Driver Decision-making at the Traffic Lights

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Background

The evaluation of road safety countermeasures often involves a before-and-after comparison of accident/violation statistics. However, when there are not many treatment sites, small-sample findings are arguably limiting in terms of transferability that is, the findings may not be applicable in the wider context. An alternative methodology is to study road users’ response to the road environment. Such an approach was adopted in researching driver decision-making at the traffic lights, at the juncture when a driver is faced with the onset of an amber light. This means that the driver behaviour is studied starting from the presentation of the fixed stimulus at the onset of the change interval till the revelation of the action. Studying the driver decision-making in response to amber onset is important in order to provide insight as to why most accidents at signalised junctions tend to occur during the signal change interval.

Experimental design

A driver faces different levels of risk depending on the junction configuration (X-junction (jtn), Top-T-jtn, Mid-T-jtn, see Figure 1), which in turn influences the decision at amber onset as to whether to stop or to go. For example, it is hypothesized that a driver at the top approach of a T-jtn would attempt to cross more often (with greater attendant risk of red-running) than at the other two types of approaches where there is risk of colliding with opposing right-turn vehicle. For this study, the sample included several sites of each approach type: 7 sites for X-jtn, 5 for Top-T-jtn and 2 for Mid-T-jtn. There are also many other factors that potentially affect the decision-making, which were measured at these sites.

Data collection

Vehicle movements at the junction approaches were captured on-site using high definition digital video photography. All feasible on-site factors that may affect a driver’s stop-go decision were extracted from the video footages in the laboratory. The factors included distance from the stopline and speed of vehicle, vehicle type, entry and exit lanes, lane change, presence of red-light camera, presence of pedestrian, presence of amber onset pre-indicator, presence of nearby vehicles and status of opposing vehicles. Altogether, information was obtained for 3026 vehicles.

Logistic regression and results

A logistic regression technique was adopted for modelling the revealed outcome with various potential factors. The univariate analysis was used for variable selection, and significant variables were chosen for multivariate logistic modelling. From the calibrated multivariate logistic model, the more significant variables associated with a relatively greater crossing propensity were found to be:
- Higher vehicle approach speed at point of amber onset
- Vehicle being nearer to the stopline at point of amber onset
- Vehicle travelling in the centre lane
- Vehicle that does not encounter opposing right-turn vehicle
- Lack of red-light surveillance camera
- The motorcycle and commercial vehicle types as compared to cars

An example of the modelled effect for risk posed by permissive opposing right-turn traffic is shown in Figure 2. The crossing propensity diminishes with larger time-to-stopline (TTSL) which represents the vehicle’s time headway to the stopline at amber onset. It is clear that the crossing decision is influenced by permissive filtering.

Concluding remark

The calibrated logistic equation provides insight into important factors that should be considered when evaluating safety countermeasures for signalised junctions, particularly in the Singapore environment. For example, factors important in the Singapore context are vehicle types, and conflicts from permissive right-turn traffic. The calibrated logistic model can be used to estimate the crossing propensity of a vehicle operating under different situational and environment conditions. The behavioural modelling provides a more fundamental evaluation of user performance, and should be useful in small-sample before-and-after studies.

Figure 1. Types of junction approaches

Figure 2. Crossing propensity for risk posed by permissive filtering
Field Evaluation of 
Green Signal Countdown Device  

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Introduction
An earlier study on traffic signal operation in conjunction with Green Signal Countdown Device (GSCD) was carried out by the Centre for Transportation Studies (Wong et al., 2000) for the Land Transport Authority (LTA) in 1999. The findings from literature search of that study suggested that a countdown device could be useful but might run the risk of having drivers using this information to race the clock in order to “beat the red light”. However, majority of the drivers perceived that GSCD would help them to stop when they were caught in the dilemma zone during the onset of amber. Also, it was revealed that a countdown timing of 9 seconds displayed in red was overwhelmingly preferred by drivers. Though the survey has shed some insight into the perceptions held by road users about GSCD, it was recommended that field trials be conducted to study the efficacy of the scheme from an engineering perspective and at the same time ascertain the consistency of the findings from the perception survey. In view of this, LTA decided to proceed ahead with the trial implementation of GSCD at one approach of a signalised junction located at the intersection of Rochor Road and North Bridge Road. A before-and-after study was designed to evaluate the impact of GSCD installation on traffic characteristics.

GSCD installation
Before deploying the GSCD on site, a number of evaluative tests were carried out to ascertain the correct size and illumination levels of the LED digit-display. Upon successful evaluation, it was mounted onto the left overhead signal pole hanging from the left side of the road as shown in Figure 1. GSCD was officially implemented and started trial operation in the early morning of 16 January 2003 with a countdown timing of 9 seconds.

Figure 1. Pictorial view of green signal countdown device (GSCD)

Data collection
Video cameras can be deployed to collect traffic data to evaluate the impacts of GSCD installation. However, past research studies carried out in NTU revealed several limitations associated with the use of video cameras in Singapore environment. Thus, the use of video cameras for data collection was deemed to be not suitable, and a special-purpose data logger was used instead. Traffic and signal timing data that can be captured by the data logger include lane-by-lane volume, speed and distance from stop-line during onset of amber, and the timings and status of each signal phase (Lum and Wong, 2001). It was then deployed on site to collect the before- and after-GSCD data, which included traffic volumes, speeds, and the timings and status of each signal phase. As voluminous data were collected, a suite of macro programs running on Microsoft Excel was specifically written to process, clean and appropriately assemble the field-collected data for the before-and-after study.

Findings and conclusions
Analysis on the collected data revealed that there was a substantial drop in red-running violations and a significant increase in the number of vehicles choosing to stop during this critical phase-change period after GSCD installation. However, the latter finding must be viewed cautiously as one may infer an increase of the likelihood in rear-end collisions between two successive vehicles due to the unexpected stopping of the front vehicle. This happened when the following driver executed a crossing action under the impression that the front vehicle should have been able to clear the junction successfully due to sufficient time as well as perceiving enough time for him/her to cross before red.

References

Introduction

Every vehicle trip that begins must terminate at some point in time and space. The increasing use of road space for the movement, as distinct from the storage, of public, private and goods vehicles is forcing increased attention to be placed on the development of high quality off-street parking systems. Furthermore, modern urban developments involve different land uses offering a diverse range of goods and services (e.g. combinations of office, shopping, entertainment and residential uses integrated into one development). This complexity adds to the variety and character of parking demand, which in turn can have a considerable impact on the utilisation of car parks and the adjacent road network.

Discrete event simulation offers a framework for representing the detailed movement of individual vehicles within traffic and parking systems (Young and Tan, 2002). This approach considers the movement of vehicles over small time increments through the application of car-following, lane-changing, give-way and parking procedures. Most simulation models have been developed to emulate movement along major road networks. None of these models treat vehicle movement within parking facilities in detail.

EPSILON (Evaluation of Parking Systems using mJcrosimulation on a Local Road Network) was developed as a research tool to represent traffic and parking within and around multi-storey car parks of urban developments with mixed uses (Tan and Young, 2002, 2003). EPSILON is designed using object-oriented programming and runs on Windows-based (2000/XP) personal computers. The object-oriented design philosophy represents the problem in terms of objects (or entities) that interact and addresses the relationships between them. This provides a high degree of flexibility in conceptualising the problem and representing different data structures. All modules except the graphics modules are coded in MS Visual Basic 6. This paper describes the main features of the EPSILON network editor.

Network objects

The traffic and parking network in the microsimulation model can be represented by a collection of nodes, links, lanes and parking spaces. These objects have unique properties embedded in each such as identification number, type and graphical description (e.g. x, y, z coordinates, and dimensions). A node can be either a source or sink where vehicles enter or leave the network, or an intersection of two or more links. A parking node specifies a group of spaces within a car park that has access to at least one building entrance. A building entrance node is used to provide the initial guidance to drivers to search for a space. A car park entry/exit control node can be used to simulate a vehicle stopping for processing of parking charges.

A link is a directional roadway that connects two nodes and can have one or more lanes. Each link is described by its start and end nodes, bearing, number of lanes and whether it has access to parking spaces. A walk link connects a parking node to one or more building entrance nodes. Vehicle movement takes place in traffic lanes. Parking spaces are specified explicitly in the network. For multi-storey parking facilities, the model considers locations of structural elements within the car park (e.g. building columns, walls). These objects can influence parking search by limiting drivers’ view of spaces.

Features of the EPSILON network editor

The network editor allows the creation of different traffic and parking layouts in an intuitive and user-friendly manner. The geometric layout and other inputs (namely, global simulation parameters and network demand data) are then fed into the microsimulation model (Tan and Young, 2002, 2003). Objects are created and positioned onto the on-screen canvas via a Windows-like graphical user interface (GUI) that supports standard mouse actions (e.g. left-click, right-click). The canvas can be split into different levels for multi-storey facilities. From the main menu bar, the following options (activated by clicking the appropriate icon) are available for network entry and editing:

- Add/remove node: a left mouse-click on the canvas adds a node at the cursor location, while a right mouse-click on a node deletes it
- Select node: a left mouse-drag on a node selects it and allows the node to be repositioned; a left-click activates a pop-up menu that allows node properties (coordinates and node type) to be viewed and edited, and polygons to be built at intersections, among others
- Add/remove link: a left mouse-drag from a start node to end node creates a directional link, while a right mouse-drag in a similar fashion deletes that link
- Select link: a left mouse-drag from a start node to an end node selects the link and allows link properties (link type and desired speed characteristics) to be viewed and edited
- Add/remove lane: a user-defined number of traffic lanes can be added or deleted from a selected link
- Add/remove space: a feature of this editor is that it allows groups of parking spaces to be ‘attached’ to a selected lane depending on user-defined settings (width, length, parking angle); parking space properties can be viewed and edited; the parking layout is automatically updated when the link alignment changes
• Add/remove structure: a right mouse-click activates a pop-up menu that allows the creation of building structures (e.g. columns, walls, polygon structures).

Figure 1 shows a screen capture of one parking level at The Heeren shopping centre that was input using the network editor.

Conclusions

One of the main strengths and also a potential Achilles’ heel of microsimulation models is that they are data hungry and require considerable effort to specify the physical network to be modelled. Traffic and parking simulation models are no exception. One practical contribution of this research is the development of an intuitive network editor that allows transport planners to visualise and create traffic and parking networks easily.

References


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Some Pitfalls in Urban Transportation Studies and Research

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Introduction

With the need to develop transportation facilities to meet increasing travel demand around the World, many urban land transportation studies are conducted each year. These range from master planning for road and public transit networks to implementation of traffic control and management measures. Decisions on a substantial amount of investment in the transportation infrastructure are made on the basis of findings from such studies. This has led to a proliferation of models and software packages for use in conducting these studies.

Concurrently, there has been a substantial amount of research work carried out by academics and researchers in the transportation field, attempting to obtain solutions to transportation and traffic problems. This has resulted in an explosion of papers proposing various models and algorithms published in journals and conference proceedings.

In this paper, some of the pitfalls in urban transportation studies and research are discussed. Only two areas, demand forecasting and traffic assignment, are covered here due to space constraints.

Demand forecasting

A major challenge a transport planner faces is to plan a facility with sufficient capacity to meet future demand. In most cases, the main technical problem is one of forecasting the expected demand over the next 15 to 20 years that the transport facility is to serve. Over the last 3 decades or so, many methods and models have been proposed for forecasting travel demand. They vary, among others, in the degree of complexity, theoretical rigour, and amount of data required. Are these models useful? In the opinion of this writer, the amount of effort and resources needed is often not justified by the accuracy of forecasts produced by many of these models.

It is not the intention of this paper to discuss whether the structures of these models were correct. Rather, regardless how rigorous and correct the model structure is, one needs to use data or model inputs to produce demand forecasts. The accuracy of these input data is far more uncertain when compared with the preciseness of the computation/estimation procedures used by some of the models.

Take, for example, disaggregate demand models that have been studied by many using various formulations for mode choice, route selection, etc. These models may be useful in identifying the travel behaviour of different market segments but are really not any better as a tool for forecasting demand than much simpler models. Regardless of the correctness of the structure of a model and how well it reveals travel choice behaviour, the fact remains that it is only as good as the aggregate data it has to rely on in order to forecast travel demand of the population. It is common knowledge that travel demand is affected by socioeconomic factors such as population and economic growth. It is also common knowledge that economic forecasts are quite uncertain, even for the short term [as evidenced by the quarterly revisions in GDP forecasts in many countries]. There is no obvious reason why transportation planners can do a better job than economists in forecasting. Even population forecasts are rather uncertain. For example, planners in Singapore had drawn up a plan in the early 1990s to accommodate a population of 4 million. They were not sure when this would happen and referred to it as Year X. Now, barely 10 years later, the population has already surpassed 4 million.

Indeed, a good forecasting model is a misnomer and actually should be called a good “back-casting” model, because the evaluation of model performance is typically based on how well the model replicated historical data. There is no evidence to indicate that it would be equally good in forecasting future demand. Invariably, the modeller then uses it to forecast future demand by assuming that (a) the same factors that affected demand in the past would still affect demand in the future; and (b) the magnitude of influence of each factor on demand would also remain the same throughout the planning period. These are two big assumptions that are likely to be invalid as time goes on. The simple fact is that no one has a clear enough crystal ball that would allow him to gaze into the future and predict what is going to happen in the next 15 to 20 years. All one needs to do is to compare forecasts produced in studies done for urban areas 20 years ago with the present demand levels. It would be a rare event indeed to find forecasts that are within 20% of the current demand.

Now, if demand forecasts are inaccurate, does one need to have demand forecasts? The answer is yes. Forecasts are still needed as targets for planning transportation facilities. However, since long term forecasts are inherently uncertain regardless of the type of model or method one uses, it is logical to opt for a simple and inexpensive method to obtain demand forecasts rather than a fancy one that requires significantly more resources and effort but is not any more accurate. Given the uncertainty of long-term forecasts, one really only need an order of magnitude estimate of the demand to be served. After all, the decision to build a two-way road with 4 or 6 lanes, for example, would not be affected by a difference of a couple thousand daily trips in the forecast. And much larger differences in ridership forecasts would be needed to influence the decision to build a transit system. Therefore, what is more important is that one should endeavour to incorporate as much flexibility as feasible in the plan so that adjustments can be made without wasting resources when the need arises. One should also update the forecasts regularly.
Traffic assignment

Traffic assignment is typically performed in network planning, traffic flow analysis and management. With advances in technologies, intelligent transportation systems (ITS) have received much interest from researchers, and many have touted it as THE way to solve traffic problems. In particular, much emphasis is being placed on dynamic traffic assignment as a tool to solve congestion by redistributing traffic on a real time basis to achieve better use of the available capacity in a road network. The literature contains a substantial number of papers on this topic but most of these are basically exercises in mathematical programming. As with studies of this type, simplifying assumptions were usually made so that the problem can be solved mathematically. In fact, most of these studies dealt with very simplistic networks and simplified demand patterns. Since there has not been any implementation of dynamic traffic assignment anywhere in the world, there is no actual data for testing and no study has been able to verify that the results actually represent a truly optimum assignment. Often, the emphasis of such studies ended up being one of finding an efficient solution to a hypothetical problem instead of addressing a real traffic issue.

Dynamic optimum assignment of traffic over a network cannot be achieved successfully in the real world because one needs to have accurate information on travel resistance [typically represented by travel time or a function of it] for all the links of the network in order to achieve optimum assignment. There are a number of factors that make it practically impossible to predict future link travel times accurately. Firstly, one cannot predict with good accuracy the traffic flows on each of the links in a network, and link travel times are dependent on link flows. The availability of traveller information/advisory systems under ITS would not be able to solve this problem as one cannot predict, for a reasonable length of time into the future, how many travellers would use each of the links. Therefore, any traffic routing advice would be based on inaccurate estimations of travel time.

A second issue is that a perfect correspondence between link travel time and link flow has yet to be found. For example, the calibrated speed-flow relationships often used in traffic flow analysis normally have R-squared values that are quite a bit less than unity. Hence, any travel time function used in the many algorithms proposed for dynamic traffic assignment would not be able to provide accurate predictions of travel time. As a consequence, the optimal assignment produced by a dynamic traffic assignment algorithm is an optimum for a non-existing situation, and a less-than-optimum one for the real case.

In addition, there is usually no real-time traffic information available for all the links of the network. This again means one cannot predict future travel time on many of the links with much accuracy, particularly for the case where the time period is longer than 10 to 15 minutes. Some researchers have proposed to use frequent short-term updating to predict travel time. Such updating does not work in actual conditions because it is not realistic to expect a driver to keep revising his link/route choice — once he has committed to a particular route, there usually is not much he can do to change his route under congested conditions. Hence, the driver’s selection of routes would not be what the proponents of dynamic traffic assignment aimed to achieve, i.e., optimal assignment of traffic so that the network is in equilibrium. This then begs the question of what is the benefit of dynamic traffic assignment.

Closure

A substantial number of studies and research has been aimed at obtaining “solutions” to transportation problems. Unfortunately, some people seemed to be so engrossed in their own little studies that they have lost sight of the important issues in the real world. What is useful is not the rigour in their modelling or the mathematical elegance of their solutions but rather a workable solution to a realistic problem. The fact that traffic congestion is not getting any better in most urban areas provides some indication that, in spite of the volume of work published, no great stride has been achieved by such studies either in the planning of transportation facilities or in managing congestion. One reason could be that most of these researchers are under pressure to publish or perish. They do research basically for the sake of publishing papers rather than addressing the real issues.

It is generally accepted that researchers in the basic sciences do fundamental research which may or may not have applications. But transportation research should be focused on the problems in the real world or it risks being irrelevant. The academic and research community in the transportation field must decide whether life should go on as usual with time and resources being spent on issues that are only of academic interest, or these should be spent on studies that have an impact on real-life transportation problems.

There is another concern: an increasing number of transportation planners and engineers, having been educated by such academics, may think that this is the way to deal with transportation problems and just follow the same path. There is already evidence that more and more transportation agencies are employing complex models and techniques in their work and making investment decisions based on the results from such tools. Given that no one can prove wrong a forecast of what would happen 20 years down the road, the danger is that a future generation will find it out when it is too late to take corrective action.