Transit (public transport) is an important component of the urban transport system in Singapore. In 2001, more than 60% of the daily trips were made using transit (MOT, 2002). More transit lines are under construction or being planned, in addition to the continuous development in bus operations. Modal integration will be the focus of the development of an integrated multi-modal transit system in Singapore. The complicated network, routes and flourishing transit services mean a wide range of choices for commuters, and as the transit system evolves the travel behaviour of public transport users will also be affected. This is in addition to an integrated service of providing information to the public, which is now being developed. With the increasing complexity in the transit network and availability of travel information on transit, this study explores the scenarios of transit path decision making in a complex situation, with input of real-time travel information. It is important to find out how commuters make their decisions about travel using transit in this increasingly complex and information-rich environment, and, in particular, how the decision of a multi-modal path of travel using transit is made. In this paper, the modelling framework to assess the preferences of transit users towards a range of factors and multi-modal alternatives is presented.

Path choice models on transit services of Singapore were developed using mixed Revealed Preference (RP) and Stated Preference (SP) information. The models were developed to determine how public transport users view the various service parameters, not only travel time but also attributes such as walking distance, number of transfers, and others. The RP models were estimated based on choice sets generated for 212 selected trips made by public transport users from a survey. Path-based and socio-economic information were used in the path size logit models estimated (Bekhor et al, 2002). A SP survey based on 44 scenarios was conducted at 12 different locations in Singapore. A total of 307 public transport users were randomly selected and they were asked about their decisions regarding one of the scenarios, each of which consists of three hypothetical alternatives representing various combinations of public transport services.

In this study, the transit path model comprises two main components: path search model and path decision model. The transit path alternatives were determined using a multi-modal k-shortest path algorithm through a path search process. Based on the three shortest paths as alternatives for choice, the path decision model was developed using the path size logit model to explain the path choice behaviour of commuters, due to the similarities between transit paths. Figure 1 gives an example on the three shortest transit paths available for an individual. The path size Logit formula to calculate the choice probability is shown as follows:

\[
P(i \mid C_n) = \frac{e^{\mu(V_{in} + b_n,PS_{in})}}{\sum_{j \in C_n} e^{\mu(V_{jn} + b_n,PS_{jn})}}
\]

For the \(n^{th}\) individual, \(V_{in}\) is the systematic utility, \(C_n\) is the choice set faced by individual \(n\) and \(PS_{in}\) is the path size variable of the \(i^{th}\) path \((i=1,2,3)\). \(PS_{in}\) was calculated based on the length of links within a path, and the relative lengths of paths that share a link (Bekhor et al, 2001).

A number of models based on pure RP data, pure SP data, and mixed RP and SP data were estimated. The results indicated that all the parameters had proper signs and most were significant. The RP and SP information show that in a complex transit network, information on the three shortest (journeys) time paths seem to be sufficient for decision making. Among the first three paths, the total journey time was found to be an important, but not the sole factor. The decision of which path to take relies on the trade-offs among attributes of not only journey time, but also walking distance, number of transfers, total number of transit stations and bus stops, and other socio-economic factors. The combination of those attributes variables in models indicates a multi-criteria path choice. In conclusion, the transit path choice models developed and calibrated in this study will provide important fundamental knowledge into the way transit services are utilised by commuters. This result is essential in a wide range of practical applications, for example, multi-modal transit service planning, transit demand modelling, and integration of the transit path choice models in ITS applications.

Reference

Pedestrian Crossing Behaviour at LTOR Junctions

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Pedestrians are well recognised to be the most vulnerable users on the roads. Road accident statistics show that pedestrians form about 30% of total road fatalities in Singapore of which about a fifth occur at pedestrian crossings. Accident investigations have found that pedestrians are partially culpable, especially when they cross using gaps in the conflicting traffic streams and in disregard of the signal indication. Many pedestrian-related accidents occur at the crossing facilities due to inadequate visual search and/or detection failures.

In order to promote and improve safety of pedestrians, it is useful to study their behaviour at the crossing facilities. A study was thus carried out which examined pedestrian crossing behaviour at selected junctions with left-turn-on-red (LTOR) traffic control.

The investigation was carried out at 5 signalised LTOR T-junctions located in different parts of Singapore. Pedestrian behaviour was studied at the signalised cross-walk across the minor approach, in terms of their crossing patterns and associated head movements in relation to the pedestrian signal indication (steady green, blinking green or red man). Head movement or visual search for on-coming vehicle serves as an indication of the pedestrian’s awareness of risk of conflicts with vehicular streams, and in particular, the LTOR vehicles.

A total of 1205 pedestrians (excluding about 5% jaywalkers) were observed as they performed the crossing manoeuvres. By field observation, the pedestrians were differentiated by gender (male versus female), and estimated age group (young: below 16 years, adult: 16-55 years, elderly: above 55 years) as well as the head movements. Other data such as crossing speeds, status of signal indication, vehicle movements in the vicinity, etc. were extracted from video recordings.

Figure 1 shows the cumulative distribution of crossing speeds of pedestrians with two types of movements, normal versus ‘Handicapped’, the latter referring to movements encumbered by accompanying children, heavy bags, etc. The respective 15th percentile crossing speeds were 1.20 m/s and 1.08 m/s; as expected, those who entered at blinking/red man, walked at a faster pace.

Figure 2 shows the pedestrian action according to gender and signal status. Overall, female pedestrians were observed to be more cautious than their male counterparts. A significant proportion of pedestrians proceeded to cross despite the fact that the signal was in not in their favour. Interestingly, not all pedestrians entered the cross-walk when they had the priority to do so; about 5% of the delayed entries was found to be due to obstruction from LTOR vehicles.

Figure 3 shows the pedestrian action according to age group. More than half of the adults were observed making crossings under inappropriate signal indications while a higher
proportion of the younger group tended to obey the law. On the other hand, a significant proportion of the elderly crossed in violation of the pedestrian signal. This appears to suggest greater risk-taking by the elderly, despite they being physically less agile in reacting to on-coming vehicles.

Figure 4 shows the proportions of field-observed head movements in relation to signal status and position on the cross-walk (first half versus second half, in either direction of movement). There was a greater tendency to look out for conflicting vehicular traffic when the signal was not in pedestrian’s favour, at all positions on the crossing. This tendency was greatest before stepping onto the cross-walk, but rather similar between the first and second halves of the cross-walk.

Concluding remarks

The findings reported here are part of on-going research into pedestrian behaviour at signalised cross-walk at junctions. The study serves to provide a better understanding of the underlying behavioural traits which shall enhance the scope of applying remedial measures.

Driver Behaviour at Junction Entrance during an Amber Blackout

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Introduction

While collecting traffic data using loop sensors connected to a special purpose data logger, an amber blackout period was observed as a result of a faulty signal system. Thus, drivers approaching that signalized intersection after the termination of the green signal light were immediately faced with no amber light indication for the entire duration of three seconds before the onset of the all-red display. This amber blackout period as witnessed by the author on site was checked and later confirmed using the signal phasing and timing data captured by the data logger. As literature on amber blackout is rather sparse, this is an excellent opportunity to investigate the influence of an amber blackout on the characteristics of red-running violations as well as those choosing to stop during this critical period.

Methodology

The methodology focused on a comparative study, which evaluated how an amber blackout would influence red-running violations and red-stopping characteristics. Data collected during the amber blackout period were compared with those collected during normal amber light operation. A total of more than twenty continuous hours of traffic data were recorded during the amber blackout period, while an identical timeframe of traffic data the following day during regular working of amber signal were also recorded for comparative study.

Red-running violations

From Table 1, the number of vehicles positioned within the zone of decision-making during the critical signal phase-change period in both cases was quite similar, 974 vehicles as compared to 949 vehicles with and without amber blackout. One may infer that the comparative study was being carried out on grounds of almost-equal numbers of vehicles at the intersection entrance during the critical signal phase-change period.

There were 441 cases of red-running violations during the amber blackout as compared to only 236 cases when signal lights were working properly. By normalizing the red violation numbers along each individual lane with respect to their lane volume, one can employ the test of proportion to assess their statistical significance. The results of the statistical test indicated that the number of red-running violations increased significantly (p-value ≅ 0.0001) during an amber blackout for all lanes studied. From the plot of hourly violations shown in Figure 1, one can also observe that the differences in red-running violations with and without amber blackout were wider during low traffic flow periods, especially from 2300 to 0600 hours in the next morning. Conversely, the highest curtailment to an increase in red-running violations occurred during the evening from 1700 to 1900 hours. From Figure 2, one can notice that almost all red-running violations occurred within the first 2 seconds when the traffic signal was working properly while only 82
percent were recorded during the amber blackout period. Those violating the red signal later than 2 seconds are subjecting themselves to serious risk of collisions. More often than not, they were deliberately crossing the intersection under such an amber blackout situation. Even though such drivers may have ascertained that they were no immediate danger, their actions would still be potentially hazardous to other road users. Also, the result of a t-test revealed a significant difference at the 95% confidence level between the mean after-red times with and without the amber blackout.

Red-stopping characteristics

As both crossing and stopping decisions are options in response to an amber blackout, it is not unexpected that most drivers may find it difficult to decide and that the decisions would be split between stopping and crossing. The analysis on characteristics of red stopping would provide a contrasting, but yet complementary, perspective to those drivers who chose to run the red signal. It was found that there were 37 red-stopping cases when signal lights were working properly as compared only to 12 numbers recorded during an amber blackout. A plot of red-stopping numbers with the time of day as shown in Figure 3 indicated that those choosing to stop during an amber blackout generally occurred in the morning and evening peak hours.

Concluding remarks

The comparative study indicated that initial indecision of drivers followed by hesitation would be their natural sequence of responses when faced with an unexpected amber blackout during this critical signal phase change period. One can conclude that drivers would decelerate initially to slow down their vehicles and then take advantage of the amber blackout by violating the red as far as traffic flow conditions (especially under low traffic volumes) permitted. The increase in red violation numbers could be attributed to drivers who (a) could have crossed during amber, slowing down their vehicles that subsequently crossed during red, (b) were located further upstream and deliberately violated the red, and (c) could have stopped but chose to violate the red signal.