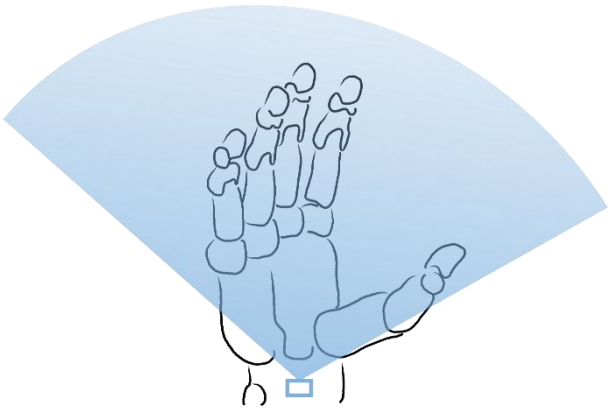

Deep Learning with Time-of-Flight Sensors

Deep Learning is becoming increasingly prevalent in image processing. In conjunction with Time-of-Flight (ToF) 3D sensor technology, higher recognition performance can be achieved compared to pure RGB images.

The multi-ToF platform, which connects various sensors to a powerful hub, is the foundation for future AI camera solutions.

AI principles

In industrial applications today we use solely “weak artificial intelligence”. Weak artificial intelligence systems are limited to solving specific problems. Weak AI obtains all the knowledge from the training data. There are 2 phases in its lifecycle: the training phase and the application phase. Since both phases are separate, a weak AI does not learn during the application phase. As a result, on the one hand, systems with guaranteed quality can be operated securely, but they have to be re-trained if new objects are added or if they change significantly over time.

In contrast to the classic methods of image processing, Deep Learning is very reliable regarding variations. Even with a large number of different classes, a well-trained system recognises objects with low contrast, strong brightness fluctuations, obfuscation of up to 60-70%, or sometimes extreme deformations. Deep Learning is therefore suitable even in applications where there is neither a controlled environment nor standardised objects.

Status of Deep Learning technology

Currently there is a wide range of Deep Learning frameworks that can be used to train different neural networks for a variety of applications. In terms of quality, there are no big differences among them. These frameworks come from research and require extensive basic knowledge in their handling. After completion of the initial data analysis, Deep Learning solutions can be reliably trained and used with the desired performance even on low-cost embedded systems. Further technical development will continue to reduce hardware costs in the coming years. Today, there are already attractively priced solutions in the field of hardware for almost every application. It can therefore be said that Deep Learning is no longer a technical problem today.

However, even with artificial intelligence there is no easy solution to complex problems. There is always a strong dependence on the respective data. The image properties, object shape and size, the type and complexity of the respective neural network play just as much a role as the quantity and distribution of the data. At this point, our customers benefit particularly from our many years of experience.

The Deep Learning effect

If there are very few data available, Deep Learning usually yields worse results than classic systems. However, Deep Learning solutions scale up almost unlimitedly with the data available.
And although the systems of classic object recognition have often benefitted from years or decades of development effort, with the right know-how you can often achieve quality comparable to the existing system at the beginning of a deep learning project.

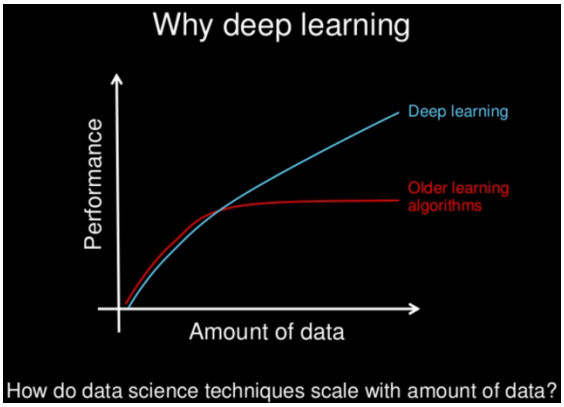

Figure 1: Why Deep Learning?

Feasibility with Deep Learning

We recommend the following rule of thumb for the self-assessment of the feasibility of a potential application: If the desired object or property in the respective image is recognisable to the human eye in less than a second, then usually it can be implemented well with the help of Deep Learning.

In industrial applications environments that are relatively controlled are available often. A variety of applications can be solved inexpensively through Deep Learning.

As a solution provider of customer-specific image processing solutions, Evotegra GmbH accompanies Deep Learning projects from the definition of the data strategy to the deep system integration on the respective target hardware.

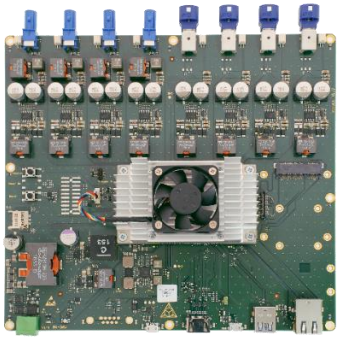

Figure 2:multi-ToF computing unit

Multi-ToF platform

An excellent example of this is BECOM's multi-ToF platform. This is an ecosystem where different sensor front-ends can be connected to an Nvidia CPU+GPU based hub. In addition to Time-of-Flight (ToF) data, you can also connect colour sensors or other wavelength sensors (IR, Hyperspectral Imaging) and provide additional channels for extended applications or to improved quality.

The first ToF sensor front-end is a close range capture module with a 110 degree wide-angle lens and a Melexis ToF sensor with QVGA resolution and up to 40 images/second. The central processing unit is based on the Deep Learning enabled Nvidia Jetson TX2 module.

Application in the beverage industry

One application is the full crate inspection in the beverage industry. Although a relatively controlled environment at first glance, a variety of colours, shapes, materials, caps or foreign objects create a wide variety of scenarios in the field. The ToF sensors provide not only the depth data but also an IR grayscale image.

This is useful for training the network and delivering more reliable results in difficult situations such as glass or highly reflective closures. Due to the active lighting, the data is also largely independent of ambient conditions.

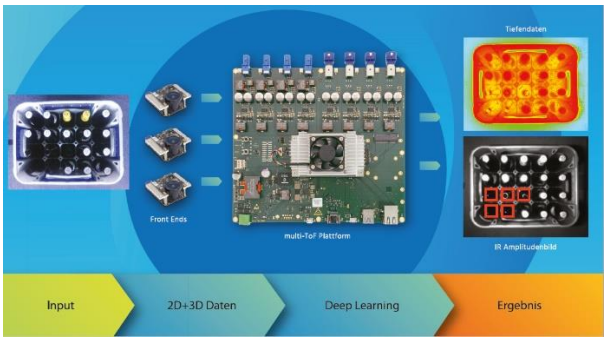

Figure 3: multi-ToF platform in the full crate inspection

The project process

A project starts with the definition of the initial classes and an initial data analysis. Then you define the data collection strategy. The GIGO principle (garbage in, garbage out) also applies to artificial intelligence (AI). The duration and cost of a project are largely determined by the time it takes to obtain the data in the required quality and quantity.

A large amount of bad data causes just as many problems as too few data. A neural network training record typically includes one to four million data points. As at the beginning of a project only a few data are available, the data is augmented, i.e. artificial variations are generated based on the data available.

The goal in the course of a project, however, is to replace the artificial data with real data. The use of assistants or special service providers for data collection requires either a great deal of post-processing work or is complicated and expensive. Instead, neural networks can support data aggregation early. At cyclic intervals, improved networks are trained with the help of the newly gained data. The effort for the extraction of the data decreases steadily in the course of a project. Meanwhile, the process integration can already take place.

Better results than with RGB

As colour is always dependant on lighting, RGB data often has only few advantages over grayscale images, especially in uncontrolled environments.
Here, an advantage of ToF comes to bear: the sensor provides a grayscale image that is synchronous with the three spatial channels X,Y,Z. Due to the spatial separation, the four ToF channels are significantly richer in information than with an RGB camera. Labels can also be transferred from one channel to the other channels with pixel precision. Compared to RGB cameras, this means that no extra effort is required to label the data. At the same time, Deep Learning algorithms with higher information content can always achieve higher recognition performance.

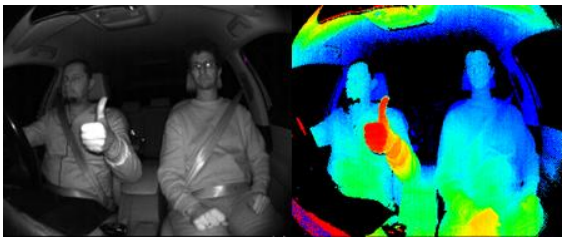

Figure 4: Grayscale and depth image of a ToF sensor

Deep Learning Ready

As part of the implementation of customer-specific solutions, the Evotegra basic software can generally be used free of charge. At the same time, the BECOM multi-ToF platform based on the Nvidia Jetson standard offers broad support for Deep Learning algorithms. Additional hardware is not required.

Conclusion

Sensor systems with a combination of images and spatial data, together with Deep Learning, achieve higher recognition performance and therefore cost advantages, without generating higher expense in the training phase.

The solutions can achieve a quality level that is comparable to the visual perception of humans in terms of quality. Quantitatively, however, these solutions are clearly superior to humans.

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EVOTEGRA
CONCEPTS & INTEGRATION

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Evotegra GmbH was founded in 2001 with a focus on system integration and since 2013 has positioned itself as a solution provider in the field of customer-specific image processing solutions with Deep Learning and artificial intelligence as well as 3D reconstruction with stereo camera systems.

Evotegra GmbH provides support for projects from the definition of the data strategy to the deep system integration into the respective processes. As a member of the Bundesverband-KI e.V. (German Federal Association of AI), we are committed to establishing Germany as an attractive business location for the AI ecosystem.

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Since 1984 BECOM has been the reliable electronic engineering, manufacturing and service partner for industrial customers. From the very first concept idea, to development and validation, right up to series production, our customers obtain everything from a single source.

Thanks to international locations and partners, customers around the globe today benefit from high quality solutions, services and know-how from our experts.

Since 2016, the Time-of-Flight specialist Bluetechnix has been part of the BECOM Group. BECOM has therefore expanded the business area with innovative sensor solutions and offers customers their decades of experience as the national Time-of-Flight pioneer. The range of services and stability of BECOM complement the innovative power of BECOM Systems and guarantee customers long-term availability and highly efficient production processes.

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