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TITLE

A review of SA line markings for suitability with lane support systems: a video analysis trial

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ABSTRACT

Two vehicles equipped with lane support systems (lane departure warning and lane keep assist) were instrumented with a GPS receiver and video cameras to record the detection rate of road line markings along an approximately 80 km route. Custom video analysis software was developed to determine the locations of line marking detections made by the vehicles post testing. An overall 97.8% detection rate was observed along the selected route, and the locations of the non-detections were further analysed to indicate possible causes of non-detections. Both lane support systems tested showed similar results for overall distances of line markings detected, but differences in the frequency of non-detections were reported.

KEYWORDS

Lane support system, lane keeping assist, lane departure warning, video analysis, Victor Harbor Road

Summary

Custom video analysis software was used to determine when the lane support systems of two vehicles could identify the lane line markings along Victor Harbor Road, South Australia. The video analysis software proved successful and produced an average line marking detection rate of 97.8% between the two test vehicles. The locations and a heat map of areas where line marking non-detections occurred was generated. The situations in which non-detections occurred were potentially attributed to shadows over the line markings, newly formed lanes, uncommon lane dividing markings and absences of line markings. Potential solutions to overcome the non-detections along Victor Harbor Road are discussed.

Contents

1 Introduction

Lane support systems are a group of technologies that assist drivers in maintaining lateral control of their vehicle. Two general types of lane support system exist, lane departure warning (LDW) and lane keep assist (LKA). LDW systems use front facing cameras along with image processing algorithms to detect the presence of line markings on the roadway. When a vehicle crosses or drifts over a line marking, without an active turn signal, the LDW system provides a warning to the driver. This warning, which may be audible and/or haptic, is intended to alert the driver such that they steer their vehicle back into the centre of the roadway.

LKA is a more advanced lane support system that utilises the same camera-based line marking detection system and has the capability to automatically provide small steering inputs to keep the vehicle in the centre of the current lane of travel. When a driver has the LKA system activated they are still required to keep their hands on the steering wheel (otherwise the system will provide a warning and deactivate). While the LKA system is operating, it is relatively easy for the driver to override any automatic steering actions with firm pressure – at which point the system will deactivate.

Both LDW and LKA systems usually have a minimum speed at which they can operate (around 50 – 60 km/h) and do not perform well when travelling through tight bends (as the front facing cameras are unable to track line markings around curves).

Several studies have investigated the effectiveness of lane support systems in preventing crashes. Jermakian (2011) explored data from the US to isolate the crash types and crash circumstances that would be most likely to benefit from the actions of lane support systems. By excluding cases that would not be relevant to the actions of lane support systems, such as those that occurred on roads with a speed limit of less than 40 mph (65 km/h), estimates for the reduction in crash risk for various types of crash were generated. Lane support systems were predicted to provide some mitigating effect in 10% of single vehicle injury crashes, 35% of head-on injury crashes, and up to 33% of sideswipe injury crashes.

Another study by Scanlon et al. (2015) simulated the actions of lane support systems on single vehicle drift-off road crashes that had been modelled from in-depth crash data collected in the US. These simulations indicated that LDW would have some effect in 20.7% of fatal and serious injury crashes. This effectiveness level increased to 27.8% when a rudimentary LKA system was applied to the crashes.

A retrospective study of the effectiveness of LDW and LKA systems in preventing single vehicle and head-on crashes in Sweden, on roads with a speed limit of 70 km/h and above, was conducted by Sternlund et al. (2017). An induced exposure method was used to compare the crash rates of vehicle models equipped with lane support systems to vehicle models without lane support systems. The analysis included 157 vehicle models with LDW, but only 11 with LKA. The results found that vehicle models equipped with lane support systems were 53% less likely to be involved in a casualty crash.

A more conservative level of effectiveness was found in an investigation by Cicchino (2018), which also consisted of a retrospective study that compared vehicle models with lane support systems to those without. Using data from the US, it was concluded that vehicles with a LDW system were 21% less likely to be involved in single vehicle, side swipe, or head on injury crashes on roads with a speed limit of 40 mph and above.

While these studies indicate that lane support systems are likely to lead to impressive reductions in lane departure type crashes, it is important to remember that they are only effective on roads with appropriate line markings. Lane support systems can offer a reliability of over 90% on typical Australian rural and remote highways where line markings have been well maintained (Mackenzie et al., 2018), but will offer no benefit on roads which do not have line markings, where the line markings are obscured by debris (such as leaves and soil), or where the line markings are faded. Even in locations where line markings exist there are several situations which can lead to unreliable performance by lane support systems, such as where there are shadows over lane markings, different line marking types, or multiple sets of line markings. A reduction in performance in these types of situations was observed by Transurban (2019) during a trail of a vehicle with a modern LKA system in Queensland.

In order to ensure lane support systems are able to operate to their full capability, it will be important to be able to identify locations where line markings are unsuitable. The LKA feature in many vehicle models display which line markings are visible to the system on the dashboard. This presents an opportunity to collect data on which line markings are suitable for use with lane support systems, and which are not, while travelling along various road sections of interest.

The aim of this project was to determine the feasibility of recording the dashboard of a vehicle and using video analysis software to identify when line markings are recognised by the lane support system. In Section 2, a trial methodology is described that involves collecting video data from two vehicles (equipped with LKA) while they are driven along Victor Harbor Road. The development and application of custom video analysis software, used to process the collected video, is that presented. The outcomes of processing the recorded video using the video analysis software are presented in Section 3, along with some results that indicate the prevalence and location of line markings that were not detected by the trial vehicle LKA systems. Finally, in Section 4, a discussion on the success of the trial video analysis software in assessing the suitability of line markings for use with lane support systems is provided, as well as some commentary on the results found for Victor Harbor Road.

Note that this report was substantially completed in September 2020 and does not consider developments after that date.

2 Methodology

Two vehicles equipped with LKA were driven along a route on Victor Harbor Road while fitted with video equipment recording the dashboard display to collect data. This data was then processed with custom video analysis software. The specific details of the project methodology are described below.

2.1 Risk assessment

As some of the activities in this project involved on-road data collection, that could potentially be distracting to the driver, a risk assessment was performed. The risk assessment was initially developed by researchers at CASR and then reviewed by the project manager from the Department for Infrastructure and Transport.

2.2 Trial vehicles

Two vehicles, equipped with modern lane support systems, were used to collect data along the trial route. The first vehicle was a 2018 Toyota Corolla and the second was a 2018 Mazda CX-9. The relevant features of the lane support system dashboard display for each vehicle are described below, along with any system limitations noted in the owner's manual.

2.2.1 2018 Toyota Corolla

The lane support system dashboard display for the Toyota Corolla is shown in Figure 2.1. The display shows two longitudinal lines which indicate when the system has detected a line marking on either the left or right side the vehicle. The line indicator is filled (solid white) when a line marking is detected and empty (blank) when no line marking is detected. In Figure 2.1, the dashboard display is indicating that the system has detected a line marking on the left side, but not on the right side.

The owner's manual of the 2018 Toyota Corolla lists the following limitations and conditions to note when using the vehicle's lane support system:

- The system is only capable of detecting white and yellow lines;
- The vehicle speed must be above 50 km/h for the system to operate;
- The system will not operate when the turn signal is activated;
- The system requires a traffic lane width of approximately 3 metres or more;
- The system will not operate through a curve with a radius of less than 150 metres;
- The system may not operate where shadows are covering or running parallel to line markings;
- The system may not operate where line markings are difficult to see due to sand, rain, puddles, or where the road surface is highly reflective;
- The system may not operate as the vehicle enters or exits a tunnel where the light conditions change quickly;
- The system may not operate where sun glare interferes with the forwards facing camera;
- The system may not operate when the vehicle is driven on a slope, around a sharp curve, or on rough road; and
- The system may not operate when the vehicle has just changed lanes, driven through an intersection, or where the road diverges or merges.

Figure 2.1
Lane support system dashboard display for the Toyota Corolla

2.2.2 2018 Mazda CX-9

The lane support system dashboard display for the Mazda CX-9 is shown in Figure 2.2. Like the display in the Toyota, there are two longitudinal lines shown which indicate when the system has detected a line marking on the left or right side the vehicle. The line indicator is filled (solid white) when a line marking is detected and empty (blank) when no line marking is detected. In Figure 2.2, the dashboard display is indicating that the system has detected a line marking on the right side, but not on the left side.

The owner's manual of the 2018 Mazda CX-9 lists the following limitations and conditions to note when using the vehicle's lane support system:

- The system is only capable of detecting white and yellow lines;
- The vehicle speed must be above 60 km/h for the system to operate;
- The system will not operate when the turn signal is activated;
- The system will not operate when the brake pedal is depressed;
- The system will not operate if the lane width is excessively narrow or wide;
- The system may not operate where there exists a temporary line for construction;
- The system may not operate where a shadow or groove filled with water creates a misleading line;
- The system may not operate where line markings are difficult to see due to bad weather (rain, fog, or snow) or where the road surface is highly reflective;

- The system may not operate as the vehicle enters or exits a tunnel where the light conditions change quickly;
- The system may not operate where there are two or more adjacent line markings;
- The system may not operate when the vehicle is driven around a sharp curve or on rough road;
- The system may not operate when the vehicle is driven through an intersection, junction, or forked road; and
- The system may not operate where there are road markings or lane markings of various shapes near an intersection.

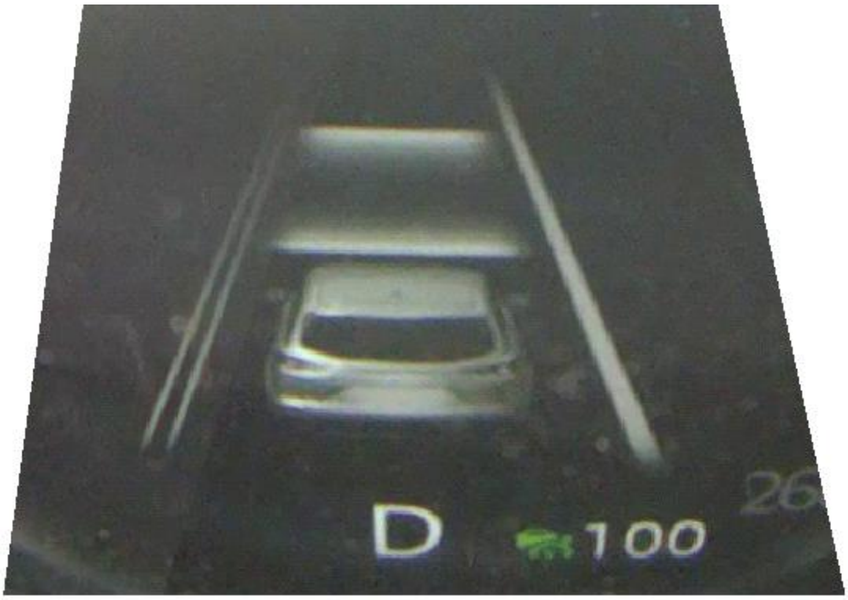

Figure 2.2
Lane support system dashboard display for the Mazda CX-9

2.3 Trial route

The route selected for analysis was Victor Harbor Road which has had a reputation due to a large number of high severity crashes. Major road upgrades have been completed in the past 15 years, but the amount of commuting traffic has been increasing due to the increasing population of the coastal towns near Victor Harbor and an expanding local tourism industry. The route begins at the exit from Main South Road in Old Noarlunga (roughly 30 km south of Adelaide), continues south along Victor Harbor Road, and ends at the roundabout intersection with Welch Road in Hindmarsh Valley (roughly 4 km north from Victor Harbor).

The majority of the route has a speed limit of either 80 km/h or 100 km/h. However, through the town of Mount Compass (roughly the halfway point) the speed limit is 60 km/h. The total length of the route is almost 45 kilometres and each data collection drive-through took approximately 30 minutes to complete in each direction.

Figure 2.3 shows a map of the route. The lane line markings are generally consistent throughout the route. The edge line is always present, except in some cases where a driveway exists, or where local roads feed off the main road. The centreline changes between many different types, but is always present, except in some cases where local roads or driveways feed off the main road.

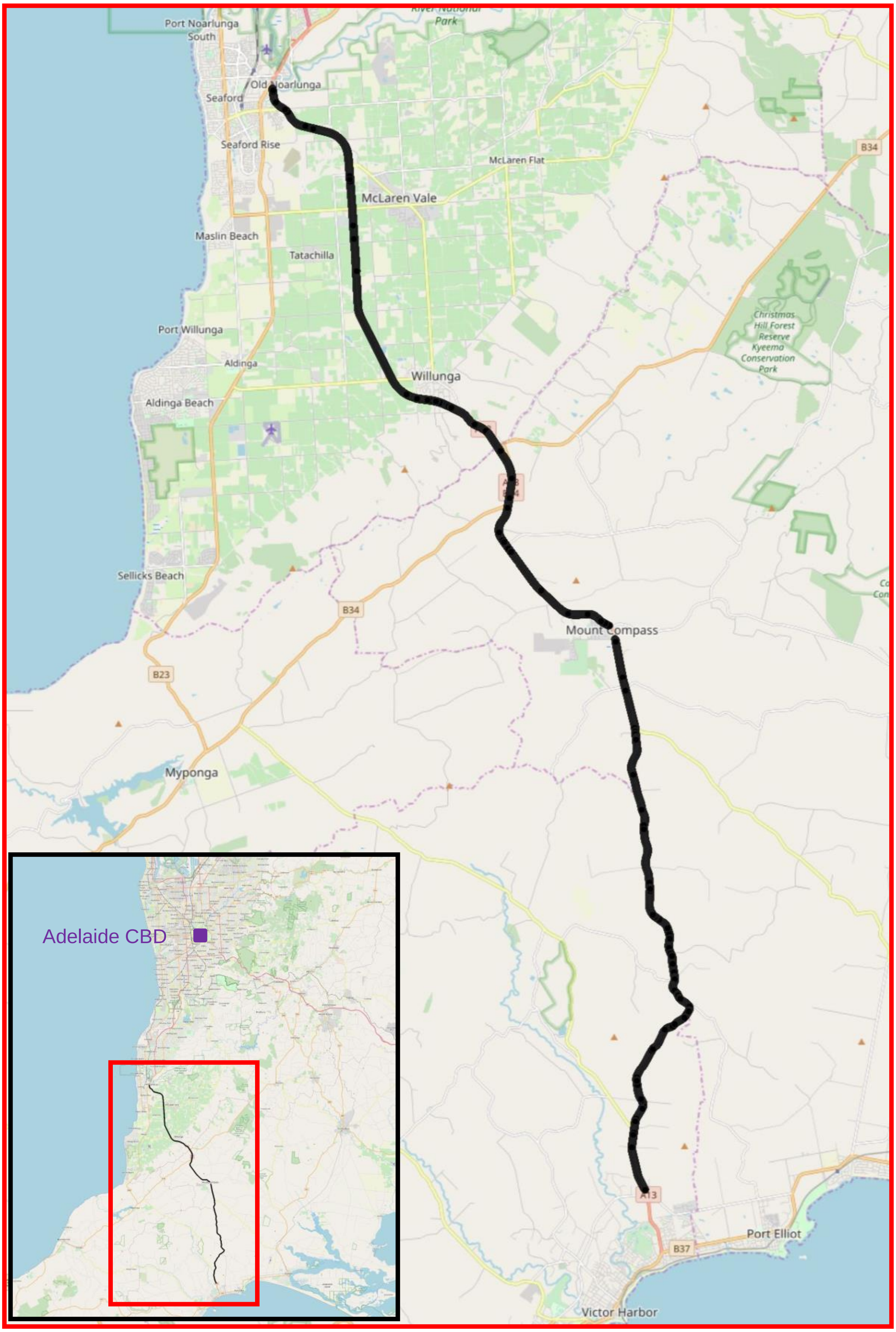

Figure 2.3
Map of trial route driven with each vehicle to collect data

2.4 Video recording equipment

A Racelogic Video VBOX HD2 data logger (Racelogic, 2018) was utilised as the main data collection system. The VBOX system is equipped with two 1080p video cameras with real-time synchronisation to data collected by a GPS engine operating at 10 Hz. The video streams from both cameras are recorded and can be further enhanced with graphical overlays showing information collected by the GPS engine.

For this project, one camera was secured to the roof of the dashboard panel, as shown in Figure 2.4, so that the lane support system display could be recorded. The second camera was attached to the inside of the windscreen, directed to record the view out the front of the vehicle, to collect details about the line markings, road infrastructure, and general traffic environment that might be important.

The two video camera streams are assembled into a layout, as shown in Figure 2.5, and overlayed with data from the GPS engine such as speed, date, and time. This video layout is recorded by the VBOX system at a frame rate of 30 frames per second (30 Hz), along with a separate file containing synchronised data from the GPS engine that includes latitude, longitude, speed, and heading, recorded at a rate of 10 datapoints per second.

Figure 2.4
Main camera secured to roof of dashboard panel

Figure 2.5
Video layout recorded during data collection

2.5 Data collections

Four data collection drives through the trial route were completed on the 30th of October 2019 between 10 am and 2 pm. A Southbound and Northbound journey was completed in each of the two trial vehicles. The lighting and weather conditions were generally consistent throughout the day. In all four journeys through the trial route the vehicles were driven by the same person who was asked to follow a driving guide and keep their style consistent.

A driving guide was created to specify a driving style that the driver could follow. The purpose of the driving guide was to maximise the opportunity to collect data on the operation of the lane support system and to maintain consistency between vehicles and journeys. The driving guide listed driving style responses to various scenarios that may have presented themselves to the driver. For example, when there was more than one lane of travel in the direction of travel, the driver was instructed to stay in the left-hand lane unless overtaking a slow-moving vehicle. The driving guide emphasised that safety should always be prioritised, and the driver was free to override any instruction they did not feel was safe. The driving guide is attached in Appendix A, listing the preferred driving style and different driving instructions for different scenarios.

To create manageable file sizes and to avoid instances where the lane support systems were disabled (such as when a turn signal indicator was turned on), multiple short clips of video were recorded throughout each vehicle run. This was achieved by the passenger manually activating and deactivating the VBOX at regular intervals and each time the trial vehicle was changing lanes or merging.

2.6 Video analysis system

The data collected by the video recording equipment consisted of a video and an associated GPS data file. The video shows a close-up view of the vehicle dashboard, where the lane support system displays whether the left and/or right line markings have been detected, and a view out the front of the vehicle. The task of the video analysis system was to process the collected video and identify when the lane support system has or has not detected a line marking on each side of the vehicle over the course of the journey along the trial route.

In order to achieve this, a custom vehicle analysis system was developed. To understand how the video analysis system operates, it is important to note the layout of the lane support system dashboard display that is being analysed, shown in Figure 2.6.

Prior to processing the video, a user manually selects four individual pixel locations that correspond to two points along each of the left and right line marking indicators in the dashboard display, as shown in Figure 2.6 with the four numbered markers. The selected pixels must be as close to the middle of each lane marking indicator as possible. Based on the locations of the selected pixels, a line equation is used to automatically derive the location of all the pixels along the centre of both line marking indicators, as shown in Figure 2.6 with the dashed lines.

After the centre of the dashboard line marking indicators have been identified, the video analysis system sequentially processes each frame of the video. In each frame the left and right line marking indicator is considered separately. For each line indicator, the average brightness of the pixels along the centre (identified using the process above) are compared to the maximum and minimum brightness of the pixels around the line indicators. If the average brightness of the pixels along the centreline is closer to the brightest pixel in the surrounding area, the video analysis system denotes that the line marking indicator is filled (on). Conversely, if the average brightness of the pixels along the centreline on the line indicator is closer to the darkest pixel in the surrounding area, the video analysis system denotes that the line marking indicator is empty (off). Some examples of this process are shown in Figure 2.7 where the solid circles (filled in) indicate that the analysis system has detected the line marking indicator is filled (on), and the empty circles show where the system has detected the indicator is empty (off).

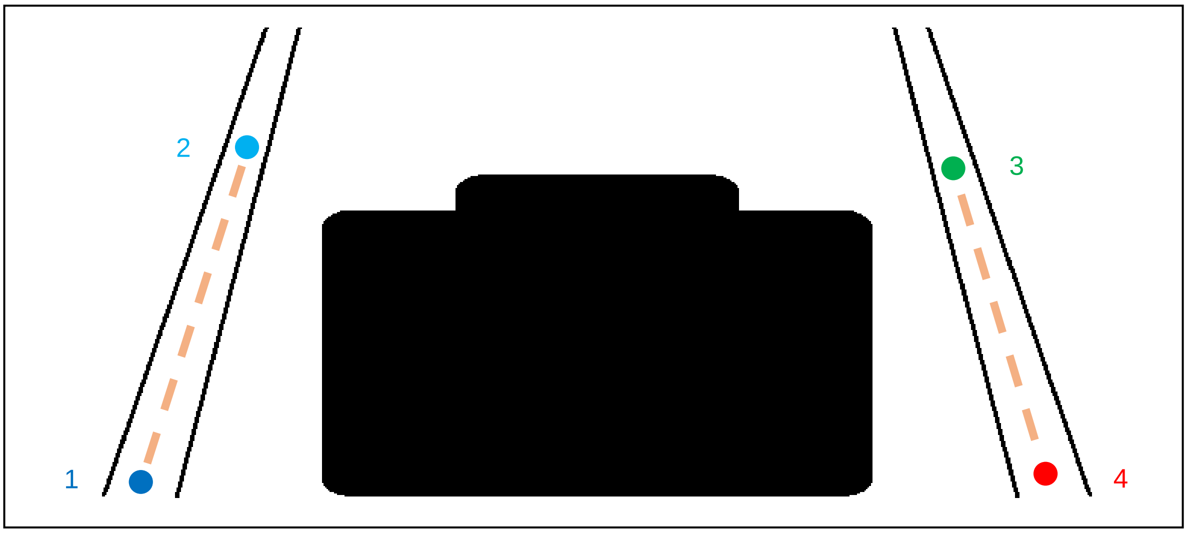

Figure 2.6
Layout of the lane support system dashboard display and video processing markers

Because the threshold value is defined by the brightness of the pixels surrounding the line indicators, the video analysis system is robust and able to cope with situations where there is a moderate amount of sun glare obscuring the dashboard display, as shown in Figure 2.8.

After identifying the status of the line marking indicators, the video analysis system links each frame of the video to the corresponding information from the GPS data file. This process results in the generation of 30 data points per second of video record that lists the following details:

- status of left line making indicator,
- status of right line marking indicator,
- latitude,
- longitude,
- direction of travel,
- speed of vehicle, and
- time.

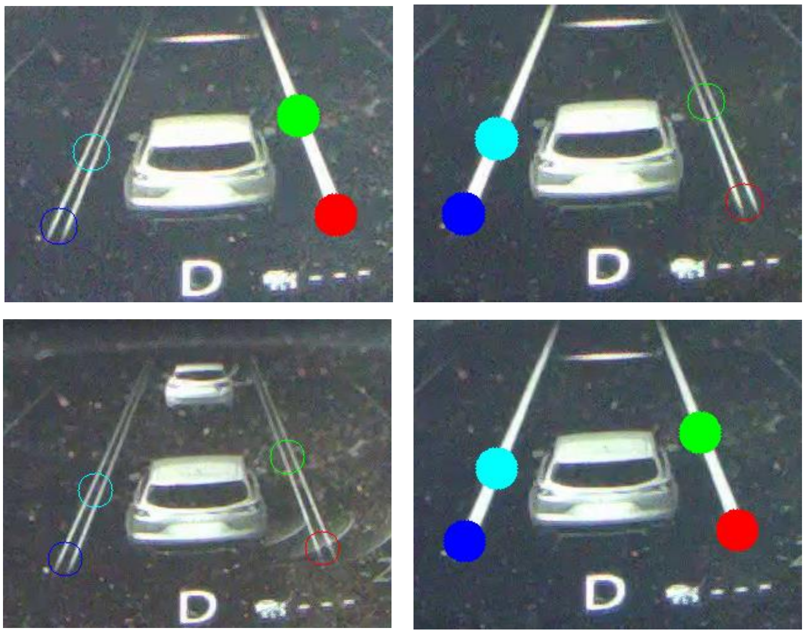

Figure 2.7
Examples of the video analysis system indicating which line markings have been detected

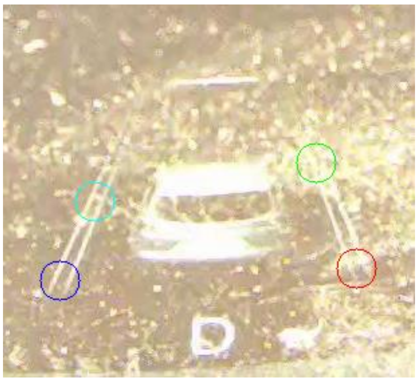

Figure 2.8
Example of the video analysis system operating correctly despite the sun glare obscuring the dashboard display

3 Results

Four data collection runs along the trial route were completed and the results are aggregated for each vehicle and each direction that it was travelling. The directions of travel have been labelled as north and south, and as each lane line side produced different results, the left and right lane lines have also been separated in the results.

As the lane support systems for both vehicles had a minimum operational travel speed, the data was filtered to only include locations where the travel speed of the vehicle was above this threshold. Any instances of overtaking or lane changing were also filtered out manually as these manoeuvres require a turn signal to be activated which disables the lane support system.

3.1 Line marking detection rates

Over the distance travelled, the LSS on the Toyota was able to detect 97.2% of line markings. Similarly, the LSS on the Mazda achieved an overall detection rate of 98.3%. The total distance travelled in the Toyota was slightly further than the Mazda due to traffic interruptions and increased overtaking manoeuvres. These results, additionally disaggregated by line side and travel direction, are shown in Table 3.1. Also shown, is the number of unique non-detection instances. The Toyota had more frequent instances of non-detections compared to the Mazda but, given both vehicles had similar overall line detection rates, these instances were for shorter periods.

Table 3.1
Line marking detection results for both trial vehicles disaggregated by line side and travel direction

	Total distance (km)	Line markings detected (km)	Line markings not detected (km)	Percentage detected	Instances of non-detections
Toyota left-side south	41.46	40.45	1.01	97.6%	28
Toyota right-side south	41.39	39.72	1.67	96.0%	59
Toyota left-side north	41.07	40.21	0.86	97.9%	24
Toyota right-side north	40.69	39.65	1.04	97.4%	36
Toyota total	164.61	160.03	4.58	97.2%	147
Mazda left-side south	41.31	40.59	0.72	98.3%	5
Mazda right-side south	41.32	40.47	0.85	97.9%	7
Mazda left-side north	40.58	40.01	0.57	98.6%	6
Mazda right-side north	40.58	40.01	0.57	98.6%	6
Mazda total	163.79	161.08	2.71	98.3%	24
Total	**328.40**	**321.11**	**7.29**	**97.8%**	**171**

An alternate disaggregation of the results by line type (centreline vs edge line) is shown in Table 3.2. Again, the resulting rates of detection for each trial vehicle are relatively similar.

Table 3.2
Line marking detection results for both trial vehicles disaggregated by line type

	Total distance (km)	Line markings detected (km)	Line markings not detected (km)	Percentage detected
Toyota edge lines	82.53	80.66	1.87	97.7%
Toyota centrelines	82.08	79.37	2.71	96.7%
Mazda edge lines	81.89	80.60	1.29	98.4%
Mazda centrelines	81.90	80.48	1.42	98.3%
Total	**328.40**	**321.11**	**7.29**	**97.8%**

The locations where the vehicles did not detect line lane markings are shown by the dots on the route map in Figure 3.1. The Toyota showed a larger number of locations, but it is important to note that many of the non-detections happened for only a short period.

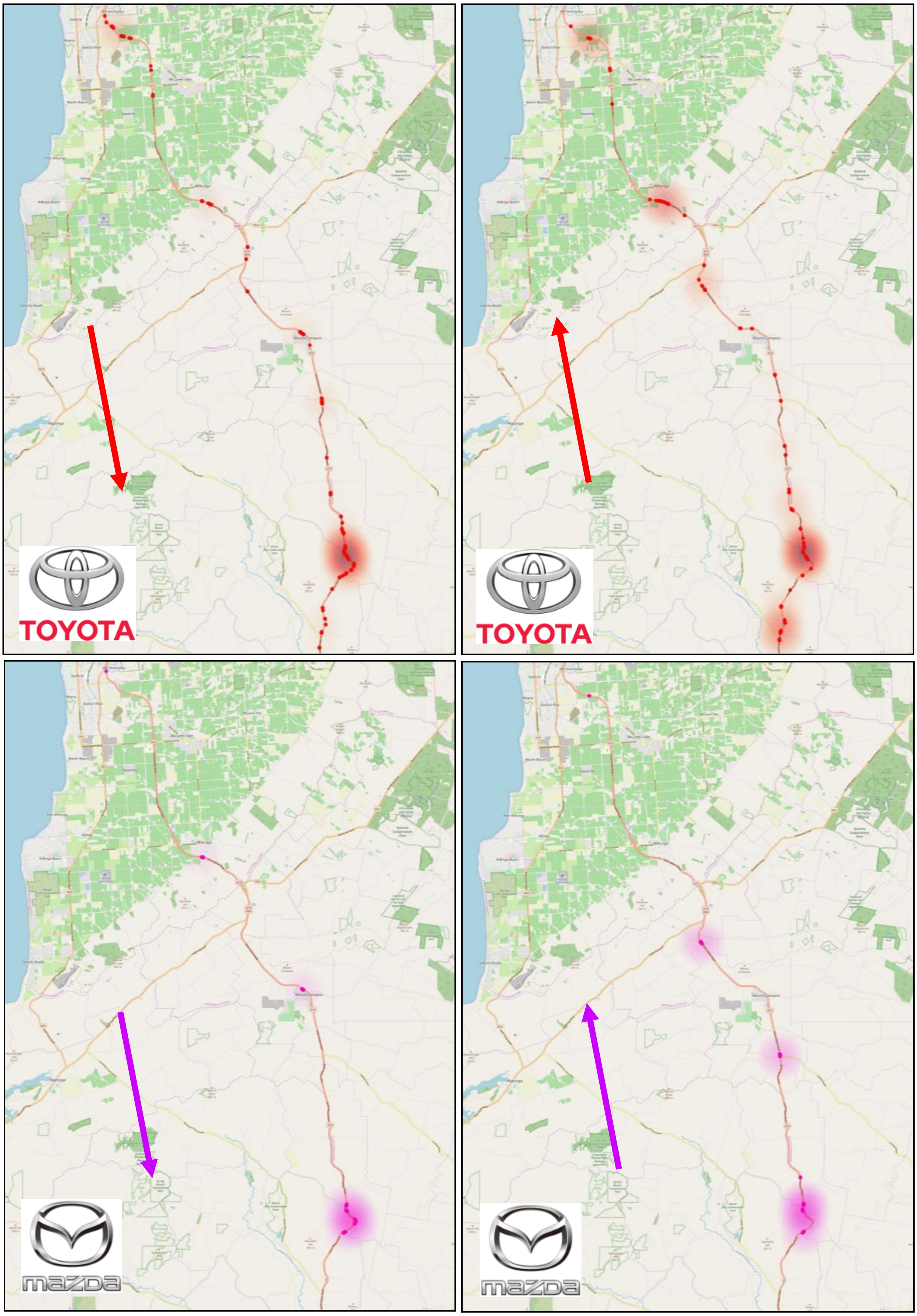

Figure 3.1
Map of line marking non-detections by vehicle lane support systems.
Left to right, top to bottom: Toyota heading south, Toyota heading north, Mazda heading south, Mazda heading north

3.2 Non-detection hotspots

The common locations for non-detections between both vehicles have been identified and highlighted in Figure 3.2. Each of these hotspots is analysed more closely in the following sections.

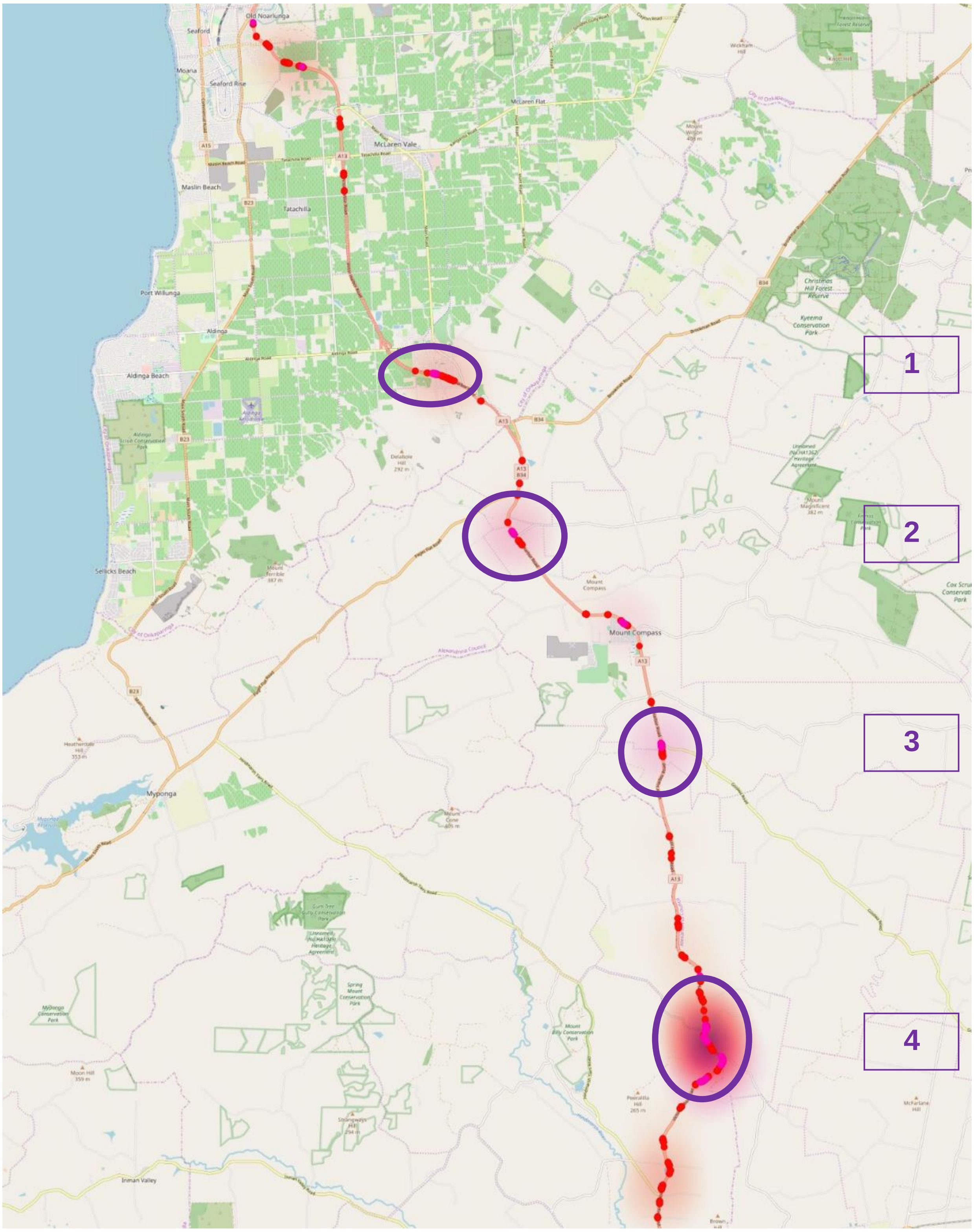

Figure 3.2
Hotspots and locations of non-detections in both vehicles

3.2.1 Hotspot 1

The first hotspot occurred travelling southbound up Willunga Hill. A video snippet from the Toyota at the specific location is shown in Figure 3.3. In both vehicles, the right-side lane line (of the left lane) was not detected for a period of up to three seconds.

Figure 3.3
View from Toyota at Hotspot 1

The location of the hotspot was investigated using Google Maps Street View to identify possible sources of the non-detection. Figure 3.4 shows a screenshot of the scene. Noticeably, the line markings dividing the southbound lanes are not typical painted lines, but rather collinear white dots. Along with the slope of the hill, these lane markings are believed to cause the lane support systems in both vehicles some confusion. Although it is worth noting that this line marking type was detected successfully for the majority of the Willunga Hill section.

Figure 3.4
Image at Hotspot 1 from Google Street View

3.2.2 Hotspot 2

The second hotspot occurred travelling in a northbound direction just after the intersection with Yundi Road. The lane marking layout immediately after the intersection changed to a painted centre median with safety bars, then transitioned to a painted centre median with an audio-tactile line in the middle of the centre median. It is possible that the lane support systems were confused by this additional audio-tactile line. However, both vehicles recovered within six seconds of initial non-detection. Figure 3.5 shows the view from the Toyota at this location and Figure 3.6 shows a Google Street View image where the transition of the centre median, which is believed to cause confusion for the lane support systems, can be seen.

Figure 3.5
View from Toyota at Hotspot 2

Figure 3.6
Image from Google Street View at Hotspot 2

3.2.3 Hotspot 3

The third hotspot was not a specific location but a cluster of non-detections within the same vicinity. After analysing the recorded video, it is believed that the non-detections occurred when a turning lane was introduced, causing the solid edge line to be replaced by a dashed line. This error repeated a handful of times for both trial vehicles. Although, in similar situations at other locations the lane support systems were observed to detect the dashed lines with no apparent error. Figure 3.7 and Figure 3.8 show views from the Toyota and Mazda respectively in situations where the lane support systems did not recognise the new dashed line.

Figure 3.7
View from Toyota near Hotspot 3

Figure 3.8
View from Mazda near Hotspot 3

3.2.4 Hotspot 4

The final hotspot was in a section of Victor Harbor Road that had tighter curves and had more vegetation on the side of the road. Two sources were suspected to be causing non-detections for both trial vehicles. Firstly, shadows were suspected to cause the lane support systems for both vehicles to lose track of the edge and centrelines. Shadows were mentioned in the vehicles' limitations for their respective lane support systems. Figure 3.9 shows the view from the Toyota in a situation where shadows are covering the edge line where a non-detection occurred.

The other suspected cause for non-detections for both vehicles may be the absence of centrelines, shown in Figure 3.10 and Figure 3.11.

Figure 3.9
View from Toyota where shadows are suspected to cause a non-detection

Figure 3.10
View from Mazda where absence of centreline is suspected to cause a non-detection

Figure 3.11
View from Toyota where absence of centreline is suspected to cause a non-detection

3.3 Video analysis process

The video analysis processing speed was roughly four times faster than the videos themselves using a 12-core processor. Some minor changes to the processing algorithms could increase the overall efficiency if required to scale for a larger project. Additionally, multiple computers could be used to process multiple vehicles simultaneously.

An issue that had to be overcome was the shifting of the dashboard camera during driving, which required new coordinates for the centres of the lane line indicators to be entered for each video. This delayed the processing of the videos, but could easily be overcome with more secure taping or the use of a mount that keeps the camera very still in relation to the dashboard display.

Another issue that arose during the video processing was the lane support systems providing driver warnings when the vehicles started crossing a lane line which consisted of the lane line indicators changing colour and flashing. This flashing caused the video processing algorithm to return false non-detections. This problem could be resolved by adding a colour inspection that could identify when the lane departure warning was activated and overwrite the results for that specific location. For this project, the results were manually overwritten.

The last issue that arose during the video processing was instances where a 'LKA active' message or 'Driver Attention Warning' (after driving for one hour without a rest) message was activated and an image appeared on the dashboard, removing the lane line indicators altogether. This scenario, although more difficult to resolve, could be fixed by including an inspection on the dashboard for the presence of the lane line indicators. Again, for this project, these issues were manually amended.

The algorithms have significant potential for scale and can analyse multiple videos simultaneously. However, they do not have the capacity yet to detect lane changes or merges, therefore requiring a user to remove the scenarios by starting and stopping the recordings, as was done in this project.

3.4 Qualitative findings

Although the results for both vehicles are quite similar, some qualitative differences between the system functionalities were noted by the occupants of the vehicles during data collection.

The Toyota lane support system was noted to be more immediate with the feedback of the lane line detection compared to the Mazda lane support system, which seemed to have a much smoother and relaxed response when there was a non-detection. The Toyota lane support system had a total count of 147 instances of non-detections compared to 24 instances of non-detections by the Mazda lane support system. The period of the Mazda non-detections was longer than the Toyota non-detections, possibly indicating that the Mazda has a slight delay with feedback, or a longer requirement for lane line detection and non-detection before feedback is displayed.

4 Discussion

Two vehicles with lane support systems were used to analyse the lane line markings along a section of Victor Harbor Road. Custom video analysis software was used to process collected video data and detect where non-detections occurred and what length of the road had sufficient lane line markings for the vehicle lane support systems. The length of Victor Harbor Road analysed was found to have a success rate of 97.8% where the lane support systems could detect both centreline and edge line, although there were some common areas and scenarios of non-detections. Thus, vehicles with lane support systems could be expected to perform well on Victor Harbor Road in suitable weather conditions.

The custom video analysis software performed reasonably well. Some potential for minor improvements was revealed, but the software was assessed to be suitable for use in further (and larger) projects.

The main limitation of this project included the inability to detect false positive non-detections, such as when the lane lines disappear for driveways or intersections. A detailed line marking map of the roads being tested could assist in providing a solution through linking the maps to a location database.

The 2.2% of the road tested that had no detections of lane line markings had some common scenarios which may have caused the non-detections. Shadows and absences of line markings may have been the most common cause of issues. A solution for the shadows covering the line markings could involve improvement of the lane support systems to operate more robustly in the presence of shadows. And a potential solution to the absence of the lane markings is for a dashed line to fill the gap between lines, to provide the lane support system a guide to where the line will be continuing.

Future work could include testing the lane support systems in the presence of rain, sun glare and darkness as they could be expected to perform worse than in the fine daylight conditions originally tested in.

Acknowledgements

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The views expressed in this report are those of the authors and do not necessarily represent those of the University of Adelaide or the funding organisation.

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Appendix A – Driving style guide

Methodology for on-road data collection:

At all times during the data collection the priority is for safe driving. This takes precedence over all data collection objectives below.

If either passenger or driver feels uncomfortable at any time, reduce speed and manoeuvre vehicle to level of comfort and safety. If needed, apply brake pedal.

Driving speed: Speed limit, set on cruise control.

Multiple lanes: Stay in left lane.

Merging lanes: When approaching a necessary lane merge (at the end of an overtaking section), stop recording the video about 2 seconds before indicating to cross lanes, and restart recording about 2 seconds after indicator has been turned off.

Curves: Reduce cruise control speed to advisory speed when approaching corner with an advisory speed sign. If advisory speed is below 60 km/h, apply brake, reduce speed to advisory speed and make note of event in the passenger document. If advisory speed is above 60 km/h, reduce speed to advised speed using cruise control function before entering corner. If speed at any time is uncomfortable to either driver or passenger, apply brake pedal to reduce speed. Around corners, the driver should aim to travel comfortably, following a consistent line. A constant speed is desirable, but not necessary.

Roadworks: Follow detour path and stop recording video. Recommence recording once roadworks is complete and speed of test vehicle is above 60 km/h.

Slow vehicle: If a vehicle is travelling at a speed slower than 20 km/h under the speed limit (where majority of vehicles would be travelling at the speed limit – i.e. not around corners), pass the vehicle where safe (preferably using a dedicated overtaking lane). If overtaking is unsafe, do not attempt.

Following distance: When following a vehicle in front, maintain a minimum of a two-second following distance. This can usually be achieved with the use of adaptive cruise control.

If the lane support system is disabled when the brake pedal is pressed, make an audible note when brakes are applied and record the event on the passenger document.

Procedure:

At start and end of video recording, audibly mention the vehicle that is being tested and the time of day.