AI-based object classification

Smartmicro, based in Germany, has been designing, developing and manufacturing high-performance radar sensors for the traffic and automotive industries for more than 20 years. Key motivations for the company's technology developments are safer roads, optimized traffic flow, autonomous driving and transforming urban areas into smart cities.

Forward-firing, multilane, multi-object traffic radar sensors are used for a variety of applications. Since 2009, when the first traffic sensors were manufactured by smartmicro, more than 50,000 have been installed worldwide. Key application uses for the sensors are intersections (multilane stop bar and advance detection, and queue length measurement); arterials (counting, classification and statistics); and enforcement (speed and red light).

Radar traffic sensors

The sensors can detect vehicles in up to eight lanes, as well as objects that have stopped. They can also track up to 256 objects simultaneously at a range of up to 450m (1,476 ft). Other key features are 4D measurement (range, speed, horizontal angle and elevation angle), and ultra-high-definition object separation for objects' ranges, speeds and angles.

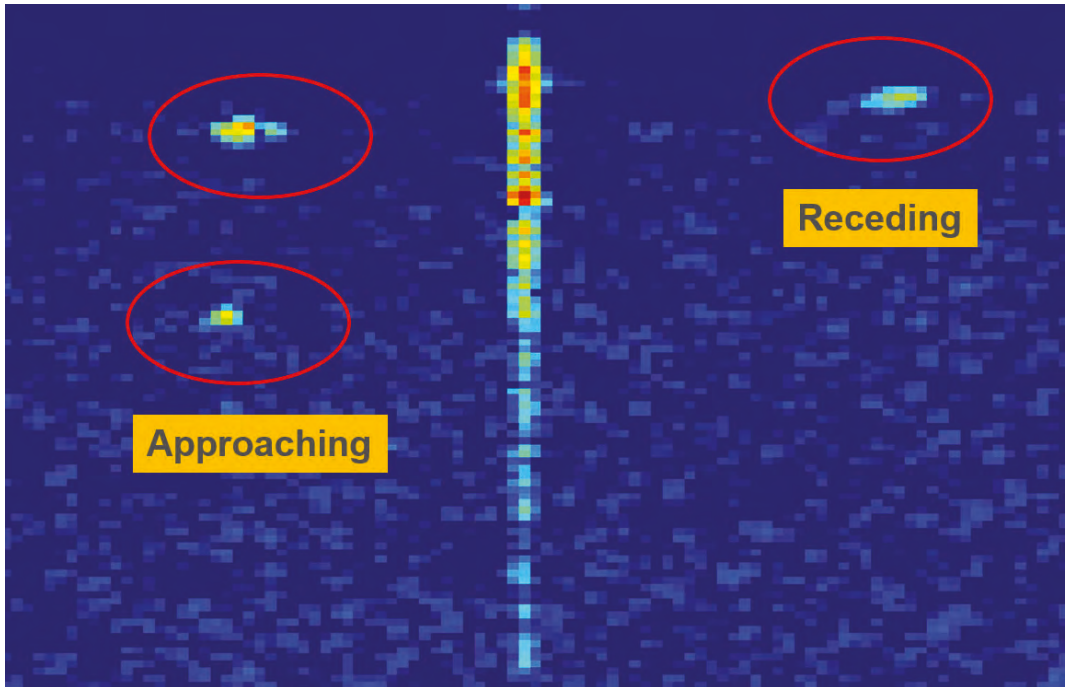
smartmicro's high-performance traffic detector is robust and reliable. With an operating temperature range of -40°C to 85°C (-40°F to 185°F), the company's sensors also set the benchmark.

Quality object classification

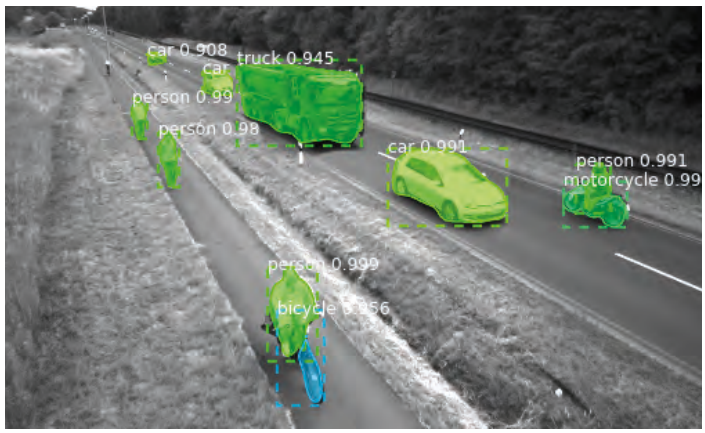
Currently the classification of objects, along with sensor fusion, are hot topics for most automotive sensor suppliers, whose goal is to make fully automated driving a reality. Performance levels of object classification can be achieved with the help of artificial intelligence (AI) implemented in deep neural networks (DNN). smartmicro stands in the front line of such classification algorithm developments and has now added this technology to its line of traffic sensors.

Together with customers, an approach was specified to identify seven classes of objects: pedestrians, bicycles, motorcycles, passenger cars, vans, trucks and large trucks.

Radar modules feature state-of-the-art antenna technology based on the multiple input,



Above: **Radar tracks approaching and receding traffic in a range-Doppler matrix**



Above: **smartmicro combines radar and video data to train its AI-based classification**

multiple output (MIMO) principle. Using principles including (transmit) beam shaping, digital beam forming on receive and 2D fast Fourier transform (FFT), a multitude of so-called range-Doppler matrices are calculated from the radar signal. Within each of these matrices, peaks and adjacent zones of energy that contain reflected energy are detected. Using image-processing-like technology, the distribution of the energy in these zones in range or Doppler dimension is algorithmically evaluated and delivers classification feature information. In addition range, speed, angular information and amplitude values are measured. At a data rate of approximately 25Hz, all the data is used as input data for classification algorithms for the seven object classes.

When classifying vehicles, forward-firing radar sensors have the advantage of being able to observe objects over a longer time – usually multiple seconds. The closer the vehicle is to the radar, the more reflection property details can be seen in the range-Doppler matrix.

"The high level of detail of our radar enables us to determine the reflection characteristics of the different vehicle classes over the tracking range," says Dr Ralph Mende, CEO of smartmicro. "These properties and their change over time are used to extract features that can be used to separate vehicle classes with in different installation situations at high reliability."

Classification training

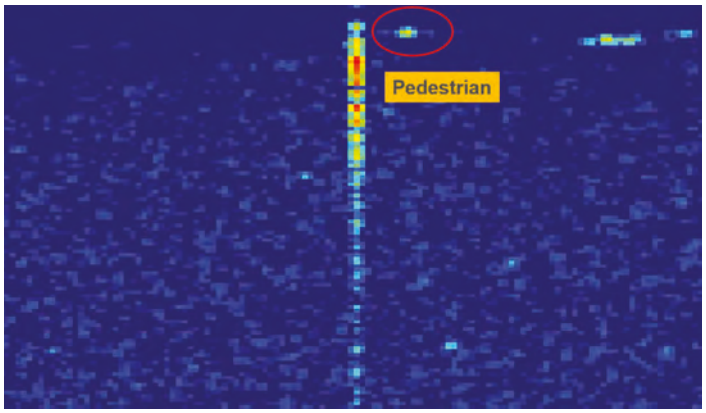
A large number of objects are used for the learning process of the classification algorithms. smartmicro uses a deep learning neural network (DNN) where, with the help of a reference system, automated learning is possible. Thousands of objects physically pass a reference sensor system. The reference data and the radar data are then used to train the classifier. Automated training is very beneficial if, for example, country-specific classifying is required.

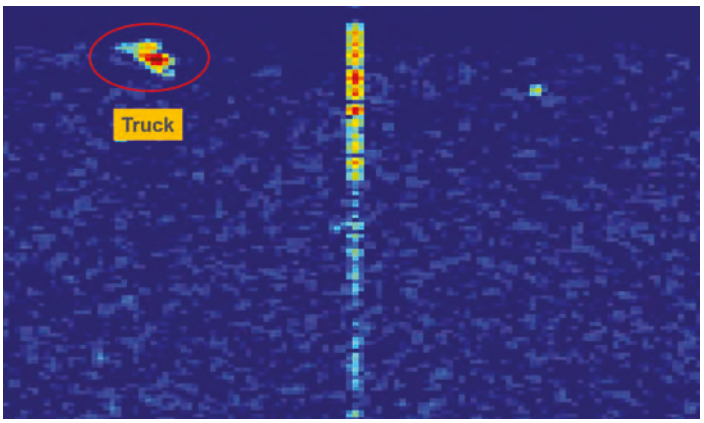
"We're now in a position where we can train our classification with country-specific data of vehicle distributions," says Mende.

In the future, smartmicro is aiming to equip more of its products with artificial intelligence. With the current AI solution, the developer has to determine and decipher samples fed into the decision trees, as well as the corresponding decision. As a result, the classification algorithm is perfectly adapted.

smartmicro's traffic radar technology is an enabler for smart cities, providing precise real-time data for traffic flow on arterials. The traffic data is transmitted to a traffic operation center (TOC) and allows an optimum traffic flow in a certain region or on a longer arterial, where the traffic flow is remotely but automatically controlled from that TOC.

Real-time object data can also be wirelessly transmitted over a vehicle-to-everything (V2X) network to connected vehicles. This can help to prevent accidents and protect vulnerable road users (VRUs) such as pedestrians and cyclists. As V2X communication is rated as one of the key drivers for connected and autonomous vehicles, this system supports all V2X equipped vehicles where even vehicles with non-connective capabilities are covered. The key for the protection of VRUs is classifying them correctly.





Left and below left: **Shapes of a pedestrian and a truck shown on smartmicro's range-Doppler matrix**

Need to know

smartmicro develops and manufactures traffic management radar sensors:

- With AI-based classification
- For the improved safety of vulnerable road users (VRUs)
- For enhancing smart cities