ULPEC Project

FACTSHEET

Event-based vision systems and their possible role in the EU Green Deal

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

What is event-based vision?

Event-based vision represents a relatively novel technology in the field of Artificial Intelligence (AI). Vision systems, also referred to as event-based 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 a wide range of AI applications, including robotics and computer vision in challenging scenarios for traditional cameras, as they can be found in autonomous vehicle and drone applications in the areas of transport, agriculture, monitoring, tracking and surveillance.

AI and the EU Green Deal

The European Green Deal defines a number of ambitious environmental and climate goals to be achieved by 2030. Reaching those goals will require a green transition of many sectors of the economy, including transport, agriculture, and the industry. In their report from May 2021[1] the *Policy Department for Economic, Scientific and Quality of Life Policies,* at the request of the *Special Committee on Artificial Intelligence in a Digital Age (AIDA)* released a report on the role of Artificial Intelligence in the European Green Deal.

The report illustrates the potential of AI to achieve a green transition in several fields of environmental policy. Specific areas that have been identified to have high potential that are also of main interest for event-based vision systems include applications (a) in agriculture that may allow for more efficient use of water, pesticides and fertilisers and thus could mitigate environmental impacts, and (b) in transport, for example as vision systems for automated vehicles, with automated driving being believed to improve driving efficiency by 10-20%[2].

However, the report raises concerns about adverse effects of current AI technologies in the light of the Green Deal goals.

One of the concerns refers to the additional energy demand of AI for autonomous vehicles as according to underlying studies the sensory technology entails an additional energy demand which may lead to a reduced range of electric vehicles of 10-15% for city driving[3]. The report further quotes a study, based on which each fully automated car will be generating around 4000 GB per day[4]. According to a study prepared for the European Commission, DG Environment, within the context of the "Service contract on future EU environment policy", 1.7 million autonomous cars (0.2% of global car fleet) would generate

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[1] http://www.europarl.europa.eu/supporting-analyses

[2] https://www.researchgate.net/publication/286202541_Help_or_hindrance_The_travel_energy_and_carbon_impact_of_highly_automated_vehicles.

[3] https://www.nature.com/articles/s41560-020-0644-3.

[4] https://datacenterfrontier.com/autonomous-cars-could-drive-a-deluge-of-data-center-demand/.

the same data volume as the present global internet traffic[5]. The network technology and the data processing infrastructure behind these data volumes would require large amounts of electricity and produce life-cycle emissions.

Limitations that have been identified for AI applications in the agricultural sector refer to the focus that is largely put on intensive and industrialised farming systems. This is partly to do with the currently high costs of AI applications and technologies in farming.

Low-power event-based vision – A solution for autonomous driving and smart agriculture

Autonomous Driving

Autonomous driving is a particularly challenging field for computer vision. 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.

Event-based vision sensors respond to the multitude of challenges and in contrast to traditional computer vision systems represent a low power solution that operates with sparse data. Sensors are modelled after biological retinas, which respond mostly to relative changes in light intensity in the field of view of individual cells[6]. 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.

Event-based cameras therefore are showing great advantages in power efficiency compared to other computer vision systems. Pixel activity is sparse, and almost no energy is needed for silent pixels. The resulting low data rates also lead to significant savings in the post-processing, making them highly attractive for embedded solutions. Power consumption for sensor systems is becoming increasingly important for autonomous vehicles, especially with the shift from combustion to electrical engines, which requires reduction of power consumption for all systems.

Key Finding #1: Low data rates of event-based vision results in low power consumption and significant energy savings in the data post-processing. This addresses the raised concerns of high energy demands of AI applications in autonomous vehicles. Novel event-based vision systems therefore directly contribute to European strategies and policies, such as the EU Green Deal[7] and the declaration on 'A Green and Digital Transformation of the EU'[8].

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[5] https://ec.europa.eu/environment/enveco/resource_efficiency/pdf/studies/issue_paper_digital_transformation_20191220_final.pdf
[6] Posch et al. 2014, Lichtsteiner et al. 2008
[7] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
[8] https://digital-strategy.ec.europa.eu/en/news/eu-countries-commit-leading-green-digital-transformation

Smart Agriculture

Besides autonomous driving, smart agriculture is becoming an increasingly important topic application field of AI. Artificial vision is becoming an essential in digital farming, for IoT connected sensors and for sensors embedded on tractors or robots that are used for monitoring plants and soil, detecting bugs and diseases, but also for precision farming, where machines and drones are using their sensors for accurately targeting specific plants (e.g. for spraying or weeding). For applications in farming machines and drones, the high speed of the sensor and high dynamic range play a big role to control precision operations while the machine is moving across the field.

Accenture[9] in an analysis of neuromorphic technology also identified precision farming as an attractive use case for neuromorphic computing and event-based vision. The EU-funded ANDANTE project[10] (ECSEL JU) targets smart farming as one of their application cases for artificial vision systems.

For monitoring tasks, the sparse output and energy efficiency of both sensors and computing elements are important, because they are continuously monitoring. Furthermore, it is expected that the event-based approach will reduce the system costs compared to traditional computer vision due to possible savings in memory, computing, transmission, resources and the overall power consumption.

Key finding #2: The provision of low power vision systems at low costs has the potential to enforce innovation in smart agriculture, to reduce the costs of AI applications and support their uptake also in smaller farms. AI technologies can that way help to address agricultural challenges at different farming scales, including the reduction of pesticides, automated weeding and harvesting and other applications that depend on object detection or increasing the quality and the profitability of agricultural production.

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9 https://www.accenture.com/_acnmedia/PDF-145/Accenture-Neuromorphic-Computing-POV.pdf

10 https://www.andante-ai.eu/digital-farming/

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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