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Predicting Travel Time System in Case of Bandar Baru Bangi

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Abstract: Road congestion is increasing due to growing of the population and vehicle ownership. Due to this problem there is a need of the advanced traveller information system in optimizing the traffic in urban area. In Malaysia the rapid increase in the use of personal transport has resulted in increased traffic congestion, accidents, inadequate parking space and air pollution, among other problems. To provide a solution to these problems, the objective of this study is to estimate and inform the dynamic travel time and ideal routes to traveller in Bandar Baru Bangi (BBB) area. Delphi program is chosen to write the program that can predict the travel time in urban roads. The system is capable to use by traveller pretrip by internet and on trip by using the SMS.

Key word: Travel time, congestion, traffic assignment, travel route.

INTRODUCTION

To enhance the quality of travel time information prediction information for travellers, there is a need to prepare a system for forecasting the dynamic travel time. Today, increased urbanization was due to the population that was increased by the number of urban and suburban trips (Shokri *et al*. 2012). Travel time information has a significant influence on different purposes and fields (Shokri *et al*. 2010). The challenge is to determine an accurate prediction of the time to reach the destination a better estimate than the travel time of the last car to complete the route (Crawley *et al*.1998). There are a number of benefits and applications of an accurate travel time prediction model, for instance it can be used directly e.g. in various driver information systems or variable-message signs, but it can also be an integral part of (or an input for) larger traffic related systems such as traffic management systems, logistics systems or personal car navigation (Bovy & Stern 1990). Due to the dramatic increase in the number of vehicles, traffic congestion has become an increasingly serious problem in large cities around the world (Shokri *et al*. 2009). Kotaro (1990) maintained that decreasing the lost of billions hours and money is demanding an efficient method that resolves traffic jamming and reduces delays. On the other hand, Greenwood & Bennett (1996) opined that in the congested condition, under heavy traffic congestion fuel consumption of vehicles increases up to 30%. The problem of urban traffic congestions is becoming more serious on daily basis, not only Malaysia but also in other developed countries and will soon be worse. These situations resulted to more road accidents, loss of urban spaces and further delay in the arrival time of employees to work and other human activities. Therefore, some other methods have to be adopted (Park and Rakha 2006).

Travel time reliability is the inconsistency of travel times in different times because of irregularity in primary conditions in different times while travel time variations on expressways are the result of interactions between demand, capacity, weather conditions, accidents, work zones and traffic composition. Sascha *et al*. (2005) added that duration of the travel is a main factor influencing motorists' choices of route, frequency, mode and trip timing. However, facilitating of travel duration information to motorists can potentially influence choices of routes and thereby reducing congestion and improving the traffic network efficiently (Ben & De Palma 1991), while it benefits users in less noticeable ways of reducing stress and decreasing uncertainty (Adler & Blue 1998). Therefore, providing travel time information to motorists through dynamic electronic road signs, radio broadcast or in-vehicle systems is gaining importance for many road authorities.

As travelling duration is a fundamental measure in transportation, accurate travel-time estimation is central to the design of advanced traveller information systems and smart transportation systems. Travel time information are the raw material for assessment of performances that can be used in many transportation analyzes such as design and operations, evaluation and transportation planning (Chien & Kuchipudi 2002). Travel-time data are important not only before starting the trip but also in transit, because these information change rapidly in an advanced travelling systems. They are significant to travellers or drivers to make decision and plan schedules. With accurate travel-time estimation, a smart routing system can suggest best alternate routes or notify the driver of potential traffic congestion; travellers can choose the optimal departure time or predict their arrival time based on estimated travel times (Hong *et al*. 2005).

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The input for the travel time prediction models can also be various. It can consist of a more traditional data originating from stationary in-road sensors (like loop detectors) or it may be the floating car data generated by moving vehicles. Most of the earlier studies in this subject, however, focused on historical data but this system is based on online volume of the vehicles data that obtained from the CCTV cameras and transfer them to the centre computer and update the travel time among all the nodes and find out all the possible routes among the zones and make them ready for travellers to choose the best path (Chien & Kuchipudi 2003)

The main aim of this research is to improve the short-term travel time prediction quality by creating a dynamic model. The proposed model also needs to be efficient and compatible with shortest path algorithms for the application as part of an on-line personal car navigation server, which needs to process routing requests in real-time.

Research Objectives:

The purpose of this study is multifold. First, it aims to use the CCTV camera as a sensor for data collection and updating the OD matrix for calculating the traffic volume in each link. Second, To calculate the proper algorithm to assign the traffic on the road network which is the cause of the preventing of the congestion on the shortest travel route with using the recursive graph traverse theory and equilibrium algorithm. Third is to estimate and update the travel time information in a short term travel time forecasting of the road network and finally, the study focuses on developing the system that informs the travel time data to the road network users via the internet or SMS to enable the users have an access to the latest traffic information pre trip and on trip. While many researchers have proposed and applied predicting travel time system methods, What makes this work distinct from others is the way of updating the OD matrix, Solving the shortage problem of the CCTV cameras, error finding, Using Recursive Graph Traverse Theory for trip assignment while this study is base on the Dynamic traffic flow.

Methodology:

The land use of an area has a direct effect on the traffic flow in that area. To investigate the traffic flow pattern in BBB (Figure 1), the total land use in BBB must be obtained. For this reason, there are some different methods such as the Study of the map of BBB provided by kajang Municipal Council, Study of the detailed map of BBB as published by Google maps and Conduct site visit to BBB. Based on the data collected for total land use in BBB, the number of vehicle trips can be calculated using the trip rates provided by Malaysian Trip Generation Manual.

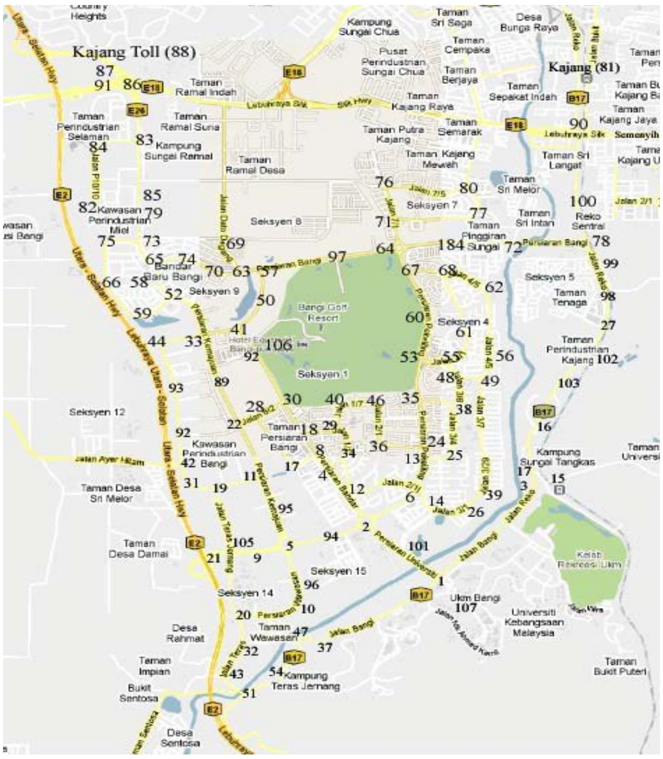

Fig. 1: Study Area.

There are 106 nodes are selected in BBB as a zones and all the available links are located among these zones. The needed information for this study is the length, capacity and the free flow of the road which are extracting from the highway capacity manual 2000. Total trip attractions and productions in all the sections in BBB for morning peak hours are 13597. The OD matrix is used for calculating out all the possible travels among the nodes. By performing the OD estimation procedure using the data obtained above, the estimated movement flow from one node to another is generated. Double constraint gravity model is used for finding out the number of the travels among the zones.

$$T_{ij} = k_i k_j \left(P_i A_j / f\left(C_{ij}\right)\right) \tag{1}$$

$$K_i = (1/\sum_j K_j A_j / f\left(C_{ij}\right) \tag{2}$$

$$K_j = (1/\sum_i K_i P_i / f\left(C_{ij}\right)) \tag{3}$$

The user-equilibrium model of traffic assignment is based on the fact that humans choose a route so as to minimize their travel time and on the assumption that such a behaviour on the individual level creates equilibrium at the system (or network) level. Flow on links (whose travel times are assumed to vary with flow) are said to be in equilibrium when no trip-maker can improve his/her travel time by unilaterally shifting to another route. The user-equilibrium model formulation is based on this area-related observation about equilibrium flows and the fact that the travel time on a route is simply a linear sum of travel times on the constituent links. The equilibrium algorithm is following the wardrobes principles. The formulation, which is a non linear programming problem, is given from formula 4 to formula 8 (Rahmat 1994).

$$\min_{x \in X} z(x) = \sum_a \int_a^{x_a} t_a \ (x_a) dx \tag{4}$$

$$\text{Subject to} \sum_k f_k^{rs} = q_{rs} : \forall\, r, s \tag{5}$$

$$x_a = \sum_r \sum_s \sum_k \delta_{a,k}^{rs} f_k^{rs} : \forall a \tag{6}$$

$$f_k^{rs} \geq 0 : \ \forall\, k, r, s \tag{7}$$

$$x_a \geq 0 \ : a \epsilon A \tag{8}$$

The formula for calculating the total minimum travel time, travel time and the flow value are shown from formula 9 to 11 respectively (Rahmat 1994).

Total minimum travel time formula: $$z = \sum_a \left[m_0 \, v_a + \frac{0.15 * m_0}{c_a^4 * 5} \, v_a^5 \right] \tag{9}$$

Travel Time formula is: $$T = T_{\circ} \left[1 + 0.15 (v/c)^4\right] \tag{10}$$

Flow value: $$v_a^n = (1 - \beta) v_a^{n-1} + \beta f_a^n \tag{11}$$

Camera:

Installed cameras along the section of the roadway are sending the constant data to the system and monitoring the roadway. The data are sent to the base station, located in the project field office. Speed and volume of the vehicles are obtained from the cameras; a computer at the base station is running to calculate the current travel times, length and do the route assignment. One of the problems of this study is the shortage of the CCTV cameras that make a problem in collecting the data. Regarding to this problem after finding the flow in each link the logic relation is calculated among the zones and the required places are identified for installing the CCTV cameras. So in each loop when the data are observed by the cameras, the flow of all the links is calculated by the have been found by the logic relation among the zones. The coefficient (relation between calculated flow and the observed flow) is calculated by the formula number 12.

$$\text{Coefficient} = \frac{\text{Calculated flow}}{\text{Observed Flow}} \tag{12}$$

The Coefficient will multiple to the previous attraction and production of the area of the camera to find out the new production and attraction.

Delay Time:

Delay time at intersection and roundabout is one part of the travel time calculation. The control delay of a through movement is the suitable delay used in an urban street evaluation. The delay time of the intersection is calculated by using formulas 13 with online collected data from the CCTV which are given in the highway capacity manual (2000) that they are as a below:

$$\mathrm{d} = \mathrm{d_1PF} + \mathrm{d_2} \tag{13}$$

$$\mathrm{d_1} = 0.5\mathrm{C}[1 - \mathrm{g/C}]^2 / \left\{1 - (\tfrac{\mathrm{g}}{\mathrm{C}})[\mathrm{Min}(1, \mathrm{X})]\right\} \tag{14}$$

Equation 14 estimates the incremental delay due to non uniform arrivals and individual cycle failures (i.e., random delay) as well as delay caused by sustained periods of oversaturation (i.e., oversaturation delay). Formula 15 and 16 shows the incremental delay and uniform delay progression adjustment factor respectively.

$$\mathrm{d_2} = 900\mathrm{T}\{(\mathrm{X} - 1) + [(\mathrm{x} - 1)^2 + 8\mathrm{kIX/cT}]^{0.5}\} \tag{15}$$

$$\mathrm{PF}{=}(1 - \mathrm{P})\mathrm{f_P} \big/ 1 - (\tfrac{\mathrm{g}}{\mathrm{C}}) \tag{16}$$

Roundabout delay time calculation is another part of the delay time that the vehicles face in travelling. Formula 17 shows the roundabout delay calculation formula.

$$W_m = W_h + 900T\left[Z + \sqrt{Z^2 + \frac{MX}{CT}}\right] \tag{17}$$

Where W_m is the average queuing delay per vehicle (sec), $W_h$is the minimum delay (sec) when entering traffic is very low, T is the duration of the flow period (hr) (i.e. the time interval during which an average arrival demand, Q_m, persists (1 hr or 0.5 hr), x is the degree of saturation of the entry lane, C is the entry lane capacity (veh/hr), Z=X-1 and m is a delay parameter given by m = $W_h\, C/450$. The second term in Equation is accounts for the presence of a queue on the entry lane to a roundabout. This is a time-dependent formula derived from the steady-state formula developed by Troutbeck and Board (1989) and is recommended to be applied at roundabouts operating near capacity or in oversaturated conditions (Austroads 1993).

Save the Data in Data Base:

The system sometimes face an error so it needs to have a historical data to use in the required time, most of the errors in this system comes from the camera failure such as disconnecting or detecting problem so the system needs to saves the calculated travel times, date, time, origin, destination and the volume of the vehicles on the roads in data base.

Contribution of the Internet and Sms System:

The predicting travel time system of this study tries to let the users know about the latest travel time information, for this purpose the users are able to be aware of the travel time and other details of the travel route via the internet or SMS system.

Server and Client Windows:

This system consist of two different windows that one of them is the server windows (figure 2). This window contain of adjustment tools that help the operator to adjust the system to the ideal condition.

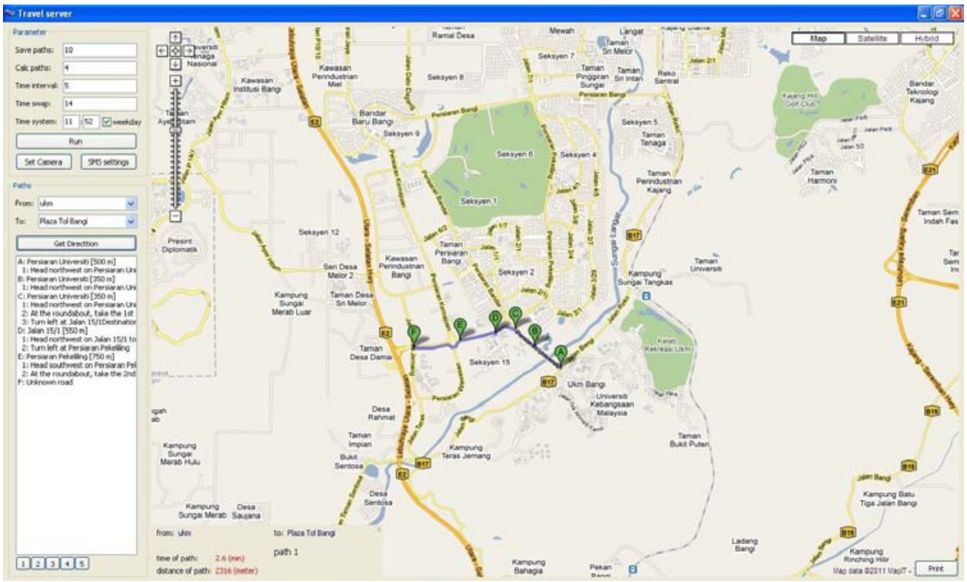

Fig. 2: Travel server windows.

The client window (Figure 3) is downloadable file that the user is able to download it from the internet and install it on the computer, this window automatically connects to the server widows and update from that. This window contain of some boxes that the user is able to key in the origin and destination to find out the best route for travelling. As shown in Figure 4.10 the client window contains of server IP, From, To, get direction and print map button.

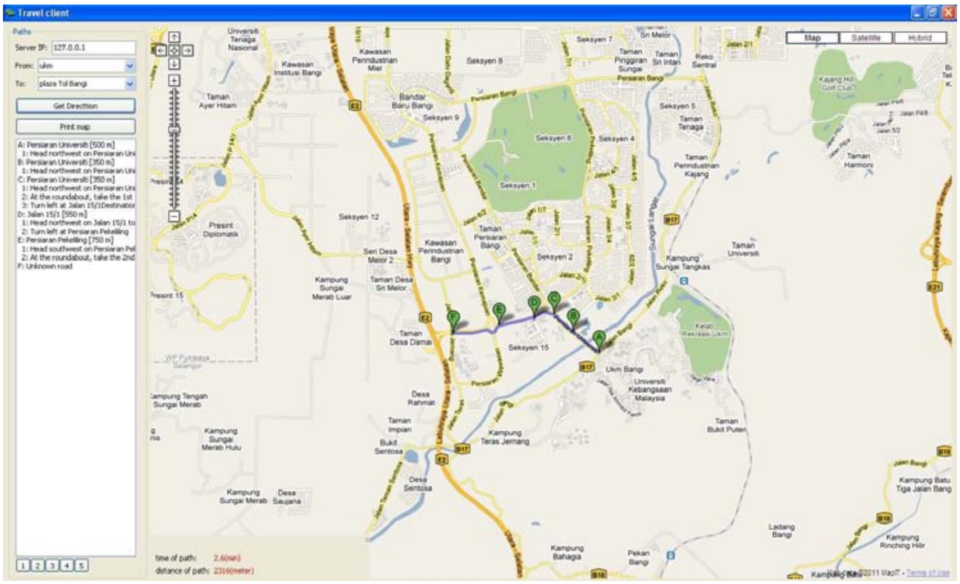

Fig. 3: Travel client windows.

Traffic Volume Validation:

The system updates regularly regarding to the specified interval time by the operator, so the validation can be in anytime by comparing the estimated result by the system and compare it with the real information which is collected from the study area. The result in this study, which include the estimated travel times and accumulated traffic volumes are validated by comparing the output results with traffic counts as well as with real travel times. There are different methods for finding out the accuracy of the model and in this study T Test, F test; Chi Square test and Regression model are used for testing the program. There are 30 different routes between the origin and destinations are chosen and the travel time of the traveller is calculated in the real situation and estimated by the system. Figure 4 shows a positive straight relation between travel times estimated by driving and travel time estimated by travel time estimation system with a very high coefficient of determination ($R^2 = 0.93$).

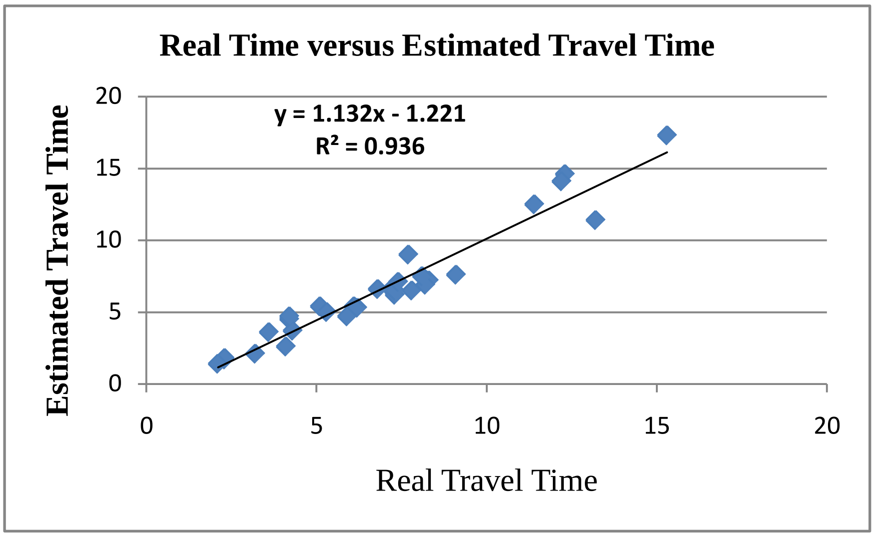

Fig. 4: Compare of the real travel time with the estimated travel time.

The E-view software is used for calculating the validation. The mean values (variance) for the two sets of travel times (real and travel time estimation (TTE) system) are 6.95 and 6.65 respectively (Table 1). The result of the test shows that the F test, T test and chi squared test are 414.4634, 1.13 and 12.70052 with the probability of 0.00, 0.00 and 0.0004 respectively. The probability for these tests indicates that there is no evidence of significant difference between the mean values obtained for real and TTE system.

Table 1: Test of null hypothesis.

	Real Travel Time	Estimated Travel time
Size	30	30
Mean	6.95	6.65
Standard deviation	3.35	3.92
R squared	0.936718	
F test	414.4634	
Probability of F statistic	0.00	
Coefficient of T test	1.13	
Probability of T test	0.00	
Chi square test	12.70052	
Probability of chi square	0.0004	

Screen Line Test:

This test tries to validate the volume of the streets with the estimated one that calculated with the system to find out the accuracy of the system. For this purpose the volume of the specific zones are counted and the volume of the mentioned zones are find out by the system. Real and estimated traffic volume is shown in Table 2 and 3.

Major Roads:

The collected data (Estimated and the real) for the major road are as a below in table 5.4.

Table 2: Screen line test for major road.

Link		Estimated Volume	Real Volume
1	16-7	8	10
2	6-13	5	4
3	12-4	6	8
4	95-11	4	4
5	105-19	4	6
6	1-101	11	13
7	94-5	9	11
8	5-95	5	6

Minor Road:

The collected data (Estimated and the real) for the minor road are as a below in table 5.5.

Table 3: Screen line test for minor roads.

Link		Estimated Volume	Real Volume
9	39-49	3	4
10	25-24	4	5
11	62-68	2	4
12	68-61	3	3
13	55-53	4	2
14	35-38	5	3

Regression analysis is used for validating in the screen line test between estimated and real volume.

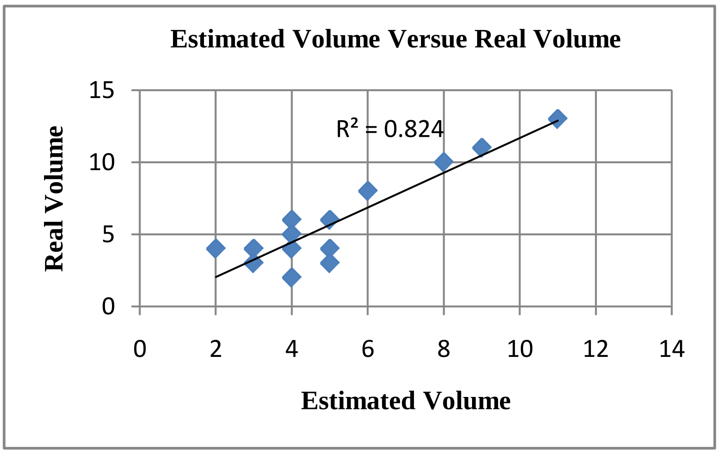

Fig. 5: Estimated volumes versus real volume.

The following chart shows the differences of the estimated and the real volume of the validated zones in the study area.

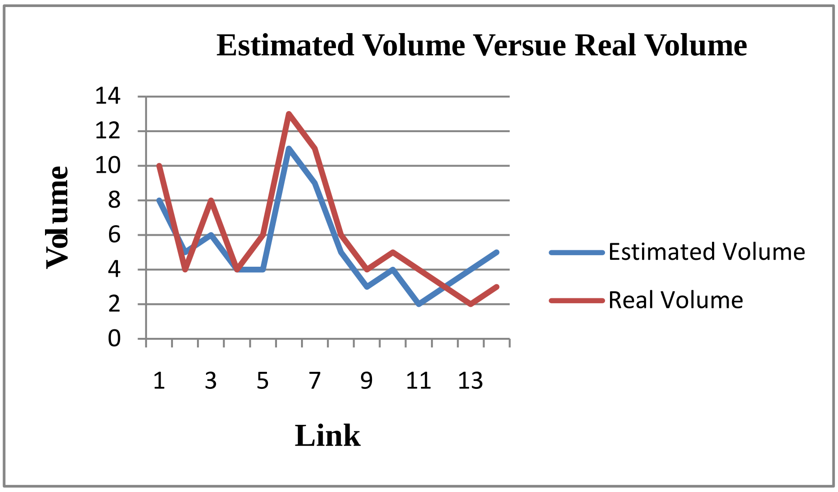

Fig. 6: Estimated volumes versus real volume.

Table 4: Test of null hypothesis.

	Real Travel Time	Estimated Travel time
Size	14	14
Mean	5.214286	5.928571
Standard deviation	2.516975	3.338915
R squared	0.824695	
F test	56.45196	
Probability of F statistic	0.00	
Coefficient of T test	0.684574	
Probability of T test	0.000000	
Chi square test	3.612414	
Probability of chi square	0.016431	

The mean values (variance) for the two sets of travel volume (real and estimated by the system) are 5.21 and 5.92 respectively (Table 5.6). The result of the test shows that the F test, T test and chi squared test are 56.45, 0.68 and 3.612 with the probability of 0.00, 0.00 and 0.016 respectively. The probability for these tests indicates that there is no evidence of significant difference between the mean values obtained for real and estimated volume by the system.

Discussion:

This study tries to avoid from informing the non accurate data to the users, for this purpose the system find out the errors and tries to use the accurate data in the system. There are two different types of error from the CCTV in this system. In the first case if the number of the vehicles falls to 10% of the previous observation of the camera, it assumes that the traffic jam happens and the vehicles are stuck in the streets and the system gives the maximum time of the travelling. Another frequent error that occur in the system is the failure of the cameras, regarding to the store of the data if the observation of the camera become zero for two interval loop the system assume that the camera is failed and the system use the historical data and with the first observation of the camera the system goes to the normal mode.

One of the most important factors of the system is the duration of the loop calculation that help the system to be update sooner and let the user know about the latest traffic information. For this purpose the system use the fine component in the loop which able the system to be update very fast and the users can access to the latest traffic information immediately.

CCTV cameras are used in the system to collect the number of the vehicles and use it as a input for the system that has some strength such as direct measurement of speed, no need for pavement cut, provide basic traffic parameters (e.g., volume, presence, occupancy, speed, headway and gap), multiple lane operation available, clarity of the image that are captured and recording and saving the data as a historical data (Oswald *et al*., 2001). While there some weakness for CCTV such as higher initial cost per camera and reduced ability to cope with low light and high contrast scenes. On the other hand the CCTV cameras data are collected and save in the data base and use it when the CCTV cameras got error.

The proposed study tries to update the OD matrix by using three different methods. There are a number of methods which are used data survey or gravity model or traffic flow counts as measurements. The aim of this study is to employ the three mentioned technique to calculate and update the OD matrix. While most of the navigation systems don’t consider the delay time of the intersections in travel time, the proposed study calculates and considers the delay time of the intersections and roundabouts. In this case the calculated travel time is more accurate and more near to the real one.

Nowadays, one of the most concerns of travellers is traffic congestion and route assignment. Although there are some other methods that they are all try to find out the best travelling route, most of them are unable to find out all the possible weight of the routes among the origin and destination in dynamic traffic condition. Recursive graph traverse theory tries to calculate all the probable routes and save all of them in a range of weight. Most of the existing methods are based on finding the best travelling route and guide the travellers to use the introduced route which are follow the all or nothing algorithm which is the cause of the congestion of the given route by the system after a while. For avoiding this problem the equilibrium is used to assign the vehicles on the road equally normally with introducing the four different roads to keep away from the congested on the suggested routes and avoid using the congested road in the offered roads to the users.

One of the applications of the above ITS is to provide the traffic management centres with real-time traffic information, using which traffic information could be fed back in real-time to the travellers. The accuracy of this information is important since it should enable the travellers to make appropriate decisions to bypass the congested sections of the network by changing departure times or their route based on this information. The travel time provided through ATIS to travellers can be categorized into three distinctive groups: historic, real-time, and predictive. Historic is based on using archived data, while real-time refers to up-to-date values acquired from the system on an ongoing basis. Predictive is the estimated future values calculated by using the historic and/or real-time values. For planning a trip in advance or on the way decisions, the predicted values would be more informative than historic or real-time information. By the time the traveller makes the trip, the road conditions might have changed; therefore when the historic or current traffic information is used, the performance of a given application will be constrained.

Conclusion:

Regarding to the validation of the study travel time estimation by the system is more reliable than estimated by the historical data like the Google or other same systems. The system is capable to inform the travel time information to the users pretrip and on trip by the internet and SMS. The accuracy of the result of the validation shows that the travel time estimation system is capable to use by the users and guide them to their destination.

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