TECHNOLOGIES FOR AUTOMATED PEDESTRIAN DETECTION AT SIGNALIZED INTERSECTIONS

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EXECUTIVE SUMMARY

The safe accommodation of vulnerable road users, as well as their equitable access to the transportation system, are fast becoming two of the most critical issues facing North American cities today. As the population ages, impairments to mobility, vision and physical strength are becoming prevalent. This can sometimes translate into accessibility limitations, resulting in hazardous situations for the users of the system.

Traffic signals are a component of the transportation system which is used by all kinds of users. While drivers of motorized vehicles do not need to take any action to be detected by a signal, pedestrians must use pushbuttons for detection at these locations. This requirement has resulted in major concerns in Winnipeg and other North American cities, particularly in addressing the equitable treatment of different users of the transportation system, and its consequent impact on road safety.

The purpose of this environmental scan is to obtain an understanding of current technologies used for the automated detection of pedestrians at signalized intersections. This is accomplished through a comprehensive literature review and jurisdictional survey regarding this issue.

INTRODUCTION

The safe accommodation of vulnerable road users, as well as their equitable access to the transportation system, are fast becoming two of the most critical issues facing North American cities today. As the population ages, impairments to mobility, vision and physical strength are becoming prevalent. These impairments can sometimes translate into accessibility limitations, resulting in hazardous situations for the users of the system.

Major concerns have been raised in Winnipeg and other North American cities regarding the use of pushbuttons. Many elderly pedestrians and pedestrians with certain types of impairments experience difficulty using pushbuttons to activate pedestrian signals. Difficulty accessing these facilities may result in safety problems for system users.

Some jurisdictions around the world have started to use automated pedestrian signals (also called passive pedestrian signals) as an alternative to push button actuation. These are signals where pedestrians do not have to initiate any action for the signal to be activated and give the pedestrian the right of way. A key issue associated with the use of these devices is to know which type of system is best suited for a given jurisdiction based on its effectiveness for pedestrian detection, cost, and other factors.

This paper discusses the results of a literature review and jurisdictional survey regarding the following: (1) types of available technologies used for pedestrian detection and current use in various jurisdictions; (2) cost issues associated with these technologies; and (3) effectiveness of these technologies, particularly as experienced by current users.

Pati (2002) indicates that to ensure safety of all pedestrians, including the visually/physically challenged, several types of new technologies have been developed. The presence of a pedestrian at a crossing could be detected by manually pushing a call button or by automated advanced detection devices. Advanced devices can continually monitor a crosswalk providing information to the controller as to when pedestrians are waiting to cross and times when the crosswalk is clear of pedestrians so that normal vehicular phases could be restored. The pedestrian detection information could also be used to extend the time of a pedestrian signal to ensure accommodation of slower moving or visually/physically challenged pedestrians to ensure crossing safety.

Hughes et al. (2006) conducted a scanning tour of innovative intersection safety practices within the United States for the U.S. Department of Transportation. In their final report they identify few jurisdictions that are either using or testing technologies for the automated detection of pedestrians. However, they conclude that "passive detection technology for pedestrians is still not developed enough for nationwide use. However, the technology offers promise for the future in terms of enhancing pedestrian safety."

This statement by Hughes et al. (2006) is clearly reflected in the available literature regarding automated pedestrian detection at signalized intersections. The literature identifies six categories of automated pedestrian detection technologies: **ultrasonic, microwave-radar, infrared, piezoelectric, laser scanners and video image processing**. They can be used individually or in combination with each other to detect pedestrians.

The jurisdictional survey found that none of the responding Canadian jurisdictions currently uses automated detection for pedestrians. Only Ottawa, Ontario reported that an operational test of one of these technologies is currently being conducted.

In the U.S., the Federal Highway Administration (FHWA) Intelligent Transportation System (ITS) Joint Program Office conducted a survey of 106 American metropolitan areas in 2004 to determine how they collected pedestrian data for different applications (other than for signal timing purposes). They found that 14 agencies in 11 states used some form of automated pedestrian detection for data collection. These jurisdictions along with the type of technology used are shown in Table 1.

Table 1: Automated detection for pedestrian data collection in the U.S., 2004.

State	Infrared	Microwave	Piezoelectric	Video Imaging
Arizona	0	0	0	2
California	2	0	1	0
Colorado	0	0	0	1
District of Columbia	0	0	0	1
Illinois	0	0	0	1
Louisiana	0	1	0	0
Maryland	0	0	0	1
Nevada	0	0	0	1
Texas	0	0	0	1
Virginia	0	0	0	1
Washington	0	0	0	1
TOTAL	**2**	**1**	**1**	**10**

Source: FHWA - ITS Joint Program Office, 2004

The jurisdictional survey conducted in this research found that in the United States three of the responding jurisdictions currently use automated detection for pedestrians at signalized intersections. The jurisdictions are Portland, Oregon; Las Vegas, Nevada; and Tucson, Arizona. The website walkinginfo.org reports that Los Angeles, California also uses automated pedestrian detection technologies. However, no response was obtained from this jurisdiction for the survey.

At the international level, beyond Canada and the United States, discussions with officials in some of the countries indicate that six countries have sites that use automated detection for pedestrians. These countries are Australia, England, Japan, New Zealand, Sweden, and The Netherlands. From the survey, it was not possible to confirm that Japan, Sweden, and The Netherlands actually use these technologies. In some cases, these jurisdictions have not returned repeated phone calls, and in other cases, language barriers made communications of the technical nature required in the survey very difficult, particularly in Japan. Calling European jurisdictions was also challenging due to time zone differences, which allowed for few viable meeting times.

The following sections present a discussion regarding details about each of the six technologies currently available for automated pedestrian detection, and results obtained from the survey.

Ultrasonic Technologies

According to Bu and Chan (2005), ultrasonic detectors emit ultrasonic waves. When pedestrians pass by, the transmitted sound wave is reflected back to the receiver.

Based on the reflected signal, objects can be detected for their presence along with their distance and speed. Ultrasonic detectors can detect objects up to 30 feet away. The installation configurations are either directly facing downward above target area or aiming from a horizontally mounted side viewing position (side fired) in order to minimize lost bounced back ultrasound energy from the target. Figure 1 illustrates a picture of an ultrasonic sensor.

There are two basic types of ultrasonic sensors, depending on the ultrasonic waveform used.

- *Pulse ultrasonic sensors* measure the distance or presence of objects by sending a pulsed ultrasound wave and then measuring the flight time of reflected sound echo.

- *Continuous wave ultrasonic sensors* output continuous ultrasonic wave of certain frequency and use Doppler principles to detect a moving object and its speed.

Figure 1: Ultrasonic sensor.
(Source: http://www.pedalcyclesafety.com/)

According to Bu and Chan (2005), ultrasonic sensors have two main limitations:

1. Pedestrians wearing clothing made of natural fiber (e.g. cotton) are harder to detect than pedestrians wearing synthetic fiber (e.g. nylon) because natural fibers are more absorbent to sound wave than synthetic fiber.
2. Change in weather conditions like temperature, pressure, humidity and wind will affect the performance of ultrasonic sensors because the speed of sound varies according to the temperature and pressure of the medium.

The jurisdictional survey did not find any cities or countries that are currently using or testing this type of technology.

Microwave-Radar Technologies

According to Bu and Chan (2005), microwave radar works in a way very similar to ultrasonic sensors. Instead of sound waves, electromagnetic waves are transmitted from an antenna. Based on the analysis of bounced back signals, objects can be detected together with their distance and speed. Figure 2 shows a picture of a microwave detector.

Microwave radars can be classified into different categories based on the transmitted electromagnetic wave form.

- Doppler radar transmits a continuous electromagnetic wave of constant frequency. The wave has a frequency shift when reflected from a moving object which can be analyzed to determine the speed. Doppler radar alone can only detect a moving object with relative speed larger than a certain threshold.

- Another type of microwave radar transmits frequency-modulated or phase-modulated signals. The distance to the object is determined by the time delay of the return signal.

- Ultra wide band (UWB) radar is a new emerging technology which has great potential in ITS application. UWB Radar transmits and receives extremely short precision timed radio wave pulses. UWB radar is capable of detection, ranging and motion sensing of people and objects with centimeter precision.

Figure 2: Microwave pedestrian detector.
Source: Peek Traffic Limited

Radar sensors can provide accurate object distance and speed without complex signal processing (required with computer vision). Radar technology can operate in different environmental conditions such as adverse weather, poor visibility or harsh environmental impacts like ice, snow or dust coverage.

The Organization for Economic Co-operation and Development (OECD, 1998) studied ways to improve safety for vulnerable road users, by finding ways to reduce pedestrian risk in urban traffic through improved accessibility for pedestrians. The aim was to find out if making traffic signals more responsive to pedestrian needs could have positive safety and mobility implications. The OECD determined that a microwave detector could easily be attached to traffic signal poles, and indications from the detector could be transmitted to the signal controller and integrated in an intelligent way.

The jurisdictional survey found that this type of technology is the most commonly used for automated pedestrian detection. The survey found that the following jurisdictions are currently using or testing microwave technology for pedestrian detection:

Portland, Oregon: In the United States, Portland, Oregon is at the forefront of automated detection for pedestrians. The city has 12 intersections retrofitted with microwave detectors that monitor both the curbside and crosswalk (Figure 3).

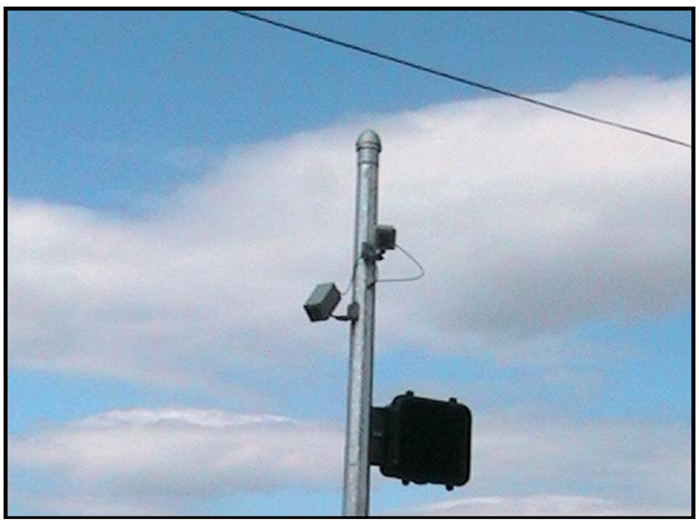

Figure 3: Microwave detector in Portland, Oregon.
Source: Sarah Stein and Dave Hatch - City of Portland

If pedestrians are detected in the crosswalk during the FLASHING DON'T WALK, the clearance interval is extended. The City has found that the curbside detectors are less effective than the crosswalk detection. As a result, pushbuttons are still used for pedestrian actuation. The City reported that there were no instances of environmental factors that negatively affect the operation of the detectors. There has been no formal study on the impact to motorists; however the engineers report that there has been no significant difference in the capacity of the intersections and no change in delay for motorists. Sites that received detectors were selected because of poor pedestrian compliance and high volumes of pedestrians with impairments. Engineers plan to consider future implementation of automated detection for pedestrians at intersections on a case by case basis.

Las Vegas, Nevada: In Las Vegas, one intersection is outfitted with microwave detectors that monitor the curbside. The detector is used to activate lights that illuminate the crossing to increase conspicuity of pedestrians and thereby increase safety at night. Extreme heat was reported to reduce the expected life of the LED lights used at the crossing but had no effect on the detector itself. There are no formal plans to expand the use of automated detection for pedestrians because there is a problem with pushbuttons being vandalized.

Tucson, Arizona: In Tucson, two intersections are outfitted with microwave detectors that monitor the crosswalk. If pedestrians are detected in the crosswalk during the FLASHING DON'T WALK, the clearance interval is extended by changing the standard walking speed of 4.0 ft/s (1.2 m/s) to 3.0 ft/s (0.9 m/s). City officials reported that heat in excess of 100°F (~38°C) resulted in missed calls. Audible and vibro-tactile feedback is given to the pedestrian when a call for a crossing has been made. There is no formal plan to expand the use of automated pedestrian detection in Tucson but engineers are interested in the possibility. The City of Tucson has also tested video detection of cyclists at crossings but found that cyclists prefer the pushbutton.

London, England: In Europe, London is at the forefront of automated detection for pedestrians. AGD brand microwave detectors are commonly used at signalized mid-block crossing locations (PUFFIN crossings - Pedestrian User-Friendly Intelligent Crossing) in conjunction with pushbuttons. The detectors primarily monitor the curbside so that if a pedestrian leaves the detection area the call is cancelled. Currently, London is running a pilot study at four test sites to adapt the technology at PUFFIN crossings for operation at signalized intersections.

Auckland, New Zealand: This city has nine intersections outfitted with microwave detectors monitoring the curbside to augment the existing pushbuttons. These detectors replaced the older piezoelectric sensors that were frequently jammed with debris. The City reported only minor increases in operating and maintenance costs and a capital cost of ~$1250 CAN per unit with 6 units per intersection. They reported that false and missed calls occurred frequently. The City has markings to show pedestrians where to stand in order to be detected. Engineers indicate that there has been no real change in vehicle capacity or delay at intersections with automated detection for pedestrians. The program to install automated detection for pedestrians has been canceled due to the false calls and minimal benefit to pedestrians. Engineers are now focusing on logic to have a more frequent pedestrian phase to reduce pedestrian delay.

The jurisdictional survey found that in addition to the jurisdictions where this technology is currently in use, there are two jurisdictions (in addition to London, England) that are currently conducting operational tests.

Ottawa, Ontario: In Canada, Ottawa is currently conducting an operational test at two intersections to monitor the curbside only. There are no pushbuttons used in conjunction with the detectors. Ottawa has reported false detection problems caused by blowing debris and parallel vehicle traffic, resulting in increased delay for motorists.

To resolve these problems the detection area of the sensor is reduced. The City reported that the detectors were harder to install and set up and required more frequent servicing by City employees than pushbuttons. The public has not been informed about the test nor has there been a response from them. There is currently no feedback (visual or audible) to the pedestrian that a call for a crossing has been made. There are no formal plans to expand the use of automated pedestrian detection in Ottawa; however, there is interest if the technology is improved.

Phoenix, Arizona: Phoenix is currently testing microwave detection at the curbside of one intersection to augment the available pushbuttons. The City found that rain and large vehicles making right turns cause false calls. The detectors required existing controllers and cabinets to be upgraded and new software to be learned by City crews. The public has not been informed about the test nor has there been a response from them. Pedestrian compliance has increased and engineers indicate that the minimal decrease in motorist delay is not a problem. The test was conducted to determine the feasibility of the technology and due to the success of the test, plans to expand the program will continue. The City also plans to test a video detector in the future.

Infrared Technologies

Infrared technologies are similar to a 'motion sensor' in home security systems or the detectors on automatically opening doors. Hughes et al. (2001) found that infrared technologies are already well established for both vehicle and off-road pedestrian detection. However, the efficiency of infrared detection methods can be degraded if the object remains still. Infrared devices, shown in Figure 4, cannot discriminate the direction of pedestrian movement, nor can they determine the number of objects detected.

Another type of infrared detector is called Passive Infrared, shown in Figure 5. Bu et al. (2007) indicate that this type of technology uses heat along with motion. These operate by detecting the body heat of pedestrians in close proximity (usually within four meters). Double sensor units are required to detect the direction of pedestrian movement. The device registers when it detects an object with a temperature that exceeds a certain threshold. However, the devices cannot distinguish whether the heat source is generated by a pedestrian or a vehicle.

Figure 4: Infrared receiver, transmitter and reflector.
Source: Bu et al. 2007

Figure 5: Passive infrared pedestrian detector.
Source: ASIM Technologies Ltd. (http://www.asim.ch/traffic/pics/ir200.jpg)

The jurisdictional survey found that only two places are currently testing this type of technology: Sydney, Australia, and Auckland, New Zealand.

Sydney, Australia: This city is currently testing AGD-625 infrared-video detectors (Figure 6) at about 20 intersections. The video monitors the curbside while the infrared monitors the crosswalk. If pedestrians are detected in the crosswalk when the clearance interval is about to end, it can be extended in one second increments, up to four seconds. Shadows, heat from the road and trees moving in the wind are reported to cause false calls. To resolve these problems the detection area of the sensor is reduced and pushbuttons are used to augment the detectors.

Figure 6: Infrared detectors in Sydney, Australia.
Source: John Tough, New South Wales Roads and Traffic Authority, Sydney

The City reported only minor increases in operating and maintenance costs and a capital cost of ~$4000 CAN per unit. Audible and vibro-tactile feedback is given to the pedestrian when a call for a crossing has been made. A locator tone to help blind and low-vision pedestrians find the pushbuttons is also provided. Engineers conducted a before and after study to evaluate the impact on traffic. They measured traffic volumes for three months before and two years after the installation of the detectors. It was determined that there had been no real change in vehicle capacity or delay at intersections with automated detection for pedestrians. The program to install automated detection for pedestrians has been canceled due to the false calls and minimal benefit to pedestrians.

Auckland, New Zealand: This jurisdiction is testing passive infrared detectors to activate audible signals for blind pedestrians. However, there has been limited success with this system.

Piezoelectric Sensors

Piezoelectricity is the property of certain materials that change their electrical properties when put under mechanical pressure.

According to Bu and Chan (2005), a piezoelectric detector is a simple reliable sensor for pedestrian detection. It does not require complex signal processing. However, it does require physical contact between the pedestrian and the sensor mat. Therefore, piezoelectric detector is usually used for intersection pedestrian crossings.

For the application of pedestrian detection, piezo-cables with piezoelectric material are usually fabricated into a “mat” (Figure 7). When a person steps onto the mat, electrical signals are generated until the person leaves the mat.

Piezoelectric detectors are used to detect the presence of a waiting pedestrian at a controlled road crossing (Figure 8) for some PUFFIN (Pedestrian User-Friendly Intelligent Crossing) and PUSSYCATS (Pedestrian Urban Safety System and Comfort at Traffic Signals) in the United Kingdom.

The jurisdictional survey found that none of the responding jurisdictions use this type of technology for pedestrian detection. Piezoelectric sensors have been used in Australia but are no longer used.

Figure 7: Piezoelectric pedestrian detector.
Source: Eco-Counter (http://www.eco-compteur.com/IMAJeditUpload/images/ECO_7038_1138440993931_Capteur-dalle-acoustique-po.jpg)

Figure 8: Australian piezoelectric sensor in a sidewalk under red painted area.
(Source: http://www.walkinginfo.org/aps/7-17.cfm)

Video Image Processing

According to Bu and Chan (2005), video cameras (Figure 9) can obtain very rich information about the surrounding environment when compared with the microwave-radar or laser scanner. However, the image sequences cannot be used for anything directly without further interpretation. Bu et al. (2007) state that the processor subtracts the static background from the image and then tracks the movements of the remaining objects (pedestrians). Extracting useful information from image sequences is very complex.

Figure 9: Video pedestrian detector.
Source: Peek Traffic Limited (http://www.peek-traffic.co.uk/furniture/images/page_images/large_images/agd625.jpg)

Bu and Chan (2005) indicate that algorithms detect pedestrians in the image sequences acquired from the video camera with two different approaches:

- Motion based approaches take into account temporal information and tries to detect the periodic features of human gait in the movement of candidate patterns. They efficiently reduce the number of false positive candidates.

- Shape based approaches rely on shape feature to recognize pedestrians. Motion based approaches use rhythmic features or motion patterns unique to human beings.

Both techniques have difficulties that must be overcome. Motion based schemes cannot detect stationary pedestrians or unusual pedestrian movements (e.g. jumping). They need pedestrian's feet or legs to be visible to extract rhythmic features or motion patterns. They also require a sequence of images, which delays the identification and increases the processing time.

Shape based methods allow the recognitions of both moving and stationary pedestrians. The primary difficulty associated with this approach is how to accommodate the wide range of variations in pedestrian appearances due to posture, articulations of body parts, lighting, clothing, and sight-line issues.

Shape based methods suffer from high false positive rates due to variation of human shape and changing lighting conditions, and heavy computation burden.
The sensor fusion approach is suggested where multiple sensors are used (e.g., radar and laser scanner) together with computer vision to reduce false positive rates.

Compared with camera operating on visible spectrum, infrared camera is not that sensitive to the change of lighting conditions. The advantage of passive infrared sensor is the ability to detect pedestrians without illuminating the environment. Pedestrians are bright and sufficiently contrasted with respect to the background in IR images and can be recognized by their shape and aspect ratio. To reduce the cost of infrared camera, which was used mostly in military applications, low-cost 16 by 16 array infra-red detectors are used in groups to count the number of pedestrians passing by and capture pedestrians' moving trajectories along certain corridors. Pedestrians can be identified by the shape recognition and their movements are tracked through vector analysis.

The jurisdictional survey found no countries or cities which are currently applying this type of technology for pedestrian detection at signalized intersections.

Laser Scanners

According to Bu and Chan (2005) laser scanners (Figure 10) emit infrared laser pulses through a rotating prism and detect the reflected pulses.

Figure 10: Pedestrian laser scanner on a forklift for warehouse safety application.
(Source: http://www.pmh-co.com/EKweb/PMH%20Features/B_features9.html)

The data from laser scanners is accurate in distance (centimeter level) and azimuth angle (from 0.25 degree to 1 degree depending on the scanning frequency). A procedure similar to image processing is applied to interpret the data.

Multiple laser scanners can be connected by a computer network and used to track pedestrians in a given area. The excellent range, accuracy and fine angular resolution make laser scanners suitable for applications in which a high resolution image of surrounding is required.

However, Bu and Chan (2005) note that since they are optical sensors, different weather conditions like fog or snow limit their detection range. The signal processing is more complex for laser scanners compared with ultrasonic or microwave radar; therefore a dedicated computer processor may be needed.

Viola et al., (2005) studied and developed a pedestrian detection system that integrates image intensity information with motion information.

- The detection style algorithm scans a detector over two consecutive frames of a video sequence. The detector is ‘trained’ to take advantage of both motion and appearance information to detect a walking person. Past approaches have built detectors based on motion information or detectors based on appearance information. The process Viola, Jones and Snow developed is the first to combine both sources of information in a single detector. The implementation described runs at about 4 frames/sec; detects pedestrians at very small scales (as small as 20 × 15 pixels), and has a very low false positive rate.

- Detection style algorithms are fast, perform exhaustive search over the entire image at every scale, and are trained using large datasets to achieve high detection rates and very low false positive rates.

- The dynamic pedestrian detector built by Viola, Jones and Snow is based on the simple rectangle filters presented by Viola and Jones (2001) for the static face detection problem. Filters were extended to act on motion pairs. They measure the differences between region averages at various scales, orientations, and aspect ratios and can be evaluated extremely rapidly. While these features are somewhat limited, experiments demonstrate that they provide useful information that can be boosted to perform accurate classification. Motion information can be extracted from pairs or sequences of images in various ways, including block motion estimation which requires the specification of a comparison window, which determines the scale of the estimate.

- The training process uses an algorithm to select a subset of features and construct a classifier. In each round the learning algorithm chooses from a heterogeneous set of filters, including the appearance filters, the motion direction filters, the motion shear filters, and the motion magnitude filters. The algorithm also picks the optimal threshold for each feature with lowest weighted error on the training examples. The resulting classifier balances intensity and motion information in order to maximize detection rates.

The jurisdictional survey found no jurisdictions applying this technology for pedestrian detection at signalized intersections at this time.

Capital Cost

Regarding the capital costs associated with acquisition and installation of these technologies, the prices vary among technologies. Furthermore, there are also price variations within each of the technologies, depending on the type of sensor or model.

According to Bu et al. (2007), the capital cost of the individual sensors and related software ranges from US $790 (for an infrared beam detector) to US $2,600 (for a passive infrared detector) per sensor. In a field application multiple sensors are required at one intersection. Additional costs include installation, calibration, wiring, and maintenance.

The jurisdictional survey did not provide any information regarding the capital cost or any other types of costs associated with each of the technologies being used or tested in those jurisdictions. In all instances, the interviewed officials were only familiar with the operational aspect of the technology but not with any of the associated costs.

Effectiveness

There are several mixed opinions regarding the effectiveness of automated pedestrian detection technologies. The jurisdictional survey found that the technology is working well in some locations, while others argue the opposite.

Hughes et al. (2001) conducted a study for the U.S. FHWA to test automated pedestrian detectors (infrared and microwave) in Los Angeles, California; Rochester, New York; and Phoenix, Arizona to determine how effective the detectors were. The following was found:

- Since automated pedestrian detectors ‘call’ the WALK signal for pedestrians who do not push the button, most pedestrians will have the opportunity to start crossing on the WALK signal. When automated pedestrian detectors were used in conjunction with the pushbutton, this resulted in a significant reduction in the percentage of pedestrians beginning to cross during the DON’T WALK signal.

- With respect to the extended crossing time for pedestrians still in the crosswalk, more pedestrians were able to complete the crossing during the (still protected) steady DON’T WALK (parallel traffic green). Fewer pedestrians were still in the street during the unprotected DON’T WALK (oncoming traffic green).

- The use of automatic pedestrian detectors in conjunction with the conventional pushbutton significantly reduced vehicle-pedestrian conflicts. In this research, Hughes et al. (2001) defined a conflict as any pedestrian-motorist interaction in which either the pedestrian or the motorist stops or slows down so that the other can proceed.

- False calls were infrequent and reduced by adjustments to the detectors. One problematic cause of false calls was heavy rain (presumably, heavy snow could also cause false calls). A false call occurs when something other than a pedestrian was detected by the sensor. False calls needlessly delay motorists at the intersection.

- Missed calls occurred when a pedestrian waiting to cross did not stand inside the detection zone. This was mitigated by modifying the detection zone. Missed calls are when a pedestrian is waiting to cross but the sensor does not detect the pedestrian. This has a direct impact on safety as it can lead to the pedestrian crossing without the right of way.

- No determination was made as to whether or not the infrared or microwave detector was more effective.

In another study, Pati (2002) researched Intelligent Transportation System technologies for pedestrian safety. The researcher states that generic pedestrian technology may suffice at locations where pedestrian activity is low, but it may not offer adequate safety and operational efficiency under the following conditions:

- Presence of a high number of pedestrians prevalent in metropolitan cities or generated during special events.

- Presence of physically or visually challenged pedestrians.

- Reduced visibility of crosswalks at night or during low light conditions.

- Inadequate roadway geometric conditions with a limited sight distance, unusual grade, or other issues.
- Adverse environmental conditions such as heavy precipitation, fog, snow/ice, storm, and hurricane.

The Organization for Economic Co-operation and Development (1998) suggested the following ways that an automated pedestrian detection system could be utilized, with the view to optimize its effectiveness.

- Triggering of the pedestrian demand to cross, before the pedestrian actually reaches the crossing point.

- Extending the length of the pedestrian green time if pedestrians are still approaching the crossing point.

- Extending the length of the crossing time if the occupancy of the crossing is above a specified level.

- Extending the length of the crossing time if any pedestrians are still in the crossing.

- Bringing the pedestrian green time forward when pedestrian demand is above a certain level.
- Reducing the pedestrian green time if no crossing pedestrians are detected.

SUMMARY

This paper identified 8 publications that addressed the issues being investigated. In addition, officials in nearly 25 jurisdictions were interviewed as part of the jurisdictional survey to obtain details about available technologies for automated pedestrian detection.

To address accessibility issues at signalized intersections, some jurisdictions have implemented advanced technologies for automated pedestrian detection. However, according to Hughes et al. (2006) “passive detection technology for pedestrians is still not developed enough for nationwide use.”

The literature identifies six categories of automated pedestrian detection technologies: **ultrasonic, microwave-radar, infrared, piezoelectric, laser scanners and video image processing**. These technologies can be used individually or in combination to detect pedestrians.

The jurisdictional survey found that none of the responding Canadian jurisdictions currently uses automated detection for pedestrians. Only Ottawa, Ontario reported that an operational test of one of these technologies is currently being conducted. In the United States three of the responding jurisdictions currently use automated detection for pedestrians at signalized intersections: Portland, Oregon; Las Vegas, Nevada; and Tucson, Arizona.

At the international level, beyond Canada and the United States, discussions with officials in some of the countries indicate that six countries have sites that use automated detection for pedestrians. These countries are Australia, England, Japan, New Zealand, Sweden, and The Netherlands.

ACKNOWLEGMENTS

The author thanks The Canadian Association of Road Safety Professionals (CARSP) for funding for the research project that led to this paper. For details on the research project see www.carsp.ca/index.php?0=page_content&1=98&2=403).

REFERENCES

Bu, F. & Chan, C. (2005). *“Pedestrian Detection in Transit Bus Application: Sensing Technologies and Safety Solutions,”* IEEE.

Bu, F.; Greene-Roesel, R.; Diogenes, M.C.; Ragland, D.R. (2007). *“Estimating Pedestrian Accident Exposure - Automated Pedestrian Counting Devices Report,”* CalTrans, Richmond, California.

Federal Highway Administration [FHWA] (2004), *“Types of Electronic Devices Used to Collect Pedestrian Data 2004 National Summary”.* U.S. Department of Transportation's ITS Joint Program Office. Accessed online at [http://www.itsdeployment.its.dot.gov/] Jan. 2008.

Hughes, W.; Chappell, D.; Chen, S. (2006). “Innovative Intersection Safety Improvement Strategies and Management Practices: A Domestic Scan,” Federal Highway Administration Report Number FHWA-SA-06-016.

Hughes, R.; Huang, H.; Zegeer, C.; Cynecki, M.(2001). *“Evaluation of Automated Pedestrian Detection at Signalized Intersections,”* Federal Highway Administration Report Number FHWA-RD-00-097. Washington, D.C.

Organization for Economic Cooperation and Development [OECD] (1998). “*Safety of vulnerable road users,”* Scientific Expert Group on the Safety of Vulnerable Road Users (RS7)

Pati, R. (2002), *“Steps Toward Enhancing Pedestrian Safety: The Pedestrian Safety and Access Market Package”. Florida Department of Transportation.*

Viola, P.; Jones, M.; Snow, D; (2005). *“Detecting Pedestrians Using Patterns of Motion and Appearance,”* International Journal of Computer Vision 63(2), 153–161, Springer Science + Business Media, Inc.

Photo Credits

ASIM Technologies Ltd. *(http://www.asim.ch/traffic/pics/ir200.jpg),* accessed on Nov 20, 2007.

Eco-Counter, *(http://www.eco-compteur.com/IMAJeditUpload/images/ECO_7038_1138440993931_Capteur-dalle-acoustique-po.jpg),* accessed on Nov 20, 2007.

John Tough, New South Wales Roads and Traffic Authority, Sydney.

Peak Traffic Limited, *(http://www.peektraffic.co.uk/furniture/images/page_images/small_images/adg220.jpg),* accessed on Nov 20, 2007.

Peek Traffic Limited, *(http://www.peek-traffic.co.uk/furniture/images/page_images/large_images/agd625.jpg),* accessed on Nov 20, 2007.

Pedalcyclesafety.com, *(http://pedalcyclesafety.com/PCSS%20Project%20Report_files/image012.jpg),* Accessed on Jan 3, 2008.

Pmh-co.com, *(http://www.pmh-co.com/EKweb/PMH%20Features/B_features9.html),* Accessed on Jan 3, 2008.

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Walkinginfo.org, *(http://www.walkinginfo.org/aps/7-17.cfm),* Accessed on Jan 3, 2008.

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Houston, Texas
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City of Las Vegas

Phoenix, Arizona
Mike Cynecki, Traffic Engineering Supervisor
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Portland, Oregon
Tod Rosinbum
City of Portland, Bureau of Transportation System, Signal and Street Lightind Division

Richmond, Virginia
Steve Hanson, Operations Manager
Department of Public Works, Division of Transportation Engineering

Tucson, Arizona
Bob Hunt, Traffic Engineering Manager
City of Tucson

International

Auckland, New Zealand
Mitch Tse, Senior Traffic Engineer
City of Auckland, Road Safety Section

Berlin, Germany
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London, England
Greg Ulph, Business Development Manager for Signals and Equipment
Traffic Operations Department, Transport for London (TfL)

Oslo, Norway
Per Laudal
City of Oslo

Sydney, Australia
John Tough, Manager of Network Operations
Roads and Traffic Athourity of New South Wales