X MARKS THE SPOT

Tomi Fält *explains different applications in which X-rays are utilised, what the latest advances are and how it provides security forces with an advantage*

The fundamentals of the X-ray technology for security screening systems date back to seventies. However, this does not mean that X-ray technology development is complete or even slowing down. The latest achievements in manufacturing technologies are making screening systems more robust, reliable and affordable. On the other hand, various new technologies are being scouted and prototyped to provide more sophisticated features for highly important threat detection assignments globally and locally. Furthermore, recent and continuing steps towards machine learning (ML), artificial intelligence (AI) and the Internet of Things provide unprecedented ways of getting the most out of screening systems in the near future.

There is no viable replacement for X-ray technology in sight. Homeland Security Research Corporation (HSRC) has not identified any noteworthy competing technologies for the screening needs of the security market, and considers the price quality relationship for

> **THE LATEST DETECTORS HAVE IMAGE RESOLUTION THAT IS ON THE SAME LEVEL AS HI-DEF TV**

X-ray imaging equipment to be excellent. The benefits of X-ray are obvious: it offers a very effective way of revealing the full content of various types of containers in a wide range of sizes. X-ray based systems and the related components have been perfected over the years to do this with high accuracy and with decreasing false alarm rates.

X-ray imaging technologies are evolving and varying to provide an optimal match for each market segment where security needs to be enforced. For example, several task-specialised computed tomography (CT) systems have been recently developed to meet the most stringent new standards for airport checkpoints. At the other end of the market, security screening systems are being deployed for other critical infrastructure like subways and train stations, sport venues and various buildings – places that can be considered potential targets for acts threatening public security.

There's also an increasing need to inspect suspicious objects at different locations without permanent system installations by using mobile X-ray machines or handheld devices. Examples include car inspections performed on the road or checking bags left alone in suspicious places. People also need to be screened at certain high-security premises like courthouses and prisons, which require very low dose X-ray systems that still perform at a high level.

Increased insecurity concerns and all the above-mentioned different applications are driving the development of X-ray technology. Current and next-generation scanning systems are seeking new detectors and enhanced technology optimised and ruggedised to provide the required performance for different use, all of which have very high duty cycles and only tolerate very low down time.

SETTING THE STANDARD

Over the years, key players in the industry have attempted to standardise certain interfaces and data formats for X-ray equipment. For example, the Association of Electrical Equipment and Medical Imaging Manufacturers has developed the Digital Imaging and Communication for Security (DICOS) standard. DICOS addresses the exchange of digital information between security-imaging equipment and other systems. However, there is no general standard for X-ray sub-system and component levels. Despite this, certain solutions and technologies have become industry standards. These standards include the construction of dual energy detectors, which have been fine tuned over the years and currently enable accurate material discrimination when used with the latest analysis algorithms.

Detectors for security CT and other security scanners are quite heavily customised for each specific application. Leading detector manufacturers have developed certain modular building blocks and technologies to enable efficient building of optimal detectors for each target application. The key components in such platforms include modern, high-efficiency scintillators and photodiodes. In addition, the image data readout and processing chains benefit from platform-type solutions based on proven and application optimised designs.

Advances in manufacturing technologies are enabling the construction of very large areas that are seamlessly covered with detector elements. These kinds of solutions can be built from tiny single-pixel photodiodes diced into separate physical dies. This approach eliminates electrical crosstalk, which could cause blurring and other artefacts in the X-ray image data. This is an extremely important feature for rapidly rotating CT systems and alternative stationary implementations that utilise high-frequency pulsed X-ray sources.

STOPPING INTERFERENCE

Robustness and protection against humidity, dust and other contaminants is achieved by implementing structures where all sensitive components are on the same substrate without exposed interfaces. The structure with the highest level of integration utilise a platform where weak current signals from photodiodes are protected and routed to the readout electronics without any connectors or otherwise exposed sections on the signal path. This kind of structure also mitigates the possibility of external electromagnetic noise coupling, which could result in image noise or glitches. Interference like this would be very difficult to correct afterwards. All of this ensures clean and stable image data for the analysis algorithms.

Improved spatial resolution is one way to improve the X-ray image quality in line scanners like baggage screening systems. The latest detectors enable image resolution that is on the same level as high-definition TV screens. A clear image that can be zoomed in on from different angles without the image getting too coarse helps security officers to quickly make fact-based decisions.

For some time now, many X-ray imaging systems have been also utilising dual or multiple views to provide more information and viewing angles. Some of the systems have quite a massive number of detectors in order to provide the amount of data required by rotating gantry-based CT systems. The advances that X-ray detectors provide make these multiview systems more robust and compact. This is achieved by streamlined detector structure and data readout architecture, which utilise modern high-speed serial links. The architecture reads the data from multiple detector elements with a high dynamic range, integrity and accuracy. Precise data synchronisation is particularly critical when the multi-angle data is used for 3D-image reconstructions.

Data is currently transmitted from detectors to the computer over high-speed interfaces, which are provided by the latest computer technology. Data is

Homeland Security Research Corporation states that X-ray is best for security screening

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streamed in real time with low latency over Internet Protocol. Today data protocols combined with modern hardware offer bandwidth and real time capabilities, which earlier had to be implemented with tailored data acquisition systems.

Modern detectors also include several features that enable advanced diagnostics and service in X-ray imaging systems. Certain detector functions can be updated remotely, even over long distances, if the system is network-connected. However, most of the security systems are isolated from public networks to eliminate cyber security risks. Local networks providing centralised access can still be used for system diagnostics and updates. The upgrading of detectors has been simplified at the entry level via a local host computer, which makes it unnecessary to open the hood.

When service is needed, detector subsystems can provide diagnostics information to system software. This helps to plan the service properly and minimises downtime on site. In addition to the actual pixel data, diagnostics data can include local voltages, sensor temperatures, humidity, operating hours and serial numbers. Several different data pattern modes can also be enabled to help identify service needs in detail.

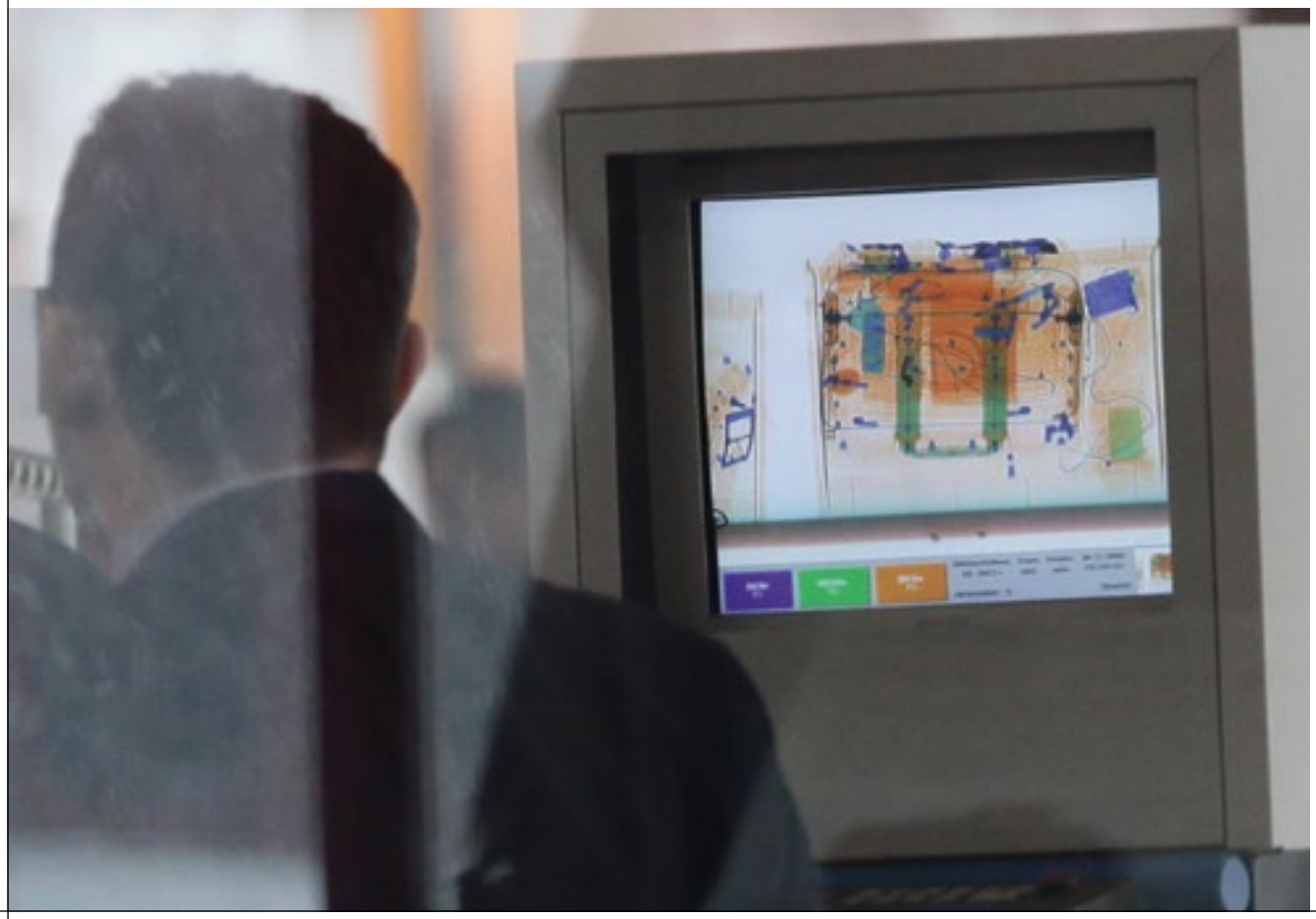
Increased availability of technology, implementation methods and computing power means that machine learning and artificial intelligence are being applied to a number of applications at an accelerating pace. It is logical that security screening is one of the first applications to exploit ML and AI. They will provide great advantages compared with the pure human interpretation of cluttered X-ray images as machines are programmed to focus on accuracy and do not become exhausted by enormous data amounts quite as easily as humans.

IT'S GOOD TO SHARE

Furthermore, multiple imaging systems can be connected to share data and learn from each other in terms of distinguishing various objects from the image data. One concrete example of such learning is new car models, which can be taught for networked truck and vehicle scanning systems using a scan of a cleared vehicle. After this, all networked systems will issue an alarm if there are alterations to the vehicle structure that indicates risk of concealed objects. The characteristics of detectors must be known, very stable and predictable when used in such systems. Transmission X-ray detectors have reached a maturity level that allows them to also serve such an operational concept.

All the advantages of X-ray technology provide security forces with greater ability to detect threats and enforce public safety. Aviation security is about to deploy new, mostly CT-based system generation. The first systems already meet the European Civil Aviation Conference Standard C3 for checkpoints and several others are waiting for certification. Passengers will soon be able to pass security checks more smoothly without removing various objects from their belongings. At the same time, security will improve as the material discrimination capability of scanners reach a new level. It is very likely that similar technologies will eventually be applied to other critical infrastructure as the threat to public security has been increasing. To foreknow has become more important than ever ●

Tomi Fält, Manager, Product Management at Detection Technology, specialises in detector technologies and their industrialisation to a number of X-ray imaging applications in the fields of security and industrial X-ray scanning.



Security detectors and scanners can be quite heavily customised for each specific application

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