Artificial Neural Network Technology Improves Gas & Flame Detection in Hazardous Areas

Company Name: General Monitors • By Shankar B. Baliga Ph.D., Manager R&D
Address: 26776 Simpatica Circle, Lake Forest, CA 92630, United States
Email : info@generalmonitors.com • Web : www.generalmonitors.com • Tel : +1-949-581-4464

A failure to detect gas leaks and flames in petrochemical operations can be disastrous, but there is also a need to distinguish dangerous gas leaks or flames from annoying false alarms. Today, process engineers are utilising a variety of gas leak and flame sensing technologies to protect people, equipment, and facilities with high reliability while at the same time seeking ways to reduce false alarms.

Fig 1. Human Brain

Currently the major technologies utilised for gas leak and flame detection are: catalytic bead, point IR, open path IR and ultrasonic for gas detection, and UV/IR or multi-spectral IR for flame detection. All of them are well-known technologies with more than a decade of proven performance and with their own advantages depending on the application. All of them also can be susceptible to false alarms under certain conditions.

False alarms from gas and flame detectors have many causes within the production, refining, storage and distribution segments of the petrochemical industry. Reducing or eliminating these potential causes of false alarms is important because they result in unnecessary and expensive process or plant shutdowns, slowing production, and requiring time-consuming reviews, paperwork or reporting.

It is difficult to detect gas leaks and flames under the best of circumstances by anyone using any of the conventional sensing technologies. Plant technicians who are nearby often fail to hear loud gas leaks or to see flames for a variety of reasons, including normal plant noise and the complexity of surrounding equipment. Wind also can dilute gas concentration by blowing gas away from sensors, while reflective surfaces can mimic infrared flame signatures.

To address these limitations, Gassonic and General Monitors (both MSA companies) have applied the concept of artificial neural networks (ANN) to develop their own neural network technology (NNT). NNT is based on the human brain (Fig 1), and this technology is now being applied to ultrasonic gas leak detectors (UGLD) and multispectral infrared (MSIR) flame detectors. Detectors equipped with NNT intelligence provide a more reliable solution to gas and flame detection because they can eliminate many false alarm sources while improving overall detection.

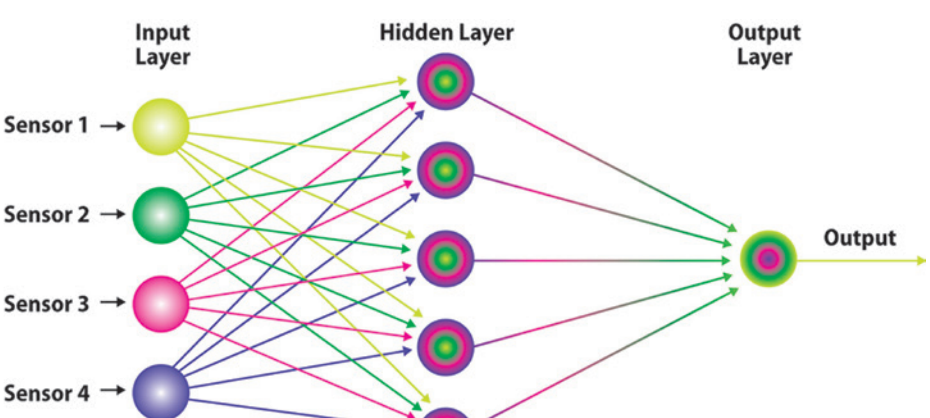

Fig 2. Simplified view of a neural network

Artificial Neural Networks

The inspiration for artificial neural networks, which are mathematical models, arose from biological neural networks. In artificial neural networks, an interconnected group of artificial neurons process information and actually change structure during a learning phase. That allows the network to model complex relationships in the data delivered by sensors in a quick search for patterns (Fig 2).

As far back as the 1940s, computer researchers have been inspired by the human brain when they developed the first conceptual model of an artificial neural network to solve certain kinds of problems that are easy for humans but difficult for computers – otherwise known as pattern recognition. There are today a variety of applications of neural networks, some of which are at work in the Gassonic Observer-i UGLD and the FL4000H Multi-Spectrum IR (MSIR) Flame Detector from General Monitors. They include:

- Pattern recognition
- Signal processing that can filter out irrelevant data
- Controls that manage decisions
- Soft sensors that analyse a collection of many measurements
- Anomaly detection – the ability to generate output when something occurs that doesn't fit patterns thus issuing alerts when something is amiss

Neural Network Technology (NNT), which is based on ANN, is in essence an artificial intelligence. A key advantage of this technology is its ability to learn. It learns through a type of apperceptive process; meaning the comprehension or assimilation of something such as a new idea can then be related in terms of previous experiences or perceptions. NNT operates similarly and is much like a human mind in the way that it enables a person to recognise a face from the distant past. For example, the brain facilitates recognition by matching a face with an image stored as a memory.

The Observer-i UGLD and the MSIR Flame Detector, just like the human brain, each have thousands of pieces of data stored in their memories from hundreds of gas leak, non-gas leak, flame and non-flame events that have been observed in the past. These detectors have been trained through NNT intelligence to recognize an actual gas leak or flame based upon that data, and they make decisions about whether they are detecting an actual gas leak or flame, even if they have not seen that exact pattern in the past.

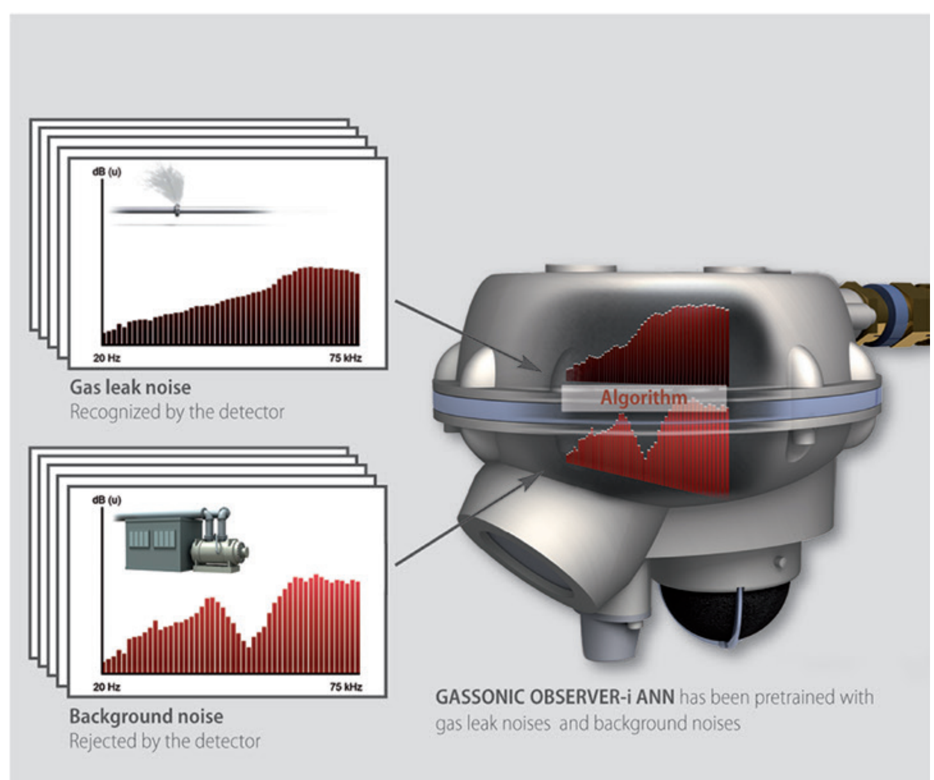

Fig 3. Gassonic Observer-i UGLD with ANN training

Ultrasonic Gas Leak Detection

A real gas leak source produces acoustic noise that normally ranges from audible frequencies up to the 60 - 70 kHz range. The acoustic noise from a false alarm source, such as a gas compressor for example, however, can easily generate high level frequencies in the range of 100 Hz to 20 kHz. The early generations of UGLDs were designed with electronic filters to screen out and ignore noise below 20 kHz, which eliminated false alarms resulting from most normal plant background noise such as gas compressors, but also limited detection of smaller real gas leaks.

For this reason, the Gassonic Observer-i UGLD has been designed as the first device of its class equipped with NNT and real-time broadband acoustic sound processing technology. The combination of these technologies is based on extensive studies and more than a decade of real recording of gas leak sounds and industrial background noise from a wide array of industry sources.

The Gassonic NNT algorithm has been factory "trained" with these recordings to automatically distinguish between unwanted acoustic background noise and dangerous gas leaks. ANN technology makes it possible to analyse the sound spectrum fully to as low as 12 kHz by eliminating the use of common high pass filters. This advanced approach provides a broader leak detection range, resulting in increased sensitivity to smaller gas leaks without interference from unwanted background noise.

Gassonic NNT intelligence allows the Observer-i UGLD (Fig 3) to be installed without time consuming "learning" sequences, and it provides industry-leading detection distance with suppression of false alarms. NNT intelligence also ensures that the detector has the same gas leak detection coverage in high and low noise areas. The detector requires no alarm set points or trigger levels to be configured, nor do these alarm parameters need to be adjusted if background ultrasound were to increase or decrease over time.

Multi-Spectrum Infrared Flame Detection

The FL4000H MSIR Flame Detector (Fig 4) from General Monitors combines a complex sensor array with NNT intelligence to provide new pattern recognition capabilities that are based on training to differentiate between real threats and normal events. MSIR technology allows area coverage up to six times greater than that of more conventional ultraviolet/infrared (UV/IR) flame detectors. MSIR technology performs under various environmental conditions and offers faster response times and increased detection distances (Fig 5).

Fig 4. General Monitors FL4000H MSIR Flame Detector

Developed with a four-sensor array, the FL4000H MSIR detects flame and non-flame events. The four sensors sample unique IR spectral wavelengths and convert those signals into a digital format to extract time and frequency data. The use of four sensors provides more data, increased detection distances, excellent immunity to false alarms, faster response times, and better performance under diverse environmental conditions. The data acquired by the four sensors is automatically conveyed to the neural network where the real work of determining the threat level is processed.

Achieving a longer range and a wider field of view means fewer detectors can cover more territory thus reducing the cost of protection. The FL4000H MSIR Detector has been "trained" to reliably differentiate between real fire threats and common activities like modulation of heated surfaces, hot air flow, reflection off water surfaces, lightning, and arc welding, to name a few.

The inherent performance differences available with the FL4000H MSIR Flame Detector are made possible through a unique combination of NNT intelligence and sophisticated sensor arrays. This design allows the flame detector to discover fire threats faster, and at greater distances. When combined with its superior false alarm immunity, protection from both fire and false alarms is now possible. These advantages can translate into substantial savings for growing industries like mid-stream oil, gas, and petroleum markets with compressor stations and processing plants as well as other large-scale manufacturing facilities.

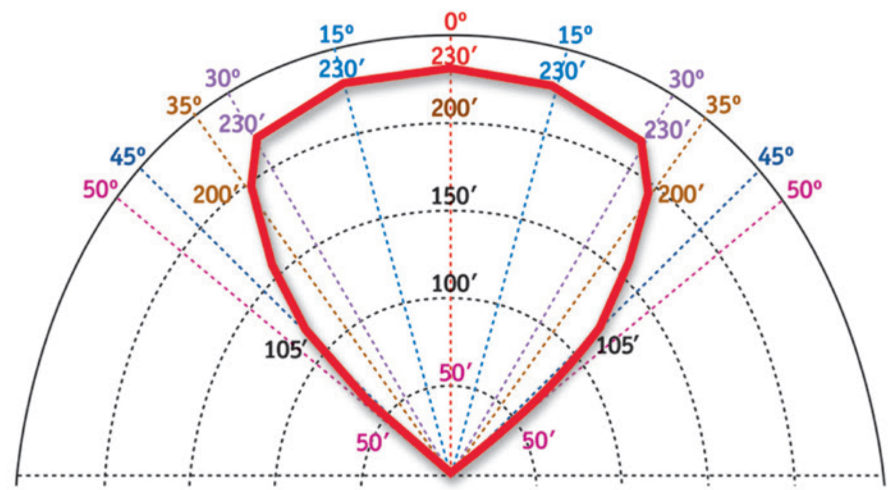

Fig 5. FL4000H Faster Response & Greater Distance

Conclusions

Combining NNT intelligence with advanced gas and flame detection sensors offers distinct performance and reliability advantages in protecting people, equipment and plants in hazardous operating environments. The capability to reduce or eliminate false alarms helps increase plant productivity while at the same time potentially preserving valuable end-products that might otherwise be damaged or lost altogether.

About The Author

Shankar Baliga is the Manager for Research and Development at General Monitors (an MSA company) in Lake Forest, California, USA. He is responsible for the development of new sensing technologies for gas and flame detection. He is a senior member of ISA, SPIE, and IEEE and a voting member on the ISA 12.13 committee for combustible gas detection instruments. Dr. Baliga received a Ph.D. in physics from Ohio State University.