656, 2013.

[20] M. I. Jasmi, A. F. N. A. Rahman, Z. A. Abas, and A. S. Shibghatullah, "Optimized Coating Design of Energy Saving Glass Using Binary Harmony Search for Better Transmission Signal," Int. J. Comput. Sci. Inf. Secur., vol. 14, no. 8, pp. 436–443, 2016.

[21] N. Hashim, Z. ZainalAbidin, A. Shibghatullah, Z. AbalAbas, and N. Yusof, "A New Model of Crypt Edge Detection Using PSO and Bi-cubic Interpolation for Iris Recognition," in Advanced Computer and Communication Engineering Technology: Proceedings of ICOCOE 2015, A. H. Sulaiman, A. M. Othman, I. M. F. Othman, A. Y. Rahim, and C. N. Pee, Eds. Cham: Springer International Publishing, 2016, pp. 659–669.

[22] Z. Abas, Z. Shaffiei, A. F. N. A. Rahman, and A. S. Shibghatullah, "Using Harmony Search for Optimising University Shuttle Bus Driver Scheduling for Better Operational Management," in ITMAR 2014, 2014, vol. 1, pp. 614–621.

[23] M. R. Ramli, Z. Abal Abas, F. Arif, and M. I. Desa, "An Analysis Review Approaches Used In Health Human Resources Planning," Int. J. Comput. Sci. Inf. Secur., vol. 14, no. 8, pp. 908–935, 2016.

[24] Z. A. Abas et al., "A supply model for nurse workforce projection in Malaysia," Health Care Manag. Sci., 2017.