Taxi Customers Travel Behavior Analysis for Allocation of Taxi Stands in Yangon City

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Abstract: TAXI is one of the important sectors in Yangon transportation and most of them are not installed model traffic detection system to analyze taxi user travel behaviors. This research explores different taxi travel behaviors by comparing hourly and daily trips frequencies as well as spatial and temporal variation of taxi trips between two services. Taxi surveying with Global Positioning System (GPS) is installed on “traditional taxis” to know taxi daily tracking and also automatics GPS trajectory big data from “on demand taxi” are used to investigate taxi user travel behaviors. Geographic Information System (GIS) and BigGIS-RTX (Big Data Research Tool Box) have to be studied to calculate taxi travel time, occupied and vacant time, and taxi origin and destination patterns. This information is useful to know taxi trip hotspot points on each township in Yangon. Moreover, it may lead to support in defining proposed taxi stands in Yangon City.

Keywords: Taxi Travel Behavior, Global Positioning System, Big Data, Taxi Stand

1. INTRODUCTION

The current urbanization and motorization put worse and worse day by day on the existing transport infrastructure in Yangon City. People in Yangon are faced traffic congestion every day and everywhere they travel. After 2011, the number of car registration is increased due to car import policy changes. In the 1990s, the number of vehicle registration is about 74,000 but in 2013, the number of vehicle rose to about 260,000. According to the government data, 66 percent of country’s vehicles are driven in Yangon. Nowadays, over 500,000 private vehicles are running in Yangon. Among them, estimated 70,000 vehicles are registered taxies so that taxi vehicles are occupied about 14% of urban transportation. Taxis registered in other regions are also running in Yangon City. The city’s excess number of taxis could provide a major level for containing congestion. Thus, the demand and supply system of taxi service in Yangon are not balance. Moreover, there is no historical taxi demand and supply data and other information about taxi services so that it is difficult to know demand location for taxi drivers whereas supply location for passengers. Taxi market in Yangon urban area combine two operational modes, hailing and dispatching. In the hailing mode, taxi continuously circulate searching for a passenger, and the passenger wait for taxis at their origin, while in the dispatching market, taxis circulate or just wait for a call from dispatching centre. In the dispatching market, a passenger contact the relative taxi service companies’ call centres asking for taxi services and the nearest taxi in the zone are assigned to him/her. Although there is no legal taxi stand market in Yangon, most of the taxi drivers are waiting for passengers at road-side parking near high densities of population and a Business District

concentrating a high percentage of daily trips. The result is that Yangon traffic condition and taxi service have been in a dilemma.

After 2015, a satellite-based taxi dispatch system, which tracks taxis using the Global Positioning System technology for automatic vehicle location identification, is currently widely deployed in Yangon. It may be one of Yangon's modernisations. Currently, there are domestic and international three transport operators in Yangon taxi service sector. The name of these transport operators are Hello Cab, Oway and Grab. Passengers can hire these dispatch taxis (on demand taxis) through their mobile phones, Facebook accounts, or through the companies' websites and call centre. And also, the spatiotemporal mobility and driving patterns of taxi can be visualized and analysed by Global Positioning System (GPS) technology. In Yangon City, GPS devices are not installed on most of the taxis which are running with traditional "hailed on the street" (hailing market). Thus, it is difficult to know traditional taxi travel patterns. This taxi service also has disadvantages because more cruising behavior of taxi drivers for searching passengers increase traffic congestion and result in unnecessary air pollution. Although the mobility of the taxi has increased day by day, there is no parking place for the taxi that means taxi stand is not created anywhere of Yangon area. This is an important issue which can reduce the effect of taxi on traffic congestion.

Taxi trajectories reflect passenger mobility over a road network. And also taxi trajectories are used to analyse the human dynamics which reflect what and where daily activities occur on each township. These taxi trajectories data can be used to improve taxi infrastructure such as proposed taxi stand location. Nowadays, these trajectories have been widely studied in many fields such as urban planning, land use modelling and traffic flow prediction. The main objective of this study is to investigate taxi user travel behavior and defining proposed taxi stands in Yangon City. Examination of occupied taxi movement, vacant taxi movement and stationary time (parking time and congestion time) of two services and identifying location characteristics that determine the number of taxi trip origin (pick up) and taxi trip destination (drop offs) that are generated on each township will be done to support the main objective.

2. LITERATURE REVIEW

Taxicab is a significant transportation mode in urban areas since it complements other public transport modes with flexible door-to-door service through uninterrupted service (Qian.et al., 2015).The GPS data are one of the main variables in this research because it can reveal underlying running mobility pattern. And also this kind of data represents a new opportunity to learn or predict relevant patterns while the network is operating (i.e.in real times). In the last decade, the real-time vehicle location system (using GPS- Global Position System and wireless communication features) attracted the attention of both taxi companies and researchers for the new kind of rich spatiotemporal information (Salanovo.et al., 2013). Taking advantage of the diversity of routes as well as accurate spatio-temporal information, taxi trip data offers a richer and more detailed glimpse into human mobility patterns (Wang et.al 2015).Specifically, the ubiquitous characteristics of this location-aware sensors (i.e. Portable; available everywhere) and of the information transmitted (i.e. a stream) increase the challenge. Moreover, they are usually tracking human behaviour (individual or in the group) and they can be used collaboratively to reveal their mobility patterns. Recently, multiple works have used the GPS historical data to analyze the spatial structure of the passenger demand. (Deng.et.al. 2011) mined this type of data to build and explore an origin-destination matrix in the city of Shanghai, China. (Yue.et al., 2009) discovered the Level of

Attractiveness (LOA) of urban-spatiotemporal clusters are discovered. The ability to identify the most frequented locations in a city can be useful for urban planning, public transportation route design, tourism agencies, public safety, etc. There are extensive works focusing on detecting significant places from GPS trajectories from personal devices (such as cell phones, the GPS localizers). Locations where a user has stayed for a minimum amount of time would be identifying as his hotspots. For the taxi GPS traces, the places of interests can be detected directly since when reasonable accuracy where passengers have been dropped off. And also, GPS traces can be compared the importance of different places by simply counting the number of drops offs at different places (Chao.et al., 2014). Another study discusses the anticipated impacts of two recently enacted taxi regulation changes on revenue increase, which are a fare increase, and the use of smart phone taxi applications (Kamaga.et al., 2015). This paper extends the detection of GPS trajectories and identifies hotspot points of passenger demand on each township. The Midtown Manhattan Pedestrian Network Development Phase One report (June 2000) recommended that the effectiveness of underutilized taxi stands in Times Square and the Theatre District be investigated and improved as a tool to reduce congestion and improve safety. Taxi stands offer a viable alternative to current practice by providing an identifiable, orderly, efficient, and quick means to secure a taxi that benefits both drivers and passengers.

3. METHOLOGY

3.1 Study Area

The study area, Yangon City, is the largest economic centre in Myanmar with a population of about 5.2 million as of 2014 and it is organized with forty-six townships. But in this research, only twenty-five townships of urban area are chosen. They are categorized with different area such as Central Business District (CBD) area, outer ring area, inner urban ring area, older suburb area and northern suburbs area. Figure 1 shows the case study area of Yangon City.

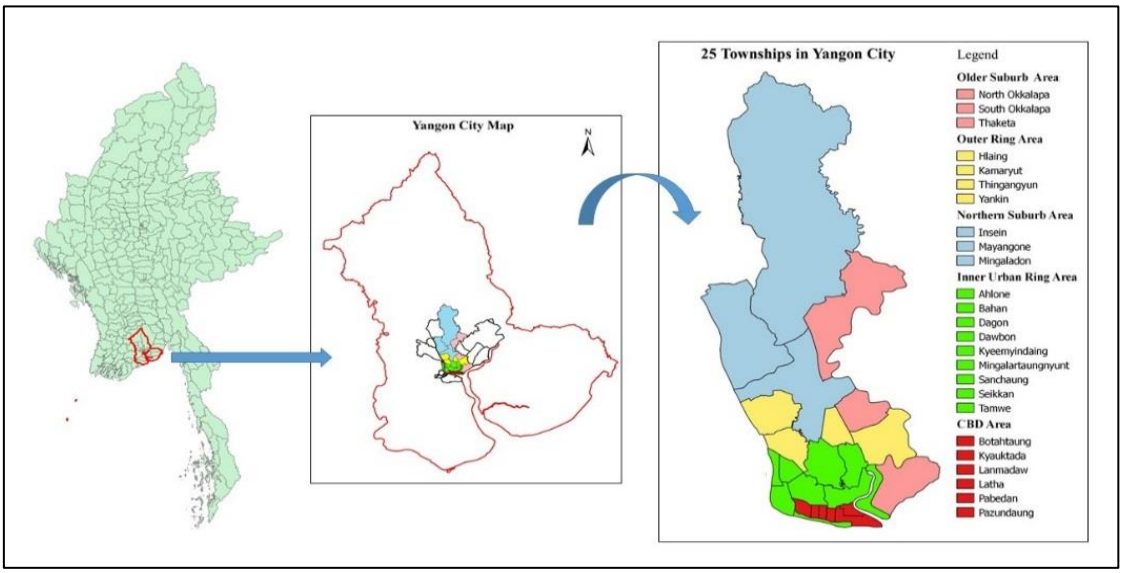


Figure1. Case Study Area of Yangon City

3.2 Method of Analysis

There are two data sources – primary data form "traditional taxi" service and secondary data form "on demand taxi" (Hello Cab Taxi) service. All GPS data are collected during the year of 2017. "Traditional taxis" are needed to collect the GPS data by installing GPS devices on board and making questionnaire survey. This survey is called semi-automatics survey. Validation of the data is needed in traditional taxi service because actual GPS data cannot be analyzed hired time and vacant time. From questionnaire survey, trip pick-up and drop-off time, origin and destination locations are useable in validation with actual GPS data. Moreover, pick-up and drop-off location of taxi trip is required to edit and making correction in ArcGIS manually with information of questionnaire survey. After editing and making correction, taxi information can be extracted in ArcGIS software. The secondary GPS data from Hello Cab Taxi is recorded GPS trajectory data automatically. These big GPS data are needed to extract by using BigGIS-RTX (Big Data Research Toolbox) [6]. Link speed and link count can be computed with Big GIS-RTX. This computation is used to make maps and data of link speed and link counts. After extracting both taxis GPS information, two taxi services can be compared by means of their O-D trip patterns, passenger travel distances and travel behaviors and so on. The next step is validation of result. Ground truth data collection, public survey and high resolution Google map are used to validate the taxi GPS data (for example, defining taxi standing points with GPS data). Data analysis and hypothesis are made to reach objective of research. The final stage of this research is to make conclusions and recommendations. Figure.2 shows work flow of this research.

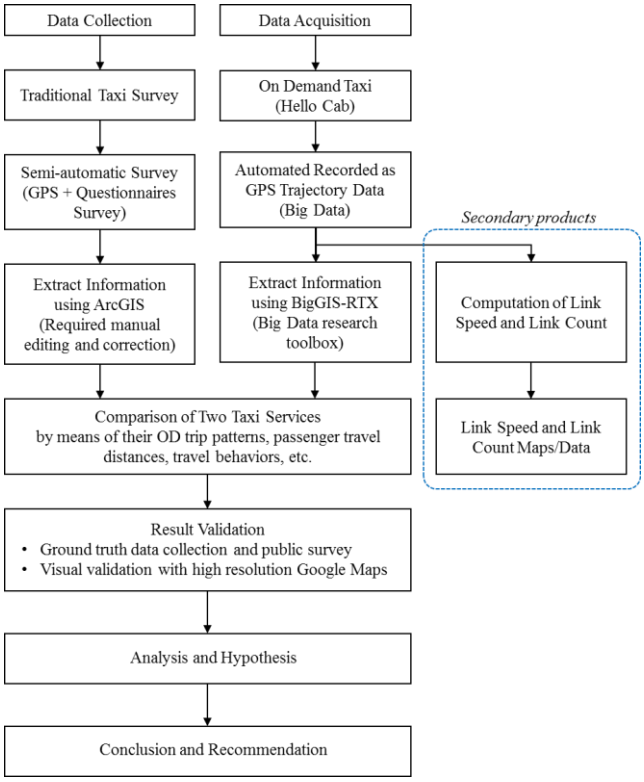


Figure2. Research Work Flow

3.3 Data Collection

The experiment was carried out by the following procedures. Firstly, the taxi GPS data used in this study was collected from two sources. The first one was collected at traditional "hailed on street" taxi services by equipping GPS devices at their vehicles. Most of the traditional taxis in case study area of Yangon City are not installed GPS devices yet. Therefore, smart phone devices enabled GPS tracking were needed to install on taxis to monitor the operation of each taxi. In this study, the taxi GPS data were collected from about 300 taxis in Yangon City. The data were collected within 31 days from 19th March, 2017 to 11st July, 2017.The duration of collection starts from 7:00A.M to 6:00P.M. The dataset of taxi trips has complete information of study time, including temporal and spatial information acquired by GPS such as id, user, GPS date and time, longitude, latitude, accuracy, speed, and bearing are automatically collected approximately every 5 seconds but not included taxi status such as hired and vacant. The second GPS data are secondary data and it was requested from a taxi service company (Hello Cab). For analysing taxi travel time, these data are more sufficient than traditional GPS data because six statuses of taxi conditions are included: free, offered, on call, hired, logged out, and on break. But this GPS system was not recorded speed data and also there were complex data format. The data included 25 days from 5th June to 29th June; 2017 is provided by Hello Cab Taxi Company. The company has their vehicles equipped with GPS receivers in order to monitor the operation of each taxi. Taxi equipped with GPS are called "floating" cars, which can monitor the running status of real time traffic. From these GPS data, 6,680 taxis are recorded and 21,582 trips of occupied trips and 24,223 trips of vacant trips are used as dataset for travel analysis. The travel time varied according to the different time period in a day, and travel time is significant factor to effect driving behaviour of the taxi.

3.4 Data Preparation

GPS data from traditional "hailed on street" taxi service are difficult to estimate occupied time, vacant time, delay time at intersection, and congestion time. To solve this problem, there have two solutions: (1) lapping map layer and GPS points (2) validate GPS points with questionnaire time. The first method include GPS point data are matched with geometries intersection map layer and Yangon road network map layer into GIS software to determine the delay time at intersection and congestion time. The second one will help to record actual occupied and vacant time. The hand written questionnaire form included trip origin address, trip destination address, pick-up and drop-up times, number of passengers and fare.

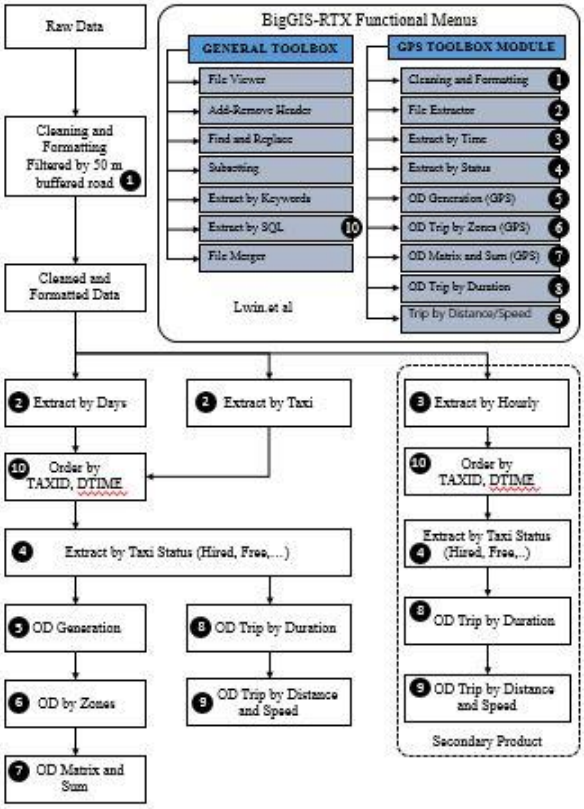


Figure3. Data Processing Workflow Using BigGIS-RTX

The secondary raw GPS data cannot be used directly for analyzing taxi travel time. Therefore, cleaning and screaming process is needed to be done for secondary big data by using BigGIS-RTX (Big Data Research Toolbox). Figure.3 shows data processing workflow using BigGIS -RTX. There are two functional menus in BigGIS- RTX to handle the big taxi GPS data. GPS toolbox module can be used to calculate the detail taxi data processing. General toolbox is essential to extract the data which apply in data processing. In Figure, data processing is mentioned step by step with the citation of serially number. Big taxi GPS data can be extracted according to taxi list and day list by BigGIS-RTX (Big Data Research Toolbox). Taxi status can also be extracted from big data so that OD trip generation and duration of OD trip can be analyzed for OD analysis. OD trip generation can produce zonal OD trips and OD matrix. Distance and speed of OD trip can be calculated by using duration of OD trip. Figure.4 shows example of Hello Cab data for one taxi. In big taxi GPS data, computation of time and location of origin and destination is based on taxi status of GPS data. For example, origin and destination will be considered the start and end points of hired status and there is not included the status of “offered” duration and “on call” duration.

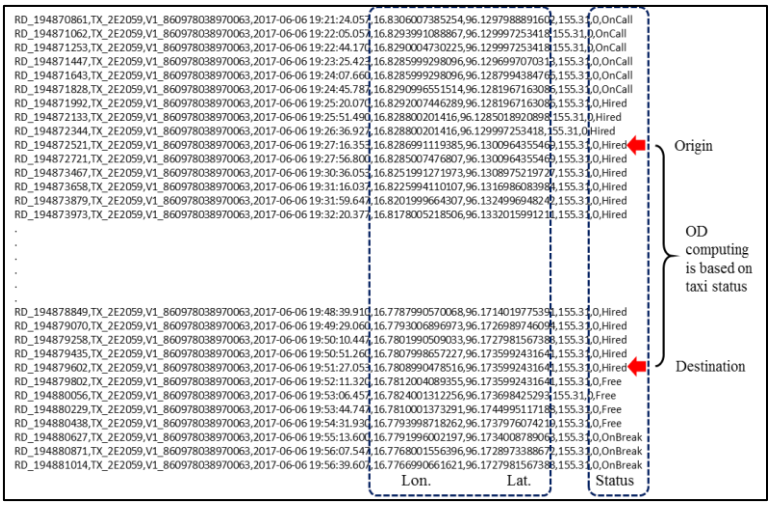


Figure4. Example of Hello Cab Data for One Taxi

4. RESULT AND ANALYSIS

4.1 Detail Origin and Destination Analysis Based on Big GPS Data

The pick-up and drop-off location of the taxi in different time periods represents origins and destination of trips, respectively, demonstrating the spatiotemporal characteristics of the passenger and driver behaviors. The research is organized with big GPS secondary data and primary GPS data. But the analysis of taxi travel behaviors are based on big GPS data as the available taxi sample data of on demand taxi is higher than primary GPS data of the traditional taxi. And also GPS data of on demand taxi can be detected the taxi status automatically so that these data are sufficient to build O-D matrix.

The taxi O-D matrix can be detected the passenger flow form township to townships. This analysis can also be identified the number of taxi trip origin (pick up) and taxi trip destination (drops offs) of taxi drivers on each township. Figure 5 shows the total origin and destination trips of “on demand taxi” by 32 townships in 24 days in Yangon City. The graph shows that the total origin and destination trips of some townships are less than the other townships. This is because (1) these are new suburbs areas (2) the taxi drivers are not willing to go these townships as they are far from CBD area and (3) the dispatch taxi market cannot extend to these townships. In this research, these kinds of townships are neglected to analysis taxi travel behavior such as building O-D matrix. Therefore, only twenty-five townships, study area, are selected for analysis. According to Project of Comprehensive Urban Transport Plan of the Greater Yangon (YUTRA), taxi trips are mostly travelling to these twenty-five townships. The time frame of taxi travel behavior analysis is 7:00 AM to 6:00 PM.

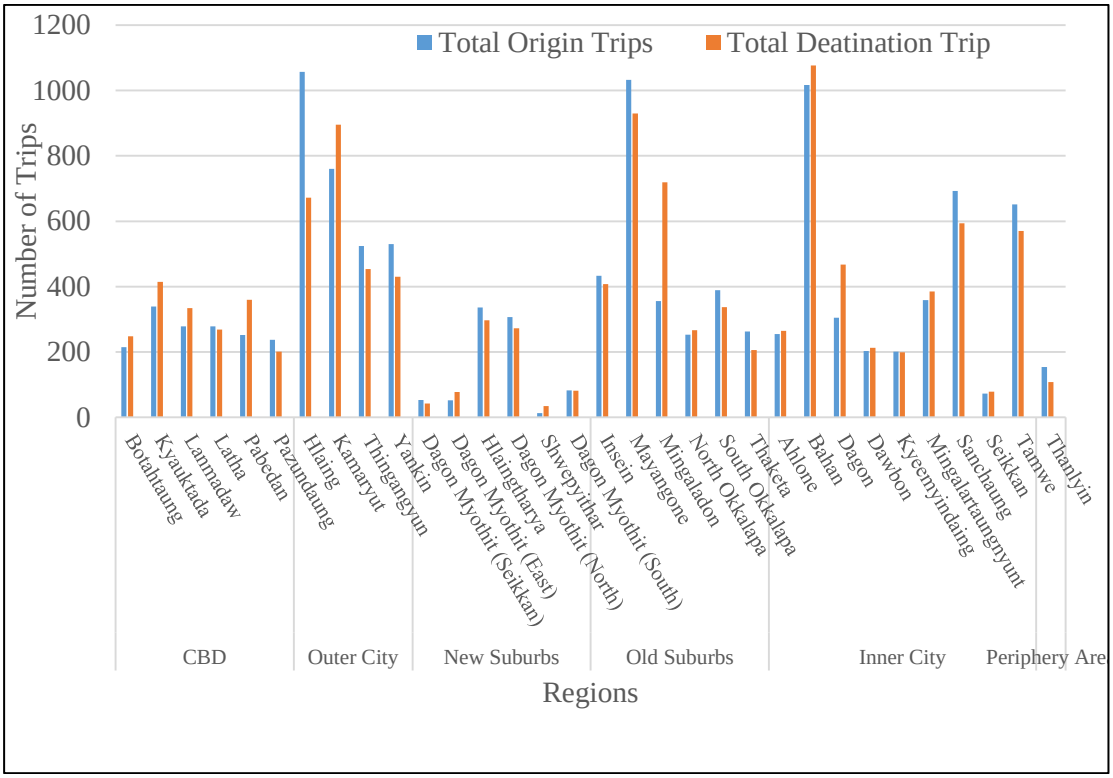


Figure5. Total Origin and Destination Trips of "On Demand Taxi" by 32 Townships in 24 Days in Yangon City.

The detail origin and destination analysis based on big GPS data of "on demand taxi." At the weekday, the daytime populations of commercial area are high and also the passengers mostly hire taxis to go to their jobs. Therefore, the weekday origin and destination trips of "on demand taxi" are more than the weekend trips. There may be a little different amount between origin and destination trips because there have anomalous taxi trips.

In this analysis, origin and destination trips are discussed with colour range, line flow pattern, hourly trip flow and morning and evening rush hour trips are also discussed. The total origin and destination trip for the weekday is 8,484 trips. The origin weekday trips are mostly occurred at outer ring area and Mayangone Township which is one of the townships of northern suburb area.

The origin weekday trips are mostly occurred at outer ring area and Mayangone Township which is one of the townships of northern suburb area. Although these areas are not business area, they are organized with university, training centers and shopping malls. Figure.6 shows weekday origin and destination trips of "on demand taxi." The destination trips of on demand taxi can be seen as highest trips at Bahan Townships as the famous religious place and the recreation places such as lake and parks are located in there. As the "on demand taxis" can give high facilities and door to door service to passengers, they choose "on demand taxi" to go to transit place such airport, bus terminal and railway station.

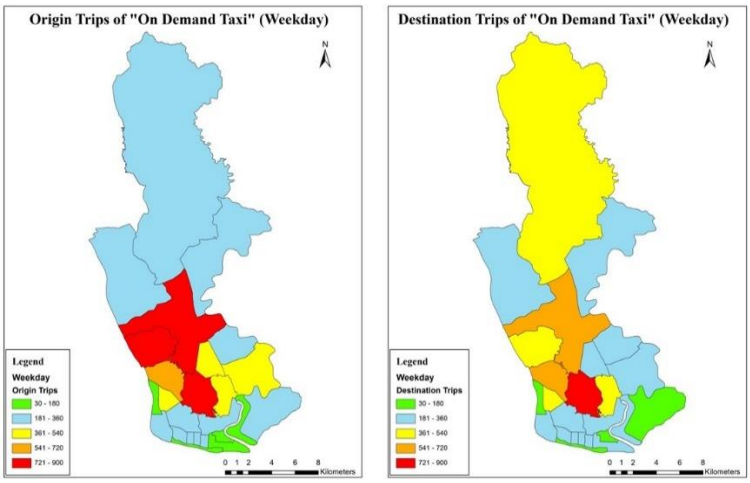


Figure6. Weekday Origin and Destination Trip of “On Demand Taxi”

Most of the weekend trips are recreational trips and many trips made to and from work are not included on weekend travel. Moreover, at weekend, the driver can get passengers less than at the weekday so that the sample size of origin and destination trips to be analysed is low. The total origin and destination trip for the weekday is 2,469 trips. Figure.7 shows weekend origin and destination trip of “on demand taxi.”

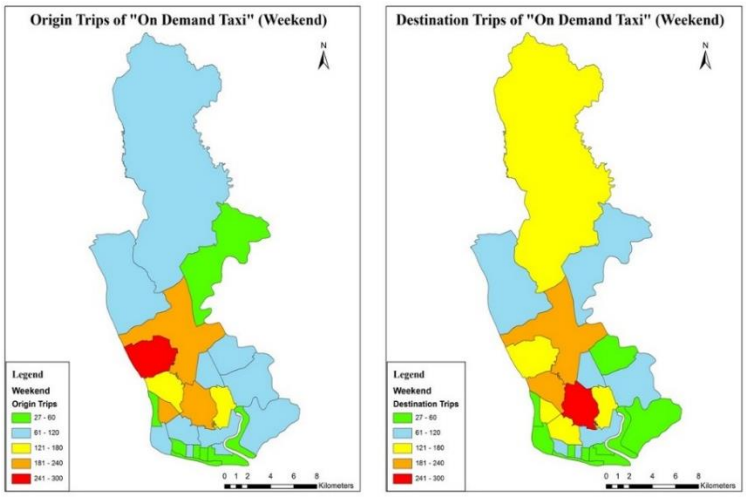
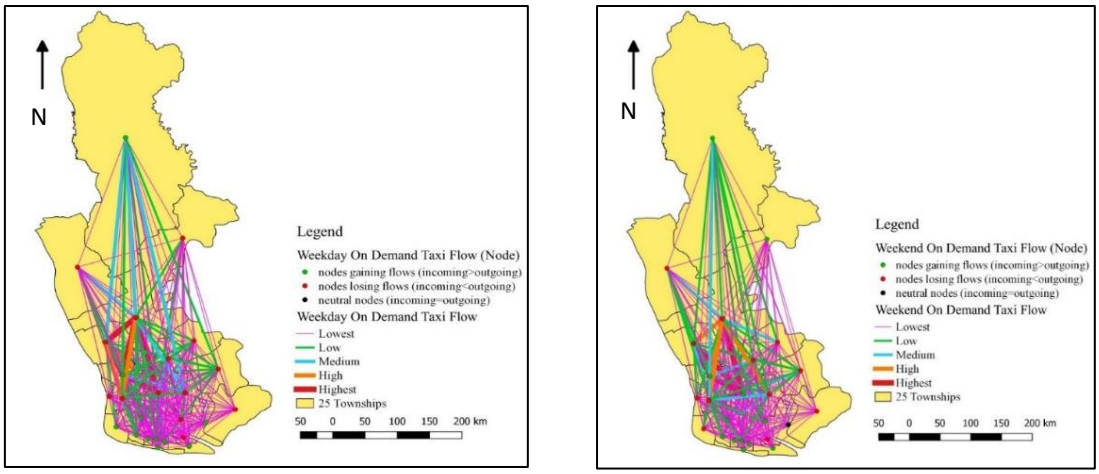


Figure7. Weekend Origin and Destination Trip of “On Demand Taxi”

This is because the wholesale market for vegetables and Hello Cab Taxi Company are situated in Hlaing Township. The second highest origin trip is occurred at Sanchaung Township, Bahan Township and Mayangone Township because these townships are organized with residential building and recreation area and most of the trips are inner zonal trips. Figure.7 shows weekend origin and destination trip of “on demand taxi.” Most of the weekend destination trips of “on demand taxi” are leading to Bahan Township because at the weekend, some of the Buddhists are going to the great Shwedagone Pagoda to pay homage with their families. The training centres, the shopping malls and parks can be seen mostly at Mayangone Township and Kamaryut Township. The weekend origin and destination trips at CBD area are less and the passengers are used “on demand taxis” to go the long distance trips.

The taxi flow is the distribution of the trip from one township to one township. The taxi flow is described with different line width bands and colours. The red line colour represents highest amount of taxi flow. The node is defined at the centre of the township. The

red colour node represents the inflow trip is less than outflow trip and green colour node shows inflow trip is greater than outflow trip. If the inflow trip and outflow are equal, the dark colour node is presented. Figure.8 (a) shows distribution of weekday flow for “on demand taxi.” The inflow taxi trips are mostly occurred at CBD area and Mingalardon Township, northern suburbs area. The taxi trips are mostly outgoing to Mayangone Township, Hlaing Township and Bahan Township.Figure.8 (b) shows the weekend origin and destination trip of “on demand taxi.” The outflow taxi trip can be seen at CBD area at weekend. The black colour node means inflow trip and outflow trip are same. Dawbon Township has the same inflow trip and outflow trip on weekend.



(a) (b)

Figure8. (a) Distribution of Weekday Flow for “On Demand Taxi”
(b) Distribution of Weekend Flow for “On Demand Taxi”

4.2 Proposing (Possible) Taxi Standing Points in Yangon City

There are two data sources for defining taxi stand points in this research. The first one is the primary taxi GPS data of “traditional taxi”. Each township in Yangon has taxi standing places but there are not actual taxi stands. As shopping centres, cinemas, pagodas and hospitals and other recreation places are having high passenger demands, the taxi drivers are waiting with long durations at these places. Finally, these places are becoming taxi standing places. The taxi drivers who stand at these taxi standing places are not permanent and can be changed. Except airport terminal, there are no seniority systems to take passengers that mean taxis are not queueing at these standing places. The taxi standing places can also be seen at the top of the streets on quarters or wards of the township and the taxi drivers who stand at these places are mostly permanent. The traditional primary taxi GPS data are mostly collected from the taxi standing places at wards of the township. There are 63 taxi standing points investigated from the GPS data of “traditional taxi” in this research. Some of “traditional taxi” standing points are near the signalized intersection and the congested road. The traditional drivers are also standing on side and road side parking. This is one of the effects to cause traffic congestion because it can decrease road capacity. Another data source is secondary big GPS data from “on demand taxi” service. From this GPS data, 62 taxi standing points are investigated. Figure.9 shows some of investigated taxi standing points in Yangon City.

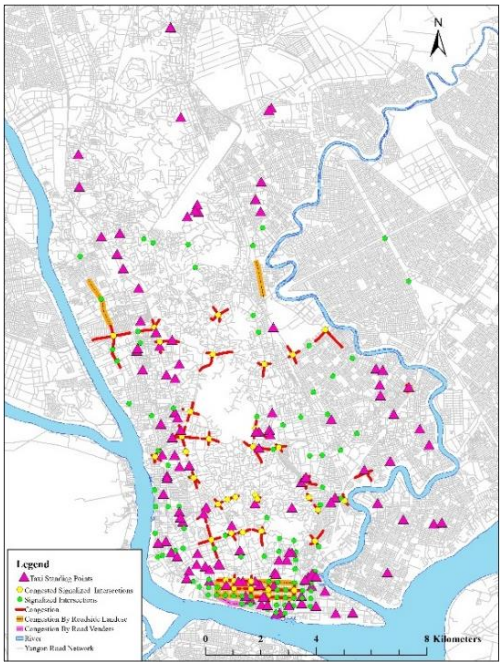


Figure9. Some of Investigated Taxi Standing Points in Yangon City

To detect the taxi standing points form big GPS data of “on demand taxi”, the status of taxi must be free or vacant condition and also the taxi travel time, distance and speed must be zero. Moreover, when the taxi is with distance zero and speed zero, it should not be defined exactly as standing condition. To define actual taxi standing points, the taxi stationary duration should be more than 10 minutes and also the more than 5 vehicles of vacant taxis are standing together at one place. The google map is used to ensure the standing location as the taxi can be stand because of signalized intersection.

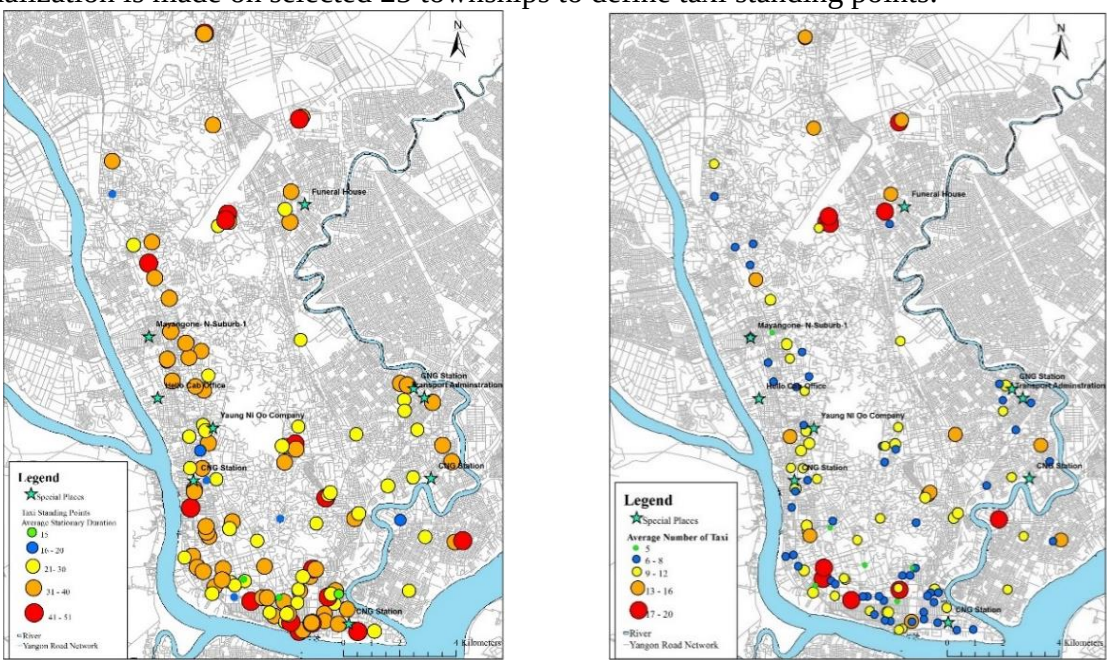
The big GPS data are handled on BigData_RTX_V3 software to analyse taxi status, the taxi travel time, distance and speed. Geographic Information System (GIS) software is used to define the taxi standing location on the map. “On demand taxis” can wait for passengers at non-congested location because they can get passengers order by assigning from Taxi Company. But this service can make congestion effect on road when they stand at road side parking and they need to take passengers at their requested origin places. The investigated taxi standing points from both taxi services can be applied in building actual taxi stands in Yangon City.

The purpose of the clustering of the average taxi stationary duration and number of taxis at studied standing points is to point out the hotspot point of taxi stand for future systematic taxi stands in Yangon City. The taxi stationary duration is calculated by average duration for each standing point. By learning the average taxi stationary duration, it can be known how long taxis are standing at each point. Sometimes, “traditional taxi” and “on demand taxi” can be situated mix at some taxi standing points. The number of “on demand taxi” at taxi standing points may be less than “traditional taxi” number. This is because dispatch taxi market (on demand taxi) is not widely used among Yangon taxi sectors during research period. Therefore, the number of “traditional taxi” is considered at “on demand taxi” standing points based on the characteristics of the location. In this research, there is having more than five vehicles at each “traditional taxi” standing point as these data are actual survey data. Average stationary duration at taxi standing points are shown in Figure.9 (a).The circle size and colour represent the amount of taxi stationary duration for each standing points. The maximum taxi stationary duration is 55 minutes and it is mostly occurred at “traditional taxi”.

The number of taxis at bus terminal and airport can be more than 20 vehicles but in this research, the numbers of taxis at these places are calculated as average. Average 5 vehicles can be calculated at each taxi standing points from big GPS data of on demand taxi. Fig.9 (b) shows average number of taxi at taxi standing points. At some taxi standing places, taxi drivers negotiate each other to take passenger with seniority system so the taxi stationary duration can be long. The more taxi number are situated at taxi standing point, the long stationary duration can be happened. If there is no seniority system, the taxi driver can get the passenger within the short stationary duration by negotiating taxi fare with the passengers. The large amount of standing taxis can be seen at the shopping centre, hospital, jetty, railway station and airport.

The other method of defining taxi standing point is visualization GPS points on the map. By visualization GPS points on the map, there can easily know the characteristics of the location on each area. In this visualization, taxi standing points, congestion points, congested signalized intersections, signalized intersections, and “traditional taxi” GPS points and “on demand taxi” GPS points are included.

Figure 10 shows example of visualization GPS points of both taxis at CBD area. The signalized intersections are continuously situated at CBD area so that most of the congestion points can be seen at this area. By visualizing the compound GPS points on the map, it can be easily separated by taxi standing points and congestion points. The taxi standing points are situated near signalized intersection, shopping mall, hospital, clinic and market. This kind of visualization is made on selected 25 townships to define taxi standing points.



(a) (b)

Figure9. (a) Average Stationary Duration at Investigated Taxi Standing Points and
(b) Average Number of Taxi at Investigated Taxi Standing Points

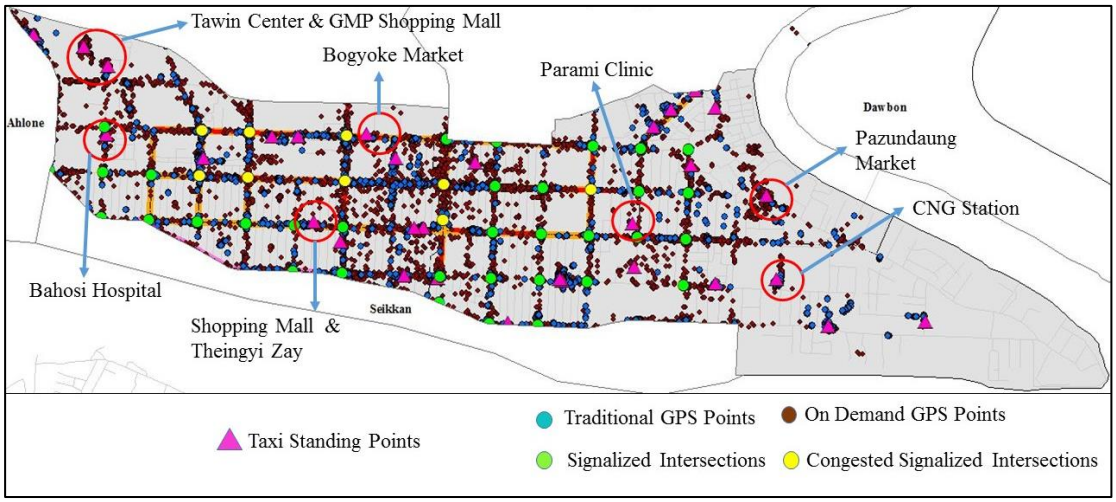


Figure 10 Shows Example of Visualization GPS Points of Both Taxis at CBD Area

The previous data analysis such as defining taxi standing points based on GPS data of both taxis, clustering average taxi stationary duration and number of taxis at taxi standing points and visualize taxi GPS points on each area can apply in proposed for possible taxi stands in Yangon City. With the taxi GPS data, some of taxi standing points can detect and also by calculating taxi stationary duration at each taxi standing point, it can be easily known how long the taxi is standing at one point. Moreover, the number of taxis at each taxi standing point demonstrated the density of passenger demand. To know the characteristics of location at each standing point, the GPS points and taxi standing points are lapping on the Yangon map layer. Finally, the location can be proposed for possible taxi stands in Yangon City with these data analyses. Fig.10 shows the proposed for possible taxi stands in Yangon City. The total proposed taxi stand is 50 stands in this research. Some taxi stand locations can be seen near in map but actual ground condition is difficult to connect each other. These proposed taxi stand locations are based on not only GPS data but also actual ground data. And also these proposed stands are only for study area, 25 Townships in Yangon City.

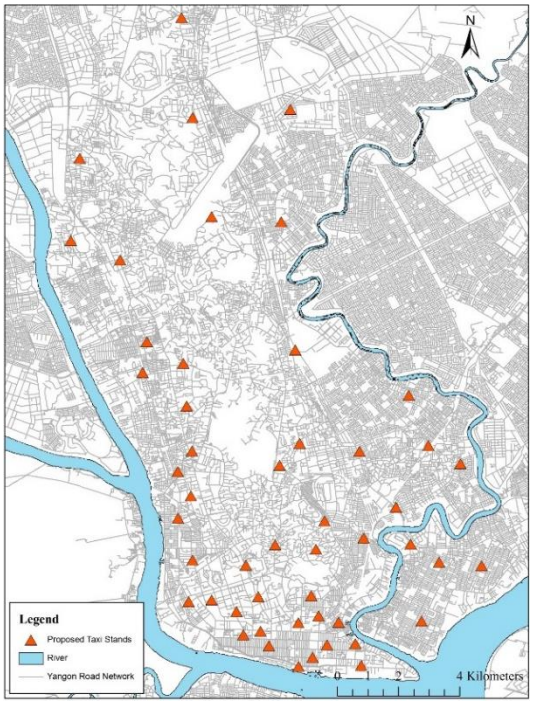


Figure10. Proposing (Possible) Taxi Stands in Yangon City

5. CONCLUSION

Nowadays, the investigation of taxi service becomes the hot issue for Myanmar government as the growing of taxi market can impact the Yangon traffic condition. Moreover, domestic and international transport operators, namely, Hello Cab, Oway Ride, and Grab are entered and emergence to compete in the Yangon taxi service sector. In this research, the comparison of different taxi services between “hailed on street” (traditional taxi) and “dispatch taxi” (on demand taxi), and the spatiotemporal pattern of taxi operation were analysed to verify the effect of taxi service on traffic congestion.

By comparing the taxi travel between “traditional taxi” and “on demand taxi” services, spatial-temporal pattern of driving behaviours between two services are investigated. This work firstly differentiates two different taxi services derived from the GPS-enabled taxi trajectory data. And also it can be support to understand taxi mobility which can cause social and economic impact on urban area. “On Demand” mostly occupied passengers at the weekday but “traditional taxi” got more occupied trips at weekend. “Traditional taxi” mostly cruises at their surrounding areas and high passenger demand areas while “on demand taxi” tends to cruise not only at city centre but also at peripheral areas. With regard to the stationary state, the “traditional taxi” generally has a much longer stationary time. The effect of the taxi on traffic congestion can be proved by detecting the stationary spots from massive trajectory data. BigGIS-RTX (Big Data Research Tool Box) is used to extract big GPS data to analyse origin and destination trip of passengers. Link speed and link count maps and data can be calculated by BigGIS-RTX. These secondary products in this research can benefit to traffic planners, road managers and public facility managers and so on. Moreover, link speed and link count data can help to define stationary condition. Based on the clustering of stationary duration and the number of stationary taxis, taxi standing places and traffic congestion are distinguished. And also ground truth data collection, public survey and visual validation with high resolution Google map are used to ensure the location of possible taxi stands. The

possible taxi stands are mostly situated at high density of people such as hospitals, shopping centre, transport terminal, residual buildings and recreation areas. As Yangon City has no stands for taxi, the hotspot GPS data and taxi standing points in this research can be used to build systematic taxi stand for each township. These stands may be reduced traffic congestion in Yangon City as taxi stationary condition at road side and on side parking cannot be happened. Moreover, these possible taxi stands are useful for not only for taxi users: taxi drivers and passengers but also transport planners.

6. LIMITATION AND FUTURE WORK

The main focus of this research is to verify the impact of taxi operation on traffic congestion in Yangon City. However, this research could not study the whole city, and only 25 townships are chosen as study area to analyze taxi services operation. Nevertheless, the primary data collected from "traditional taxis" have limitation in defining sample size because of time and resources. In this research, secondary GPS data are only used from Hello Cab Taxi Company, one of the taxi service companies in Yangon taxi transport sector. The taxi GPS data is time dependent data. The time the data collected for this research is that the dispatching taxi market (on demand taxi) is not grown widely and popular and other international taxi transport operators such as Uber and Grab are starting emerge in Yangon taxi sector. Moreover, this research focuses on day time taxi travel analysis and it could not be provided for night time travel analysis.

Future research should focus on the daily people flow mobility patterns that can be studied by lapping taxi GPS data with land use map. Based on big GPS data, it should be studied passenger searching the model and the real time information system for taxi drivers. When the taxi stand are provided systematically in Yangon City based on the possible taxi stands in this research, the investigation of road congestion condition and land use should be analysed.

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