AI and Machine Learning in the Real World

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Introduction

Machine Learning is at the core of Artificial Intelligence (AI). It is the ability of a machine to learn from data: a computer program is said to learn from experience when performing a given task if its performance on the task improves with experience.

Machine learning techniques allow us to devise state-of-the-art smart products that use computation to improve their performance and utility over time rather than being fixed at the time of manufacture.

There are various methods for implementing machine learning algorithms, but a common approach is to copy how human brains work with an artificial neural network. This simulates a network of neurons in software that can process a set of diverse inputs and produce appropriate outputs. These algorithms usually require large sets of example data to 'train' their neural network to achieve high levels of accuracy.

This brochure aims to illustrate how Plextek's skills in AI and machine learning technology could benefit your next project

About Plextek

We have a 30 year history of providing technology solutions to a variety of organisations. Plextek understands today's key challenges for smarter technology development and can generate both the ideas and deliverable solutions to the assured level of security, performance, resilience and ergonomics that you need. We are a product development company that works with clients to achieve results based on their specific requirements.

Our engineering experience, supported by our library of IP for key technology elements, aids accelerated time to market and greater cost effectiveness.

Contents

Technology

AI on the Edge

Modern complex infrastructure is typically laden with a variety of sensors for monitoring safety, security and equipment status. These sensors typically communicate with a central server, sending sensor data and receiving instructions or commands in return. When this type of system scales in size it can create challenging communication problems due to the number of nodes involved and frequency of data transactions.

Underground utilities surveillance

Monitoring the health status of underground ducts for the emergence of faults

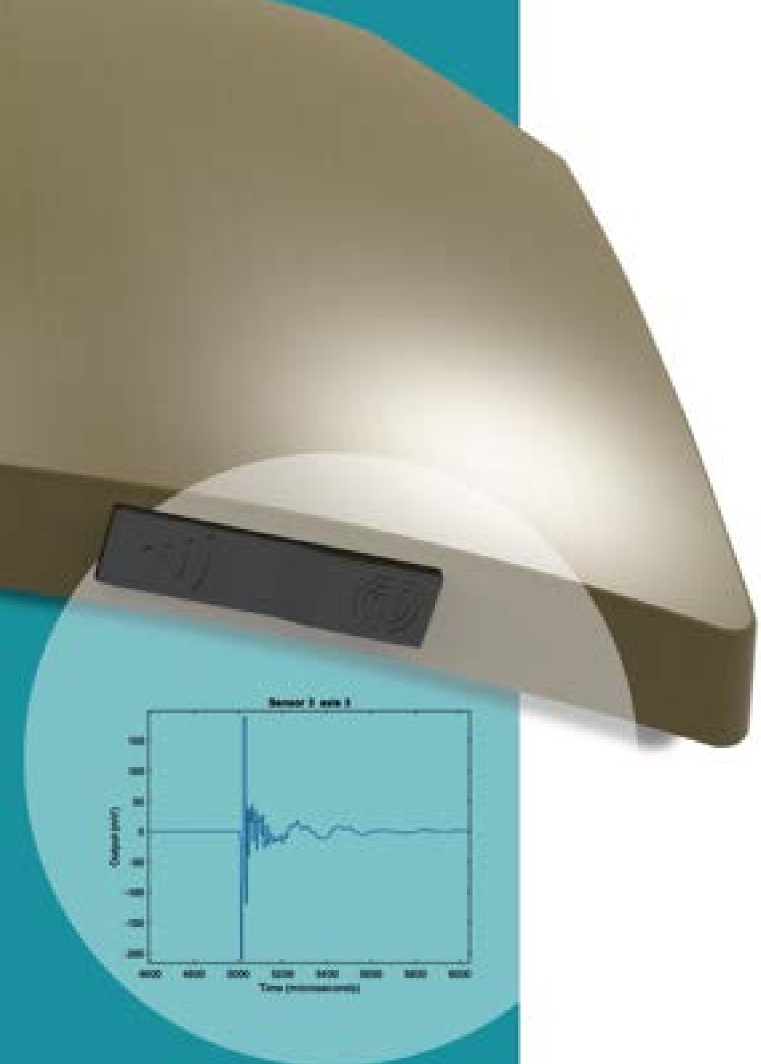
The challenge of embedding machine intelligence at a sensor on the 'edge' of a network is how to do so without dramatically increasing the size, power consumption and cost of the device.

An alternative approach is to embed intelligence within the sensors themselves. Sensors can make decisions faster locally and thus limit communication with a central server to only the important and actionable information.

The challenge of embedding machine intelligence at a sensor on the 'edge' of a network is how to do so without dramatically increasing the size, power consumption and cost of the device. Plextek achieves this through building on our world-leading expertise in low power electronics and IoT systems. We develop and integrate advanced algorithms onto small footprint devices that locally process and analyse complex sensor data. The result is small and cost-effective devices containing high levels of intelligence that support both small and large scale deployments of remote and autonomous systems.

Smart parking bay occupancy sensors

Miniature devices employ AI algorithms to assess internal sensor data and detect changes in the occupancy status of parking bays.



Example signature measured by a ceramic armour monitoring device that can identify the signal characteristics associated with crack formation following an impact event.

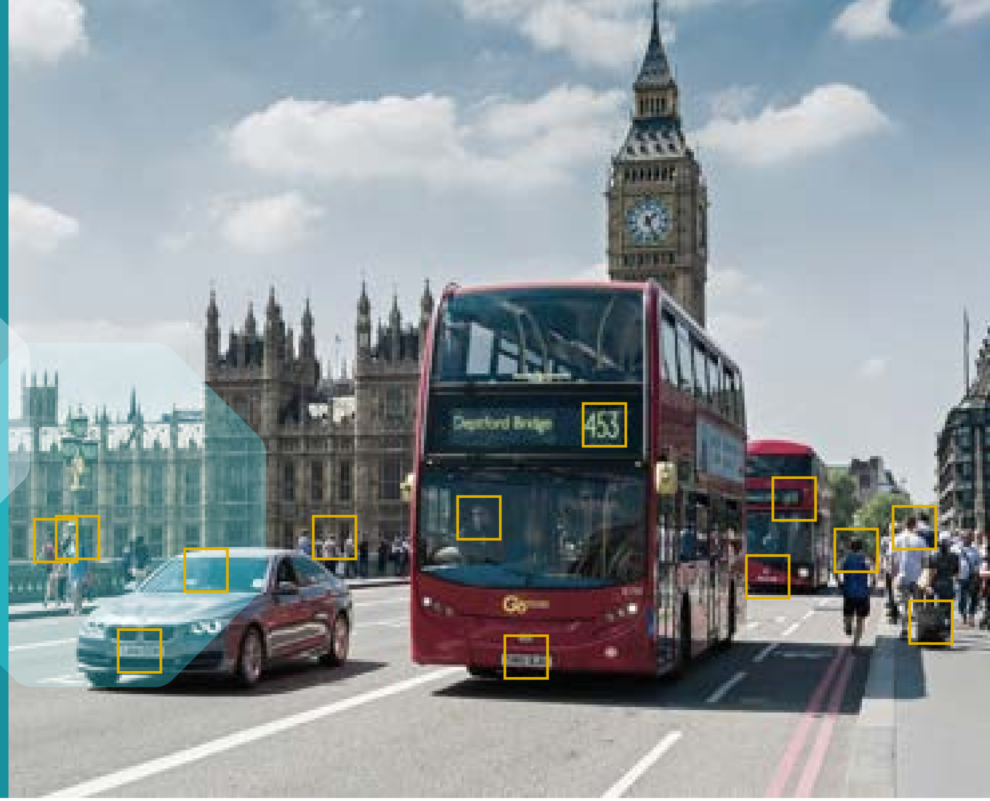
Signal Analysis

Most real-world sensors produce an output signal that varies with time. Simple examples include accelerometers, power meters and gas sensors. A more complex example is a receiver used to monitor specific activity in the radio frequency spectrum.

Features of interest within such signals are often buried within noise or obscured by less important features, so can be difficult to extract with traditional, hard-coded algorithms. This can result in sensors with high false alarm rates or poor detection performance.

Using advanced machine learning algorithms, sensors can learn to characterise both background noise and features of interest, improving discrimination and performance. In addition to improving basic sensor performance, embedded AI can increase the potential scope of a sensor’s utility, for example, by reacting to trends in sensor data that might indicate the impending failure of the equipment being monitored.

Transfer Learning



A significant area of AI research has been to develop the ability of neural networks to recognise specific objects in images and video. In recent years, a particular type of neural network called a convolutional neural network has approached and perhaps exceeded human-level performance in these tasks. This development was enabled by the availability of millions of labelled images containing a range of common objects such as chairs, televisions, bikes, cars, planes, birds, cows, dogs or people, which are needed to train the networks.

But what if you need to train a neural network for a class of objects for which no large, labelled dataset exists? This is where transfer learning can help. If you take a neural network that has been pre-trained on a large open source image database, you can re-train that network to classify a new object, using relatively few training examples. This process of taking a neural network, pre-trained to solve one problem and modifying it to solve another, is known as transfer learning. The advantage of this approach is that you need fewer training examples to yield a particular performance in comparison to using a blank neural network.

Humans do this instinctively, which is why we only need to see one image of a zebra to be very good at distinguishing between a zebra and a horse, whereas a typical neural network would need thousands of example images.

Explainable AI

Artificial Intelligence techniques such as deep learning can be used with large quantities of training data to produce black box models with good performance. A feature of such methods is that the internal workings of these models cannot be understood by humans, which means that it is not possible to determine why a specific outcome was produced. Thankfully, in many applications, it is not necessary to know how an AI system works, only to verify that it does.

However, for some use cases, explaining what led an AI system to generate a specific output is of considerable importance. One area where this is vital is in human-machine interaction. For humans to work well with a machine it is necessary for humans to trust the output of its algorithms. While successful performance over time can build such trust, it would be better if the algorithm could explain why decisions have been made. This would help a human to trust the algorithm and, just as importantly, to know when not to trust the output. Indeed, for some safety-critical applications, explaining how and why a model behaves in any given circumstance might be an absolute requirement.

At Plextek, we are working with machine learning techniques that have an explainable model at their core. These approaches typically restrict the degree to which the model can adapt, sacrificing performance, but provide the ability to examine the model at any time and explain its behaviour. For embedded system design, these approaches can be a good compromise, delivering better performance than hard-coded designs, while avoiding the black box of typical AI techniques.

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Applications

Concealed Threat Detection

Reducing cargo screening times at airports while maintaining effectiveness is a difficult challenge.

Plextek has produced a small, hand-held 60GHz radar device that can be used to detect items concealed behind opaque barriers, or within other objects that would otherwise be invisible to the naked eye. Contraband that is hidden behind any non-metallic surface can then be visualised, alerting the security officer that unexpected items are present. Search times are reduced by avoiding unpacking or dismantling, except in those cases where the hand-held device indicates that this is required.

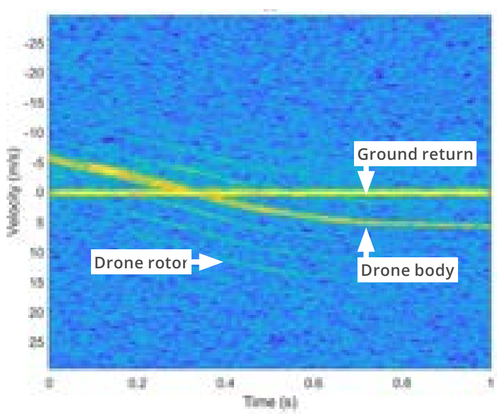
The application of embedded AI enhances both material discrimination and object identification.

Drone Detection

The threat to air traffic from drones, whether intentional or accidental, is well known. Radar is a key tool in the arsenal of methods that can be used to detect drones in critical areas such as airports, power stations and at public events. While a radar is the optimum sensor for automated drone detection, additional processing is needed to provide discrimination between, say, a small drone and a bird, or between two types of drone. AI techniques can assist in the automatic analysis of the target’s Doppler signature, which provides this discrimination.

Class: Drone – 99% probability

Sub-Class: Fixed Wing – 95% probability



Spectrogram of raw radar data showing return from the ground and from a drone, which approaches then receeds from the radar.

Aerial Surveillance

Detecting and tracking aircraft in the vicinity of wind farms is a long-standing problem for air surveillance radars. Wind turbines are massive structures that generate large radar returns from air traffic radars and these can mask the wanted returns from any aircraft flying over them. This problem is of increasing importance in the UK and elsewhere, as huge offshore wind farms are rolled out.

Plextek has combined its expertise in traditional radar signal processing with advanced AI-based methods to identify and remove wind farm noise. This enables us to mitigate the effect of wind turbines on the radar data, enabling the accurate detection and tracking of aircraft as they fly over wind farms.

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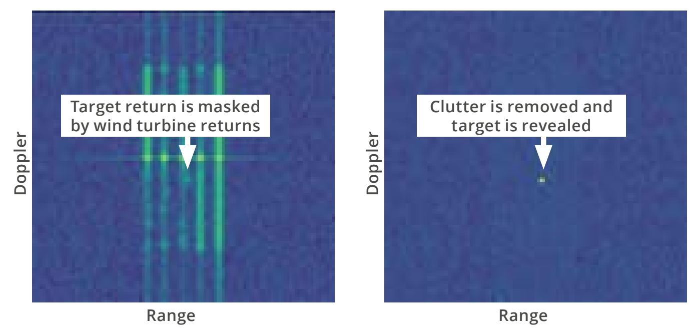
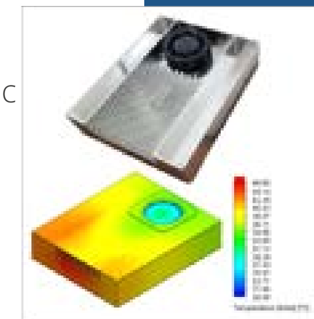
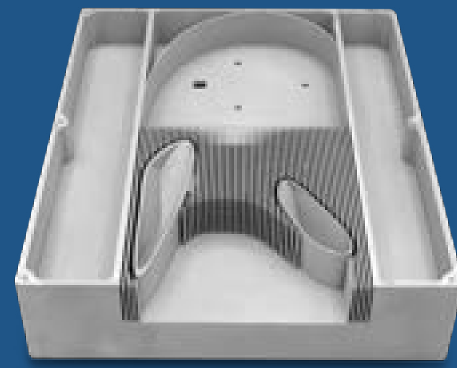


Heatsink Design

Thermal management considerations are a major factor in determining the size and weight of many types of portable electronic equipment, affecting a device's utility and its endurance. The heatsink is a critical component in thermal management, but traditional heatsink design provides very limited flexibility in shape and form factor. This is because it is based on profiles that are simple to extrude, cast or machine.





However, if we realise the resultant design through a 3D printing process, we can remove almost all constraints on physical form factor. Plextek exploits this using AI-driven, generative design combined with 3D printing. We use machine learning to explore a multitude of possible combinations for heatsink profile, based on constraints such as material type, size, weight, strength and cost, to realise a step change in heatsink weight and thermal efficiency.

The heatsinks produced using these methods are often quite organic in appearance and efficiency improvements of up to 40% can be achieved.

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Plextek

Exceptional technology
to positively impact the future

Get in touch to find out how Plextek can help you to deliver your next innovation in technology.

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