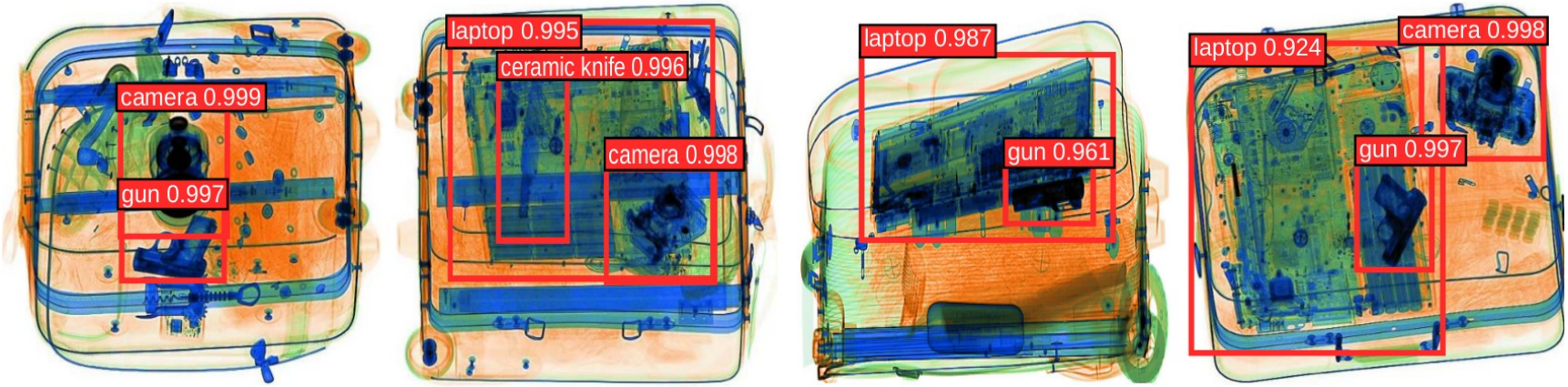
Automatic Prohibited and Illicit Item Detection in X-ray and Computed Tomography Security Screening – *a research snapshot*



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July 2019 – CBP-ADEPT-02 (rev. 02)

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Images – [Akcay, Breckon et al. 2018 – Durham University]

So What ? / Who Cares ?

- *Space:* **Baggage & Parcel Inspection**
  (carry on and hold, extensible to freight)

- *Problem:*
  - **Prohibited Item Detection** (by shape/material … guns / knives / other - ?)
  - **Anomalous Item Detection** (by knowing what is abnormal - ?)

- *Solution:*
  - ***3rd party, world-leading automatic object detection & classification algorithms***
    - *using 2nd / 3rd generation deep learning techniques*

- Results: **~98%+, < 1 sec., FP <1%, invariant** **(on firearms detection, > 95% for other)**
- *TRL:* 6

- Contact me: toby.breckon@durham.ac.uk

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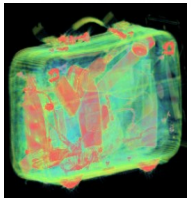
Concept of Operation



3D CT

2D X-ray

Deep Learning
Convolutional Neural Networks

?

- Complex / Cluttered ?
- prohibited items ?
- illicit items ?

EDS

Operative Review

Images – [Breckon et al. 2013-2018 – Durham University]

Durham

- **3rd oldest** university in England (1832)
- **World leading** university (top 100)
- **UK ranking: top 5**
  Engineering & Computer Science
- **Engineering & Computer Science**
  - Nvidia Research Centre
  - Intel Parallel Computing Centre
- *Within* **X-ray Security:**
  - 12 years experience
  - threat detection, threat image projection, anomaly detection

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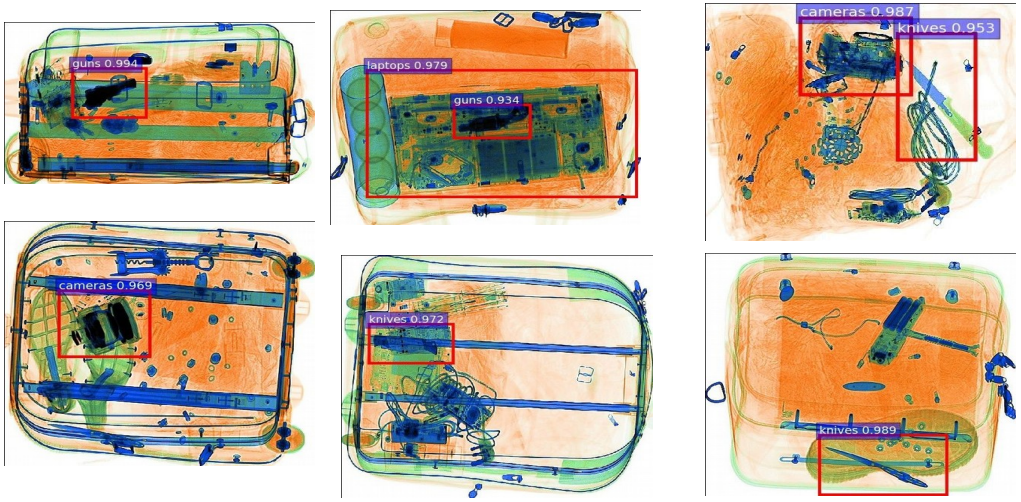
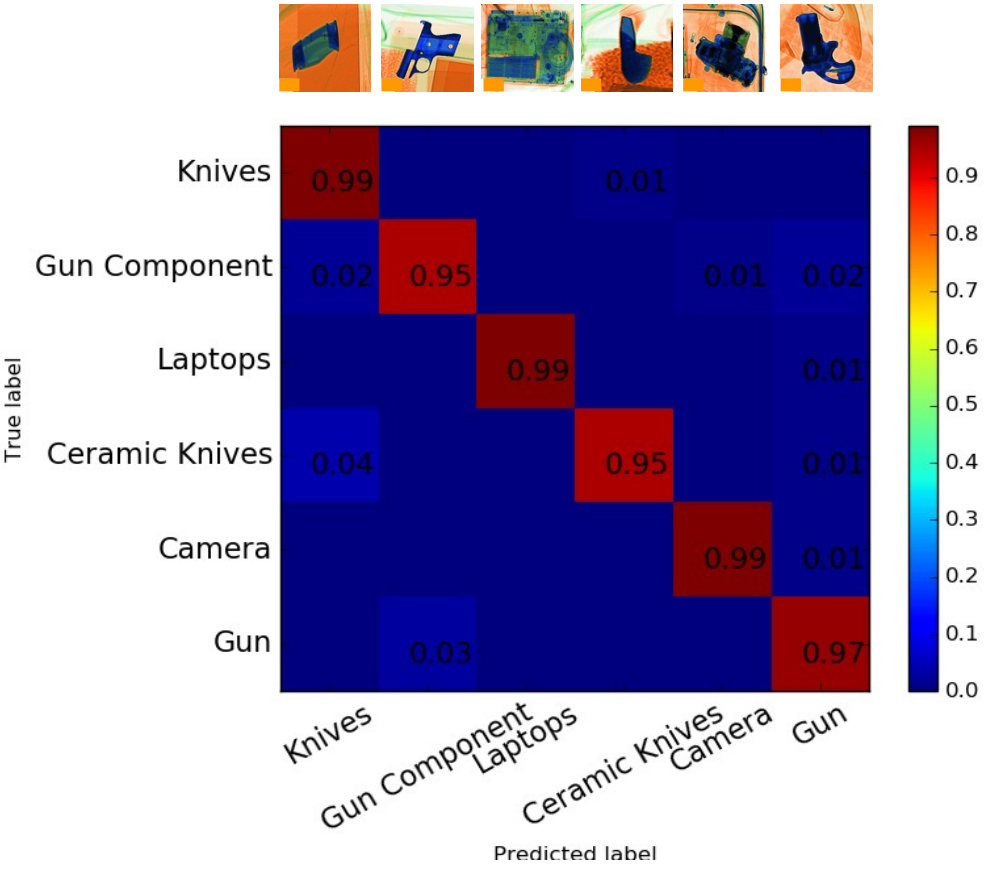
Deep Learning for Object Detection in 2D X-ray





Method	Class	True +	False +
[Akcay et al. 2016]	Firearm	98.62	0.21

- **1st generation** deep net approaches
  - **95% (True+)** over **6 object categories**
  - established **X-ray training via transfer learning** (which everyone uses now) [Akcay et al. 2016]

Images – [Akcay, Breckon et al. 2016 – Durham University]

Deep Learning for Object Detection in 2D X-ray

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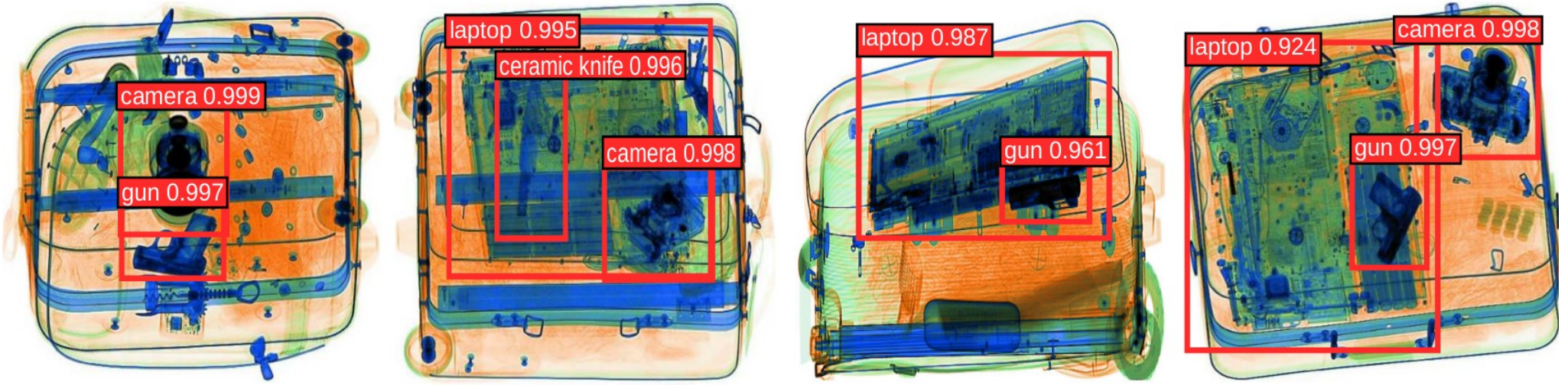
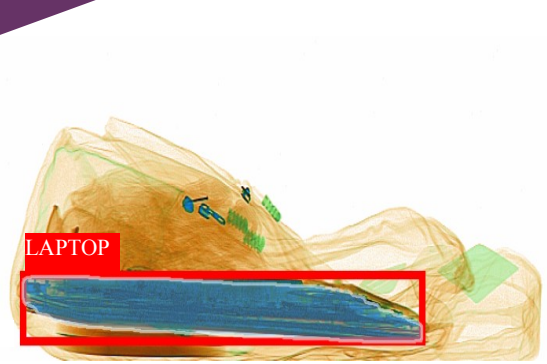


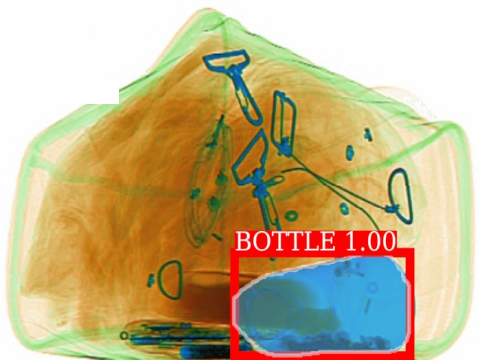
Method	Class	True +	False +
[Akcay et al. 2017 / 2018]	Firearm	99.5+	< 0.5

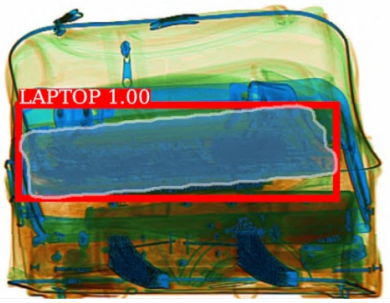
- **2nd generation** deep net approaches
  - high PD (true+), low PFA (false+) [Akcay et al. 2017]
  - leading global results; UK government test dataset [Akcay et al. 2018]

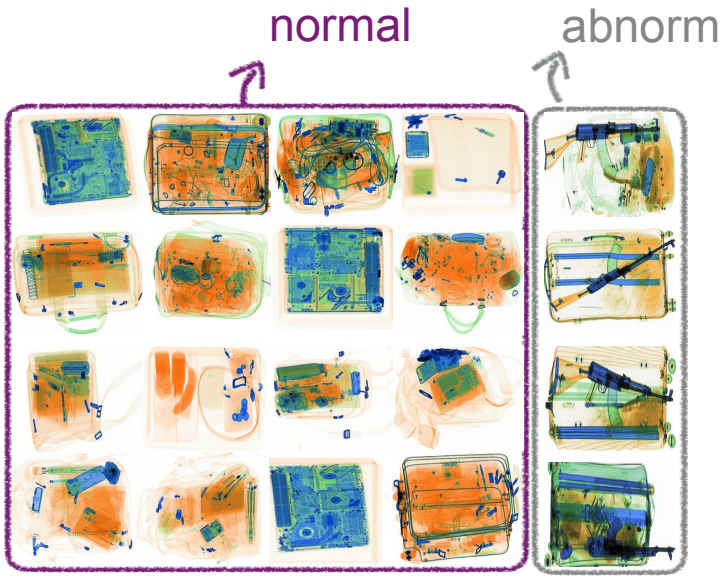
Images – [Akcay, Breckon et al. 2018 – Durham University]

Deep Learning for Anomaly Detection in 2D X-ray









	Durham X-ray Dataset (Dbf3)				HMG (FFOP)
Method	gun	gun-parts	knife	overall	full-weapon
AnoGAN	0.598	0.511	**0.599**	0.569	0.703
~~Eff-GAN~~	~~0.614~~	~~0.591~~	0.587	~~0.597~~	~~0.712~~
GANomaly	**0.747**	**0.662**	~~0.520~~	**0.643**	**0.882**

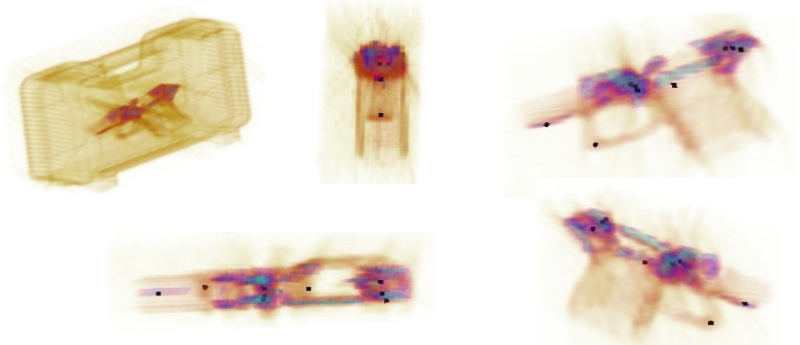
Statistic: AUC

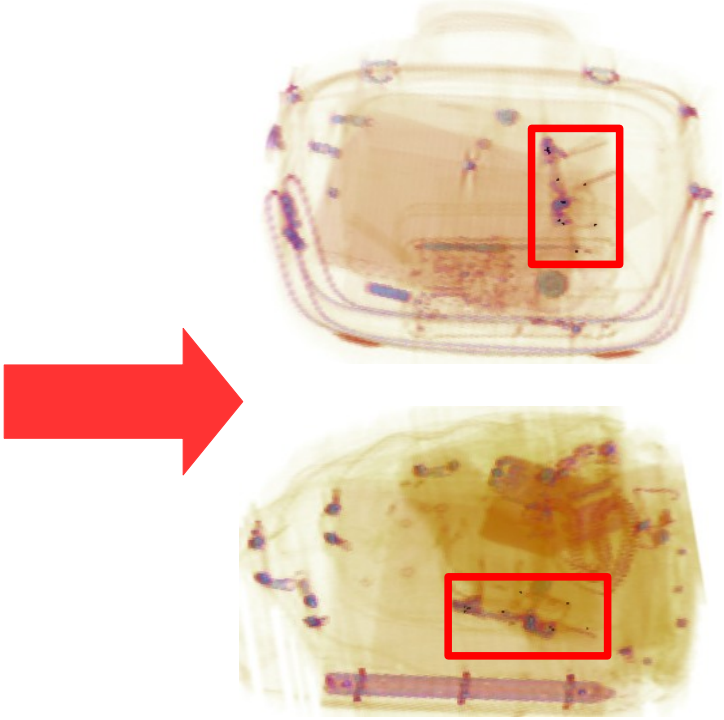
- **3rd generation** deep net approaches
  - need **normal-only training data** - **GANomaly** [Akcay et al. 2018]
  - use of **object-wise and component-wise anomalies** [Gaus et al. 2019 + in press]

Images – [Gaus, Akcay, Breckon et al. 2018/19 – Durham University]

Also available in 3D CT …

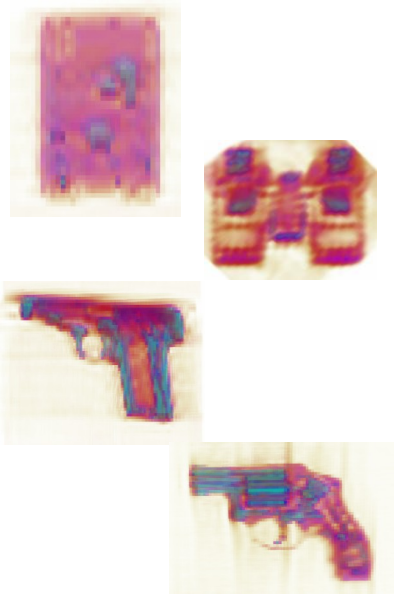
[prior work]

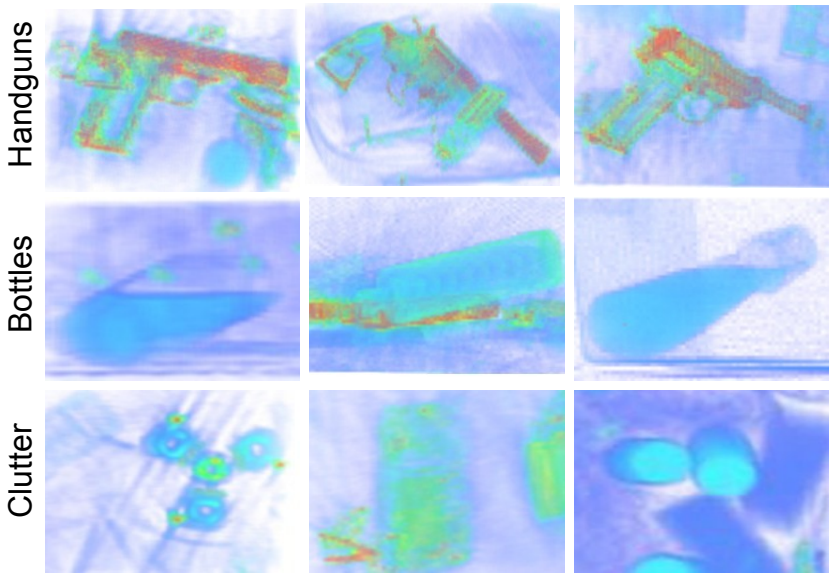




Single signature feature-point based **detection**: ~90% detection

Images [Flitton, Breckon, Megherbi - 2010]





Working with:

CPNI Centre for the Protection of National Infrastructure

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REVEAL

Department for Transport

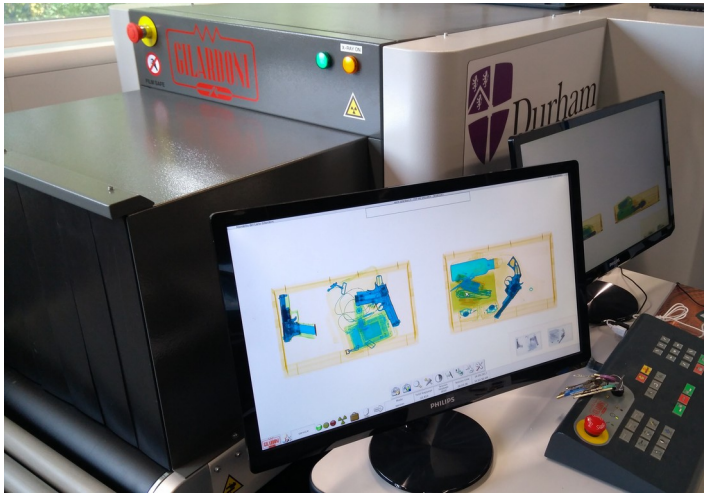
Metropolitan Police

Home Office Scientific Development Branch

“bag of visual words” generalized signature **classification** : ~98+% detection, low FP (<1%)

Images - [Mouton, Breckon, 2014] [Mouton, Breckon 2015] [Flitton, Breckon 2015] [Flitton, Breckon 2012]

Experience in the Field ...



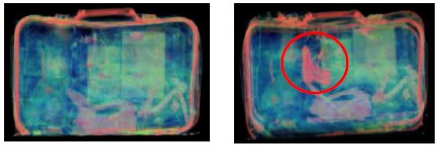
- **Training Data:**
  - CT : ~800-1,000+ bags
  - 2D X-ray : UK gov. + our own on-site X-ray scanner (~100,000+ images)

- **Funding:** 2007 → 2019+
  - *Today*: 10+ years, 10+ projects and 25+ publications later

HM Government

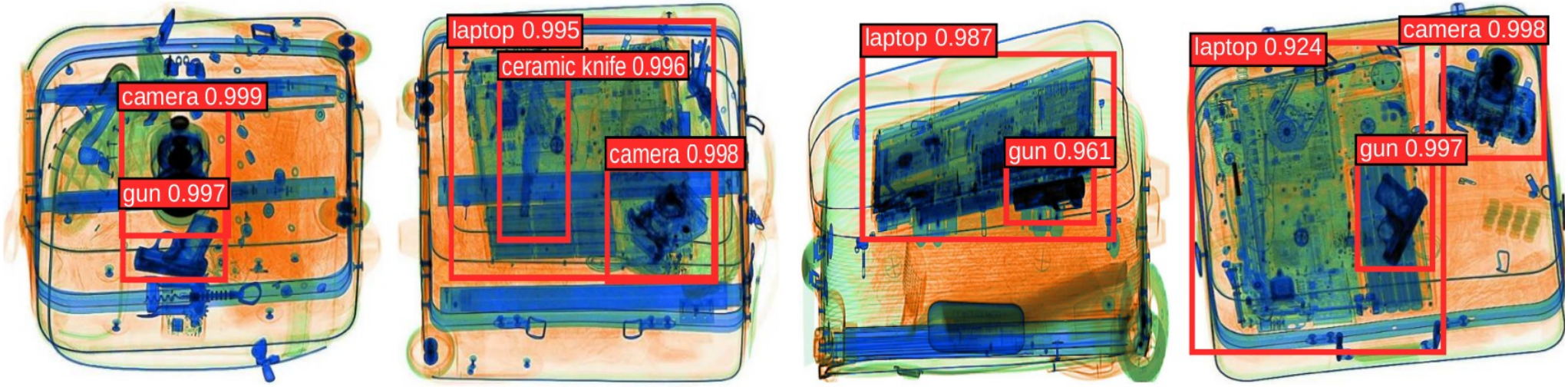
- **Publications:** *"never unreasonably withheld"*
  - published in leading conference / journal venues
  - wider impact in generalized 3D object recognition + medical CT

- **Algorithm Deployment:** 3D TIP solution



Images – [Breckon et al. 2012/13 – Durham University]

Automatic Prohibited and Contraband Item Detection in X-ray and Computed Tomography Security Screening – *a research snapshot*



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Images – [Akcay, Breckon et al. 2018 – Durham University]

References : Latest Technical Publications

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GANomaly: Semi-Supervised Anomaly Detection via Adversarial Training (S. Akcay, A. Atapour-Abarghouei, T.P. Breckon), In Proc. Asian Conference on Computer Vision, Springer, 2018.

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Materials-Based 3D Segmentation of Unknown Objects from Dual-Energy Computed Tomography Imagery in Baggage Security Screening (A. Mouton, T.P. Breckon), In Pattern Recognition, Elsevier, Volume 48, No. 6, pp. 1961–1978, 2015.
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3D Object Classification in Baggage Computed Tomography Imagery using Randomised Clustering Forests (A. Mouton, T.P. Breckon, G.T. Flitton, N. Megherbi), In Proc. International Conference on Image Processing, IEEE, pp. 5202-5206, 2014

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All available open access - full listing including all other references.