School of Computer Science and Software Engineering
Monash University

Digital Systems Honors (1200), Clayton Campus

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Semi-automated Detection and Measurement of Pavement Defects.

Tim Evans 13062719

Tim Ferguson.

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1. Introduction.

Roads are a major public asset in Australia, with Australians traveling an estimated 192,209 million kilometers in the 12 months ended 31 October 2002 [1].
To efficiently manage these assets road authorities need accurate, up-to-date information on the condition of their road networks.
Defects[2] such as …

- Wear and Polishing – areas of smooth black tar occurring on asphalt surfaces.
- Pop-outs – areas where pressure from blow has forced the surface of the road to be raised.
- Pot Holes – areas where there is an absence of asphalt or a hole. Pot holes usually emerge from areas where there has been severe cracking.
- Cracks – areas where the road surface has been split apart, classified as longitudinal transverse and crocodile or combination cracking.

Ideally all of these road defects must be recorded and monitored, of particular interest is the cracking defect, as most other defects first reveal themselves as minor cracking. So detection and measurement will provide very valuable information on the condition of road surfaces.

Presently the common method for ascertaining the state of road surfaces is manual inspection. A survey vehicle travels along the road to be inspected at around 20km/h. One person drives the vehicle and calls out imperfections in the road surface while another notes the location and type of imperfection on a laptop.
This is process is expensive, time consuming, dangerous and has the potential to be inaccurate and inconsistent, due the subjective nature of the people performing the analysis.
Several other techniques have been used to solve this problem with a great degree of success such as laser inspection and semi automated and fully automated video capture and processing systems.

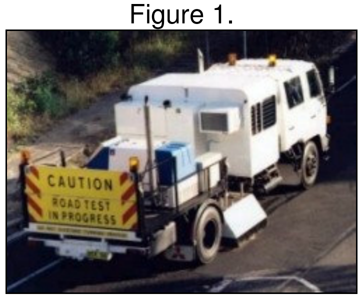
In this project I aim to create a semi-automated system for detecting and measuring cracks and imperfections in road surfaces.

2. Research Context.

Currently several companies offer a solution to the problem of monitoring road surface conditions. Some such solutions are CSIRO's road crack detection vehicle, the PAVUE system by OPQ systems and Roadware's wisecrax crack detection system.
Unfortunately due to the commercial nature of these systems information on their operation is limited.

The CSIRO with the help of the Roads and Traffic Authority of NSW produced a system called the RoadCrack system. The CSIRO's road fault detection system[3] uses a specially modified van for with a series of scan line cameras under a skirt in the middle of the vehicle to acquire road surface footage. The cameras are mounted perpendicular to the surface of the road, mounted with the cameras under the skirt is a series of lights which provide constant illumination to the road surface.
The system is capable of detecting cracks and deformations on several types of surfaces such as bitumen, asphalt and cement roads. The vehicle can travel at speeds from 10km/h up to 105km/h and can detect cracks as small as 1mm in width. All image processing is done online as the van travels down the road with reports available at the end of a run. Reports are made for each 100m segment of road surveyed, the images captured by the system are not stored.
2 people are required to operate the vehicle.

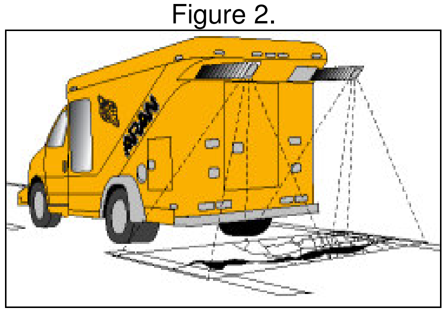
Figure 1.



CSIRO Road Crack Vehicle.

An American company roadware produce the wisecrax system[4]. It is similar to the CSIRO's system with the ability to detect cracks and deformations as small as 3mm on several types of surfaces with a maximum operating speed of 80km/h. However instead of cameras mounted under the vehicle cameras are mounted from booms extending from the rear of the vehicle. The road surface is illuminated by strobe lights.

Figure 2.



Roadware's wisecrax system.

The footage acquired by the wisecrax system is processed off line overnight, reports on the location of defects and their severity are produced, all images captured by the system are also stored off line.

The PAVUE system[5] is a new system developed in Sweden used to detect road surface faults. Because the PAVUE system is relatively new there is little public information available on it's operation. The system uses a series of four cameras with synchronised flashing lights to capture the road surface data. Reports are then generated offline with the road surface data.

Figure 3.

PAUVE vehicle.

As mentioned before because of the commercial nature of the problem, there are limited published papers and documents pertaining to the problem as a whole.
Several papers have looked at problems such as measurement[6] and storing of cracking data[7], individually but usually assume perfect data.

The concept of using image processing to extract data from real world images is not a new one, in particular the use of edge detection[8][11] algorithms and other segmentation techniques on noisy and otherwise imperfect images. Of interest is also research that has been done on verifying edges[9] and elimination of false edges[10].

3. Research Plan and Methods.

3.1 Data Acquisition.

The first thing to consider is the acquisition of the road surface data.
Time will be spent looking at the best way to capture footage of the road surfaces. I currently have access to a vehicle which can acquire footage of a road surface in 1 metre increments and store them as a video. However the camera used to capture the road surface data is mounted from an angle of elevation of approximately 30 degrees, with no form of artificial lighting to illuminate the captured area.
The vehicle is currently used for capture of road image data. This data is then used for manual inspection. Consequently this allows access to over 22,000km of existing video footage taken from this view point, which has also been manually inspected for defects and the defects have been noted at relevant locations.

Figure 4.

Test vehicle Camera orientation.

Figure 5.

Test vehicle Camera orientation.

With such a vast sample set of data research into techniques of flattening images out from a perspective view to an orthogonal view will be looked into, and the ability for an automated system to detect defects from this angle will be explored. Flattening is required to allow for easier detection and measuring of the pavement defects.

With all automated systems researched the cameras are mounted perpendicular to the road surface. This is the ideal configuration for the cameras as the road surface data acquired is of a higher resolution than the data obtained from a perspective view and then flattened.
Also in most automated systems multiple cameras have been used to create higher resolution images.

Also all automated systems researched have some form of artificial lighting this helps to provide a nice clean set of images which aren’t disturbed by varying lighting conditions. This would be ideal however several edge detection techniques exist which are invariant to changes in lighting.

The possibility of changing the orientation and the number of cameras exists and will be perused as will the possibility to illuminate the area of road which is being captured.

Because of the nature of the data from the road surfaces all images used will be greyscale.

Due to the possible lack of availability of access to the test vehicle all examination of data will be done offline. This will also provide greater flexibility.

3.2 Image processing.

The next step will be the extraction of useful information from the road footage. As mentioned in the research context vast amounts of research has been carried out on different techniques for identification of interesting areas in images. Most techniques require some form of image segmentation.

In the case being studied here some of the following techniques for image segmentation will be considered,

- Standard Filters and averaging masks – a look into how simple filters and masks can enhance the images will be looked at.
- Standard Edge detection techniques including Prewitt and Sobel filters[11] – edge detection is the most common approach in detection of discontinuities in grey scale images.
- Edge Flow [12] - looking at texture and the changes in texture between sections of an image to detect edges.
- Thresholding, Edge linking and Boundary Detection [13]- A way to eliminate noise and other discontinuities in edges detected and assemble meaningful edges.
- Snaking / Edge linking [14]- A way of tracing through an image when point of interest are specified.

A combination of one or more of these or other methods will used to identify the defects with a focus on cracking.

Programming will be done in C under a UNIX based environment.

Effectiveness of the system will be evaluated on the grey scale data sets provided by the image acquisition system. These results will then be compared to the results from the common practice of manual inspection on the same set of data.

4. **Time Table**

30 may – Completion of majority of research into image segmentation techniques acquisition. Final plan settled upon, start looking into modification of test vehicle. Testing of different image segmentation techniques on existing data begins.

3 June – Interim presentation.

11 June – Literature review draft.

14 June – Complete testing of different image segmentation techniques on existing data. Modification of Vehicle complete, new road data to work with.

26 June – Completion of testing of different techniques on images acquired using different acquisition methods, start implementing system.

28 July – Literature review due.

14 September – Final Implementation of system and begin final testing.

October Final presentation.

5. Difficulties

My access to the test vehicle may be limited.

Ideally road capture must be done when the weather is good, winter does not lend itself to good road acquisition, with rain, moisture on the road and less light in the day.

If I'm not able to alter it in any way, the existing cameras orientation may pose a problem. The resolution of the cameras and the auto gain features inbuilt into the cameras may also provide problems.

6. Special Facilities

The facilities provided in the honours lab should be sufficient.

7. Deliverables

Results of the defect detection system, a system which detects major faults and defects in road surfaces.
Comparison between my system and one of manual inspection.
Comparison of the system on images taken using the two different perspectives.

8. Relevance

The system proposed will provide a solution to the problem of semi automated fault detection in road surfaces which will be more flexible than current solutions, as footage of the road surfaces will be recorded so accurate comparisons between different techniques can be made.

Also with the detection of defects done off line, changing and improving the algorithms is easily accomplished as is tailoring the system for an areas specific needs.

The system will be cost effective when compared to the other solutions mentioned, the complete system proposed will cost under $250,000 where as the commercial solutions cost millions of dollars.

Investigation into perspective data acquisition of road surfaces and then detection of defects in such data may lead to the possibility of common government vehicles such as police cars used in the acquisition of road image data.

Making automated systems more accessible and more accurate will remove the need for manual inspection, as mentioned manual inspection is dangerous expensive and time consuming.

9. Proposed chapter headings for thesis.

1. Introduction
2. Methods for Image acquisition of road surfaces.
    - -Existing methods
    - -Possible methods
3. Methods for fault detection and image segmentation in road surface images.
    - -Existing methods
    - -Possible methods
4. Evaluation of possible acquisition and detection methods and combinations.
5. Discussion of implementation
6. Results
7. Conclusion and further work
8. Bibliography

10. Bibliography.

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