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

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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
Concept of Operation

Deep Learning
Convolutional Neural Networks

- Complex / Cluttered?
- Prohibited items?
- Illicit items?

Operative Review

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
Deep Learning for Object Detection in 2D X-ray

- **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]

<table>
<thead>
<tr>
<th>Method</th>
<th>Class</th>
<th>True +</th>
<th>False +</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Akcay et al. 2016]</td>
<td>Firearm</td>
<td>98.62</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Images – [Akcay, Breckon et al. 2016 – Durham University]
Deep Learning for Object Detection in 2D X-ray

- **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]

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<tr>
<td>[Akcay et al. 2017 / 2018]</td>
<td>Firearm</td>
<td>99.5+</td>
<td>&lt; 0.5</td>
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</tbody>
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Images – [Akcay, Breckon et al. 2018 – Durham University]
Deep Learning for Anomaly Detection in 2D X-ray

- **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]
Also available in 3D CT ...

[prior work]

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

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

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

• **Algorithm Deployment:** 3D TIP solution
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Images – [Akcay, Breckon et al. 2018 – Durham University]
X-ray Detection:


3D CT Detection & Segmentation:

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