Bringing AI and Computer Vision to Transportation Risk Management

How Intel and IncluIT are using the Intel® Distribution of OpenVINO™ toolkit to enhance fleet management and safety and reduce costs

The rapid growth of cities worldwide is putting greater pressure on trucking companies to find new and better ways to manage their fleets. Among the most critical challenges is improving fleet and driver behaviors, especially as it relates to the danger experienced at increasingly busy intersections.

According to the Insurance Institute for Highway Safety (IIHS), more than 4,000 people died in large-truck crashes in the US in 2016.¹ The majority of those killed, about 82 percent, were occupants of passenger vehicles or pedestrians.¹ By 2017, fatalities from large-truck crashes had reached their highest level in 29 years.²

In its pursuit of a solution, US National Transportation Safety Board research found that 30 to 40 percent of all semi-truck accidents involve some element of driver fatigue.³ Many semi-truck drivers are paid by the mile or the load, placing pressure on drivers to work longer hours. Not surprisingly, the Centers for Disease Control and Prevention cite truck drivers as more likely to drive fatigued than the general population.⁴

Intel and IncluIT partner on fleet safety

Intel and long-time partner IncluIT, a leader in software design and development based in Cordoba, Argentina, believed that they could help address the risks attendant to changing transportation demands.

The two companies understood that Internet of Things (IoT) solutions represent an unprecedented opportunity to transform the way trucking businesses deal with today’s transportation issues. The benefits were many and included improved operational efficiency, reduced costs, and decreased risk.

To enhance efficiency on the road, IncluIT turned to a roster of new and emerging tools spanning edge computing, artificial intelligence (AI), computer vision, and an open-source Intel solution designed to help bring it all together, the Intel® Distribution of OpenVINO™ toolkit.

Harnessing the Intel® Distribution of OpenVINO™ toolkit

Intel and IncluIT wanted to test the Intel® Distribution of OpenVINO™ toolkit as a means for building non-ADAS solutions that aid truck drivers and meet evolving transportation needs through driver training. They turned to the toolkit because it allows driver monitoring to prevent and reduce risks by identifying and inferencing potentially dangerous situations.
Expedite development

The toolkit also helps speed development of applications and solutions that emulate human vision. This includes supporting high-performance computer vision applications, learning inference capabilities, and important AI demands. Based on convolutional neural networks (CNN), the Intel Distribution of OpenVINO™ toolkit would broaden IncluIT’s ability to gather and analyze data at the edge, which aligned perfectly with initial project aims.

Extend workloads

In addition, the toolkit can extend IncluIT workloads across Intel® hardware (including accelerators) and maximize performance. It enables deep learning inference at the edge while also scaling across Intel Vision Products to provide the following:

1. The Intel® Deep Learning Deployment toolkit, which offers a Model Optimizer (developer tool) and an Inference Engine (runtime component), which provides a single API and runtime for neural network acceleration
2. Pretrained models and samples
3. Optimized functions for OpenCV and OpenVX*

Achieve heterogeneous execution

IncluIT liked that the Intel Distribution of OpenVINO toolkit supports heterogeneous execution across computer vision accelerators—from CPUs and GPUs to the Intel® Neural Compute Stick and FPGAs—using a common API. Working with Intel, IncluIT learned that the toolkit’s library of functions and preoptimized kernels can also accelerate time to market should the project move to the productization stage.

Adapt to market needs

With the new toolkit, as well as currently available developer kits, IncluIT could reduce time to prototype, expedite the path to production, and provide a design that can scale and evolve to keep pace with changing market demands.

Initial transportation use cases

Early investigations saw IncluIT explore a range of transportation applications for vehicles as diverse as vans, medium- and long-haul trucks, buses, and heavy machinery. Considered use cases ranged from counting the number of people traveling on public transportation to recognizing and reporting untended packages in transportation terminals to theft prevention on trucks. Those that made the list for further investigation included driver authentication using facial recognition, collision near misses, and driver management.

Seeing a path to efficient trucking

External Vehicle Monitoring

IncluIT is also employing the Intel Distribution of OpenVINO™ toolkit and OpenCV to develop a 360° View External Vehicle Monitoring application. Using the toolkit’s model detection capability, pedestrians and vehicles can be detected with great accuracy.

The pedestrian and vehicle detection model being used is included with OpenVINO™ out-of-the-box. The application is written in Python.

Multiple cameras

In another innovative use of the Intel Distribution of OpenVINO™ toolkit, new digital trucks can be outfitted with multiple cameras to deliver a host of monitoring and operational benefits. Such trucks might come equipped with the following:

- An outside camera for object detection event recording
- An in-cab camera for forward-facing camera for object detection based event recording, road asset collection
- An in-cab camera to track drowsy or distracted driving

The Digital Truck
Taking fleet efficiency to the next level

Working in its hometown of Cordoba, Argentina, IncluIT wanted to engage municipal leaders about the company’s early efforts to address transportation risk reduction and to identify any new use cases related to the city’s needs. The city showed great interest in the work IncluIT had been doing and saw obvious benefits for the local transportation industry and the drivers who serve it.

IncluIT focused on the development of a proof of concept (POC) that specifically addresses fleet management and driver management. In an effort to optimize its logistical processes, the transportation industry desires preventative capabilities that work in real time to help drivers avoid potentially dangerous situations. IncluIT’s aim was to help companies reduce the risk to drivers and cargo, avoid costly emergency stops, and sharpen their competitive advantage.

The team proposed developing an architecture that could be subdivided into two parts: a hardware architecture focused on the edge processing and a cloud architecture for the messaging and dashboarding between the vehicles and the Fleet Control Center.

IncluIT studied competitors to determine if anything similar was currently available in the market. Finding nothing, it capitalized on what it had already learned about the industry and relevant technologies and launched a POC aimed at reducing driving risk by using vision technology to advance fleet management and driver management.

The POC: Fleet management and driver management

IncluIT’s Driver Management System is deployed inside the vehicle, running on an on-board computer. The POC showcases the advantages of AI and the open-source Intel OpenVINO™ toolkit by using AI to bring significant benefits to fleet control and risk reduction. Built on an architecture based on edge processing and cloud streaming, the system tracks driver behavior, alerting the driver of potentially dangerous situations.

The POC uses the model detection capabilities of the Intel Distribution of the OpenVINO™ toolkit, enabling users to read faces with great accuracy. To do that the toolkit relies on two detection models: facial recognition and gesture detection. The models are used to capture different levels of activity and driver behavior in near real time, specifically looking for evidence of drowsiness or distraction.

Capturing driver behavior

To detect potential fatigue the solution starts with the image captured inside an identified region of interest (ROI) on the driver’s face. The model feeds a facial landmark detector to identify points of interest. Six points are plotted for each eye and six points for the mouth to calculate an eye aspect ratio (EAR). These points determine if the eye and mouth are open or closed. Once there is a positive for a blink or yawn, the number of frames of those events is counted.

Blinking duration is also monitored and calculated. The combination of blinking frequency and duration allows the system to determine when the driver has departed from a regular blinking pattern and is exhibiting behaviors that exceed the established limits.

Finally, using the face’s ROI, the head-pose detector model provided by the Intel Distribution of OpenVINO toolkit detects when the face is not centered or not looking to the front. By developing a functional logic that detects the head position, the POC permits users to recognize whether the driver’s head position is centered. With this data, the relative position of the eyes can be inferred for monitoring gaze attention.

Drowsiness state

![Figure 1: Given the [gearStatus=Driving] when the user blinks/yawns repeatedly, then the Driver management System will detect this facial expression as drowsiness status indicators.]

Distraction state: Eyes out of the road

![Figure 2: Given the [gearStatus=Driving] and the [vehicleSpeed>5km/h] when the driver moves the head to a side, then the Driver Management System will detect an "eyes out of road" event.]

![Figure 3: Given the [gearStatus=Reverse] and the [vehicleSpeed>5km/h] when the driver moves the head to a side, then the Driver Management System will not detect an "eyes out of road" event, since it’s expected that the driver will look to the sides when the vehicle moves in reverse.]
Stop looking at (...)

Recording events to minimize risk

When the established threshold for these behaviors is reached, the system provides two different response options. The first for demo purposes, it offers a VU meter that illustrates values based on the type of behavior detected, their persistency within a specific unit of time, and the number of behaviors detected. The second is an ability to record these events and passed to the cloud for future driver coaching.

Today, vehicles as diverse as vans, medium- and long-haul trucks, buses, and heavy machinery can have upwards of hundreds of sensors that are all connected through communication protocols like on-board diagnostics II (OBD II). By connecting to the OBD bus, key truck data can be captured, including critical operational data such as speed and temperature.

IncluIT determined these sensors could be leveraged for a range of use cases focused on aiding drivers. The data could be used for the development of a digital dashboard offering drivers real-time vehicle status, customizable based on the type of vehicle and associated needs. This additional intelligence now supports enhanced predictive maintenance, helping reduce costs and downtime.

The bulk of the POC’s calculations are done at the edge (i.e., in the vehicle). Not requiring huge servers to process the data in the cloud, IncluIT chose to use Amazon Web Services (AWS). AWS is accessed through AWS IoT Core and stored on an AWS Dynamo Database. IncluIT also uses AWS Elasticsearch, Logstash, and Kibana (ELK), an open source stack, for modest processing and to generate the dynamic dashboards used by the Fleet Control Center to track, evaluate, and assist drivers.

**Driver management POC: The technology**

- The Intel Distribution of OpenVINO™ toolkit
- Intel® Core™ CPU with integrated graphics
- Intel Neural Compute Stick and Intel® Myriad™ X VPU
- OpenCV
- AWS
- AWS Dynamo Database
- AWS ELK
- Standard USB Video Class (UVC) camera
IncluIT POCs build market momentum

With the IncluIT Driver Management System POC, the Intel Distribution of OpenVINO™ toolkit provided an end-to-end solution able to boost inference applications with high throughput and efficiency and reduce costs. It enabled IncluIT to quickly stand up the solution with a three-person team, despite small budgets and an accelerated development schedule. The resulting POC garnered considerable industry attention and shows enormous real-world potential.

Both the near-misses detection and driver management POCs have been integrated into the Intel® IoT DevCloud platform. This developer tool enabled IncluIT to run the inference processes on different hardware targets. As a result of the performance analysis, both solutions have now been included in the official Intel® IoT DevCloud platform tutorial guides.

In the near term, IncluIT will concentrate on in-vehicle implementation and collaborating with transportation companies and hardware integrators to build and bring to market the driver management system able to make a real difference on the road and in the lives of drivers.

Learn more about the projects and players

Find more details about the Intel Distribution of OpenVINO toolkit at software.intel.com/en-us/openvino-toolkit.

Additional information about the Intel Distribution of OpenVINO toolkit are available at docs.openvinotoolkit.org/latest/demos_python_demos_object_detection_demo_ssd_async_README.html.

Dig deeper into the IncluIT Driver Management System POC at github.com/incluit/OpenVino-Driver-Behaviour.

Learn more about IncluIT at incluit.com.

Spotlight: Near-misses detection

IncluIT also sought to help drivers avoid collisions in future situations. Based on the Intel Distribution of OpenVINO™ toolkit, what was eventually dubbed the near-misses detection system enables city planners to implement AI models for vehicle and pedestrian recognition within a city’s intersections.

What is it?

The Near Misses Detection System is an open-source solution that implements artificial intelligence to identify potentially dangerous situations in a city’s traffic and help city planners rectify dangerous situations in the future.

The system can be deployed in smart cameras meant for traffic monitoring purposes as well as any outdoor video monitoring system located in parking lots, parks, airports, and other public places.

What does it do?

1. The system uses video processing and the generation of data related to incidents in a given intersection to identify and track all objects that pass through or stay within defined areas of interest.
2. All information is processed at the edge and streamed to cloud services where it is analyzed, ordered, and displayed within customizable dashboards.
3. Because the solution can be integrated with external cameras, it offers even greater detection and inferencing capabilities.
4. With several interfaces inside to connect to cameras, its software components can decode video images and merge video streams from multiple cameras to provide a complete picture of an intersection.

Learn more about IncluIT’s Near-Misses Detection System at github.com/incluit/openvino-for-smartcity.


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