Pedestrian and Weather Sensors for Dynamic Traffic Light Allocation

DETAILS

SECTOR | Transport

STAGE | Operations and Maintenance

TECHNOLOGIES | Motion Sensors, Thermal Sensors, Weather Detector, Bluetooth Sensors, Smartphone Accelerometer, Artificial Intelligence (AI)

SUMMARY

Pedestrian sensors are technologies that can be installed at road intersections to detect whether and how many pedestrians are waiting to cross the road. They can also detect pedestrians whilst they are crossing the road. They can differentiate between pedestrians, cars and cyclists using thermal and Bluetooth technologies. The information gathered by the sensors can be used to optimize traffic light operations. This aims to balance two main objectives: (1) improve safety for pedestrians crossing at intersections and (2) optimize traffic lights to minimize delays for vehicles.

Traditional intersections work using a loop system which allocates green light phases to road users and pedestrians in a pre-defined fixed order, not linked to the actual density nor the speed of pedestrians. Furthermore, the length of the green light allocation for pedestrians to cross is of a fixed length, calculated based on average walking speeds. Depending on the walking speed of the pedestrians crossing, and the density of those pedestrians, the length may not be enough, or, conversely, may be too long. The system also presents safety risks for pedestrians, if the length of time they are given to cross is not long enough, they may still be in the road when vehicles begin moving. Each year, over half a million pedestrians die worldwide in automobile accidents, which represents 65% of the total automobile-related fatalities[1]. An average of 29% of pedestrian fatalities and injuries occur at road intersections[2]. These pedestrian fatalities have an economic cost estimated to affect global GDP by up to 3%[3]. In low- and middle-income countries, road traffic accidents can cost USD 64.5 billion per year[4].

Through the utilization of pedestrian sensors, the traffic lights at an intersection can be made dynamic to respond to real-time conditions. If no pedestrians are waiting to cross, the system will skip the green light allocation for the pedestrian crossing, and instead extend the length of the green light allocation to road vehicles. Where large numbers of pedestrians are crossing the road, or a pedestrian requires more time to cross the road (e.g. elderly person, limited ability person, child) the sensors will detect this and lengthen the green light allocation until the crossing is clear. Pedestrian sensors can also gather pedestrian demand information to

---

[1] "Pedestrian sensing for increased traffic safety and efficiency at signalized intersections", Wouter Favoreel, Accessed 7 May 2020.

[2] "Pedestrians Involved in Road Crashes in South Australia", Department of Planning, Transport and Infrastructure South Australia, Accessed 20 May 2020.

[3] "Pedestrian sensing for increased traffic safety and efficiency at signalized intersections", Wouter Favoreel, Accessed 7 May 2020.

[4] "Pedestrian sensing for increased traffic safety and efficiency at signalized intersections", Wouter Favoreel, Accessed 7 May 2020.

influence decision making, and enable call cancellation, dynamic clearance time, dynamic pedestrian countdown signals, pedestrian priority, and replace push buttons.

Similarly, weather sensors are used to gather data about the weather conditions (e.g. temperature, precipitation level, fog detection, humidity etc.) to optimize the road network in response to real time conditions. Trigger points are set for each weather condition or combination of conditions, which will prompt response programs across the network. These responses could include changes to traffic light phases for cars and pedestrians and changes to speed limits. Such responses can also be triggered manually by a traffic operating control centre.

Weather conditions can impact driver visibility (e.g. fog, precipitation) and capabilities (e.g. temperature extremes, high winds, precipitation), vehicle performance (e.g. traction, stability, manoeuvrability), and road friction (e.g. snow, sleet, ice, precipitation). These conditions increase the risk of road traffic accidents between vehicles, and with other road users such as pedestrians, cyclists, and motorbikes. In the US, weather conditions account for 21% (1,235,000) of road traffic accidents each year, resulting in 5,000 deaths[5]. The frequency and severity of weather conditions are increasing, thereby increasing the risk of road accidents. In some jurisdictions, sharp increases in temperature and the rate of sandstorms have altered rainfall patterns, which is believed to have led to an increase in road traffic accidents. Adaptation measures should be explored to address the increasing safety risk on road networks.

In the future, data from sensors may be utilized to create dynamic spaces that adapt to real time demand and safety requirements. Such sensors can also be utilized as part of a wider Internet of Things (IoT) connected network by feeding data to the wider network to integrate with traffic management solutions (see *Real-Time Traffic management Use Case*) and can similarly feed data to Smart Motorways systems to adapt the driving behaviour of autonomous vehicles in response to real time conditions *(see also the Vehicle to Infrastructure (V2I) Use Case)*.

VALUE CREATED

Improving efficiency and reducing costs:

- Improve optimization of road network (weather sensors) and intersections (pedestrian sensors) thereby reducing travel times and congestion.

Enhancing economic, social and environmental value:

- Reduce the economic cost associated with road traffic accidents – in 2015 the cost of road traffic accidents in Australia was estimated at AUD 22.2 billion, of that there was an AUD 3.17 billion cost to government through emergency responses, health services and foregone tax revenue[6].
- Reduce risk of road traffic accidents and enhance public safety of all road users by adapting the road network to suit the specific conditions and optimise crossings to encourage more active travel modes.
- Use collected weather data to monitor climate and air quality and track improvements made by environmental initiatives.

POLICY TOOLS AND LEVERS

Legislation and regulation: Governments need to introduce policies and performance criteria to be met by the sensors, as well as the priority framework (i.e. should vehicle demand or pedestrian demand be prioritised) to ensure safety of all. Furthermore, governments could provide incentives for the technology to be developed, as it can be used for other purposes such as weather forecasting, scientific research and road conditions. Data privacy regulations and security procedures for the collection, usage and storage of sensitive information obtained should be developed.

[5] "How Do Weather Events Impact Roads?", US Department of Transportation, Accessed 7 May 2020.
[6] "Cost of Road Trauma in Australia", Australian Automobile Association, Accessed 7 May 2020.

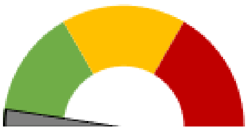
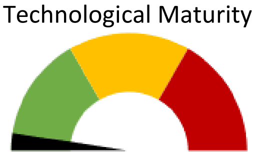
Effective institutions: Understanding and implementing requirements for pedestrian and weather sensors into the early planning and design phases of road and pathways infrastructure projects, as well as in city master planning, requires putting in place effective institutions looking at the 'whole-of-network' planning.

Transition of workforce capabilities: Understanding the demand and the planning of road crossings is important, as well as understanding how to use and maintain such sensors once they are implemented. Operations staff will need to be appropriately trained.

Funding and financing: The funding models should consider the benefits on traffic optimisation and safety improvement produced by investing in such sensors and their supporting analytical solutions.

Procurement and contract management: Contracts with technology providers could include clauses that encourage data sharing. This would enable local authorities to utilize the sensor data to enable intelligent asset management of the road network and assist future city planning by utilizing the data for other smart applications across environment, connected devices, lighting etc. By making the data open source, it could be used to facilitate the ongoing development of technologies for traffic management needs and to enable broader scientific and technological research in areas including weather forecasting and climate change.

IMPLEMENTATION

Ease of Implementation 	Such sensors and their analytical solutions are easy to implement by mounting them on existing poles or integrating them with Smart Streetlights *(see also Smart Street Lighting use case)*, or integrating them in to roadside solutions. The number and locations should be planned accurately to enable the expected outcomes and performances to be met.
Cost 	Sensor technology is relatively cheap today and is continuing to decrease in price, making the capital investment in this technology low. An investment in this technology can produce noticeable improvements in operations efficiency and road safety, with the cost benefiting the wider economy.
Country Readiness 	Such solutions already exist and are already in use in many global cities such as London, Paris, and Copenhagen. Most advanced countries are ready and already implementing them, while in developing countries these solutions are mainly at a trial phase in specific cities or suburbs.
Technological Maturity 	Two categories of weather-related road sensors have already been developed and used for detecting the condition of the road surface. The first of these is imbedded directly into the road surface and the second non-invasive option is installed either adjacent to or over the road. The main technical area for development is the communication interface. For thorough weather information relay, condition specific sensors for predicting rainfall or snowfall, monitoring road conditions, detecting fog etc. need to be implemented and relayed appropriately depending on the weather conditions vehicles are facing at that time. For Pedestrian Sensor systems, the detectors used (video cameras, sensors, etc.) are already developed technologies widely used throughout multiple industries. However, the integration of these technologies and the corresponding response plans need to be designed according to each government strategy.

RISKS AND MITIGATIONS

Implementation risk

Risk: The number and locations of the sensors should be planned accurately according to defined objectives in order to enable the expected outcomes and performances to be met, This is the first step to implementation and requires detailed planning and design.

Pedestrian Sensors: Integrating the individual technical components could pose a challenge to system designers, due to the real-time response requirements of the system. Furthermore, a monitoring system needs to be developed and implemented for maintenance purposes, enabling immediate communication with a designated response team.

Weather Sensors: Open-pored asphalt is used more commonly on roads since it is better for draining water and is less noisy, however sensors cannot be installed in this sort of material, therefore non-invasive sensor technology needs to be developed to the same level of competency.

Mitigation: To ensure reliable information, a maintenance plan needs to be in place, with regular checks of accuracy in weather and pedestrian density and speed readings. During the implementation, sensor providers must ensure calibration to reach the desired performance. Integration with traffic signals is also important and requires the right communication infrastructure.

Social risk

Risk: Personal security issues related to camera footage and sensor use could pose a hinderance to user acceptance. However, this can be mitigated by ensuring enough security in the acquiring and storing of personal information.

Mitigation: Personal data protection should be put in place and the benefits on safety should also be communicated to get the population on board with such systems.

Safety and (Cyber)security risk

Risk: With the incorporation of user location information with sensor technology, user's personal security is at risk. Therefore, the government and service providers need to ensure data privacy. Furthermore, the potential for hacking into weather sensors and dynamic speed limit signage could pose a threat to drivers. Therefore, developers must ensure that the weather sensor and connected dynamic speed limit system is secure.

Mitigation: Governments need to make decisions related to the implementation of such systems, such as which crossings should be dynamic or should utilise pedestrian sensors, and how regularly maintenance will be undertaken.

EXAMPLES

Example	Implementation	Cost	Timeframe
Smart Crossing Trial, Queensland	Smart-crossing trial at the Bourbong-Maryborough Street intersection in 2019 in Queensland, Australia.	The success of the trial prompted the State Government to commit AUD 3 million for an extra 300 installations across Queensland.	The trial took place in 2019. The subsequent roll out across the state was expected to take place over a two year period from late 2019.
Pedestrian Recognition IoT, Finland	Pilot of an IoT and AI based solution that detects when a pedestrian is planning to cross the street at an intersection. Partnership between the City of Tampere and Tieto software company.	The system was able to achieve up to 99% accuracy - and 75% at night.	The pilot was developed as part of the Smart Tampere development program's 6Aika City IoT project, in 2019.
Starling Crossing, South London	A pilot project was commissioned by the UK insurance company Direct Line and advertising agency Saatchi & Saatchi. The crossing was created by tech firm Umbrellium.	High investments, also including research budgets.	The prototype was tested in South London in 2017.