CONFLICT ANALYSIS WITH REAL-TIME VIDEO ANALYSIS

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ABSTRACT

Video analytics was used in Nelson at the intersection of Waimea Road and Motueka Street to identify when and where conflicts occur between pedestrians / cyclists and vehicle movements. This signalised intersection is considered busy and required a safety review following several collisions between cyclists and other road users. The road safety concerns prompted Stantec to utilise a newer, digital approach to better understand the nature of the conflicts between the user groups primarily the locations and times of day.

A UK based company provided the hardware and video analytics software to identify and track road users. This data was further analysed spatial-temporally by Stantec to identify conflicting movements. Vehicle classification and movement counts were also performed. While vehicles were reliably classified into a dozen categories (including emergency vehicles and Motorbikes) there were limitations with the ability to derive an accurate and reliable location for each road user. These errors can be mitigated in future with improved camera placement. Regardless of the limitations, using this digital data collection approach Stantec acquired more precise data when compared to traditional methods. This was particularly relevant when regarding the duration of the study period and the nature and location of conflicts.

INTRODUCTION

Concerned with the performance of a busy local intersection, Nelson City Council commissioned Stantec to undertake a study into how road users behave while passing through the signalised intersection of Waimea Road and Motueka Street. This study was focused on conflicts between cyclist and vehicle movements and the areas of the intersection these events most commonly occurred. At the time of this study (January 2019) Stantec were in the process of exploring the capabilities of new vehicle tracking and identification cameras on loan from a UK company called Vivacity. It was proposed that these cameras be used to monitor the intersection for several weeks in order to collect a more detailed, continuous data set. The resulting data set would be significantly larger than what would be collected using traditional methods resulting in a more representative analysis. The data provided by these sensors would allow us to discern to what movements were taking place within the intersection, where and when conflicts occur, and the behaviour of road users before and after a conflict occurs.

This study, while focusing on the improving the safety of the Waimea Road and Motueka Street intersection, provided an opportunity to thoroughly test the capabilities of these cameras. Stantec were interested in the performance capabilities and the data provided by these units. It is noted that similar studies have been undertaken within NZ that utilise vehicle tracking cameras to collect count data. None of the studies investigated by Stantec were found to utilise this technology of conflict detection and analysis.

TECHNOLOGY

The cameras provided by Vivacity use on board video analytics to identify vehicle type and record the path it takes as it traverses across the cameras field of view. The paths the vehicles take are recorded each frame as an X and Y position on the field of view. While there are some fluctuations in the frame rate based due to the variability of the demands on the processor this was ignored as the variation from 30 frames per second was negligible. These cameras were wired into the traffic signals pole for power.

The units Stantec was provided had not been tested and calibrated for New Zealand's 4G network and so instead were configured to connect to a nearby Wi-Fi router with a pre-set SSID and password. Stantec provided several low power 4G routers for the cameras to connect to which shared the same power supply as the cameras. As these devices process the video footage locally the data requirements were negligible when compared to streaming the footage for cloud-based processing. The ability to stream the footage however was a build in feature, which was utilised to validate aspects of the analysis.

Every five minutes the cameras would connect to Vivacity's servers through the installed routers and upload the vehicle path and classification data collected since the last synchronisation. This data was geocoded by Vivacity and was made available via an API (Application – Program Interface) for analysis. This data was also presented in a dashboard showing the volumes by mode for each approach of the intersection throughout the day. It was noted that, at the time of installation. these cameras were only of counting vehicles using each lane (crossing a virtual trip wire) and were not capable of classifying origin-destination movements through the intersection. To determine the movements of each road user further analysis on the path data would need to be conducted.

For this study two cameras were installed on opposite corners of the intersection each with a clear view of the Waimea through movement and one of the Motueka approaches as shown in Figures 1 and 2. The locations of these cameras were limited by where traffic signals were installed as streetlights would not provide power during the day. For future studies solar power should be investigated to allow for more flexibility in installation location.

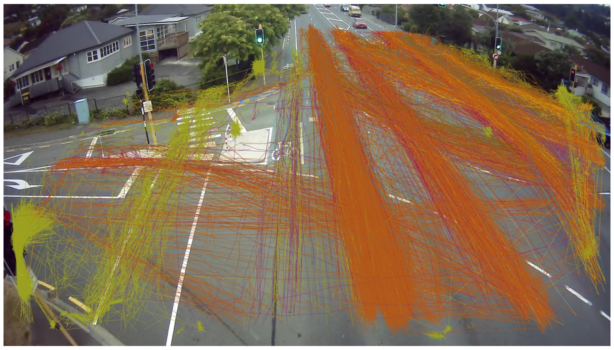

Figure 1: Sensor 1 - Waimea South

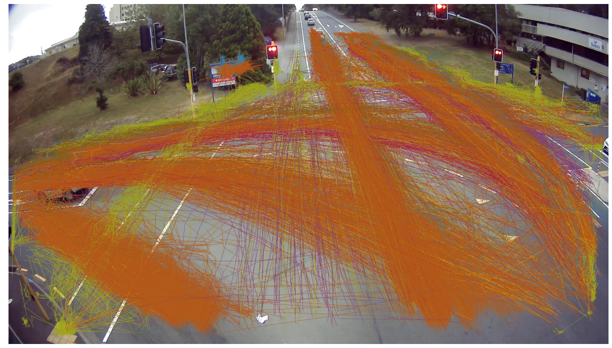

Figure 2: Sensor 2 - Waimea North

Figures 1 and 2 show that the Waimea road through movements were tracked the best. These movements were the primary concern for this study as they had been linked to the cyclist crashes which incited this study. These were also the busiest movements. The path data for the turning movements furthest away from the cameras yielded a poorer quality of data. Objects identified at the edges of the camera's field of view caused some issues for the tracking algorithm. With this in mind, the data collected from these cameras could be improved with an adjustment of the cameras angle to better utilise the undistorted range of view.

ANALYSIS METHODOLOGY

Several analysis tools were set for the extraction and processing of Vivacity's data. Firstly, a tool would poll Vivacity's API to download the data sets to a local database. This tool could be run continuously (polling every five-minute interval) or set to download all entries for any time/date range. This tool would transform the data from an object orientated layout into a spatial tabular format. The coordinate system was also converted from WGS84 to NZTM to make the comparison of distances between road users quicker and simpler to calculate. Figure 3 below shows the classified vehicle path data mapped for 11th January 2019 from 8:00am to 8:15am. The triangles in the Figure indicate the location of the cameras.

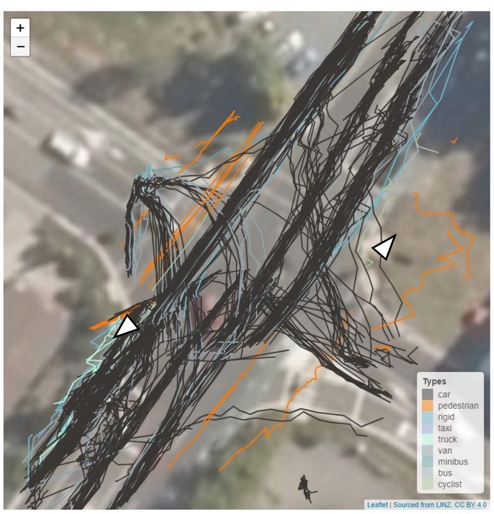

Figure 3: Both Sensors - Spatially Mapped Classified Vehicle Paths

Due to a combination of camera placement coupled with the geocoding and spatial mapping of the vehicle path data by Vivacity, the resulting data set does not perfectly reflect the actual intersection movements. Movements closest to the edges of the camera's lens are distorted and fluctuations in paths further away from the camera are intensified. These inaccuracies mostly impact the data associated with the turning movements, while the through movement data is mostly reflective of observed behaviour.

Following the download and geospatial transformation a separate process would analyse the data in five-minute bins. Conflicts for this project were defined as any instance where a vehicle centerpoint occupied a space within two meters and within one second of a cyclist / pedestrian. While we were not using a continuous data set (30 frames per second), the granularity of the data acquired was deemed small enough to use without further interpolation. Each entry in the data set was attributed to a road user ID and had an exact position and timestamp. A spatial-temporal match was done on this data set to identify whenever the conflict conditions occurred between the path of a cyclist / pedestrian and any vehicle. These points were flagged and were later joined into paths showing how road users behaved around each other during a conflict period. Figure 4 hows the conflicts that occurred on 24th January 2019 between 8:00am and 8:15. For this image full cyclist paths have been shown while only the parts of the vehicle path that were found to conflict with the cyclists were shown.

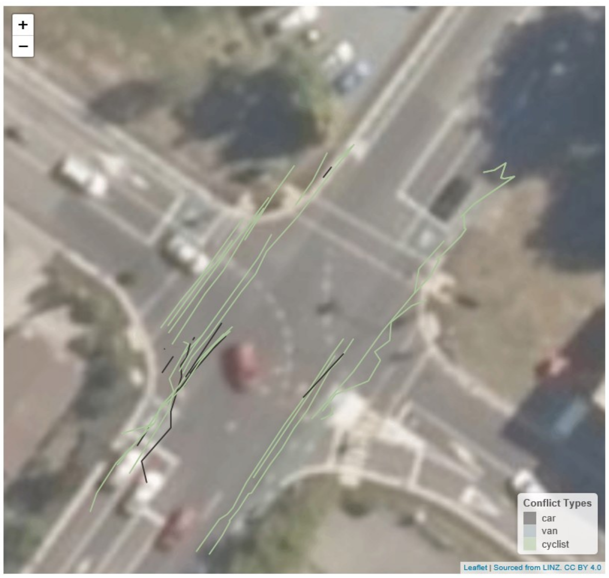

Figure 4: Conflicts Only

Vehicle paths through the intersection were interpreted as best as possible to undertaken movement counts for the purpose of providing context for the conflicts observed. With the placement of the cameras it was often the case (especially for the Waimea road through movement) for road users to exit the visible range of one camera partway through the intersection while entering the visible range of the other camera. This transition would not be simultaneous with each road user occupying the visible range of both cameras for several frames. Rather than undertaking the task of mapping each movement between the two cameras an estimate volume was generated for each camera separately for the movements that could be observed, based on where the road user appeared/disappeared. The movement estimates for each sensor were compared and where they differed an average was taken. The count estimates for the through movement were consistently within 10% of each other. Further work to improve the results of this count could be done with further analysis. Improved camera placement methods would also assist in obtaining a more accurate count, however an exact count was not required for the results of the study.

RESULTS

This data was presented as a web dashboard as shown in Figure 5 for the use of Stantec's Safety team and Nelson City Council to use in their investigation. Figure 6 shows the dashboard outputs of the vehicle count estimates for the selected data as well as the specified time period. Likewise Figure 7 shows the count of conflicts detected. The types of vehicle classifications can be seen in the legend for Figure 6, these are as follows:

- Pedestrian
- Cyclist
- Motorbike
- Car
- Taxi
- Van
- Minibus
- Bus
- Truck
- Ridged
- Emergency car
- Emergency van

Figure 5: Data Display Dashboard

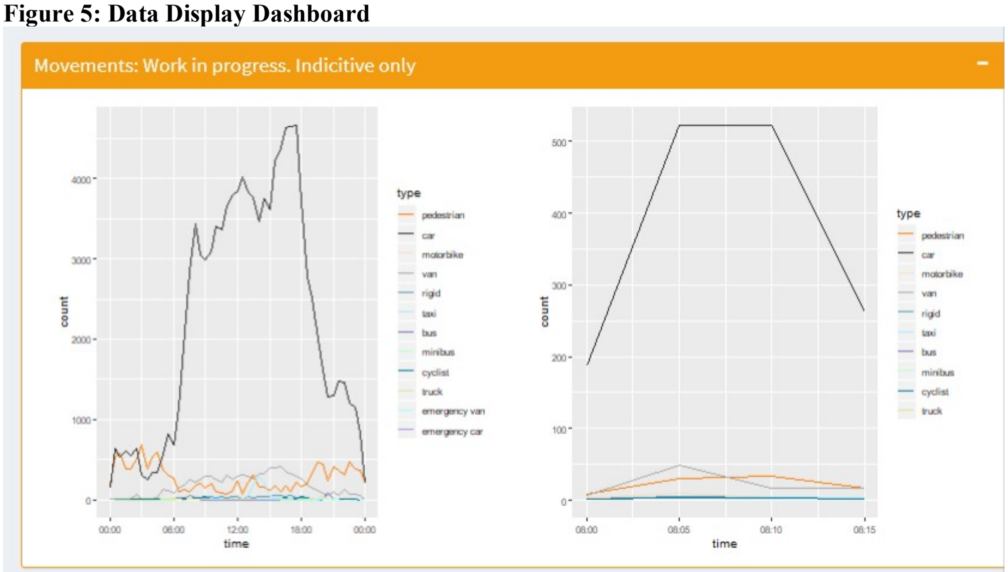

Figure 6: Movement Counts

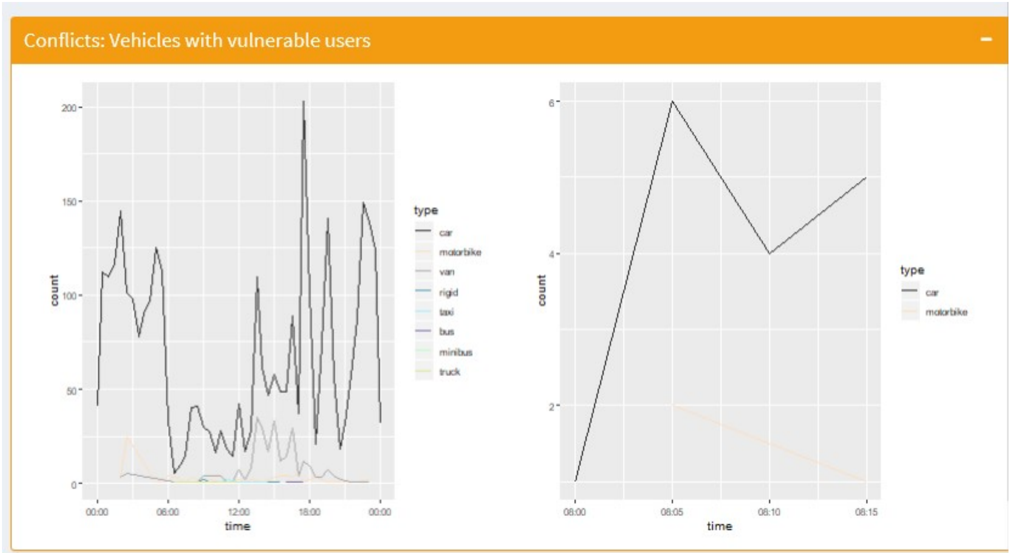

Figure 7: Conflicts Count

While there are significant improvements that could be made in the acquisition and processing of the data, we saw consistently throughout the day the cyclists would opt to dismount and utilise the pedestrian crossings rather than cycle through the intersection. We saw that most of the conflicts occurred with vehicles on the Waimea road through movements entering the proximity of cyclists on the same movement.

Collating the locations of conflicts within the intersection we were able to identify a few key locations and movements where conflicts occurred frequently throughout all hours of the day. It was these movements where cyclists were also seen to be using the pedestrian crossing rather than risk an incident. This information will be used in future safety engineering work around this intersection to better optimise it for cyclists.

This technology, and those like it, while having room for improvement have provided a level of automation to the data collection and processing. With some adjustments to the methodology and analysis a more specific, targeted approach will be able to be undertaken to address safety concerns.

CONCLUSIONS

The use of the cameras provided by Vivacity allowed Stantec to conduct a continuous analysis of the performance of this busy intersection without needing to repetitively visit the site or manually watch hours of video footage. The methodology used in this analysis can be run in near real-time with a delay of just over five-minutes between an observed event and the analysis. While the placement of the sensors coupled with some of the data transformation methods resulted in a dataset which proved unreliable in places and challenging to analyse in others, the lessons learnt from this trial will allow for these errors to be mitigated in the future. The variation in vehicle path data along the movements of interest was small enough for a conflict analysis to take place resulting in an understanding of conflict locations and road user behaviour surrounding them. This will be the focus of future safety engineering work at this intersection.

While some refinement must be made to the methodology in order to improve the reliability of the full dataset, this project demonstrates the capabilities of some of the data collection and analysis technology currently in the market and what conclusions can be reached by adapting current methodologies.

AUTHOR CONTRIBUTION STATEMENT

Andrew Liese: Undertook the technology review, Data Extraction, Transformations and analysis and developed the dashboard and analytics.

James Newton: Was the project lead and safety engineering on this project and conducted the initial review of this paper