International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Transport Management for Vehicles Routing Arrangement: A Case Study of Prevention and Suppression Patrol of Thai Police Stations

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Abstract: ***Coronavirus disease has affected economics and society, resulting in increasing crime problems. Under circumstances with limited patrol officers, prevention and suppression operations must be analyzed for vehicle routing for prevention and suppression patrols to reduce the patrol distance, time and fuel. This research aims to analyze the vehicle routing arrangement of prevention and suppression patrol officers and to develop a routing process model of prevention and suppression patrol management. Quantitative research is applied with the traveling salesman problem (TSP), which is utilized to establish prevention and suppression patrol routes. Qualitative research is applied with content analysis, which is utilized to develop the routing process model. The vehicle routes of the prevention and suppression patrol are arranged in the route set. These results show the average route, distance and shortest patrol time of the patrol officers, which cover all risk point patrols. Additionally, a patrol routing model is presented to arrange the process of prevention and suppression patrol operation. This key process is applied to manage the prevention and suppression patrol well, and these benefits are to reduce the patrol distance, patrol time and fuel cost. Additionally, this practice has increased the patrol rounds at risk points, resulting in the reduction in crimes and upgrading good practices in patrol operations.***

Keywords: Vehicles Routing Arrangement, Traveling SalesmanProblem, Prevention and Suppression Patrol, Police Station

1. Introduction

Coronavirus disease 2019 (COVID-19) has resulted in an outbreak around the world that has an effect on the world economy and society. Crime problems and disorders are increasing to society, and people need more security in life and property from the state. The Royal Thai Police is the main organization that is an important operation to protect the life and property of the people by preventing crime. This main goal of achieving mission policies is defined as police station practice for reducing public crime and preventive and suppressive crime (Famega 2005).

Therefore, efficiency of prevention and suppression is inevitably needed. Equipment and knowledge of prevention and suppression management require the development of crime prevention and suppression practices. The police patrol (patrol officers) has played an important role in achieving the primary duty of the police station. When crime prevention is achieved, this support increase is improved to the safety of society and life people in the whole system. Police patrols are a significant part of crime prevention and the quality that is necessary for prevention and suppression operations (Sherman et al. 2014). These data show that prevention and suppression work is developed to reduce crime management if there is a plan for good management and good prevention and suppression.

Reducing crime and being able to stop the incident, the main practice of prevention and suppression are worked in the patrol with patrol planning consisting of checkpoints or risk points. These arranged patrol routes are covered in areas responsible for police stations in various risk areas from the analysis of problems and obstacles in the operation of the patrol through a weekly meeting with the analysis of crime conditions. This finding found the main problem in the route of the patrol, which limited the patrol officers, patrol time and cost.

These problems are solved transport and logistics management by the traveling salesman problem (TSP). Patrol route analysis in the area is arranged by the efficiency distance, time and cost of patrol operation planning (Zia et al. 2018; Almahasneh & Koczy 2020). Therefore, these problems are interested in finding first solutions to solve these complications and to improve the efficiency of prevention and suppression patrol routes. This research aims to analyze vehicle routing arrangements of prevention and suppression patrols and to develop a patrol process model. This information supports the efficiency of prevention and suppression patrols and increases the maintenance of life/property safety of people; additionally, potential crime problems must be reduced.

2. Literature Reviews

2.1 Prevention and suppression patrol concepts

Prevention and suppression crime refer to the various methods that are classified as eliminating the incident source, eliminating the desire to commit wrongdoing and eliminating the potential for wrongdoing. These main police duties are operated to break the crime scene in which arresting and controlling criminals are to avoid the crime of committing

added crime and punishing criminals to cause disgust. Anti-crime measurement can be divided into two measures: 1.) Preventive measurement includes basic preventive procedures in which there are similarities and differences between these normal and proactive preventive measures. 2.) the measurement to suppress that are divided into normal suppression measurement and aggressive suppression.

In addition, crime prevention theory is classified into two groups: 1.) The theory reduces the likelihood of wrongdoing criminals, eliminating or reducing the likelihood of wrongdoing 2.) Informal social control theory is based on the assumption that crime is caused by community weakness and social control failure (Greenberg et al., 1985). Furthermore, modern crime prevention theory, "5 theories, 1 principle", is 1.) Law enforcement theory of catching criminals that crime prevention is the primary job of the police and more important than investigation. 2.) Police community relations theory is a friendly community that reduces conflicts and increases communication channels between the police and the public 3.) Community policing police theory serves as service provider 4.) Crime control through environmental design theory 5.) Broken window theory as an inspector of order 6.) Principles of development and problem solving that fluctuate according to community guidelines by acting as an analyst and problem solving (Herbert Gans 1962).

2.2 Traveling Salesman Problem (TSP)

In the concept solving of the route problem deciding, there is one starting point and multiple endpoints (travel to each point only once) by the route that this travel must portable through every point and finally return to the starting point. The objective is to analyze all travel points with the lowest distance. These data will affect the travel efficiency in terms of duration and fuel consumption and route management system. Thought is widely applied to solve problems in various fields, such as cargo routing, tourism routing, and travel planning. The TSP problem has been focused on the route of travel when there are N cities or places for needing to be traveled. The journey will travel from any one of N cities by route travel. Through all cities in N and return to the starting city to tread like a walking loop.

Various studies have applied this concept to develop the utilization of distance, time and cost. Tao's (2008) TSP problem solution based on an improved genetic algorithm state that the PMX crossover method can be applied to TSP. Its shortcomings are: 1.) The scope is strictly limited for PMX crossover methods, and PMX crossover methods cannot realize partial chromosomes. 2.) The PMX crossover method, where a 2-point crossover is not good for excellent chromosomal heredity. According to Su et al. (2009) New crossover operator of genetic algorithms for the TSP. With the new crossover method "cut-blend crossover" for the genetic algorithm for the salesperson travel problem, cut-blend crossover may be the best crossover. The proposal was inserted in the process of the New Genetic Algorithm in which well-known standard problems such as oliver30, eil76, ch130 and pcb442 were used in TSPLIB for experimentation. The new crossover is better than the old methods, such as OX and ER, and is especially suitable for the problem of large sizes.

Yi et al. (2010) stated that the improved hybrid genetic algorithm for solving TSP based on Handel-C, the salesperson travel problem (TSP), is a common problem that can be easily explained. However, it is difficult to solve the problem with good performance, and this problem is widely applied in practice. Therefore, solving the salesperson journey (TSP) quickly and efficiently is very important in practice. The genetic algorithm is a method for finding answers by optimizing problem solving. In this research, Handel –C language was used to write a simple program and improve the genetic algorithm to solve the problem. The results showed that the algorithm's performance was greatly improved. According to Nian& Jinhua (2011). The hybrid genetic algorithm for TSP uses a simple genetic algorithm for solving salesperson travel problems. The best route uses very randomness and does not consider neighborhoods. To reduce randomness, this research proposes a hybrid genetic algorithm based on an algorithm that improves usability by obtaining data from previous versions. It will also increase the local search process to make it more useful, and information that will be sent to obtain the best answers.

Hassan (2012) developed an improved greedy crossover to solve the symmetric traveling salesman problem in which the travel salesman problem (TSP) is the most famous optimization problem. In this research, an improved version of the greedy crossover presented greedy crossover to conventional crossover in the past by comparing speed and accuracy. According to Sangwan et al. (2018), the traveling salesman problem (TSP) is a classical combinatorial optimization problem that is simple to state but very difficult to solve. The problem is to find the shortest tour through a set of N vertices so that each vertex is visited exactly once. This problem is known to be NP-hard and cannot be solved exactly in polynomial time. Many exact and heuristic algorithms have been developed in the field of operations research (OR) to solve this problem. In this paper, we provide an overview of different approaches used for solving the travelling salesman problem.

3. Methodologies

3.1 Research Design

This research designed mix method research in two phases: the quantitative research approach of the first phase to find the route of prevention and suppression patrol arrangement to the route set. In the secondary phase, the prevention and suppression patrol process model are developed with a flow process chart as the framework of the research approach shown in figure 1.

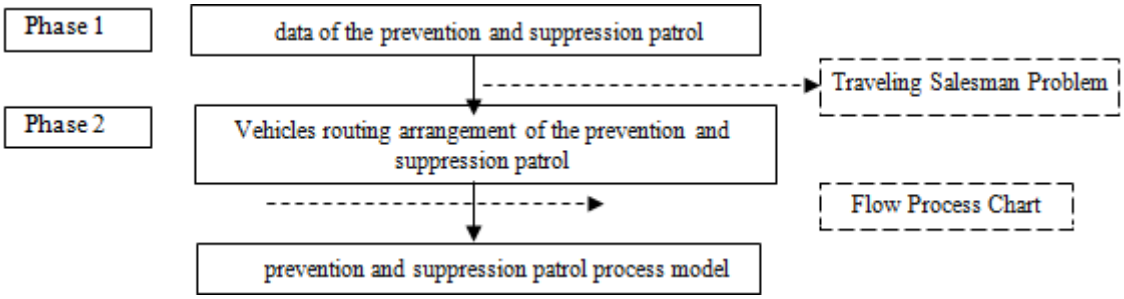

Figure 1: Framework of qualitative research approach

3.2 Population and sample

The population in this study is the data on distance patrol, time patrol, and fuel consumption of the area in responsibility of a police station in Chonburi Province, Thailand. There are a total of two responsible monitoring areas. In this research, nonprobability sampling was used purposive sampling with judgmental sampling methods that focused on the study of the main routes in red cabinet inspection (risk points). The inspection area is responsible for a case study, which has a total of twelve risk points.

3.3 Data analysis

The traveling salesman problem (TSP) is a tool for solving the problem of deciding the route of travel when there is one starting point and multiple endpoints (travel to each point only once) by the route. The travel must travel through every point and finally return to the starting point, as shown in figure 2. The objective is to analyze all travel points with the lowest distance. These data will affect the travel efficiency in terms of duration and fuel consumption and route management system (Pintea et al. 2017; Attie et al. 2019) TSP is a model of the travel to N Cities or N Places which this travel will travel from any one of N Cities by that route. Through all cities in N and return to the starting city to walk like a walking loop (Hougardy& Wilde 2015).

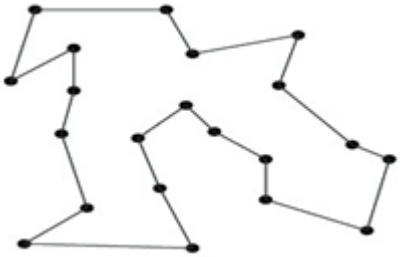

Figure 2 TSP Routing

4. Results and Discussion

4.1 Vehicles Routing Arrangement for the Prevention and Suppression Patrol

Police patrol officers organized patrols into two turns of twelve hours each as the first section (between 08.01 am. – 8.00 pm.) and the second section (between 8.01 pm. – 08.00 am.). The red checkpoints (risk checkpoints of patrol) in the responsible area show twelve checkpoints, which the police station to all twelve checkpoints of the responsible area using the numbers 0-12 as a symbol instead. Table 1 summarizes the preceding vehicle routing arrangements that present the average data of the route, distance and time of patrol vehicles of the district patrol. Patrol officers have three sets for supporting the prevention and suppression patrol on official days (Monday-Friday) and holidays (Saturday-Sunday).

The results of vehicle patrol routes analyzed by the traveling salesman problem (TSP) using the nearest neighbor method (choosing to patrol to the city that is closest distance from the current checkpoint) are presented in Table 2. These are shown the distance routes between each checkpoint of the vehicle patrol route at all twelve checkpoints using Google Maps.

Starting from police station (0), which is the point where the vehicle patrol must round to inspect each responsibility area by choosing the shortest distance routes in the table and agreeing with the point in the row patrol to that main position with the shortest distance, the total distance must be calculated to be 29.7 kilometers. Therefore, these vehicle patrol results are utilized on official days (Monday-Friday), and holidays (Saturday-Sunday) are route 0-1-2-12-9-8-7-6-5-4-3-11- 10 and back to 0, as shown in Table 3.

The results of vehicle patrol routes by TSP analysis are shown in vehicle patrol districts (routes 0-1-2-12-9-8-7-6-5-4-3-11- 10 and back to 0) on official days (Monday-Friday) and holidays (Saturday-Sunday). The results showed that round of this district uses a total distance of 31.5 kilometers, a period of 78 minutes, and an amount of fuel of 1.819 liters. The results of the comparison of distances before and after vehicles patrol routes are arranged by analyzing TSP found that the average distance routes of before the patrol route arranged, the distance was 32.87 kilometers, time 139.58 minutes. After the patrol route was 31.5 kilometers, time 76 minutes on official days and the patrol route was 31.5 kilometers, time 74 minutes on holidays. The patrol routing distance was reduced by 1.37 kilometers, the patrol time was reduced by 63.58 minutes on official days and was reduced by 65.58 minutes on holidays.

After arranging vehicle patrol routes, there was a noticeable reduction in duration, and a number of factors led to the shortening of time, such as streamlined traffic conditions and red checkpoints after analyzing the TSP. Additionally, efficiency improvement reduces the patrol time and distance; moreover, patrol officers can increase the patrol cycle of vehicle patrols per route. Table 4 shows the results summary of the comparison of distances before and after the routing of the patrol on official days and holidays, which represent the efficiency improvement.

Table 1 The average data of the route, distance and time of patrol vehicles (before vehicle routing arrangement)

Set	Time	Day	Average distance (Kilometer)	Average time (Minute)
1	08.01am. – 8.00 pm.	Official days	46.2	367
		Holidays	33.3	188
	8.01 pm. – 08.00 am.	Official days	38.4	400
		Holidays	63	281
2	08.01am. – 8.00 pm.	Official days	27.3	100
		Holidays	23.1	66
	8.01 pm. – 08.00 am.	Official days	23.4	71
		Holidays	23.0	53
3	08.01am. – 8.00 pm.	Official days	42.1	43
		Holidays	29.9	27
	8.01 pm. – 08.00 am.	Official days	21.6	38
		Holidays	23.2	41
			32.87	139.58

Table 2: Routing between each checkpoint of vehicle patrol route by analyzing the TSP

From/ Arrived	0	1	2	3	4	5	6	7	8	9	10	11	12
0	0	1.1	1.9	3.7	2.6	2.7	1.4	3.2	3.1	2.4	6.0	4.2	2.9
1	1.1	0	0.950	3.2	2.4	3.4	2.0	3.8	3.0	1.6	4.8	2.2	0.950
2	1.9	0.950	0	5.1	3.2	4.2	2.8	4.5	4.1	2.4	4.5	2.0	0.650
3	3.7	3.2	5.1	0	1.5	2.7	3.8	5.5	6.1	4.5	7.0	4.0	2.7
4	2.6	2.4	3.2	1.5	0	1.2	2.8	4.6	6.0	4.4	6.5	3.9	2.6
5	2.7	3.4	4.2	2.7	1.2	0	2.6	4.4	5.8	5.2	8.1	5.5	4.2
6	1.4	2.0	2.8	3.8	2.8	2.6	0	1.8	3.2	3.6	6.8	4.2	2.9
7	3.2	3.8	4.5	5.5	4.6	4.4	1.8	0	1.6	4.0	6.6	4.7	4.8
8	3.1	3.0	4.1	6.1	6.0	5.8	3.2	1.6	0	2.3	5.0	3.1	3.9
9	2.4	1.6	2.4	4.5	4.4	5.2	3.6	4.0	2.3	0	4.9	2.4	2.3
10	6.0	4.8	4.5	7.0	6.5	8.1	6.8	6.6	5.0	4.9	0	3.9	4.8
11	4.2	2.2	2.0	4.0	3.9	5.5	4.2	4.7	3.1	2.4	3.9	0	3.0
12	2.9	0.950	0.650	2.7	2.6	4.2	2.9	4.8	3.9	2.3	4.8	3.0	0

Table 3: Routing between each checkpoint of vehicle patrol route by analyzing the TSP

Official days					Holidays				
From	Arrived	Distance (Kilometer)	Cumulative distance (Kilometer)	Cumulative time (Minute)	From	Arrived	Distance (Kilometer)	Cumulative distance (Kilometer)	Cumulative time (Minute)
0	1	0.7	0.7	4	0	1	0.7	0.7	4
1	2	0.950	1.65	7	1	2	0.950	1.65	7
2	12	3.2	4.85	13	2	12	3.2	4.85	12
12	9	2.1	6.95	21	12	9	2.1	6.95	20
9	8	2.8	9.75	29	9	8	2.8	9.75	28
8	7	1.5	11.25	32	8	7	1.5	11.25	30
7	6	1.7	12.95	36	7	6	1.7	12.95	34
6	5	2.6	15.55	41	6	5	2.6	15.55	39
5	4	1.8	17.35	45	5	4	1.8	17.35	43
4	3	0.950	18.3	48	4	3	0.950	18.3	46
3	11	4.4	22.7	63	3	11	4.4	22.7	60
11	10	2.1	24.8	67	11	10	2.1	24.8	62
10	0	6.7	31.5	78	10	0	6.7	31.5	74

Table 4: Routing patrol before and after by analyzing the traveling salesman problem (TSP) at 1 day, 1 week (7 days), 1 month (30 days) and 1 year (365 days).

Dimensions	Comparison (Before-After)	Period				
		Round examination	Day	Week	Month	Year
Distance (Kilometer)	Before	32.87	65.74	230.09	986.1	11,997.55
	After	31.5	63	220.5	945	11,497.5
	Reduce	1.37	2.74	9.59	41.1	500.05
Time (Minute)	Before	139.58	279.16	977.06	4,187.4	50,946.7
	After	76	152	532	2,280	27,740
	Reduce	63.58	127.16	445.06	1,907.4	23,206.7
Fuel (Liter)	Before	1.835	3.67	12.845	55.05	669.775
	After	1.819	3.638	12.733	54.57	663.935
	Reduce	0.016	0.032	0.112	0.48	5.84

4.2 A process model of patrol routing arrangement for prevention and suppression

A flow process chat is applied to develop the process model of patrol routing arrangements that are preferred for process mapping for prevention and suppression routing. First, the structure of the inspection plan collects data by patrol route point information and distance from each point using Google Maps, although the information is not competing and needs survey data. This completed information to the secondary phase is analyzed with TSP using the Microsoft Excel program to obtain a patrol routing arrangement; however, the results are nonaccepted and need to check the database. In the third phase, patrol routing of prevention and suppression is designed in introduction practice and is analyzed criminally to improve the results. In the fourth phase, a patrol routing arrangement is tested in the introduction practice, and these results show high performance for improving the final phase. Nevertheless, patrol route testing shows low performance and needs to be returned to the first phase to improve the new task. In the final phase, a patrol route practice plan is developed to operate the patrol routing of patrol policies for prevention and suppression management, as shown in Figure 3.

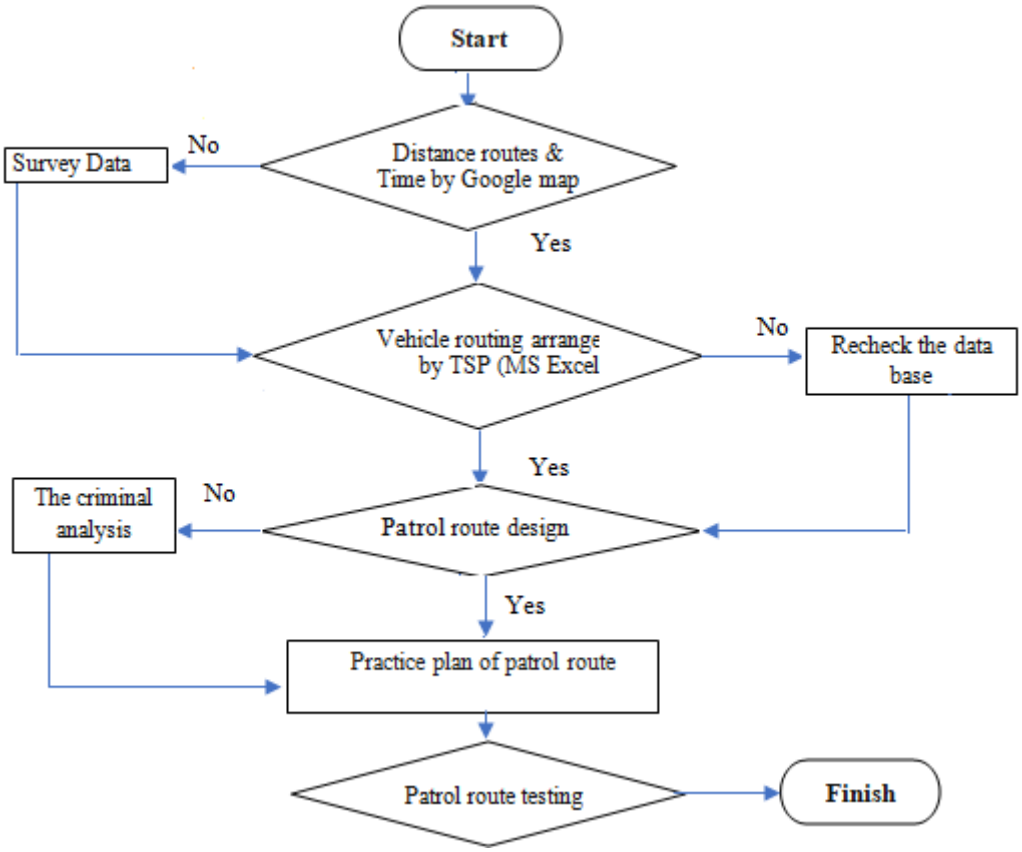

Figure 3: Process model of prevention and suppression patrol management

5. Conclusions

This research is focused on vehicle routing arrangements to improve the effectiveness of patrol routing by applying the traveling salesman problem (TSP) concept to patrol routing. The results of before and after on vehicles routing arrangement are represent the comparative results from applying the (TSP) to vehicles routing arrangement that are reduce the patrol time and distance effecting to reduce the fuel use. Police stations and patrol officers have a limited number of patrol officers and limited patrol time for prevention and suppression. These results are the first solution for improving management, which is the utilization of police use, time efficiency, and cost reduction in fuel use. This model is to propose the process that is applied to manage the prevention and suppression patrol and these benefits presenting of the utilization in patrol distance, patrol time and fuel cost. Additionally, this practice has increased the patrol rounds at risk points, resulting in the reduction in crimes and upgrading good practices in patrol operations. Additionally, the patrol cycle of vehicle patrols per route is increased after patrol routing on official days and holidays. The implementation practice is presented by a process model of patrol routing arrangement for the prevention and suppression that is applied to operate patrol officers toward effectiveness management. Finally, this research introduced a patrol routing arrangement that considered three factors, focusing on patrol time, distance and fuel use. Future research will improve more conditions, including the numbers of criminals, new technology improvements, traffic operations and suspended cases.

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