Autonomous Driving just became safer

Research creates reliable computing node that will become a Cognitive Edge under automotive industry standards. In autonomous driving the node will be used for collision avoidance and AI-based dynamic path tracking.

The definition of a FRACTAL node is a flexible edge node whose architecture must support the characteristics for adaptability, context-awareness, openness, safety, security, reliability, low power, and fractality. The research project FRACTAL was structured to work packages for specification of the FRACTAL system, development of hardware, software, safety, and security components, as well as verification and validation of the achievements. The main contribution of Virtual Vehicle Research GmbH was the lead in the validation use-case "Autonomous SPIDER Robot for implementing safe movements".

Objective of FRACTAL was to create a reliable computing node that will create a Cognitive Edge under industry standards. The computing node will be the building block of scalable Internet of Things. Main achievement of the project is the FRACTAL system, it can be seen as a three-layer architecture: The node layer refers to infrastructure, such as AI accelerator or computing power; the service orchestration layer enables to manage the services that run over the node. The application layer contains the specific functionalities, deployed over nodes. It describes the business logic for the different applications or use-cases.

The SPIDER use-case had two objectives: Co-execution of safety-relevant, security-relevant as well as AI based tasks; and fail-operational capabilities with a single computing device even in the presence of common-cause faults. Within the use-case two robot functions were implemented as FRACTAL nodes to verify the use-case goals and validate the implemented FRACTAL components. A collision avoidance function was implemented to demonstrate the execution of a safety-relevant task on a multi-core computing platform. A dynamic path tracking controller was implemented to demonstrate the execution of an AI-based task using hardware acceleration.

The nodes were deployed on a stack completely relying on open source for both, software, and hardware. Using a FPGA board, a NOEL-V based hardware architecture was synthesized, running the open-source robotics framework ROS2 on a Debian based Linux operating system.

The collision avoidance function is to avoid damage and human harm by preventing collisions or reducing the impact speed in the event of an unavoidable crash. Environmental sensors are utilized to measure the distance to surrounding objects, and initiating speed limits or emergency stops. To operate on a multi-core platform, while avoiding inference from other tasks or processes, two FRACTAL components were applied. The Safe Software Diverse Redundancy Library (SafeSoftDR) detects common cause failures by diverse (time-staggered) redundant execution of critical tasks. The Safe Statistics Unit (EdgeSU) monitors multicore interference and signals interrupts.

The dynamic path tracking controller is based on an artificial neural network trained to steer the SPIDER towards a predefined path, while avoiding collisions. The training is conducted by means of proximal policy optimization, an algorithm from the field of reinforcement learning. The model was deployed in the open neural network exchange format (ONNX), and the open-source FRACTAL component LEDEL was used for inference at the edge, enabled by another FRACTAL component, a redundant acceleration scheme using RISC-V cores.