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Verification of Puffin Modelling Using VISSIM

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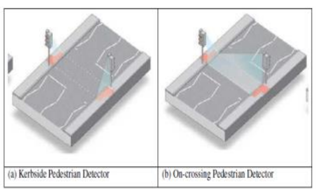
Graphical abstract



Abstract

Puffin crossing is the most recent signalised crossings in UK. The operation of Puffin signal control is mainly based on traffic condition hence could impose longer waiting time on pedestrian. Therefore there is a need to review on the operation of the signal control strategy of Puffin crossings to make it more pedestrian responsive without imposing significant delay to other road users. Research to date has shown that VISSIM model is more suitable for the evaluation of signal control improvement. The latest signal controlled pedestrian crossing facility, the Puffin, has been modelled and tested in VISSIM micro-simulation model. The objective of this study is to verify the Puffin coding using VISSIM microsimulation software. It is to ensure that the Puffin signal control in VISSIM is working as in a real traffic condition. For this purpose a suitable mid-block section was selected at Market Street, United Kingdom. Pedestrians' characteristics, vehicular characteristics, geometric layout of the site were retrieved from video recording. All these characteristics were coded in Puffin model using VISSIM micro-simulation. The results proved that the Puffin model in VISSIM is able to reproduce site representative condition. The findings in this study are significant in the whole modelling process.

Keywords: VISSIM; puffin crossings, signal control

1.0 INTRODUCTION

A Puffin crossing is the current pedestrian facility preferred for signalised crossings and there is a movement towards using Puffin crossings instead of Pelican crossings[1]. A Puffin gives more safety protection to pedestrians by using a steady red signal to vehicular traffic instead of flashing amber at Pelican crossings. Pedestrian detector systems have been introduced in Puffin crossings to improve the operational efficiency of pedestrian crossings and as an improvement to the Pelican crossing. Kerbside detection was used as an initial detector to confirm the pedestrian presence on the kerb and has not crossed the road before the pedestrian phase was initiated. Otherwise, the call for pedestrian phase will be cancelled[2]. It is to ensure that traffic was kept moving when there are no pedestrians waiting on the footpath before the pedestrian phase was initiated. This reduces the number of 'unnecessary' pedestrian phases which can affect the traffic delay. Another detection system on the Puffin crossing is on-crossing pedestrian detectors which are used to monitor pedestrians on the crossing. The intent is to reduce traffic delay, by starting the vehicle green period as soon as pedestrians were clear of the crossing. Figure 1 shows the kerbside detection and on-crossing detection on Puffin crossings.

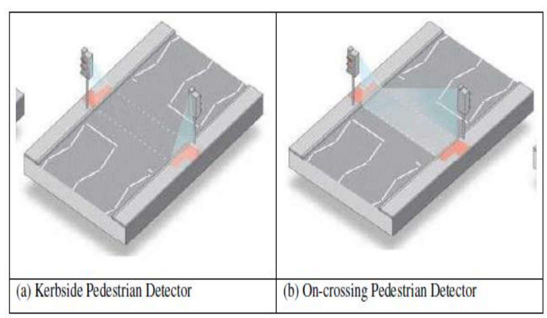


Figure 1 Kerbside and on-crossing pedestrian detector[2]

Installing pedestrian detectors on Puffin crossings should reduce unnecessary delays to traffic and allowing more efficient use of road capacity by making the drivers to keep on moving unless a pedestrian was detected on the crossing[3,4]. The detectors control the traffic lights so that pedestrian have enough time to cross safely, but also change them to green as soon as the crossing was clear and there was no-one else was waiting to cross.

A main concern with Puffin crossings is in spite of making a clear safety protection to road users, the control strategy of a Puffin pedestrian crossing is still dominated largely by the needs of traffic, according to the control strategy and traffic detection in operation. This can lead to disproportionately high delays to pedestrians[5] hence in turn could lead to reductions in pedestrian traffic and encourage pedestrians to 'violate' the traffic signal control. In fact, the main benefit of the kerbside detection is to cancel unnecessary pedestrian phases – a benefit particularly to road traffic.

As the Puffin crossing is the most advanced signal controlled pedestrian crossing facility in the UK, and is becoming commonplace, it is appropriate to review the strategy in full, including its operational sequence and timing. In this study, VISSIM microsimulation software was used to evaluate the performance of Puffin signal control in a non-destructive method, Therefore, it is then a requirement to code the Puffin logic in VISSIM micro-simulation for evaluation purpose.

The model verification was conducted to determine the validity of the logic for Puffin signal control. It was necessary to identify any coding errors in the model. Coding errors can distort the model calibration process by adopting incorrect values for calibration parameters. Accordingly, fixing model coding errors was an important task throughout the whole modelling process.

2.0 LITERATURE REVIEW

Micro-simulation models have been used widely in transportation research applications due to their ability to evaluate complex range of circumstances that arises in practice in a non-destructive method. The main task of a microscopic traffic simulation is to support traffic management decisions. While some of the commercially available micro-simulation packages are in theory able to simulate pedestrians, the primary purpose of these models clearly lies in simulating motorised traffic[6,7]. The modelling of pedestrians have only been in the context of their affect on vehicular traffic i.e., delay caused to vehicles due to pedestrians crossing the streets.

Specific pedestrian micro-simulation techniques have been steadily improved over the last decade and have been applied to crowd movement, building evacuation and pedestrian waiting behaviour at crossings. Among them are the Social Force model[8], Pedestrian Speed Decision Algorithm[9], cellular automata[10] and field floor model[11]. There are many of such models now available and significant research has been done on the strengths and weaknesses of each model[12,13,14,15]. However these models, though excellent for pedestrian behavioural simulations, are not much use for analysing pedestrian movement characteristics in urban street environments as they do not model vehicular traffic, road networks and traffic control features.

One of the commercial micro-simulation software that integrates vehicular traffic, pedestrians and traffic signal control for the interaction between vehicle and pedestrians is VISSIM[16]. The ability of VISSIM to model the interactions between vehicle and pedestrians under various circumstances has been proved by previous research[5,17,18,19,20]. The *Social Force Model* has been integrated in VISSIM and this is the recent development in VISSIM to model the behaviour of pedestrians. *The Social Force Model* is used in this research because it can be realistically model the behaviour of pedestrians compared to the other two methods namely: No Interaction method and Car-Following method.

3.0 METHODOLOGY

Setting up the simulation model was the first step and comprised of tasks and activities that were conducted prior to commencement of the model verification in VISSIM. The tasks consist of site selection, field data collection, and network coding.

The study was conducted on isolated vehicle actuated control at Market Street, Manchester, which is a single carriageway Puffin crossing with no central refuge. An exploratory approach using data from a video recording from the site has been used to develop the verification procedure. Pedestrians' characteristics, vehicular characteristics and geometric layout of the site were retrieved over a period of an hour video recording. The input data needed in VISSIM model includes traffic flow, vehicle speed, travel times, pedestrian behaviours on the crossing and signal timing. The road has a single lane in each direction. Three vehicle classes in the video were defined for the use in the road network; Car (95%), Heavy Goods Vehicle (3%) and bus (2%). Figure 2 shows the basic layout of the road section studied, as coded in VISSIM.

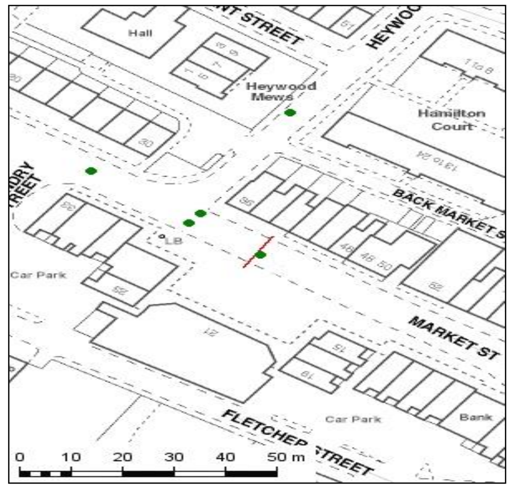


Figure 2 Map of Market Street, Manchester

Figure 2 shows the road layout of Market Street, Manchester. Data on road geometry was obtained from a 1:20 scale map of the site such as the location and width of pedestrian crossings, vehicle stop lines, width of road links and the number of lanes per link. Standard signal timing parameters such as intergreen time, minimum green time and pedestrian phase time for both sites was provided by the Greater Manchester Authority. Some of the parameters were cross-checked with the observation site.

Traffic counts of both vehicles and pedestrians were necessary in order to introduce site representative flows in the micro-simulation model. Table 1 and Table 2 show the vehicle flows and pedestrian flow at Market Street, Manchester and these were coded in VISSIM.

Table 1 Vehicle flows per hour at Market Street, Manchester

Traffic Volume (veh/h)		
Direction from	Southbound	Northbound
Through movement	809	484
Right turning	35	38
Left turning	26	16
Total	870	538

Table 2 Pedestrian flows per hour at Market Street, Manchester

Pedestrian Volume (ped/h)		
Direction from	Westbound	Eastbound
Total	15	65

The desired speed distribution of vehicle was required as a VISSIM input data. If not hindered by other vehicles, a driver will travel at their desired speed (with a small stochastic variation). Desired speed distributions for vehicles were coded in the model based on the actual speeds of vehicles at free flow conditions. Figure 3 below shows a cumulative distribution of vehicle desired speed at Market Street.

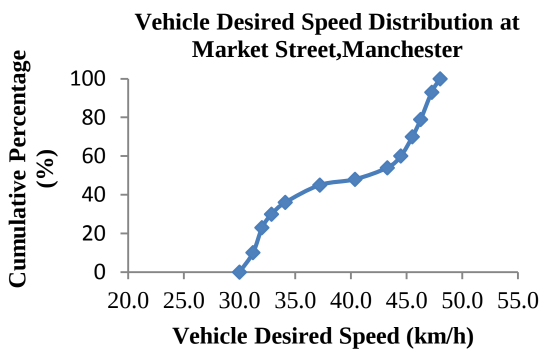


Figure 3 Vehicle desired speed distribution at Market Street, Manchester

The desired vehicle speeds varies linearly between 30.0 km/h to 48.0 km/h as shown in Figure 3. The vehicle desired speed distribution was taken from 324 vehicles at free flow. The mean of the vehicle desired speed distribution is 40.1 km/h with a standard deviation 6.5. Pedestrian speed data at Market Street were measured from video recordings. Similarly, desired speed distributions for pedestrians were coded in the model based on the pedestrians' actual speed at free flow condition. Figure 4 shows the pedestrian desired speed at Market Street, Manchester.

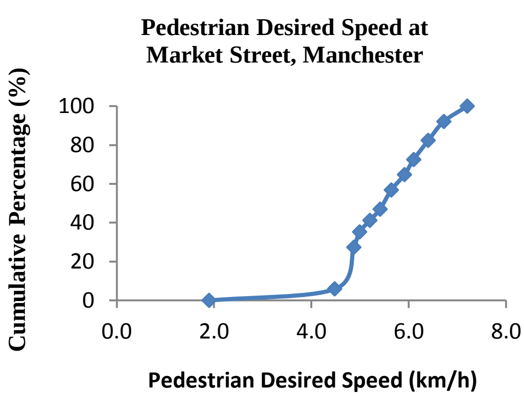


Figure 4 Pedestrian desired speed distribution (km/h) at Market Street, Manchester

Based on the video observations, pedestrian desired speed at Market Street, Manchester was between 1.9 km/h to 7.20 km/h as shown in Figure 4 with the 15th percentile speed at 4.8 km/h and 85th percentile speed at 6.6 km/h. Note that the standard speed often used in design is 1.2 metres/sec and this equates to 4.32 km/h.

From the video observation, pedestrians were classified into three types, according to their behaviour when arriving in pedestrian red phase (Red Man): a) obey signal, b) press the button but ignore red (gap-crossing when there is an opportunity), c) do not press the button and ignore red (gap-crossing when there is an opportunity). For the present study, gap selection attributes of pedestrians at signalised crossing were derived from field data collected at signalised crossing in Market Street, Manchester. The methodology by which these data were collected is described in Transportation Research Board[21].

The code checking was conducted as to test the ability of the model to reflect the Puffin signal control operations, including gap-acceptance and call-cancels. A series of simulation runs were conducted to determine if the model was functioning as intended. Ten simulation runs of the model with ten different random seeds were conducted and taking into account day-to-day variation of the traffic. Input data of the model such as traffic volumes, speeds and traffic signal timing were based on the data collected at Market Street network. Then, model verification based upon signal timing changes was performed by comparing the output of simulation runs with the field measurements. VISSIM allowed visual viewing of the simulation runs so that any visual errors can easily be detected instantly. Accordingly, model coding can be fixed throughout the whole modelling process.

4.0 RESULTS AND DISCUSSION

Signal stage changes were analysed initially as an accurate representation of the actual Puffin signal control. This is the first and fundamental requirement. If this is inaccurate, then other performance parameters (e.g. average journey time) will be inaccurate, because they are, in part, dependant on signal timings.

Model error checking based upon the number of signal cycles was performed by comparing the stage change frequency between simulation runs and field measurements. Ten simulation runs of the model with different random seed numbers were conducted using default model parameters in order to get the necessary output. Table 3 shows the number of cycle measured on the Market Street and average cycle number from 10 simulation runs.

Table 3 Numbers of signal cycle: field vs simulation

Field	Simulation	RMSP
38	39	1.9%

The cycle number of signal control from both real site and simulation model is 38 and 39 respectively as shown in Table 3. The Root Mean Square Percentage (RMSP) was calculated to check the goodness of the fit between number of cycle of the calibration site and simulation model. RMSP 1.9% shows a high satisfaction of goodness of fit between simulated and field signal timing changes, which is less than 15%. The simulation model was able to produce a close matched signal timing changes as in the field measurements.

Secondly, to check whether the vehicle green time in simulation model matches the real site. A non-parametric method, Wilcoxon Signed Ranks test was executed to compare the mean of simulated green time and the mean of the actual green time. The results for statistical correlation are as shown in Table 4.

Table 4 Statistical correlation between the mean of actual and simulated green time using Wilcoxon Signed Ranks test

Mean Green Time (seconds)		Z	Asymp. Sig. (2-tailed)
Field	Simulation	-0.153^{a}	0.878
81.4	81.2		

^{a}Based on positive ranks

The mean green time for vehicles is almost identical in both field observation and simulation runs. The results in Table 4 showed that the mean of the simulated green time was not significantly different from the mean of the actual green time at the 95% confidence level ($Z = -0.153$, $p = 0.878$).

Further verification was conducted on the variable red clearance period. Table 5 shows the mean of the variable red clearance period of the Market Street network and the mean of green time for 10 simulation runs. Comparison of mean of red clearance period between field measurement and individual VISSIM runs were made using Wilcoxon Signed Ranks test. The results for statistical correlation are shown in Table 5.

Table 5 Statistical correlation between mean of actual and simulated red clearance period using Wilcoxon Signed Ranks test

Mean Red Time (seconds)		Z	Asymp. Sig. (2-tailed)
Field	Simulation	-0.718[a]	0.473
10.5	9.8		

[a]Based on negative ranks

Again, the values of the mean red clearance period were not significantly different at the 95% confidence level ($Z = -0.718$, $p = 0.473$).

The close match between the simulation and the field measurements in Tables 3, 4 and 5, shows that the model is suitable for further analysis. This involves the procedure for verification of other input parameters and followed by the procedure for calibration and validation.

■5.0 CONCLUSIONS

Among the signalised pedestrian crossings commonly used in Britain, the Puffin crossing gives more safety protection to pedestrians and is the crossing type recommended by the Department of Transport. Despite this improvement, the control strategy of Puffin pedestrian crossing is still operated within the existing traffic control system in operation. This could lead to reactions in pedestrian traffic and encourages pedestrians to violate traffic signal control. The signal control facility at pedestrian crossings could be improved by taking into account of the total delay to all road users including the pedestrians. This research has shown that VISSIM is a suitable tool for evaluating these possibilities and that the Puffin model in VISSIMin producing a good agreement between simulation results and field measurements. The finding is significantly important in the procedure of reviewing the operation of Puffin signal control in VISSIM.

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