Geographic information system application for improving Chiang Mai University tourism routes

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Abstract: Chiang Mai University (CMU) is ranked as an attractive destination for Chinese tourists. The university has launched a 'Visit CMU' project to serve the tourists with the electric-power vehicles for campus sightseeing. In addition, the tourism schedule has not satisfied the university's expectation including unattractive locations in a current route, therefore, an objective of this research is to study and propose an optimal tourism route in CMU. Travel time data of each point were collected and analysed by a statistical method. Attractive sightseeing places were selected from experts by using an interview. Lastly, all data were employed to generate a computer-simulated scenario by a geographic information system (GIS) program. The results of this research showed that the generated optimal tourism route in GIS by adopting operation times of each tourism electric power vehicles point which had different characteristics and experts' suggested tourism points reduced the travel time and distance.

Keywords: tourism; logistics; vehicle routing problem; VRP; geographic information system; GIS; university traffic.

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1 Introduction

Chiang Mai is one of the most Thai attractive tourism destinations for foreign tourists, especially from People's Republic of China (PRC). This province has not only a number of beautiful places but also Lanna culture, lifestyles and traditions which are a colourful combination of various elements from both historic and multi-ethnic perspectives. Chinese tourists have travelled in Chiang Mai around 40,000 people in 2011 and sharply increased to 150,000 people in 2014 (Tourism Authority of Thailand, 2014). Sangkakorn et al. (2013) surveyed Chiang Mai tourist attractions from Chinese travellers by using a questionnaire and found that Tha Phae gate was ranked in the first place (73.4%), followed by Phrathat Doi Suthep temple (58.5%), Chiang Mai night bazaar (58.5%) and Chiang Mai University (CMU) (53.6%).

The university has launched clean and green transport service projects to solve a transportation problem by operating electric-powered vehicles. On one hand, a CMU electric shuttle car project is established to serve CMU students and staff. On the other hand, a 'Visit CMU' project serves a campus tourist's sightseeing. The first project was analysed and proposed solutions for improving the logistics system via simulation models (Wanitwattanakosol et al., 2014). However, there are significant gaps in the tourism project to bridge for better performance.

The 'Visit CMU' project was designed to handle foreign tourists, especially, Chinese visitors. It should be noted that the project approximately supports three hundred Chinese passengers per day. CMU travel service centre has provided visitors to scenic and historic locations with information on the attractive locations and other items relevant to tourism. Nevertheless, the project has increased university traffic problems. In addition, the tourism schedule has not satisfied the university's expectation (30 minutes per trip) including unattractive locations by operating a current route. Hence, the CMU tourism logistics system should be improved to provide quality tourism services by considering university constraints.

The tourism logistics system is a highly complex and dynamic phenomenon from several groups of activities (Mrnjavac and Ivanovic, 2007). The tourism sector structure determines the value chain and all stakeholder interaction in the destination attractiveness. Tourism logistics aims to continuously optimise flows of goods, people, information, energy, knowledge, capital and waste (Stipanović and Rudan, 2014). The development of tourism logistics requires understanding of the behaviour and needs of tourists together with designing a responsive logistics system. System responsiveness evaluation, new route design and implementation should be considered to develop an effective creative tourism and logistics policies (Ngamsirijit, 2015). Hensher (1993) stated that tourism research and transport research are strongly relative identical in theoretical and analytical tools. Moreover, the substantive problem is often of mutual interest.

Vehicle routing problem (VRP) is considered to encompass all of study and practice in transportation models (Pillac et al., 2013). The traditional objective in the standard VRP is to minimise the total distance travelled by all vehicles for satisfying the demands of a set of customers, subject to side constraints (Demir et al., 2014). Maden et al. (2010) examined the effects of using road timetable data using real data for a vehicle fleet delivering electrical wholesale items in the South West of the UK. Travel times were derived from a vehicle to travel along any road in the network that particularly vary during morning and evening rush hours. The results demonstrated that using a proposed heuristic provide a more reliable basis of the total distance, the total required time and the total CO_2 emissions. Buhrkal et al. (2012) applied a heuristic approach for the waste collection VRP with time window of Danish garbage collection company instances. The models were built to find cost optimal routes for garbage trucks while respecting customer time windows and two break types concerning the driving times. These two case studies are referred into forward and reverse logistics operations, respectively. Mingle and Xiaoming (2016) made a framework to find the shortest tourism line by spending the less time in an economic perspective. As shown in the results, a feasible measure based on a 201 5A Class Chinese touring scenic region was investigated the performance as an appropriate schedule.

Only a few papers have addressed the issues of routing in the tourism VRP context. The 'Visit CMU' project is considered for the study. This paper also addresses the utilisation of the computer-simulated scenario by a GIS program. An objective of this research is to study and propose an optimal tourism route in CMU. The rest of this paper is structured into different sections. Tourism VRP is reviewed the interfaces among these concepts and analysed their relationships in Section 2. Section 3 outlines the research methodology. Results and discussion are described in Section 4. Finally, Section 5 concludes this research and scopes for future research.

2 Tourism VRP

A growth rate of international tourism demand plays a significant role in the economic growth of a small tourism-driven economy (Schubert et al., 2011). Tourists tend to select a vacation experience on all components of a complex tourism system based on the quality and satisfaction (Weiermair, 2000). Enright and Newton (2004) stated that a destination's tourism competitiveness has become a major economic issue. They proposed quantitative measures of competitiveness by combining generic factor of competitiveness and the mainstream factors of destination attractiveness. The Delphi technique is a widely-used and accepted method for achieving convergence of opinions from experts within tourism researches. Rio and Nunes (2012) used this technique to identify and select 36 sustainable dimension factors. Route tourism can play a catalytic role in the world's best hope for securing sustainability in travel and tourism, especially for an economic pillar. It is one of the important parts in a market-driven approach to tourism destination development (Lourens, 2007).

The tourism route is not a new phenomenon which was originated with the growth of pleasure motoring and car-based tourism during the first decades of the 20th century (Denstadli and Jacobsen, 2011). A challenging in vehicles routing area and related transportation, distribution and logistics industry is to find the shortest path in road networks (Nha et al., 2012). VRP is an example of a combinatorial optimisation problem and is known as NP-hard. Eksioglu et al. (2009) investigated a taxonomic review of the VRP literature in five different aspects as:

1 type of study
2 scenario characteristics
3 problem physical characteristics
4 information characteristics
5 data characteristics.

VRP has been widely studied by a number of researchers from OR-LIBRARY to practical contexts. Silva and Leal (2011) proposed multiple ant colony system (MACS) by implementing in the Java environment for comparing results of six standard VRPs with benchmark algorithms. These problems were determined the minimum cost routes to meet the demand of customers. Ganesh et al. (2014) modelled the VRP with delivery and collection of a public healthcare system. A public health care system with central blood banks, regional blood banks and blood camps was considered for the study to ensure that all blood-related demands are met. An example application of the VRP in tourism transportation planning was proposed by Iliopoulou et al. (2015). A design of efficient routes of a seaplane service was solved with the use of a genetic algorithm for generating routes serving neighbouring the Aegean Sea islands and fully satisfy local ridership between them. However, it should be recognised tourism perspectives on VRP developments in theory and applications because of there are also significant gaps in the tourism sectors used to test models limiting more general applicability.

Moreover, information plays a key role in tourism paradigm for deciding different plans of action by their complexity, often being intermingled, non-transparent, individualistically-dynamic and requiring the achievement of multiple goals (Wöber, 2003). Buhalis and Law (2008) affirmed that information communication technologies have changed radically the efficiency and effectiveness of tourism organisations such as mobile phones with global position systems (GPSs). Kennedy-Eden and Gretzel (2012) developed taxonomies of mobile apps in tourism by establishing service provided and the level of user interactivity. The first taxonomy comprised navigation, social, mobile marketing, security/emergency, transactional, entertainment and information. Preferences, location sensitive, security, control through web, content added, aesthetics and same for all were classified into the taxonomy for user interactivity level. Beeco et al. (2013) used GPS to track travel routes of four groups: low planning and low wandering (ambivalent travellers), low planning and high wandering (traditional wanderers), high planning and low wandering (traditional planners) and high planning and high wandering (planned wanderers).

Development for applied tourism geographical research has been in the use of geographic information systems (GISs) which incorporates more sophisticated systems to search, query, present and analyse data in a spatial context (Hall and Page, 2009). The spatial character intrinsic to the routing field requires the integration of GIS and optimisation approaches to handling spatial and non-spatial data in transportation applications (Tlili et al., 2014). McKercher et al. (2012) found the behaviour patterns of first-time and repeat tourists to Hong Kong by employing GPS combined with an analysis using GIS. Results revealed that two groups spent different amounts of time at the same locations and visit during different times of the day.

3 Research methodology

This section presents an approach for finding the optimal tourism route by applying various concepts. Firstly, basic data of a CMU tourism routes were observed in describing the general operation context. In essence, CMU route tourism simply means linking together a series of attractions in order to promote sightseeing in the campus. During the tour, tourists will be guided and lectured about the university’s history and dimensions beyond the natural attractiveness including academic arenas, university’s researches and social services. Travel time data of each station point were collected and analysed by a statistical method for determining a significant distribution at a 95% confidence interval. In order to gather consensual ideas about the attractive elements for CMU, the research team adopted a Delphi method using an iterative process. The individual interviews allowed better interaction with the experts, making explicit their assumptions and collecting more detailed comments. Finally, all data were employed to generate a computer-simulated scenario by a GIS program. This GIS information created a new opportunity to eliminate the limitations identified by gathering accurate information on the time-space movements of tourists at a fine level. There are three steps as described below.

3.1 CMU tourism route observation and data collection

The CMU route for tourists was observed to conduct basic information by interviewing transportation service officers. The attractions are selected and developed adequate to the main theme and applying management methods. Numerical duration data with noises (such as traffic congestion) of electric-powered vehicles were obtained by using time study sheets. The quality of results by mimicking a model is rigorously related to the quality of the input data and probability distribution functions. The Input Analyser was employed to observe historical data for estimating a probability distribution and parameters. All statistical distributions were analysed by the goodness of fit tests (the Kolmogorov-Smirnov test or the chi-square test). P-value is an index measuring the strength of evidence against the null hypothesis. Hence, this research adopted the p-value approach to hypothesis testing at 0.05 for the observed level of significance. GPS track point data also were recorded in a regular and structured way. Probability distribution functions and GPS data were used in a simulation unit for managing, analysing and presenting data with reference to the basic cartographic topography.

3.2 A Delphi survey

This step presented results of the Delphi technique conducted into expert opinion on CMU attractive locations to develop the tourism route. Pertinent questions were prepared to ask two tourism academicians and the Visit CMU project supervisor. Following the Delphi procedure, the study comprised two rounds of deliberation. For each iteration, respondents involved individual interviews. The first questionnaire included questions that covered an existing CMU route tourism. After reviewing the results from the first round of the Delphi study, the research team devised statements that summarised the consensus for each of the identity elements and used them to prepare a new questionnaire. The same participants then received the revised questionnaire. A review of the results from the second round of questioning showed more consensus about the attractive elements. The traditional usage of the Delphi technique is a predicting process. A closely-adapted approach could enjoy the benefits of being able to generate opinion from geographically-dispersed experts and move towards consensus on any issue (Miller, 2001).

3.3 A simulated model and implementation

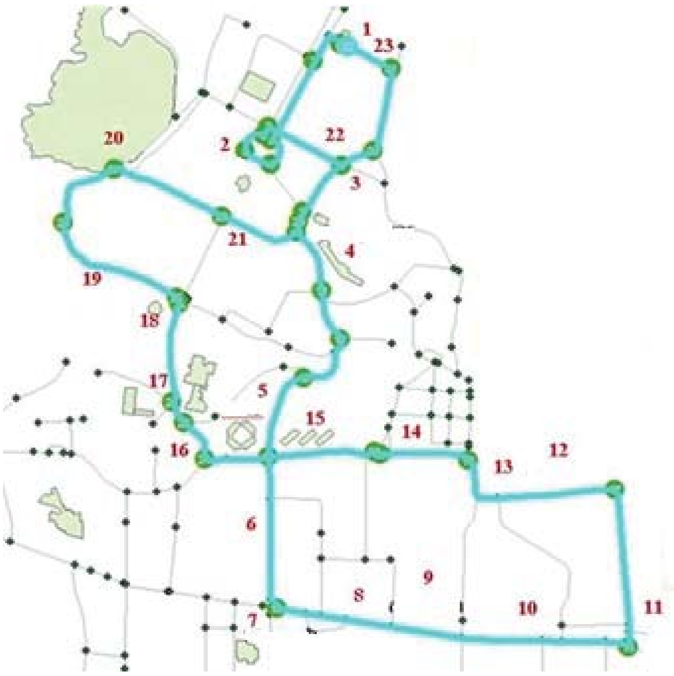
The GIS simulated model by using spatial data and attribute data is capable of performing spatial analysis for displaying spatial information and describing tourism issues. Point locations around the CMU tourism route were collected with a GPS phone tracker application (Find My Latitude and Longitude application). The data points were input into the ArcGIS 10.2.2 software package to create a point coverage representing discrete point locations. These data were converted into shapefiles format in Universal Transverse Mercator (UTM) Grid Coordinate. A satellite imagery was used to digitise data for CMU geodatabase. The UTM projection was integrated with the satellite images for georeferencing. After georeferencing the map, the main geographic features such as roads, polygon buildings and CMU landmarks were digitised and incorporated into the baseline GIS database. Next, the corrected data were verified their position on the ground and validated by checking the ArcGIS 10.2.2 topology toolbar. A CMU geodatabase network dataset was created for setting tourism route conditions. The ArcGIS Network Analyst was performed to optimise distance and time. Finally, the proposed route was implemented to compare with simulation results.

4 Results and discussions

To develop the optimal tourism route, an overview of CMU tourism route should be described for understanding the current route problem. The University daily opens for tourists during 8:00 AM–6:00 PM and provides a touring of the campus by operating six electric cars. The maximum certified carrying capacity is 13 passengers. A starting tourism point is the car park point at the front of the university. Tourists are not allowed to get down from the electric car while they are touring the campus. However, they are allowed to get down at Angkaew reservoir to walk around and take photographs for 15 minutes. After that, the electric car brings tourists back to the same car park; the round trip is around 30 to 40 minutes.

A general CMU tourism trip as shown in Figure 1 is 5,797.01 metres, covering 22 positions as described in Table 1. Except in peak hours on a weekday between 4:00–6:00 PM, the trip is rerouted to 5,120.43 metres which covered 19 positions as exhibited in Figure 2 and Table 2. Typically, the electric car is released from the starting point either at the maximum capacity or waiting 15 minutes. It should be noted that a tourism schedule could not be established on this excess demand circumstance.

Figure 1 General CMU tourism trip (see online version for colours)



Nineteen points covering the existing routes were designed for collecting duration data. This dataset was analysed in numerical experiments by using the input analyser. Each point was fitted best based on theoretical distribution to the observed 97 time data. Figure 3 displays a sample of the electric-powered vehicle analysis that departs from the first station. The first collected point was distributed with Weibull distribution (corresponding p-value = 0.407). Table 3 exhibits the summary of collected point distribution characteristics. It should be notified that some noise data were screened from specified collected points. Table 4 shows average duration times for both CMU tourism types. The board of university expects that each trip should not exceed 30 minutes.

Next, subject selection and the time frames are two parts which should be regarded carefully when conducting and completing a Delphi study (Hsu and Sandford, 2007). By applying two round Delphi technique, three experts answered questions such as which places should be a sightseeing for the CMU tourism trip? How to improve the CMU tourism trip? Results by using the Delphi were essential for designing the tourism route. Three experts agreed that Sala Dham Hall, clock tower, Pin Mala Art Hall and Angkaew reservoir are attractive locations. Nevertheless, a story of each place plays an important role to present to tourists when they are travelling in the proposed route. These suggested locations must be contained in a rerouting plan.

Table 1 Description of general CMU tourism trip

Position	*Place*	*Position*	*Place*
1	Car Park	13	Women's Dormitory(b)
2	Sala Dham Hall	14	Tennis Court
3	Office of the University	15	Women's Dormitory(c)
4	Faculty of Political Science and Public Administration	16	College of Arts, Media and Technology
5	Student Union	17	University Library
6	Men's Dormitory	18	Pin Mala Art Hall
7	Clock Tower	19	Faculty of Social Sciences
8	Rujirawong Swimming Pool	20	Angkaew Reservoir
9	Main Stadium	21	Information Technology Service Centre
10	International College	22	Rugby Field
11	Gas Station	23	Car Park
12	Women's Dormitory (a)		

Figure 2 Peak hours CMU tourism trip (see online version for colours)

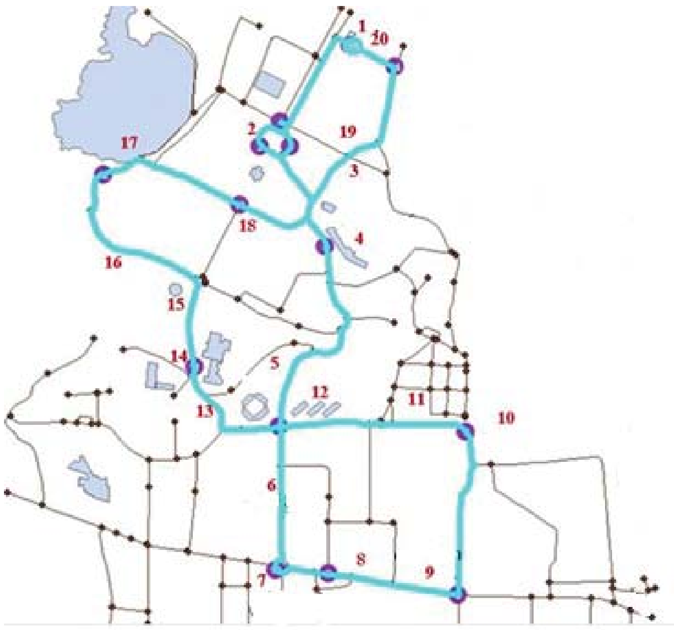
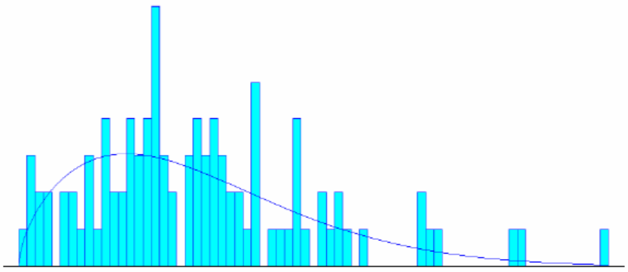


Table 2 Description of peak hours CMU tourism trip

Position	*Place*	*Position*	*Place*
1	Car Park	11	Tennis Court
2	Sala Dham Hall	12	Women's Dormitory(c)
3	Office of the University	13	College of Arts, Media and Technology
4	Faculty of Political Science and Public Administration	14	University Library
5	Student Union	15	Pin Mala Art Hall
6	Men's Dormitory	16	Faculty of Social Sciences
7	Clock Tower	17	Angkaew Reservoir
8	Rujirawong Swimming Pool	18	Information Technology Service Centre
9	Main Stadium	19	Rugby Field
10	Women's Dormitory (b)	20	Car Park

Figure 3 Histogram and the data characteristic of the first point (see online version for colours)



Distribution Summary
Distribution: Weibull
Expression: 43.5 + WEIB(0, 0)
Square Error: 0.009037
Time unit: Minute
Corresponding p-value: 0.407

Point locations were collected with a GPS phone tracker application and converted in UTM format for developing the baseline geodatabase as displayed in Table 5. There are some advantages in using UTM coordinate system such as grid squares are the same size and shape throughout the map, all measurements are done in metres, coordinates are always positive, etc. (Geokov, 2016). ArcGIS 10.2.2 software package created discrete point locations as illustrated in Figure 4. The satellite image from ArcMap was used to digitise data and integrated with the UTM projection for georeferencing as indicated in Figure 5. Next, CMU main geographic features were digitised as lines and polygons for roads and CMU landmarks as shown in Figures 6 and 7, respectively.

Table 3 Summary of the CMU tourism distributed characteristics (start from car park)

Point	*Collected point*	*Data points*	*Distribution*	*P-value*
1	Sala Dham Hall junction	97	Weibull	0.407
2	Sala Dham Hall roundabout	97	Weibull	0.234
3	Office of the University junction	97	Gamma	0.26
4	Faculty of Political Science and Public Administration	97	Gamma	0.179
5	Student Union junction	92	Triangular	0.448
6	Men's Dormitory	94	Erlang	0.613
7	Clock Tower junction	70	Triangular	0.258
8	Rujirawong Swimming Pool	97	Erlang	0.111
9	Main Stadium	97	Lognormal	0.0615
10	Women's Dormitory (b)	79	Normal	0.362
11	Tennis Court	84	Triangular	0.189
12	Women's Dormitory (c)	97	Lognormal	0.659
13	College of Arts, Media and Technology	75	Gamma	0.0975
14	Pin Mala Art Hall	97	Normal	0.0642
15	Angkaew Reservoir	97	Normal	0.0554
16	Information Technology Service Centre	82	Beta	0.589
17	Faculty of Political Science and Public Administration	97	Erlang	0.607
18	Office of the University junction	97	Gamma	0.307
19	Car park	78	Beta	0.323

Figure 4 Referenced locations in the software package (see online version for colours)

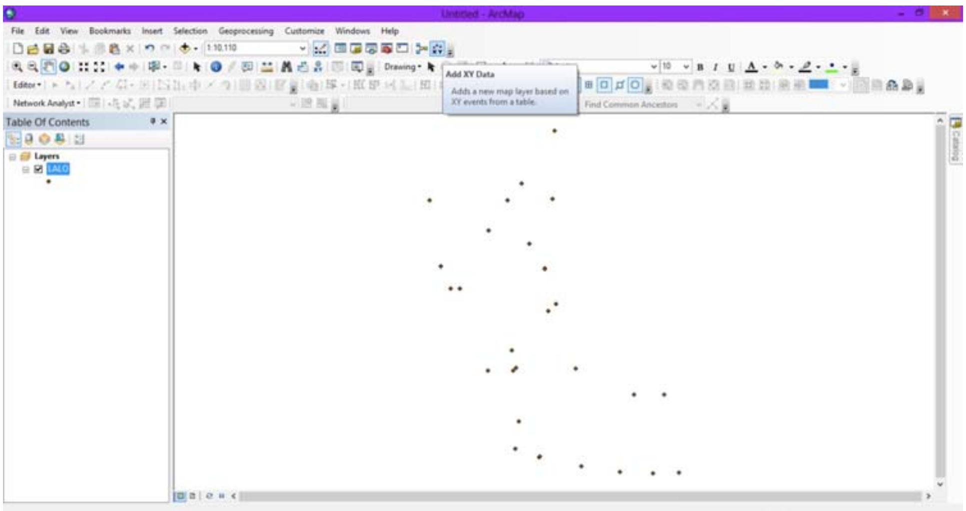


Table 4 Average duration time of CMU tourism trips (unit: minute)

Point	*General trip*	*Peak-hour trip*
1	1.05	1.09
2	1.42	1.51
3	0.29	0.28
4	0.35	0.35
5	1.51	2.06
6	0.59	1.04
7	0.21	0.24
8	0.27	0.28
9	0.27	0.37
10	3.06	4.41
11	0.52	0.52
12	0.54	0.57
13	0.31	0.35
14	1.16	1.17
15	1.51	1.55
16	0.58	1.05
17	0.30	0.30
18	0.34	0.36
19	1.24	1.29
Parking at Angkaew Reservoir	15.00	15.00
Total	35.00	37.46

Table 5 CMU tracking point locations

Point location	*GPS coordinate*		*UTM*	
	Latitude	*Longitude*	*Easting*	*Northing*
Car Park	18.807697	98.954742	495231	2079550
Sala Dham Hall	18.805302	98.953033	495051	2079285
Office of the University	18.805353	98.954651	495221	2079291
Student Union Junction	18.799454	98.953232	495072	2078638
Clock Tower	18.796778	98.953308	495080	2078342
Rujirawong Swimming Pool	18.796516	98.954208	495175	2078313
International College	18.795961	98.959236	495704	2078252
Women’s Dormitory (a)	18.798630	98.958687	495647	2078547
Women’s Dormitory (b)	18.798651	98.957611	495533	2078549
University Library	18.801554	98.950974	494834	2078871
Pin Mala Art Hall	18.802279	98.951317	494870	2078951
Angkaew Reservoir	18.805313	98.950218	494754	2079287
Information Technology Service Centre	18.804274	98.952339	494978	2079172

Figure 5 The satellite image (see online version for colours)

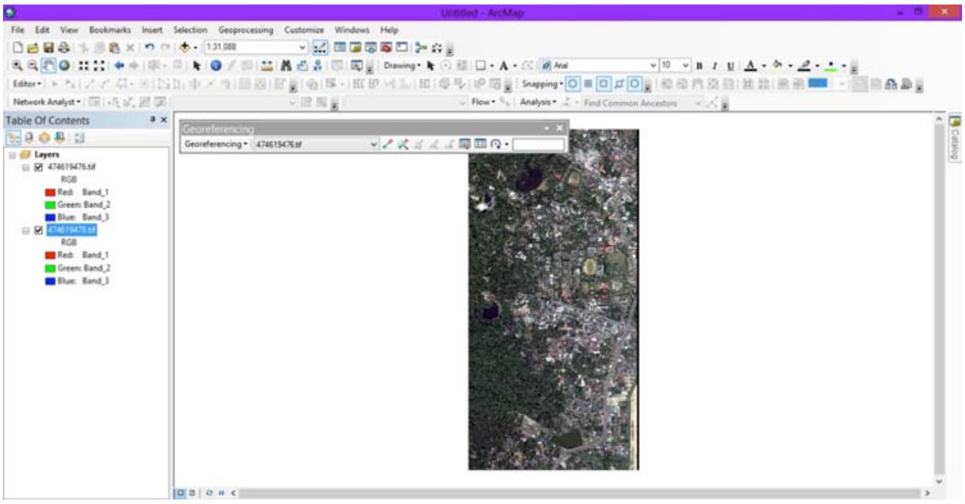
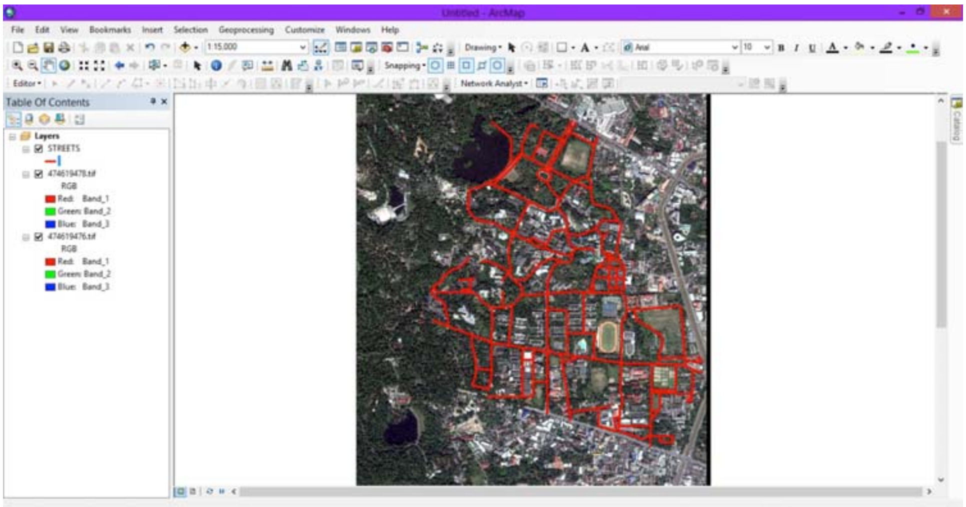


Figure 6 The digitised CMU roads (see online version for colours)



This research observed that there were no discrepancies in the data between ground verification and the satellite-based maps. Therefore, the GIS database was highly accurate. The topology toolbar was used to determine the model validity and check data quality which is the presence of gaps or overlaps in a polygon. This tool could set rules for the topology such as Must Not Overlap, Must Not Intersect, etc. as exhibited in Figure 8. Finally, the topology was checked the validity as shown in Figure 9.

The network dataset was created for setting tourism route attributes such as one-way restriction, time, distance, etc. The ArcGIS Network Analyst was performed based on the network dataset to optimise distance and time. All attractive locations were set for finding a new route. The simulated new route was 4,230.10 metres which comprised of 14 positions as shown in Figure 10. This proposed trip started from car park, including

Sala Dham Hall, Office of the University, Faculty of Political Science and Public Administration, Student Union, Men's Dormitory, Clock Tower, College of Arts, Media and Technology, University Library, Pin Mala Art Hall, Faculty of Social Sciences, Angkaew Reservoir, Information Technology Service Centre, Rugby Field and Car Park. It was found that the simulated travel time was 15 minutes.

Figure 7 The digitised CMU landmarks (see online version for colours)

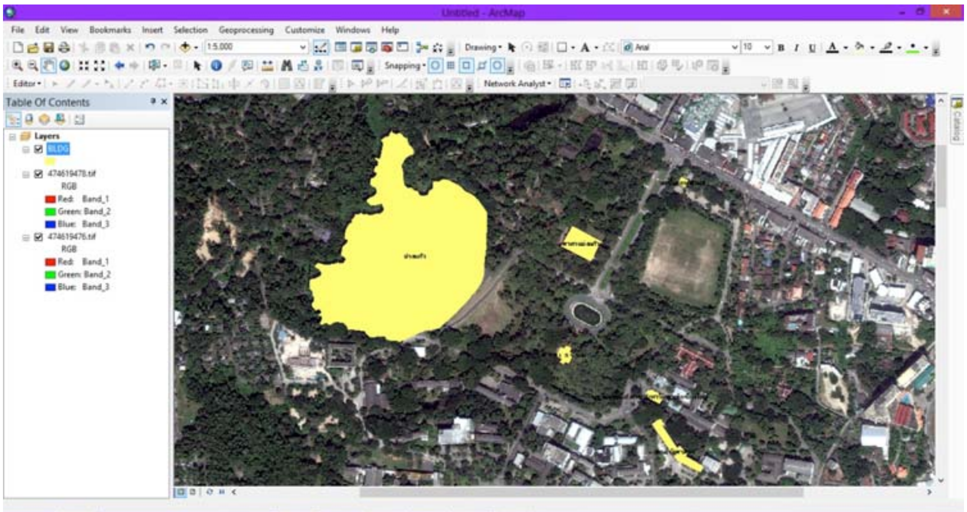
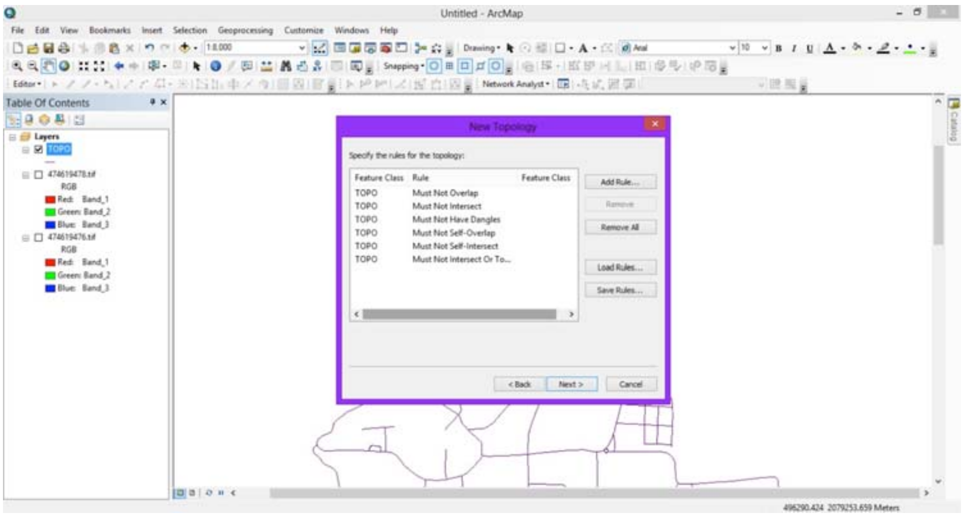


Figure 8 Rule specifications for the topology (see online version for colours)



The proposed trip was also implemented for comparing results with the simulation result. Five tested trips were conducted as 15.57, 15.26, 15.10, 14.55 and 15.26 minutes. The average difference times between the simulation model and pilot tests were 23 seconds. The percent difference of the simulation and pilot studies was 2.55. Thus, the rerouting tourism plan could satisfy the university expectation (30 minutes per trip).

Figure 9 The validated topology (see online version for colours)

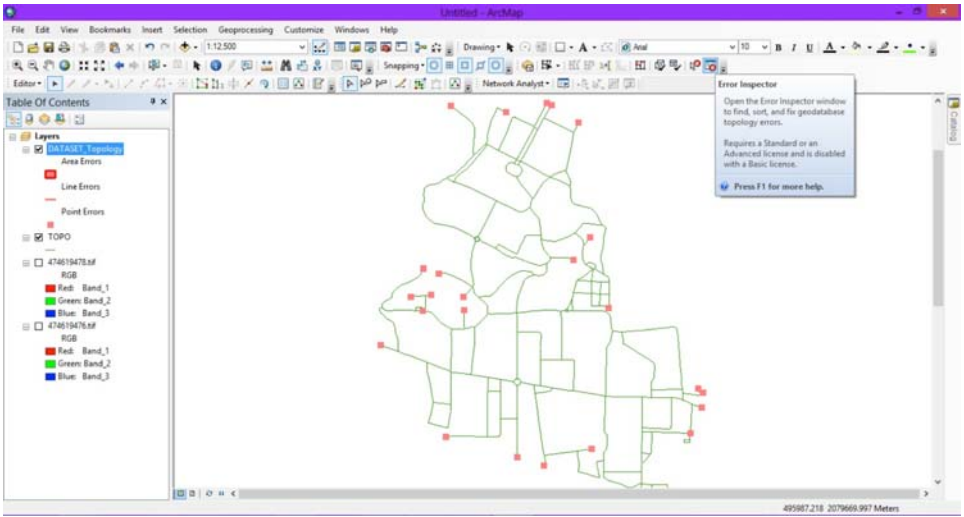


Figure 10 The simulated tourism trip (see online version for colours)

5 Conclusions

The optimal tourism route in CMU was generated by adopting operation times and experts' suggested tourism locations. The simulated route is capable of a better solution than current routes. It decreases the distance when comparing the general trip and the peak hour trip as 27.03% and 17.39%, respectively. It also reduces travelling time as 25.00% and 33.21%, respectively. The proposed route should be of some advantages such as waiting time reduction, tourist growth support and efficient electricity management. The tourism schedule could be satisfied the university's expectation.

The main contributions of this research are:

1. VRP was applied in the tourism environment
2. the computer-simulated scenario by a GIS program was employed to solve the university problem
3. numerical experiments with real data were conducted and compared with the pilot study.

In term of a managerial implication, the tourism destination concept and GIS alone have limited capacity of improving tourism routes, but combined both of them could support improvement initiatives. Limitations of this research study are:

1. the model was based on the assumption that the speed of the electric-powered vehicles were regularly constant. If the actual situation, there are many factors that affect the speed of the vehicle such as the slope of the road, the driving speed of each driver, the traffic conditions at different times
2. the locating data form the cell phone tracking application based on GPS may be error as far as 50 feet from the exact location of the phone.

For future research, a scheduling problem should be solved by applying different heuristics.

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