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Video Analytics towards Vision Zero

Microsoft, the City of Bellevue, and the University of Washington are using video analytics and machine learning systems to make roads safer.

According to the World Health Organization, over 1.2 million people die each year on the world's roads, and between 20 and 50 million suffer non-fatal injuries. In the United States, more than 19,000 people were killed in the first six months of 2016, up 9 percent compared with the same period in 2015. Yet despite the massive death toll, work to *prevent* traffic fatalities in the first place has been woefully lacking.

Many governmental agencies continue to rely on traditional traffic safety approaches. They intervene only after enough police crash reports are filed to trigger a "High Accident Corridor" designation. This *reactive* approach to preventing crash recurrence has well-documented limitations:

- At most locations, the number of crashes is very small and subject to chance variations;
- Not all crashes are reported and the level of reporting is uneven regarding the type of road users involved, the exact location and the severity of injuries;
- Numerous "close calls" are not documented;
- Behavioral or situational aspects of the events are not covered; and
- Many years of crash data is typically required to develop an understanding of the situation

Solutions for a Safer World

Although traffic collisions can happen anywhere, there are often early warning signals in the form of near-miss events at specific locations (*Figure 2*). These signals could provide insight into when, where, and why crashes are most likely to occur, helping transportation professionals to better target safety improvement projects. New technology now in development offers unprecedented ways to map, manage, and analyze near-miss data in real time. This data will provide essential information so that governments can evaluate the effectiveness of current safety programs and pinpoint interventions.

Advances in video analytics and machine learning can help jurisdictions whose goal is to end traffic deaths and serious injuries on their roadways. For these "Vision Zero" cities, traffic crashes are no longer regarded as "accidents," but as preventable incidents that can be systematically addressed (*Figure 1*). In terms of human lives and property damage, near-misses are zero-cost learning opportunities, compared to learning from actual crashes and their grim consequences.

In recognition of these opportunities to enhance public safety, Microsoft Corp. and the City of Bellevue, in collaboration with the University of Washington, entered into a partnership to develop a video analytics platform that could fundamentally transform how jurisdictions approach traffic safety analysis (*Figure 3*).

Figure 1: *Vision Zero calls for a proactive approach. It seeks to identify risk and design transportation systems in a way that prevents serious injuries or fatalities.*

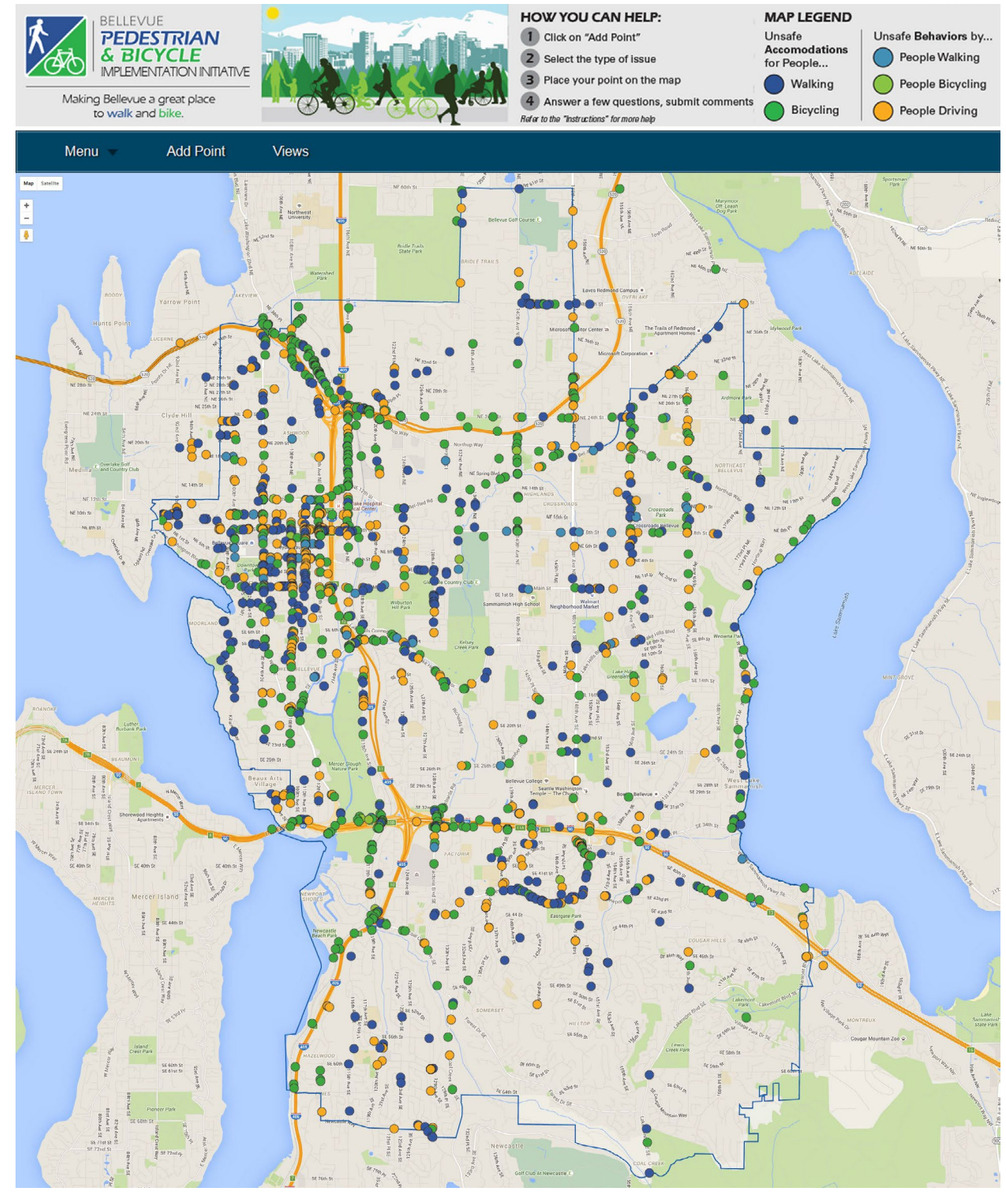

Figure 2: *To supplement traditional crash report data-sets, some jurisdictions, including the City of Bellevue, have pursued online mapping platforms that invite the public to pinpoint intersections or streets where they have experienced a "near-miss" event. While useful at cataloguing the wide-range of community concerns in a jurisdiction, these event-focused social media platforms – based on anecdotal evidence – lack the specifics needed to make effective investments to fix the problems.*

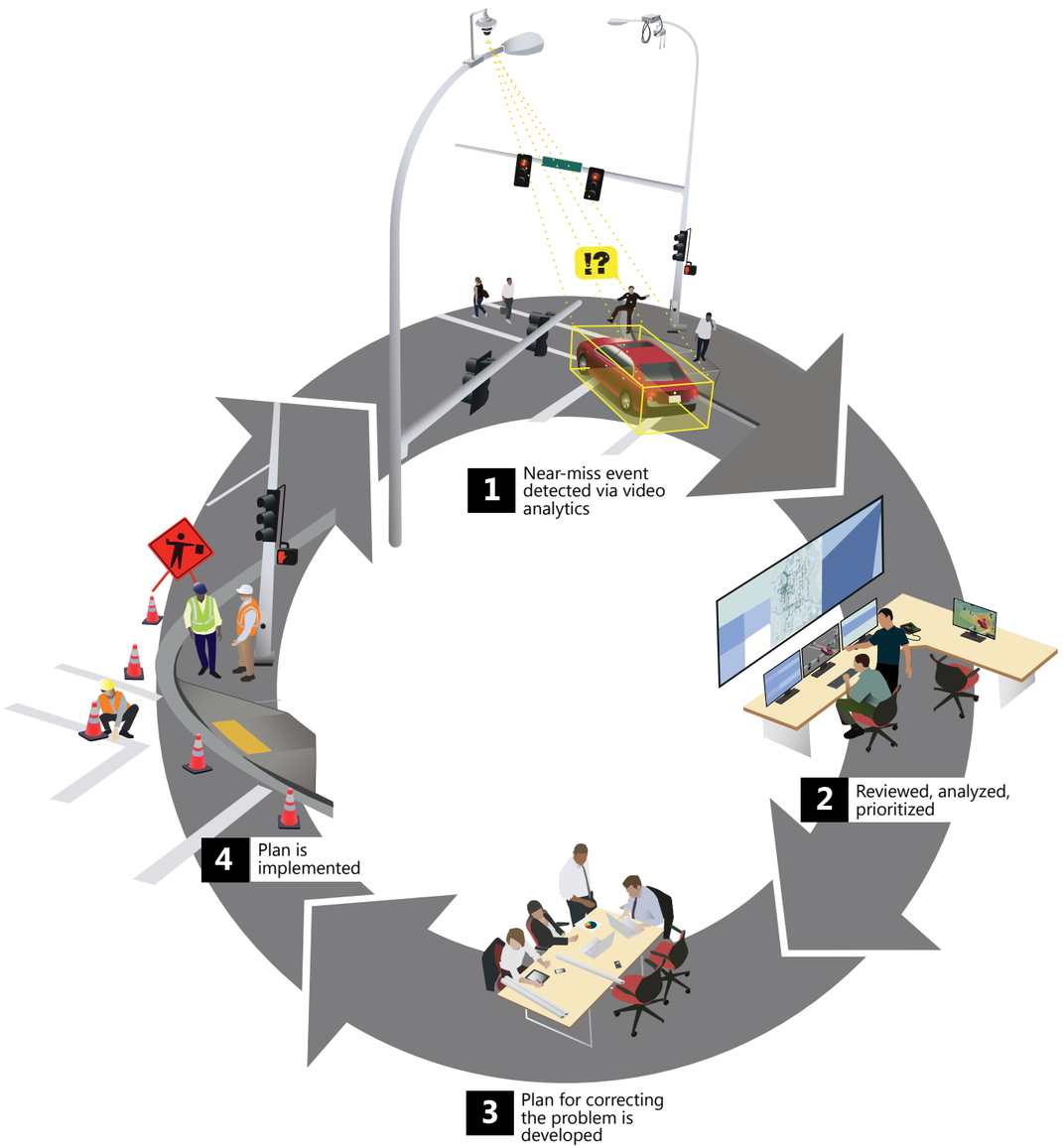

Figure 3: *The algorithms under development aim to create a 24/7 predictive crash analysis system that flags near-misses in real-time, enabling public works departments to implement safety countermeasures before someone gets hurt.*

Video analytics is the computerized processing and analysis of video streams to determine events and trends over time at a given location (*Figure 4*).

Although stand-alone data processing systems exist for analyzing traffic from pre-recorded video, these methods are limiting and costly because data can only be captured for a discrete number of sites over a defined time period. This technology development partnership differs from previous approaches by leveraging Bellevue's existing traffic camera system to simultaneously detect, differentiate, count, and track the movements of pedestrians, bicyclists and vehicles (*Figure 5*). If this data can be automatically analyzed continuously across the traffic camera system citywide, it presents a great opportunity to better understand and optimize a transportation system.

The system is designed to generate real-time count reports (*Figures 6*) that classify vehicles by turning movement (through, left or right), by direction of approach (northbound, southbound, etc.) and by mode (car, bus, motorcycle, truck, bicycle, pedestrian). In addition to data on the type and motion of road users at intersections, speed and derivatives of speed (e.g., acceleration and jerk) can be calculated continuously to better understand steering and braking behaviors. This data has the potential to identify near-miss events, which are much more frequent and more useful than crash reports in detecting systemic safety problems.

Understanding the root causes for near-miss incidents could enable local governments to take proactive, corrective actions to reduce the potential for future crashes. Performance dashboards are under development to flag these high-risk locations that warrant intervention. The dashboards are based on a predetermined, numeric scale of near-miss conditions. A higher score indicates a higher risk of collision, adjusted for the number of road users passing through the intersection (*Figures 7 and 8*).

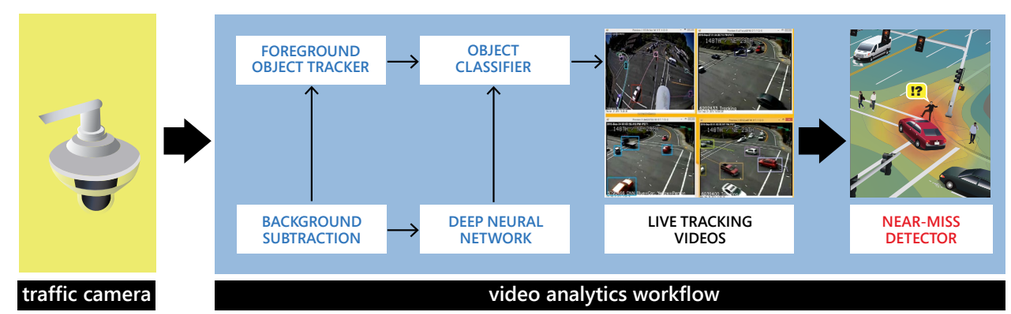

Figure 4: *The system tracks objects on live feeds from a city-wide camera installation, classifying objects into vehicles/pedestrians/bicycles using a deep neural network, and flagging near-miss events.*

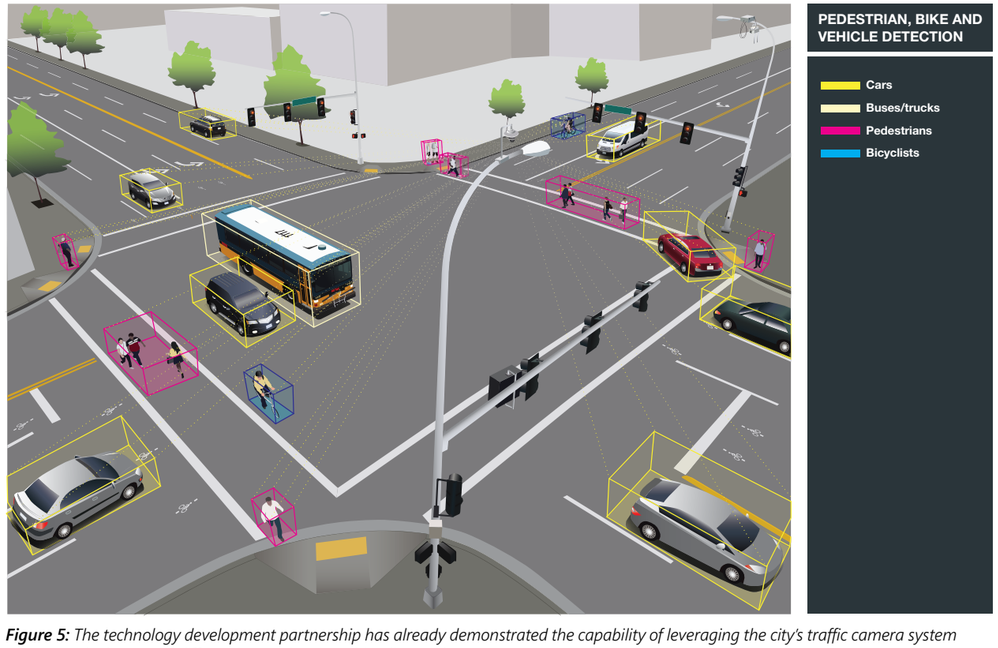

Figure 5: *The technology development partnership has already demonstrated the capability of leveraging the city's traffic camera system to accurately detect and differentiate pedestrians, bicyclists and cars.*

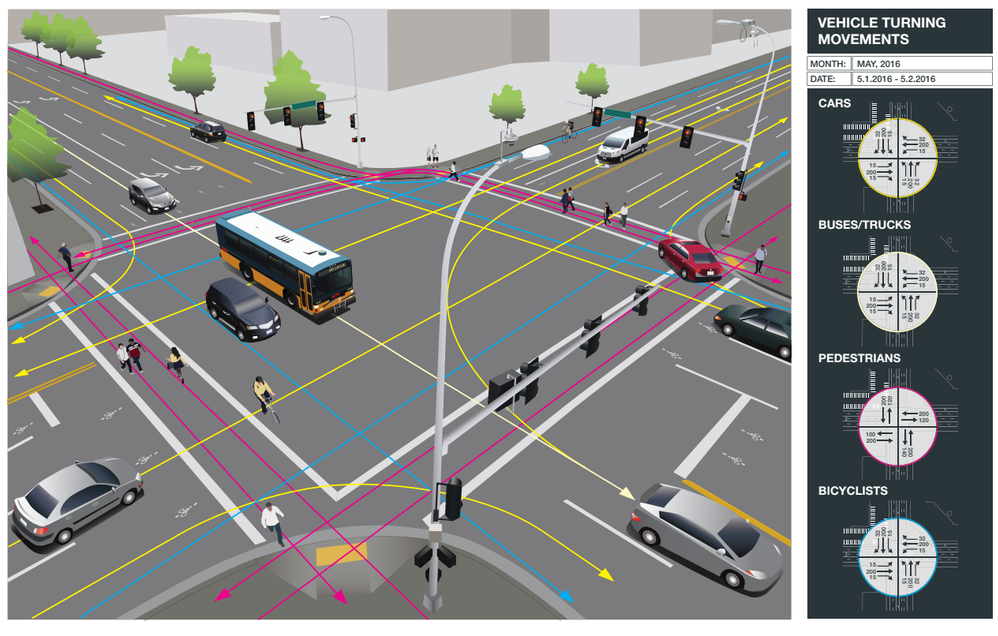

Figure 6: *The city's traffic camera system also can be used to count and track the movements of pedestrians, bicyclists and cars.*

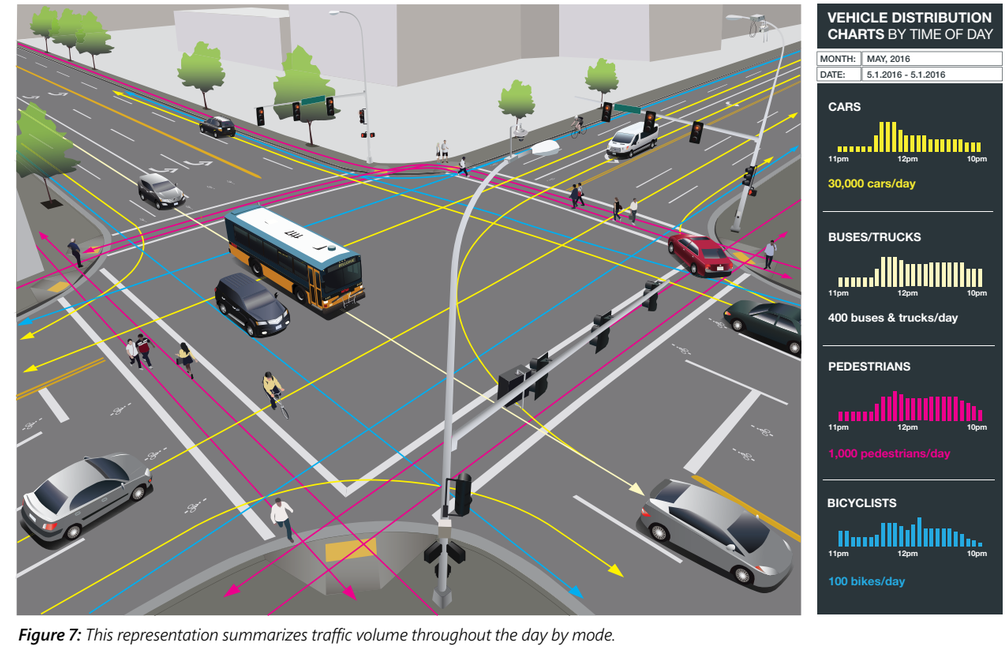

Figure 7: *This representation summarizes traffic volume throughout the day by mode.*

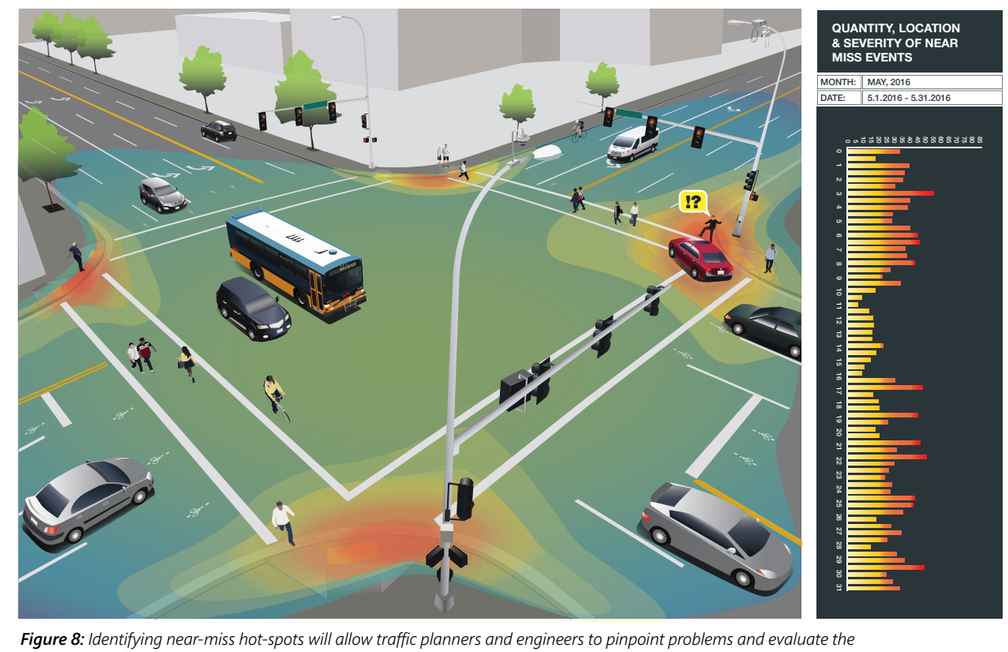

Figure 8: *Identifying near-miss hot-spots will allow traffic planners and engineers to pinpoint problems and evaluate the effectiveness of countermeasures.*

Video Analytics: Big Data, Big Opportunities

Traffic camera infrastructure is typically deployed by cities to observe roadway conditions and adjust signal operations. In this partnership, Microsoft is developing a proprietary video analytics system that has the potential to convert raw video footage from a city's camera network into useful data that can be searched, managed, and used to create a real-time, transportation safety analysis system. Using live video feeds the system will track objects and classify them into relevant categories.

A powerful tool, the video analytics system will run seamlessly across a cluster of many machines, enabling it to process and analyze many camera streams simultaneously, backed by the Azure cloud. Underlying the platform is a tracker technology that is tuned to detect and follow the trajectory of moving objects across varying camera views, lighting, and weather. The objects are classified into relevant categories – for example, pedestrians, bicycles or cars – using a Deep Neural Network (DNN), a machine-learning system inspired by the central nervous systems of animals. It will learn based on the training data it receives (*Figure 9*).

All of these components together will enable the video analytics system to identify important traffic and safety events, such as flagging instances where a car abruptly stops or swerves to avoid hitting a pedestrian. The events will be assigned numerical values that transportation professionals can then assess.

To help the DNN learn, the City of Bellevue is assisting Microsoft in promoting a crowd-sourcing platform that invites the public to participate in labeling video footage from Bellevue's traffic camera system. Accuracy of the DNN will continue to improve as the number of people participating in the crowd-sourcing exercise increases. As a result, the video analytics system will be suitable for handling large-scale data across a city's entire traffic camera system.

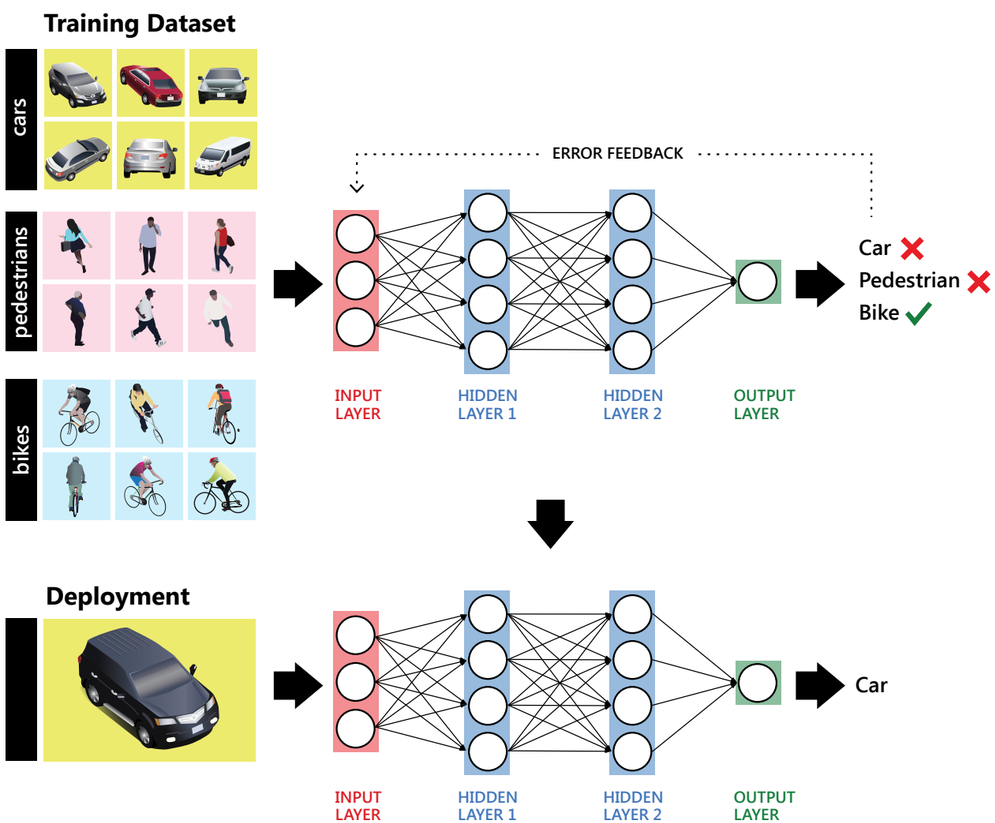

Figure 9: *Deep Neural Network algorithms learn from off-line training inputs to detect subtle variations among different objects and then make data-driven predictions of observed data during real-world deployment.*

Measuring Success

In addition to the potential for saving lives by predicting where collisions could happen and working proactively to prevent them, the video analytics system provides an opportunity to measure how well such improvements are working after the investments are made. The partnership aims to meet community expectations that government be responsive, transparent, and accountable in its decisions and expenditures (*Figure 10*).

An example of how video analytics could be leveraged to assess performance, is the city's Bicycle Rapid Implementation Program, or BRIP, which establishes an investment strategy to install new and upgraded bicycle facilities citywide.

Video analytics will enable Bellevue to quantify whether BRIP investments have increased bicycle usage and improved safety rates compared to other streets where no treatments were implemented. The feedback loop also will allow the City to clearly demonstrate how well it's progressing in meeting its Vision Zero goal.

Figure 10: *Making Vision Zero a reality in Bellevue involves collaborating with stakeholders such as Amy Carlson, a vice president at CH2M HILL, to gain useful insight into which metrics should be used to assess program investments over time.*

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