EXPERT KNOWLEDGE

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Connecting Embedded Intelligence
How Devices are Becoming Increasingly Intelligent

Artificial intelligence will be one of the hot topics at embedded world 2020, both on exhibition stands and at the embedded world Conference. But what does "AI" mean in context with "embedded"? What distinguishes embedded technology from the AI offerings of the cloud and internet giants? What does AI do and how is the technology integrated into devices for industrial applications and consumers? - This will be discussed at the embedded world Conference and demonstrated in the exhibition halls.

Artificial Intelligence (AI) deals with the automation of intelligent behavior and machine learning (ML). Artificial Intelligence is one of the pioneering driving forces of the digital revolution for existing and future applications.

Nowadays, this is more and more true for "large" "big data" oriented applications, in which attempts are made, e.g. to recognize and predict patterns from immensely large amounts of data in social networks to classify or anticipate customer behavior. However, this applies increasingly also to industrial applications. Particularly relevant are all applications in which behavior, properties, states, maintenance intervals or remaining terms must also be analyzed or predicted.

Intelligence moves from cloud to devices

Such edge applications are often based on embedded systems that have much less processing power than the traditional cloud servers, on which the AI and ML problems are normally computed. Despite the limited memory and computing resources of embedded microcontrollers, this area is booming massively. The major reason is the fascinating ability to build small, cost-effective, autonomous and adaptive systems. This goes well beyond the functionality of traditional static model-based control algorithms. Autonomous vehicles, autonomous robots or interactive assistants are just

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a few examples. Embedded systems do not usually stand alone in the sense of edge computing, but often interact with other resources in the cloud (cloud computing) or on intermediate systems and gateways, Therefore, so-called fog computing is becoming increasingly important in this context.

In classic embedded AI systems, learning takes place in the cloud and decisions are made in the edge. More and more, however, also architectures are designed in which solutions for problems of limited complexity are learned on the embedded end node (edge system). In addition, more and more applications can be observed in which multi-level learning takes place. This promises advantages not only in terms of load balancing, but also for the confidentiality of information, since only prelearned, i.e. abstracted models are passed on to the next level.

Intelligent and autonomous systems at embedded world

In the course of these multilevel and coupled solutions, load balancing and information exchange between the involved Fog-Computing nodes gain a significantly growing importance. For this reason, in its 18th year the world's largest embedded systems conference, the embedded world Conference (ewC), has chosen the motto "Connecting Embedded Intelligence". The ewC thus takes up again the title of one of its predecessor events from the 90s. At that time, "Embedded Intelligence" was more or less a vision of the future. Today, in an age of ever cheaper computing and communication performance, new architectures between edge, cloud and fog computing and further developed algorithms, real products and solutions with immense possibilities and connectivity solutions are already available, are being launched on the market or are being further developed in the R&D units for new applications.

The following applications are currently in the limelight

- Automated **pattern recognition in images** lends even more dynamism to the already booming application area of "Embedded Vision" (to which the ewC also dedicates an entire track). Not only are camera systems becoming cheaper, more energy-efficient and smaller. Applications such as pedestrian recognition in autonomous

vehicles, identification of people by facial recognition with the - sometimes questionable - possibility of monitoring people and tracing their movement patterns and actions), fingerprint matching or industrial optical quality control (Automated Optical Inspection, AOI) are now also supported by such systems.

- **Condition monitoring** and the predictive maintenance of machines, plants or plant components is a core area of the fourth industrial revolution (Industry 4.0, I 4.0).
- And finally, autonomous systems in general benefit considerably from developments in order to further optimize complex decisions with "additional experience". This includes all future-oriented areas of **autonomous driving**, autonomous **robotics**, possibly also collaborative robotics or **intelligent assistance systems**.

In addition, there are numerous other applications that can benefit from the use of AI and ML. In general, AI-based systems can always be used advantageously where problems become so complex or so unstructured that the methods of classical modelling would be too time-consuming to develop, too expensive or too inflexible.

Challenges for software developers

This approach turns the classic software development model upside down. The model of reality is no longer created manually, but is often first analyzed and then synthesized. Following the traditional way, the complex problem is broken down into smaller subproblems, which are then solved and validated in their parts. Instead, the models are generated automatically in their entirety. However, this also means that a quasi "unknown" and often very complex model is available and must now be validated. Questions of complexity management, system stability, testing and test coverage must be tackled in a completely new way, especially when these algorithms implement safety-critical functions.

embedded world Conference

These topics relating to "Intelligent and Autonomous Systems" will also be in the limelight at the world's largest leading trade fair and the embedded world Conference taking place in Nuremberg from 25 to 27 February 2020.

In a total of 26 lectures in four specialized sessions, experts will provide answers to the above questions over two whole days.

The program of the embedded world Conference is available at www.embedded–world.eu.

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