ADLINK
LEADING EDGE COMPUTING

Solution Brief

ADLINK Driver Fatigue Monitoring Solution Boosts Road Safety

ADLINK ODM Services



www.adlinktech.com

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Introduction to Driver Fatigue and Monitoring Systems

Many drivers (and commercial employers) treat fatigue and drowsiness as an inescapable fact of modern life, like having to work while sick with a cold. However, the human and financial tolls caused by drowsy driving every year are staggering. Finding practical solutions has become imperative.

A large survey conducted across Europe revealed that 17% of drivers admitted to falling asleep behind the wheel within the past two years. In the U.S., the National Highway Traffic Safety Administration found that, at some point in their lives, 37% of drivers reported having fallen asleep while driving, and 2.4% of fatal crashes involved drowsy drivers. In India, the Central Road Research Institute claims that 40% of major expressway accidents are due to drivers dozing off. Also concerning is the AAA Foundation for Traffic Safety's conclusion that actual drowsy driving fatalities may be over 8 times higher than officially reported. (One can assume that such underreporting also applies to figures such as the Fatality Analysis Reporting System's estimation that 1.5% of large truck accident fatalities were due to driver fatigue.) The monetary costs of these tragedies carry their own weight. As a reference point, in 2016, the Governors Highway Safety Association released a U.S.-centric report showing "the annual societal cost of fatigue-related fatal and injury crashes is a staggering $109 billion, not including property damage."

Not surprisingly, manufacturers have pursued driver fatigue monitoring and alert systems for many years. A 2009 paper by the U.S. Department of Transportation examined a range of approaches, including infrared pupil brightness, percent of time eyes are closed (PERCLOS), head pose tracking, and blink analysis. At the time, one company was noteworthy for exploring a two-camera approach to naturalistic driver behavior. A subsequent paper released in 2015 by the Minnesota Department of Transportation provided a solid roundup of emerging monitoring technologies, which still heavily featured PERCLOS but also examined monitoring heart rates, brain waves, and skin conduction. Two sources noted in the paper examined analysis on lane-keeping and steering wheel behaviors.

When a fatigue monitoring system detects potentially dangerous behavior, it will typically issue a real-time auditory alarm to jolt the driver back to alertness. Some systems may integrate a flashing "nag light" or add vibration into the driver's seat or an aftermarket cushion. Commercial solutions aimed at vehicle fleets may notify a remote operations center, which in turn could review event footage and, if deemed advisable, notify a manager.



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Customer Application and Challenges

A driver fatigue monitoring solution manufacturer approached ADLINK with a need to create a next-generation product able to capitalize on modern advances in compute and graphics processing. The OEM had over a decade in the monitoring solutions space and more than 20 years of experience in conducting scientific research into applying artificial intelligence (AI) to driver safety, with an emphasis in the commercial transport sector.

The OEM's solution featured four hardware components: 1) a dash-mounted, in-cab sensor to track eye closure and head position; 2) an optional forward-facing camera; 3) a vibration motor for installation in the driver's seat; and 4) a fanless computer/controller. The system was designed to detect multiple variables:

- Driver fatigue
- Driver distraction
- Phone usage
- Vehicle location
- Vehicle speed

While detection seems simple on the surface, accuracy can be surprisingly difficult. For example, eyeglasses have long been problematic for eye-monitoring algorithms. The best solutions, such as the one under development by this OEM, detect many variables simultaneously, including whether the driver might be distracted by phone use. This multivariate detection involved significant video analysis processing driven by AI algorithms.

However, this level of processing comes with its own requirements. Most video analysis benefits from parallel processing, which in turn benefits from a multi-core processor and/or processing certain parts of the analysis workload using a graphics core with parallel architecture. This alone wouldn't be difficult given the capabilities of modern processors, but the monitoring controller also had size and power constraints. In an automotive cabin, the computer would likely be mounted on the dash or, optionally, under the dash or seat. The OEM wanted the smallest possible footprint, yet the system also needed to dissipate the heat (via a silent integrated chassis heatsink rather than a fan) generated by processor(s), memory, and storage components. The customer had encountered technical issues with at least one prior competing solution that could not meet these size and thermal demands.

The OEM also required a solution able to operate reliably in any of its existing markets around the world. Vehicles might need to operate for prolonged periods in the stifling humidity of a rain forest, the chill of sprawling tundra, or the oppressive heat and dust of a desert. Beyond that, vehicles would subject monitoring systems to endless hours of shock and vibration on roadways or even dirt roads. Conventional automotive computing systems inherently require ruggedness, but with an eye on global sales and exceptionally demanding use cases, ruggedness and reliability were paramount.

Similarly, the cameras in this solution needed to be industrial grade, not merely repurposed consumer cameras. Industrial cameras emphasize stability and ruggedness. Often, they feature a higher grade of sensor for improved clarity and light sensitivity as well as the ability to capture at higher frame rates. The higher spectral ranges in industrial cameras typically yield more accuracy from image processing algorithms in machine vision-type applications. Within this application, both front- and driver-facing cameras would feed data to the computer for real-time analysis, including in night and high-vibration conditions, so camera quality was particularly important.

After all of the above, the OEM had an expected list of business needs. The solution needed to be cost effective and competitive. The ODM solution supplier needed to accommodate system integration requests around items such as heatsink and smart camera implementation. The customer wanted a supply partner that could provide both design expertise as well as manufacturing capacity while remaining flexible, nimble, and receptive.

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ADLINK’s Solution

ADLINK arrived at this customer’s request with decades of experience in the embedded and military vehicle markets. After analyzing the challenges and constraints, ADLINK selected a compute solution based on the Intel Atom® x5-E3940 Processor. This CPU, designed with IoT solutions in mind, offers four cores, 2MB of L2 cache, and a 1.8 GHz burst frequency. The chip’s 14 nm lithographic process helps keep operating power consumption down to only 9.5W TDP, which in turn allows the entire compute solution to consume less than 36 watts with no need for active cooling. Intel’s integrated HD Graphics 500 engine runs at a 600 MHz (burst) frequency and supports up to 4K video at 60 Hz with no need for a discrete GPU. In short, the E3940 provides ample performance in a compact footprint for high-resolution dual-camera and parallelized AI computation to provide reliable real-time results, allowing the system to measure just 181.5(w) x 71.9(d) x 123.4(h) mm.

The 1.2MP driver-facing camera supports a variable frame rate ranging from 42 to 56 FPS. Integrated motion tracking uses a three-axis accelerometer and three-axis gyroscope. The camera also includes an infrared filter for extended visibility in night conditions. The forward-facing camera offers many of the same specifications, although it has no need for infrared and captures at an average rate of 30 FPS.

ADLINK paid special attention to the ruggedness of the system. The controller can operate in temperatures from -40°C to 65°C and withstand non-condensing humidity of up to 90 percent. The solution carries an Ingress Protection Rating of IP50, which means that dust cannot enter the enclosure in sufficient quantity to hamper device operation. Perhaps most importantly, ADLINK built the monitoring system to meet MIL-STD-810G, Method 516.6, Procedure V specifications. This ensures the solution can withstand crash hazard conditions of up to 75G.

ADLINK tailored the entire driver fatigue and monitoring system to eliminate any elements that might unnecessarily increase cost or complexity. At every point, the focus remained on design quality and cost-efficiency. As a result of its broad manufacturing capabilities and existing solution expertise, ADLINK was able to design and deliver a complete monitoring solution on budget and within the customer’s accelerated time-to-market window. In part, this was thanks to ADLINK already being an established player in the industrial, rugged machine vision market. Similarly, ADLINK already had ample experience and breadth in the fanless embedded computer space, with solutions ranging in footprint from palm-size to rackmount. ADLINK already had well-developed technical support channels for these lines, worldwide distribution and networks, and decades of experience in key account development, and was positioned to take the client from concept to mass production with speed, precision, and satisfaction.

Conclusion

Vehicular accidents involving driver fatigue continue to claim hundreds of lives annually, injure many thousands more, and incur staggering financial costs. Some estimates report that monitoring and alert systems such as those designed and manufactured by ADLINK could prevent up to 90% of such accidents. Knowing that the stakes here were literally life and death, ADLINK took care to create a best-of-breed monitoring solution that met every need set out by the client. Its quad-core, graphics-rich compute module and surrounding components, including a rugged dual-camera system, were built to withstand harsh road conditions and many years of prolonged use. ADLINK delivered the reliable, cost-effective solution that competing ODMs could not, and today the solution is in use on roadways, and helping save lives around the world.

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