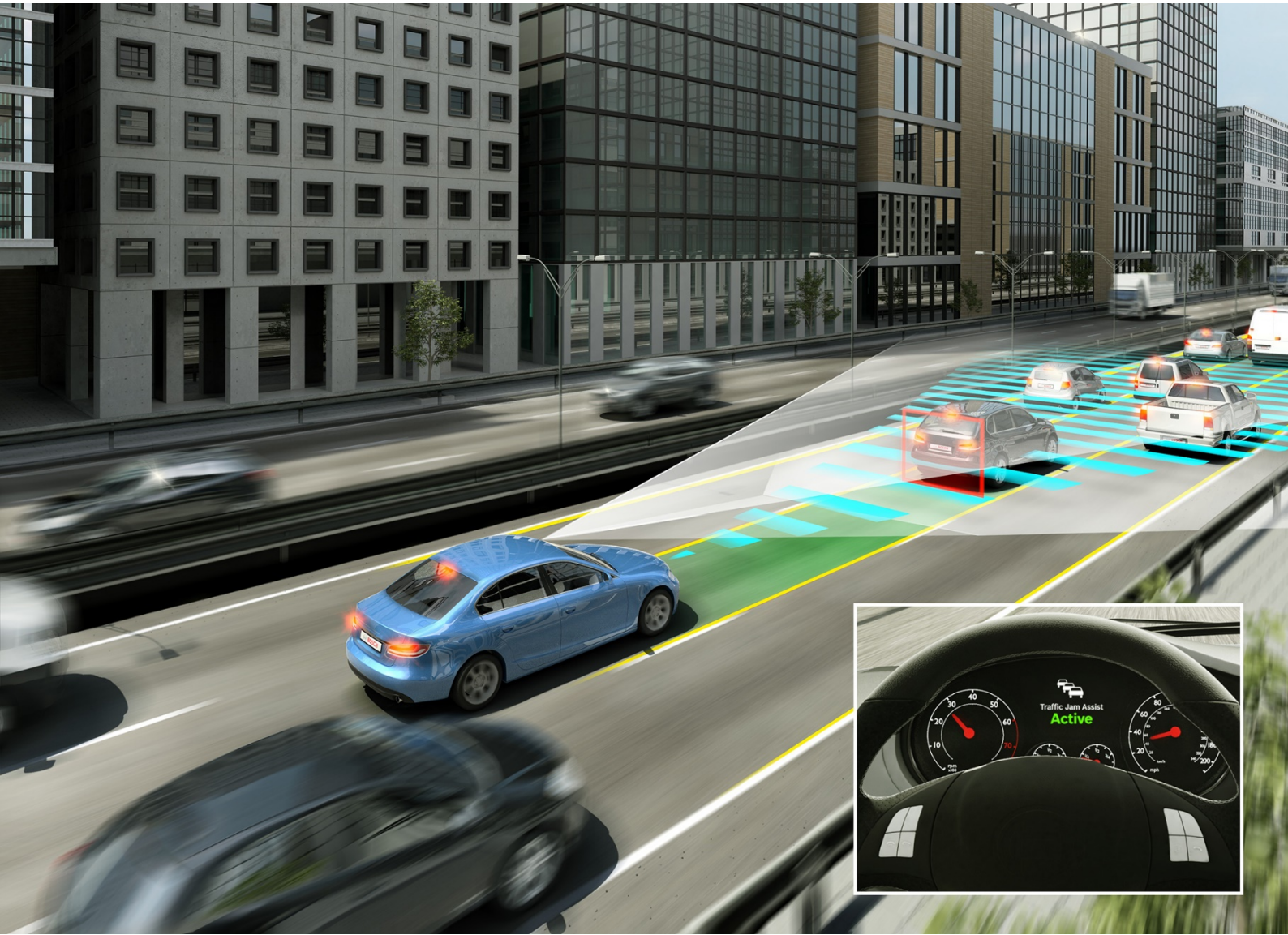
ULPEC Project

FACTSHEET

Event-based vision for automated driving – A promising technology for the future

Key results and findings from the ULPEC Horizon 2020 research and innovation project (www.ulpecproject.eu)



What is event-based vision?

Event cameras are bio-inspired sensors that differ from conventional frame cameras: Instead of capturing images at a fixed rate, they asynchronously measure per-pixel brightness changes, and output a stream of events that encode the time, location and sign of the brightness changes. Event cameras offer attractive properties compared to traditional cameras: high temporal resolution (in the order of µs), very high dynamic range (140 dB vs. 60 dB), low power consumption, and high pixel bandwidth (on the order of kHz) resulting in reduced motion blur. Hence, event cameras have a large potential for robotics and computer vision in challenging scenarios for traditional cameras, such as low-latency, high speed, and high dynamic range.

Vision systems for autonomous driving – A challenging field

Autonomous driving is a particularly challenging field for vision systems. It has strong requirements on the reliability, safety, robustness, and accuracy of perception systems, which must operate under drastically changing light, weather, and traffic conditions. Decisions such as the activation of an emergency brake assist are taken in fractions of seconds with the computational resources available on board of the vehicle since cloud-based solutions have too high latency.

An additional, social challenge that autonomous driving faces is that of low user acceptance. ***Automotive World*** recently stated that 'human-like vision' was pivotal to unlocking autonomous driving[1]: *"The average consumer doesn't trust self-driving vehicles. And in the development of any kind of technology, it is pivotal to keep the end-user in mind. What will ensure that their car is driving safely? What will ensure they feel safe in their vehicle? Vehicles that see the way they do, in a way they can understand. The human body is built with two eyes that report to one neural network. With this 'system' they navigate traffic, slow down to a stop, and park their car. So what's stopping autonomous vehicles from driving the same way?"*

The importance of event-based vision systems for autonomous driving is highlighted by Tesla's recent move towards 'Tesla Vision'[2], their camera-based Autopilot system. Beginning in May 2021, Tesla's Model 3 and Model Y vehicles built for the North American market will no longer be equipped with radar. Instead, these will be the first Tesla vehicles to rely on camera vision and neural net processing to deliver Autopilot, Full-Self Driving and certain active safety features.

Advantages of event-based vision systems

Event-based vision sensors respond to the multitude of challenges and the end-user need for human-like vision. They are modelled after biological retinas, which respond mostly to relative changes in light intensity in the field of view of individual cells[3]. Compared to conventional vision sensors, which record frames that read out the intensity at all pixels at the same sampling time, this creates a much sparser response, and therefore reduces the amount of information that needs to be transferred and processed later. This results in a much lower energy demand compared to existing computer vision systems, which makes the technology a strong candidate for AI applications targeted at contributing to the EU

[1] https://www.automotiveworld.com/articles/human-like-vision-pivotal-to-unlocking-autonomous-driving/
[2] https://www.tesla.com/support/transitioning-tesla-vision
[3] Posch et al. 2014, Lichtsteiner et al. 2008

Green Deal goals. Possible applications besides the automotive sector include smart farming and robotics and drone applications that involve object detection.

Further technology advantages lie in the fact that pixels in event-based vision sensors operate asynchronously and independently, which allows them to generate output with extremely high temporal resolution, indicating changes precisely when they happen in the scene, instead of waiting until the next frame is recorded at an artificially introduced time step. By detecting relative rather than absolute intensity changes event-based vision sensors can operate under a much greater variety of lighting conditions than conventional cameras. In combination with the pixel-independent results this even produces useful input in the challenging case where the visual field contains both very bright and dark areas. This is for example the case in the presence of shadows and bright sunlight.

Costs of event-based vision sensors have gone down rapidly, in particular due to reducing pixel costs with new 3D stacking technology and are now competitive with standard frame-based cameras. It is even expected that an event-based system will reduce system costs due to savings in memory, compute, transmission, resources and overall power consumption.

ULPEC breakthroughs on the way to event-based vision systems for the automotive sector

- ULPEC developed a high speed, ultra-low power microsystem – as 'System-on-a-Chip' – for visual data processing that is natively brain inspired and that will pave the way to a new generation of miniaturised smart systems with significant improvements in power consumption and latency.

- ULPEC designed a neural network to support the implementation of a recognition algorithm for object detection and tracking in the automotive domain.

- ULPEC co-developed the design, technology and algorithm as an industrial roadmap that can provide an alternative to traditional solutions.

- ULPEC created the first publicly available event-based automotive databases for training neural network architectures and developing suitable algorithms for object detection.

  ULPEC partner Prophesee has made the two datasets openly available at

  https://www.prophesee.ai/dataset-n-cars/

  and

  https://www.prophesee.ai/2020/01/24/prophesee-gen1-automotive-detection-dataset/

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