GIS Analysis for People Flow in Jakarta Using Person Trip Survey Data

Suseno Wangsit Wijaya[1], Yoshihide Sekimoto[2], Takehiro Kashiyama[3], Hiroshi Kanasugi[4]

[1, 2, 3, 4] Institute of Industrial Science, University of Tokyo
Ce507, 4-6-1, Komaba, Meguro-ku, Tokyo 153-8505, Japan Tel: +81-3-5452-6406
Email :
[1]wijaya@iis.u-tokyo.ac.jp
[2]sekimoto@iis.u-tokyo.ac.jp
[3]ksym@iis.u-tokyo.ac.jp
[4]yok@iis.u-tokyo.ac.jp

ABSTRACT : Jakarta is capital city of Indonesia which has complicated congestion due to too much user but limited road volume and railway network. Thus, urban planning and transportation management for such megapolitan city is necessary. Applying GIS is one of the option to create transportation network, analyse traffic volume and determine the fastest route. This initial research aim to generate information related people flow in Jakarta using survey person trip data such as vehicle transport, purpose and location of their home, school or workplace. This information was conducted by using questionnaire. Despite questionnaires have lower temporal and spatial resolution than CDR (Call Data Records) and mobile phone GPS data, but it still be able to give dynamic picture about people flow in Jakarta. This research mainly used point feature from each ID and line feature of road data. In addition, polygon feature also necessary to process people density in each grid. Conversion of road line feature from Open Street Map to road network was also conducted. Then, person trip of each ID from their origin to destination can be simulated by using fastest time method. The result are interpolation of people flow data. Furthermore, several parameter can be calculated (e.i., average speed and average distance).The result showed the highest number of people travel from 6.00 am to 7.00 a.m and most of them using mini bus, followed by motorcycle and car.

KEYWORD : urban planning, person trip, people flow, road network, fastest time.

1. INTRODUCTION

As megapolitan city, jakarta urban planning andtransportation management should integrated with it's buffer region. The greater Jakarta called Jabodetabek, contain Jakarta province and several regency around it. Jakarta traffic congestion not only caused by local Jakarta people but also people from sorround Jakarta who commute to their schools or working place in Jakarta. 1,382,296 people commute to Jakarta from surrounded regency (BPS, 2015). This situation can be worse because the increasing people and private vehicle every year didn't balance with development road volume and rail network. It is urgently needed to develop an efficient and reliable transportation network to recall investments to the region (Pasific Consultant International, 2004).

Several countermeasure to overcome traffic congestion in Jakarta can adopt from the other big cities around the world. There are alternative to solve it, in example upgrade road capacity, built new road network, control the traffic volume with odd or even number, and optimize the public transportation. For the first step, some activity is needed to simulation of people flow in Jakarta. People flow simulation can be determined using questionnaire, CDR (Call Data Records) and mobile phone GPS data. Despite questionnaires have lower temporal and spatial resolution than CDR and mobile phone GPS data, but it still be able to give dynamic picture about people flow in Jakarta. Sekimoto et al. (2011) predicted the movement of people in metropolitan Tokyo and metropolitan Hanoi using the person trip survey which is a survey that asks a sample of around 10% about their daily movement patterns.

An issues that complicates people flow simulation is simulate and modeling real behavior. Simulating the motion of realistic, large, dense crowds of autonomous agents is still a challenge (Pelechano et al., 2007). This information can processing much more detail and gave clear vision using GIS technology. This research aim to generate spatial information related people flow in Jakarta using person trip survey data.

2. METHODOLOGY

Person trip survey is a method to analyze individual travel behavior based on person's travel activity record in a certain day. The questionnaire to document several information related people flow, in example home,

workplace, origin, destination, departure time, arrival time, purpose, type of vehicle and another personal information such as gender, age, and occupation. The total sample was 417,047 in the Jakarta metropolitan and surrounded area in the 2002 survey. This questionnaire requires position and time for each trip between origin and destination, each trip could consist of subtrips.

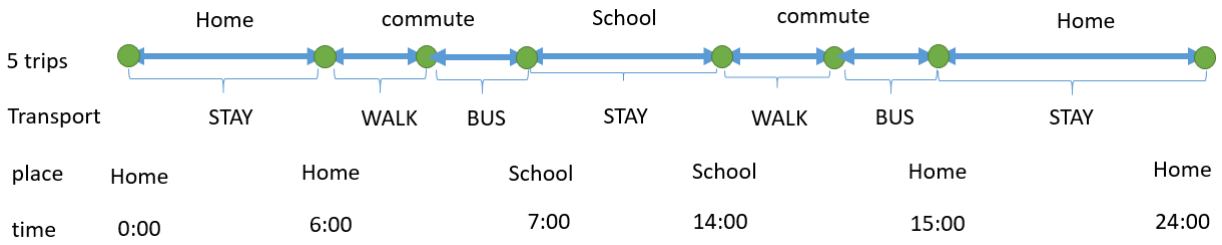


Figure 1. Example of trip and subtrip in one day

Open Street Map data used as road network, it is already contain road volume, maximum speed and one way flow. Some adjustment needed to adjust with the real condition. To process network analysis, it is necessary to build the network from line feature. OSM2PO act as converter and routing engine that run in java software. It's makes OSM data routable and compatible with pgRouting and Quantum GIS. PgRouting and editing topology used to establish departure node and arrival node then connected each road link. Some isolated network should be eliminate.

Person trip questionnaire have origin and destination for each trip and sub-trip, but there are gap which link that they use to reach their destination. To fill the gap, interpolation method is needed. The interpolation of route choices in this research used simple Dijkstra (1959) method, shorest path between Origin and Destination nodes, with time duration as a link cost of OSM data. This interpolation didn't consider link congestion, all ID's can go over all links without waiting at a node.

To process big data, approximately 400,000 trip ID is quite challenging. Simulator in java software is needed to get the better result from this big data. Simulator consider the traffic volume, road capacity and magnification factor to build the route network for each trip and subtrip. After the route network and interpolation was concluded, we can calculate the avarage of speed per hour, avarage speed per link ID and grid mesh density. Grid mesh density can give information about the estimation distribution of population in Jakarta by multiply magnification factor to transport type that used each ID.

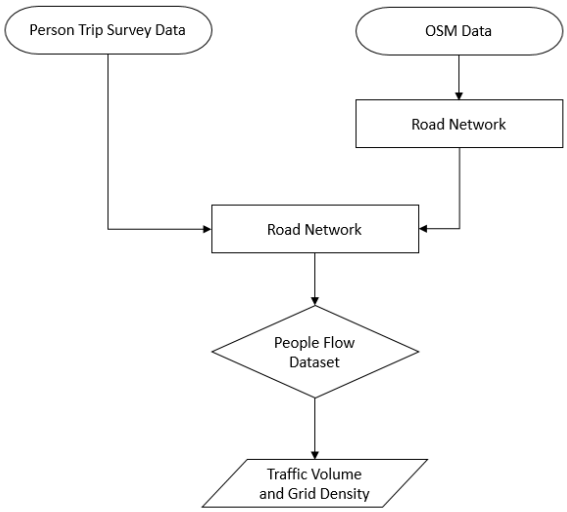


Figure 2. Flowchart of people flow analysis using person trip survey data

3. RESULT AND DISCUSSION

The participant composisition of the survey dominated by young people aged 20 – 30 years old and student aged 10 – 20 years old. The highest purpose each ID move was went home then goes to school and to work respectively. More then half participant used public transportation as their trasport type and approximately a quarter of them used motorcycle.

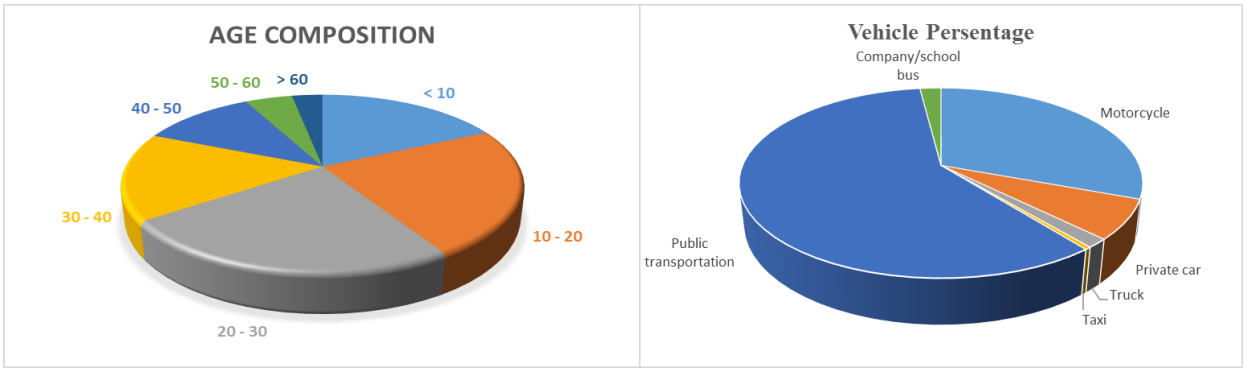


Figure 3. Composition of participant ages and their vehicle

The hourly trip moving and their transport type calculation also provided from the Person Trip survey. This calculation assigning trips to road networks and counting the number of trip and transport type for each trip each ID. The result showed the highest number of people travel from 6.00 am to 8.00 a.m. The peak movement also happens at 12.00 – 01.00 p.m and 16.00 p.m – 17.00 p.m. This result agreeable because office hour in Indonesia start from 08.00 a.m – 04.00 p.m, morning school start from 07.00 a.m to 12.00 a.m and afternoon class start at 01.00 p.m to 05.00 p.m.

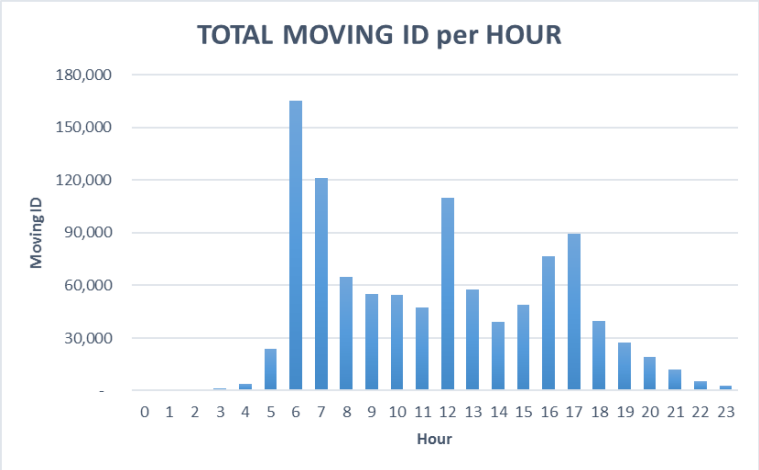
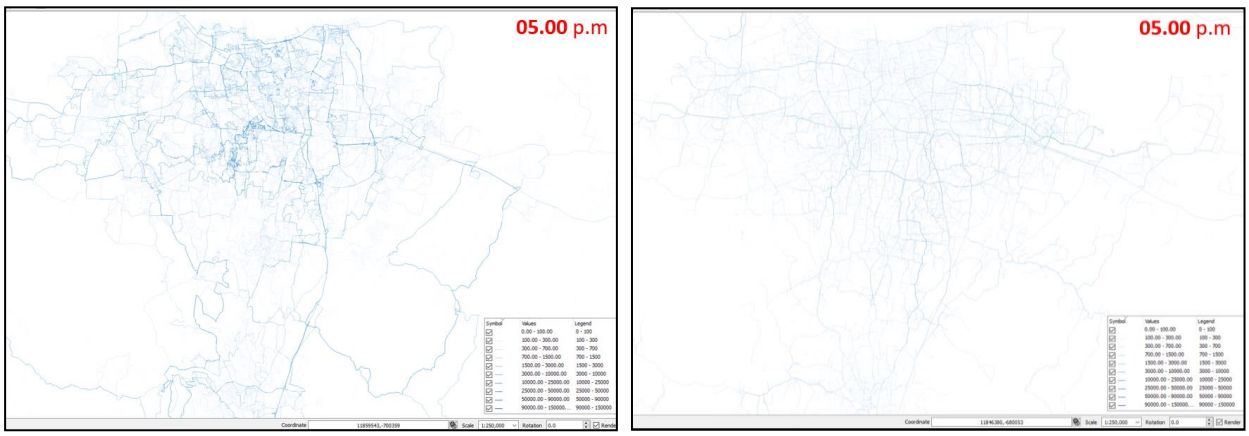


Figure 4. Hourly trip moving

After the road network establish from OSM data, it's contain departure node and arrival node which connected each road link. Estimation the routes for each Origin - Destination of ID trips can done in two ways, didn't consider link congestion with Incremental Traffic Assignment (ITA) method or consider the traffic volume and road capacity by simulator.

ITA method relevant to assign a large number of trips to road networks with relatively small computational complexity (Hasegawa, 2014). The trips in the dataset were assigned using the free travel time along the routes computed by Dijkstra's algorithm. The highest average traffic volume is at 5 p.m – 6 p.m, it could be caused by the peak of people that travel back to their home from school and work. ITA method output just traffic/link volume, the method didn't provide people flow interpolation for each ID.



(a) (b)

Figure 5. Link volume by ITA method (a) and simulator (b)

Dark blue line show higher link volume then light blue (Figure 5). Dark blue line dominated in highway road and arterial road, while light blue dominated in collector road and local/residential road. Almost all ITA method result have higher number of link volume then simulator. The ITA method didn't consider the traffic volume and road capacity, so every ID free to travel along the link without waiting at a node.

Simulator utilize the people location on at certain time. In simulator, the origin - destination movement model chooses consider the traffic volume and road capacity through road networks. Then the fastest routes for those destinations are provided by Dijkstra's algorithm using road network data. The destinations also include stay to represent stationary people. The distance weighted with congestion intensity is used to determine routes. The traffic congestion is modeled using queues related to each road. ID's can go over all links but should waiting at a node in certain circumstances. Simulator output was traffic/link volume and people flow interpolation for each ID.

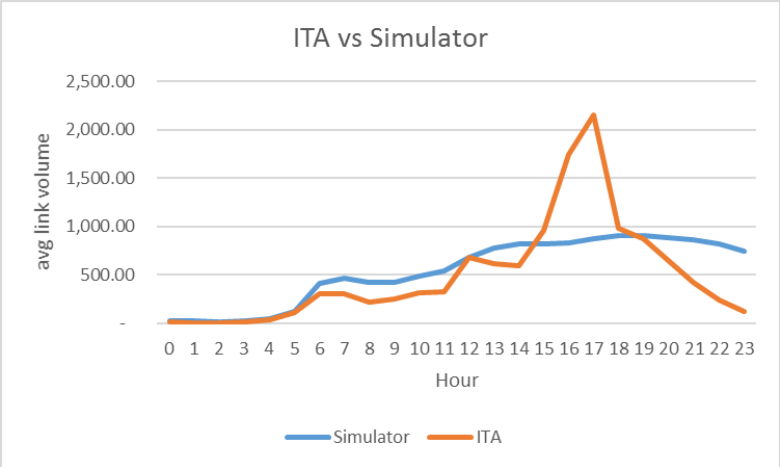


Figure 6. Comparison between ITA and Simulator each hour

Figure 6 show the average link volume by ITA and simulator. In the beginning ITA and simulator value just flat with very small movement in link volume. From 04.00 a.m ITA average link volume start to increase gradually and reach the peak at 05.00 p.m then decrease significanly, while the simulator average link volume rise slowly from 04.00 a.m then almost constant from 04.00 p.m to 23.00 p.m.

From the simulator result, we have spasial-temporal data interpolation and can calculate grid mesh density that give information about the distribution of ID per hour. Grid density also could estimate population in Jakarta by magnification factor. The magnification factor to estimate population is multiply the ID by their transport type or passager capacity unit. This aggregate data could be an overview of people flow on an urban microscopic scale.

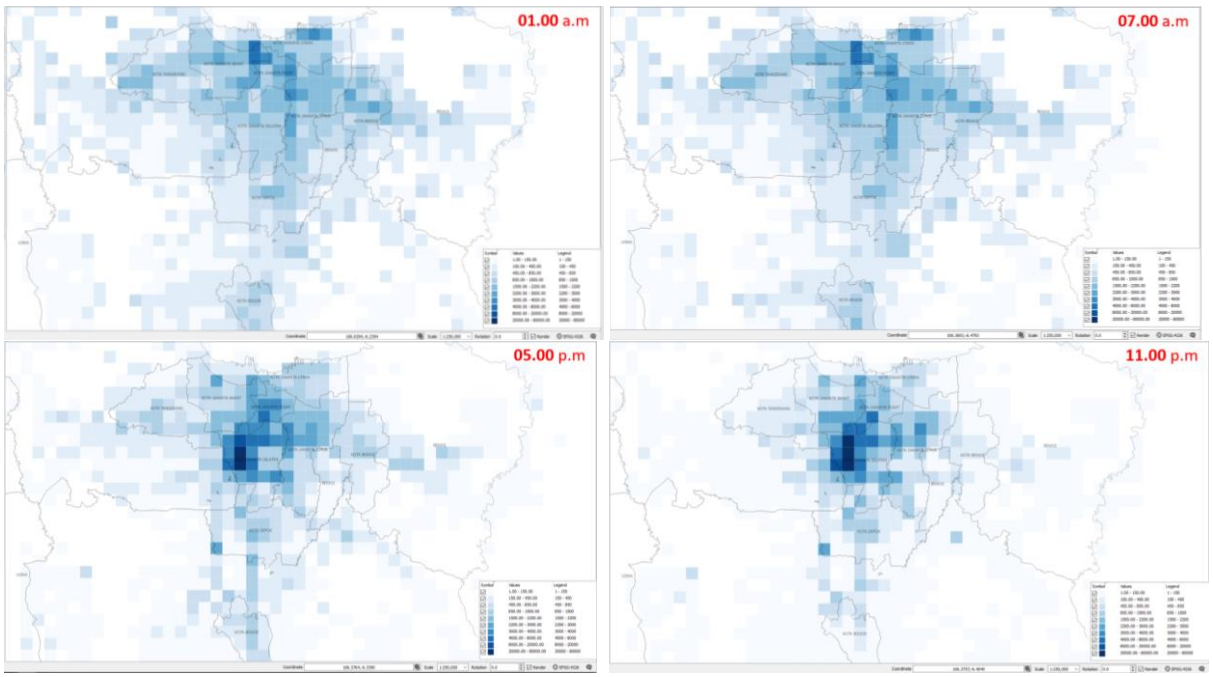


Figure 7. ID's grid mesh density

Figure 7 indicates the number of people aggregated according to a 2-km^2 mesh. The image ilustrated spread people distribution at their home at 01.a.m then move and concentrate in Jakarta. The picture shows a change between daytime and nighttime (for example, between 01:00 a.m and 07:00 a.m and 05:00 p.m and 11:00p.m), especially in South Jakarta and Central Jakarta.

4. CONCLUSION

Person trip survey data by questionnaires can give a lot of information related to urban planning and transportation management. We can make routing, calculate the traffic volume, and aggregate grid mesh density. The result showed the highest number of people travel from 6.00 am to 7.00 a.m and the highest average traffic volume is at 5 p.m – 6 p.m. From grid mesh density data, we can overview that a lot of people come from another regency near Jakarta to school and to work. For further study we look possibilities to obtain CDR data, probe data and GPS data with validation for this calculation.

Acknowledgment

We thanks Pacific Consultants International, Japan International Cooperation Agency (JICA) and National Development Planning Agency Republic Indonesia (Bappenas) for providing person trip survey data.

Reference

BPS (Badan Pusat Statistics). 2015. Transportation Statistics of DKI Jakarta. BPS Provinsi DKI Jakarta. Jakarta.

Dijkstra, E.W. 1959. A note on two problems in connexion with graphs. Numerische Mathematik. 1, 1 (1959), 269–271.

Pelechano, N., Allbeck, J.M. and Badler, N.I. (2007), "Controlling individual agents in high-density crowd simulation", Proceedings of the 2007 ACM SIGGRAPH/Eurographics Symposium on Computer Animation, Eurographics Association, pp. 99–108.

Hasegawa, Y., Sekimoto,Y., Kashiyama, T., and Kanasugi, H. 2014. Transportation Melting Pot Dhaka: Road-link Based Traffic Volume Estimation from Sparse CDR Data, The 1st International Conference on IoT in Urban Space (Urb-IoT 2014). Rome.

Sekimoto, Y., Shibasaki, R., Kanasugi, H., Usui, T., and Shimazaki, Y. (2011). Pflow: Reconstructing people flow recycling large-scale social survey data.IEEE Pervasive Computing, 10(4), 0027-35.

Pacific Consultants International. 2004. The Study on Integrated Transportation Master Plan for Jabodetabek (Phase 2). Final Report. Jakarta