IBEX

WHITE PAPER:

PORTABLE SECURITY INSPECTION

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Quality Management System accredited to ISO9001:2008 and ISO13485:2012

Abstract

Routine baggage scanning such as that carried out at border controls uses multiple energy methods to generate images containing information on the materials present and some access to partial 3D views. This requires X-ray sources running at different kVp and multiple detectors, making bulky equipment which is not practical for inspecting suspect packages *in situ*.

IBEX works together with partners to implement single-scan, materials-sensitive imaging in a compact unit for portable security inspection and threat detection applications.

Introduction

Machines used for routine baggage inspection are large and fixed. When a suspect package, such as an abandoned bag, is discovered, it cannot be moved to a fixed scanner. A convenient, portable system which can be deployed *in situ* and delivers diagnostic images rapidly is required. It must handle a variable experimental geometry, since the source-to-detector distance and precise orientation may not be closely controlled. It must be rugged, for deployment in a range of environments. It must also allow close inspection of the images over a range of zoom levels and contrast stretches as security operators seek to identify potential threats.

IBEX Multi-Absorption Plate (MAP) technology allows the energy-dependent information normally lost in single-kVp X-ray imaging to be restored, enabling classifyication of materials within an X-ray image in a single acquisition at a single kVp using a single detector. This saves time and system complexity compared to multiple energy, multi-scan systems. Since the MAP is a passive device which can be incorporated into (or behind) the detector cover-plate, the detector system remains robust.

Multi-Absorption Plate (MAP) Technology

IBEX MAP (Multi-Absorption Plate) technology modulates the X-ray spectrum incident on the detector in a regular manner across its surface. IBEX technology is described in detail in our White Paper, available from the Resources page of our website.

Experiment

Security applications typically seek to distinguish organic materials (plastics) from so-called “poor” metals (light metals such as aluminium) and metals (denser metals such as steel). To this end, the system was trained using wedges of PMMA, aluminium and steel over a range of thicknesses.

Objects to be imaged may cover a wide range of thicknesses, and even block the X-ray beam altogether. It is important not to deliver misleading information, and therefore limits may optionally be set on thickness ranges for which IBEX technology will deliver materials classification. Thinner or thicker than these limits, no classification is delivered.

A range of test objects has been measured using IBEX’s in-house X-ray systems (continuous and pulsed X-ray sources with flat-panel detectors) and using a development partner's line-scanning detector and portable X-ray generator.

In security applications, materials classified images are typically presented using orange to indicate organic material, green to indicate poor metals and blue to indicate metals. IBEX presents the information overlaid on a conventional X-ray absorption-contrast image, which gives an additional, qualitative sense of the relative thickness of the different features. The absorption-contrast image is obtained by stripping from the original data the shadow of the MAP. Materials data may also be presented independently.

Example results

Figure 1 shows the materials classification of a printed circuit board (PCB) overlaid on its MAP-stripped absorption contrast image. A typical

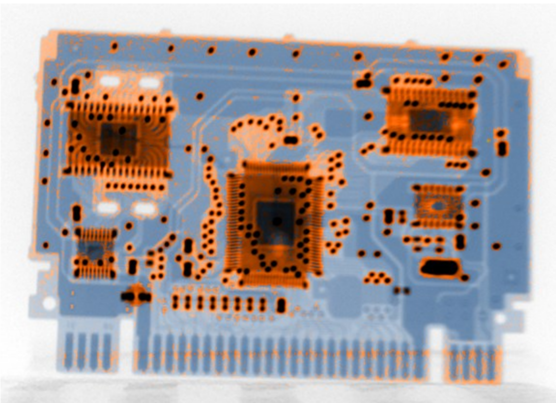

Figure 1: Materials classified image of a PCB, collected using a portable, pulsed X-ray generator running at 100 kVp, 1 mAs and a flat panel detector with 127 μm pixel size. Regions of the image classified as organic material are coloured orange, and metals, blue. There are no "poor" metals (normally coloured green). Classification limits applied, leaving some regions of the image

colourisation used for security screening images has been applied, and the application of classification limits leaves some regions of the image unclassified. The sample was mounted in an expanded foam block to hold it vertical, since the X-ray system had a horizontal geometry. This explains the classification as organic of some parts of the connectors at the bottom of the PCB.

Sample objects are often complex, not giving a single material along the whole length of the X-ray beam path. Regardless of the technology used, the material classification delivered represents an aggregate of the materials encountered by the X-ray beam hitting that pixel of the detector. So, a thin sheet of steel within some thickness of plastic may be classified as a poor metal, even though none of the individual materials is a poor metal.

Figure 2a shows the absorption contrast image of a desk telephone — a mix of organic materials and metals. This was obtained by stripping the shadow of the MAP from the data. Absorption contrast cannot show which materials are which, but gives important information on detailed shapes. The materials classification overlay is shown in Figure 2b, where the effects of multiple materials in the X-ray beam path can be seen — for example, the copper plane of the PCB within the plastic casing of the telephone is shown as poor metal, rather than metal. However, this does allow finer metal features, such as PCB legs and wires, to be distinguished, as the beam path then crosses a higher proportion which is metal. A close-up of a part of each image is show in Figure 3.

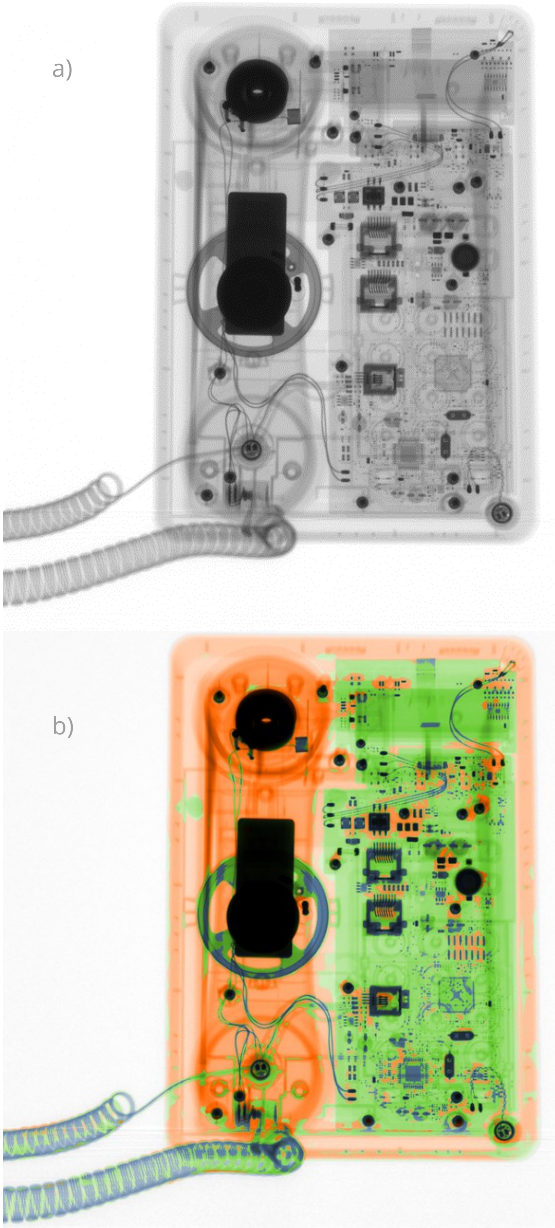

Figure 2: a): MAP-stripped absorption contrast image of a telephone. b): materials classified image. Continuous X-ray generator running at 120 kVp, flat-panel detector with 127 μm pixel size. Classification limits applied.

Figure 4 shows a materials classification image of a laptop. Again, the copper planes of the PCBs appear as poor metals since the beam also passes through a significant fraction of organic matter in these areas.

a)

b)

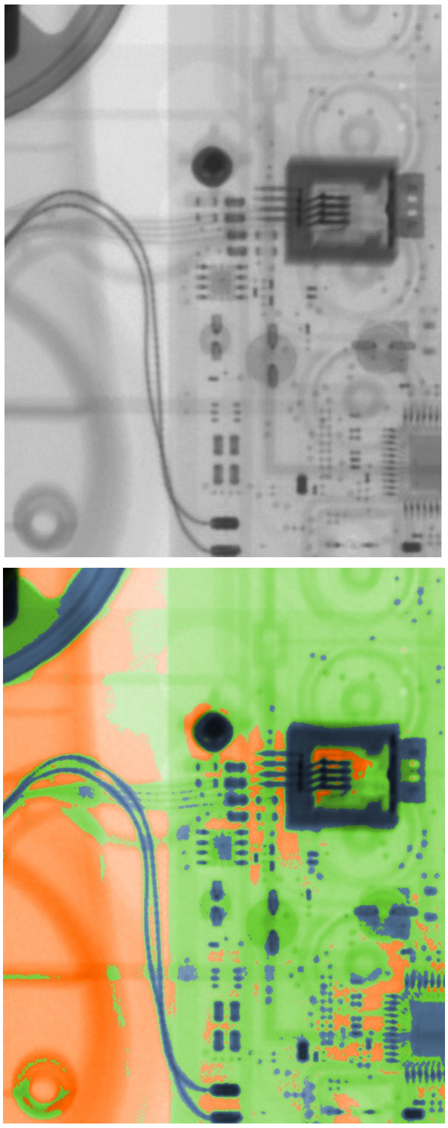

Figure 3: Close-up of a region of Figure 2. a): MAP-stripped absorption contrast image. b): materials classified overlay image.

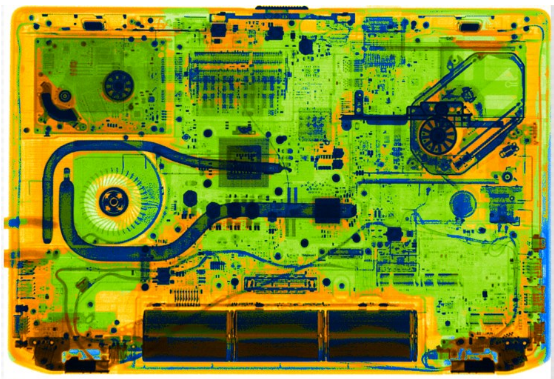

Figure 4: Materials classified image of a laptop, collected using a portable, continuous X-ray generator running at 120 kVp and a line-scanner detector. Classification limits not applied.

The examples above illustrate materials classification on a range of complex samples which include multiple, overlapping materials, fine features, gradual edges and dense blocks with abrupt, strongly-contrasting edges, all of which may be encountered in security inspection applications.

Figure 5 shows materials classification of a set of test objects inside a carry-on suitcase.

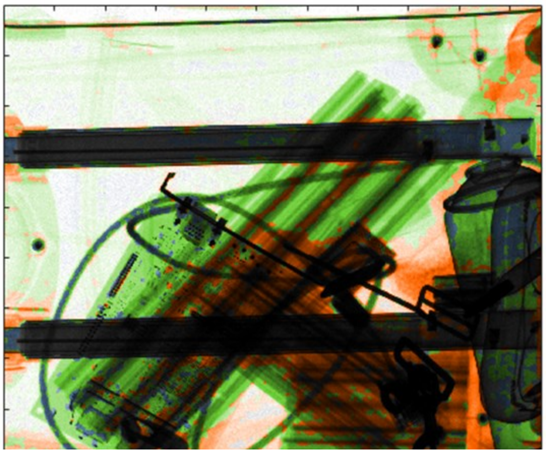

Figure 5: Materials classified image of objects in a carry-on suitcase, collected using a portable, continuous X-ray generator running at 120 kVp and a line-scanner detector. Classification limits applied. It is not unusual in a security scanning system for heavier plastics such as PVC to be classified as poor metals but judicious choice of training materials, or a bias in the analysis, can get around this.

IBEX is working on technology which allows the effects of a material present in the object to be stripped from the materials classification image, in order to reveal the remaining materials — for example, to remove the effect of a bag or container in order to show the materials inside it.

Conclusions

The capability of IBEX technology in portable security scanning has been demonstrated using test objects. Materials classification images have been produced equivalent to those obtained by dual energy methods, which normally require multiple sources and/or detectors and/or multiple scans.

Work is underway to develop technology to remove the effect of a particular material of selected thickness from a materials classified image, in order to reveal, for example, the materials inside a bag or container.

About IBEX

IBEX Innovations Limited was created in 2010 to develop and commercialise an innovative X-ray detector technology.

IBEX is based in modern facilities on the NETPark Science Park in the North-East of England, where it employs a team of highly skilled scientists, engineers and business professionals.

IBEX is supported by private venture capital investment and grant funding from both the UK Government and the European Commission.

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