Unexpected Item in the Bagging Area: Anomaly Detection in X-ray security imaging

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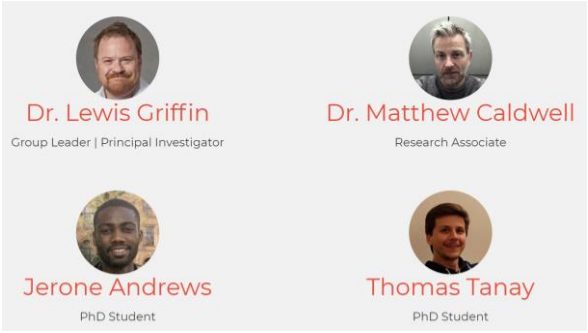
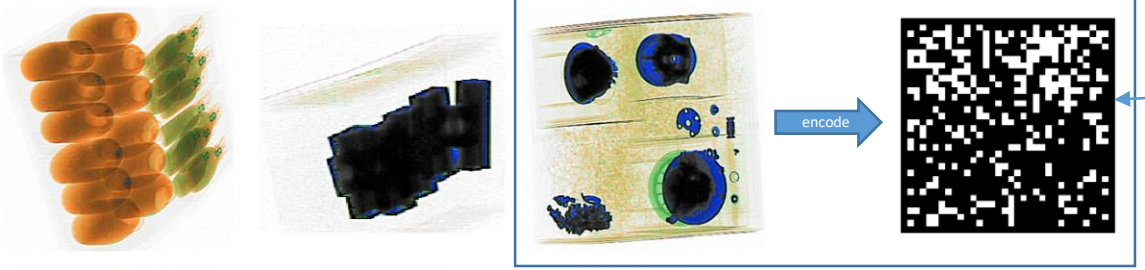
compass

Computational Security Science (COMPASS), a research group in UCL's Computer Science Department developing state-of-the-art methods for the domain. We work with a range of academic, industrial, and governmental partners to produce a step-change in automated capabilities.



Overview: Detecting Anomalies in Parcels



representation

Big sample of SoC

stream-of-commerce parcels

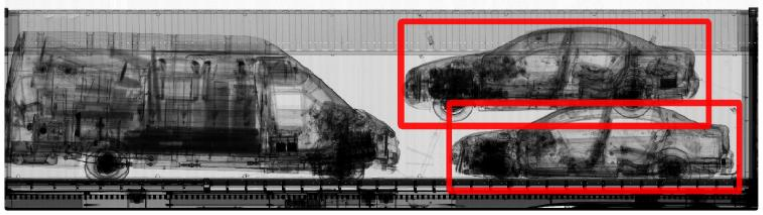
compare

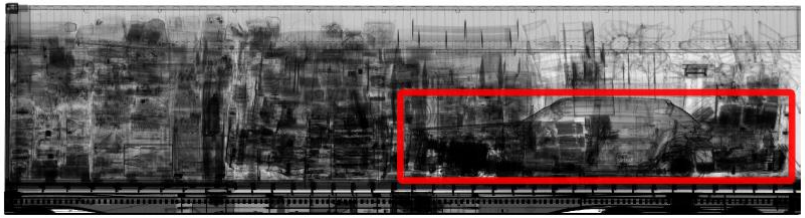
test image

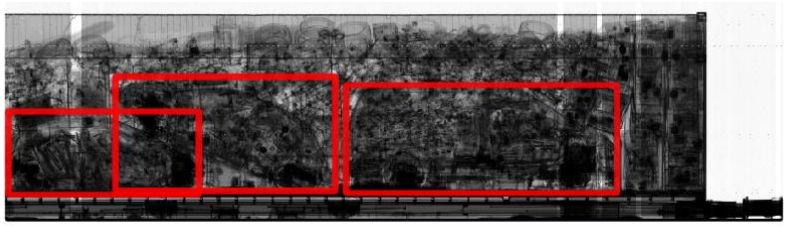
----- 90% of firearms detected while raising false alarms on 18% of SoC-----

Threat Detection

Cars in Cargo Containers

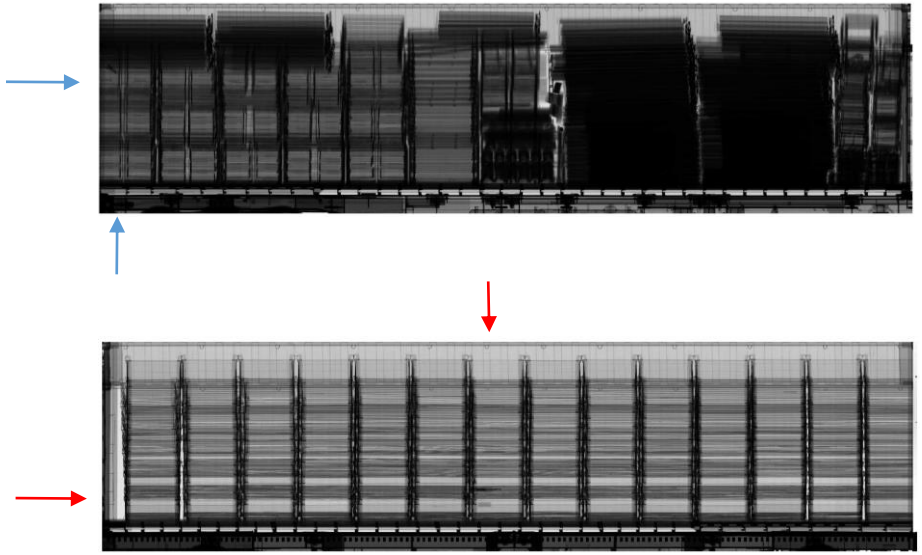






100% detection of cars with
false-positives in 1-in-450 containers.

Guns in Cargo Containers



95% of randomly placed firearms detected
with false alarms in 1-in-120 containers.

Types of Anomaly

A = Appearance
What's that unusual shape?

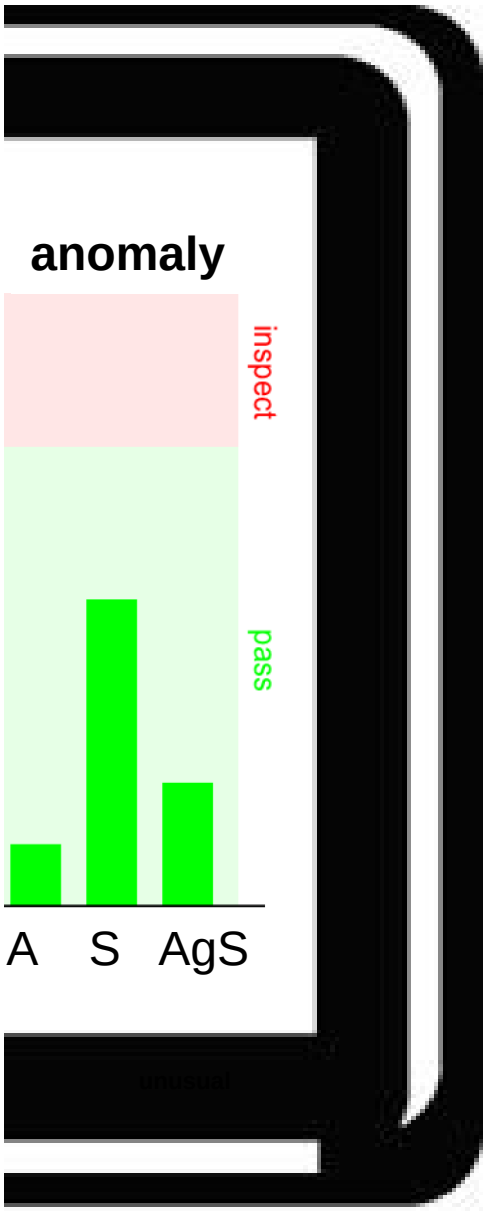
S = Semantic
A meat grinder! in a cabin bag!

AgS = Appearance given Semantics
Hmm. That's a funny-looking toner cartridge.

A-R = Relative
Why does that pallet of lemons look different from that one?

P-R = Passenger-relative
Strange luggage for a business traveller.

F-R = …

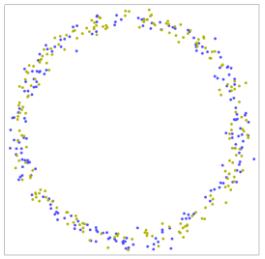


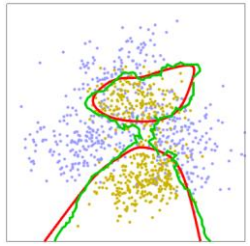
Representation is key

training

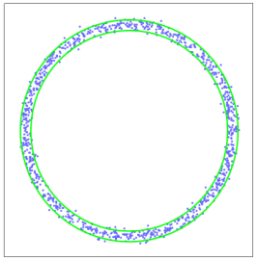
testing

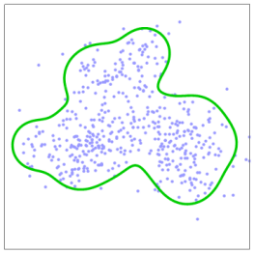
TD





AD

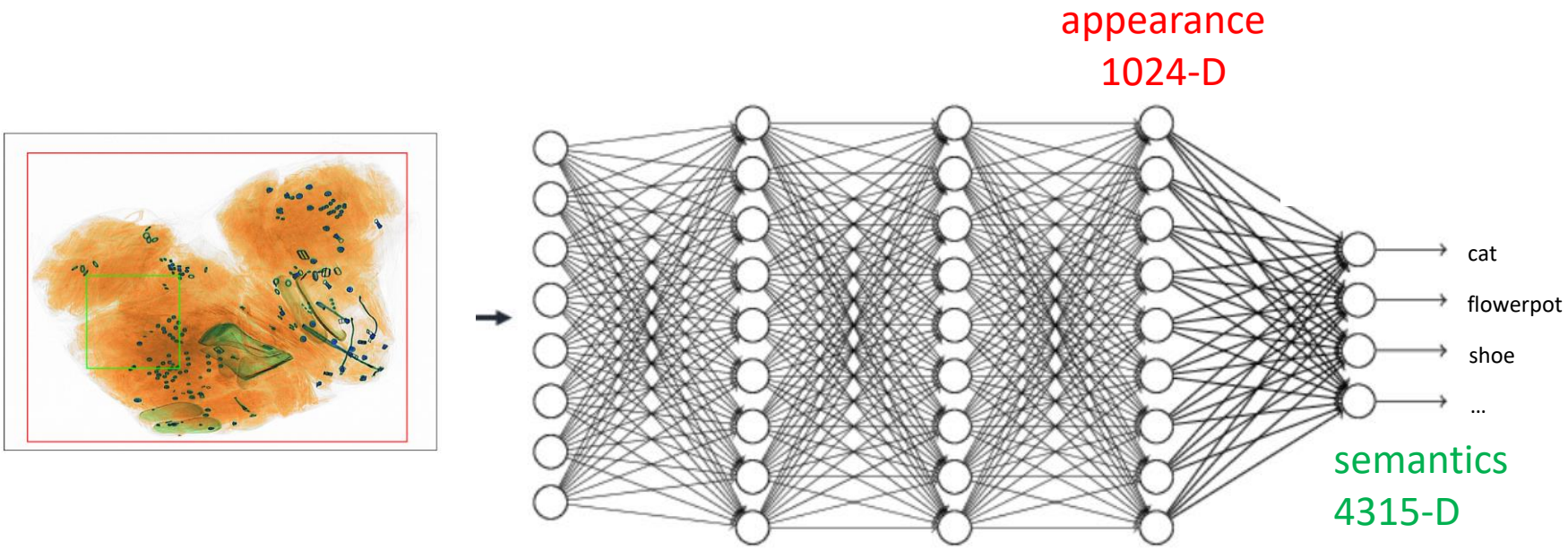




92% AUROC using a representation based on identity

An effective representation for X-ray

- Activations from a CNN trained to classify objects in photographs.
  - From a late pooling layer for an appearance representation
  - From the final logit layer for a semantic representation

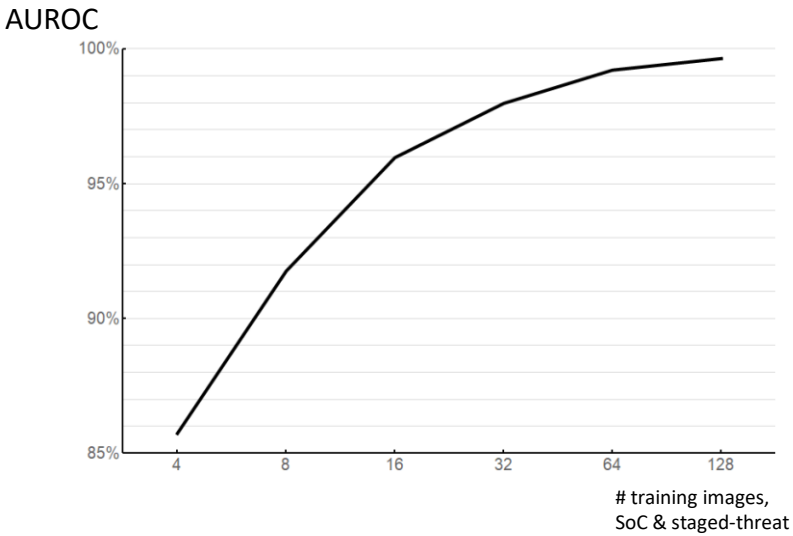


Q: How well does the photo network ‘see’ X-ray images?

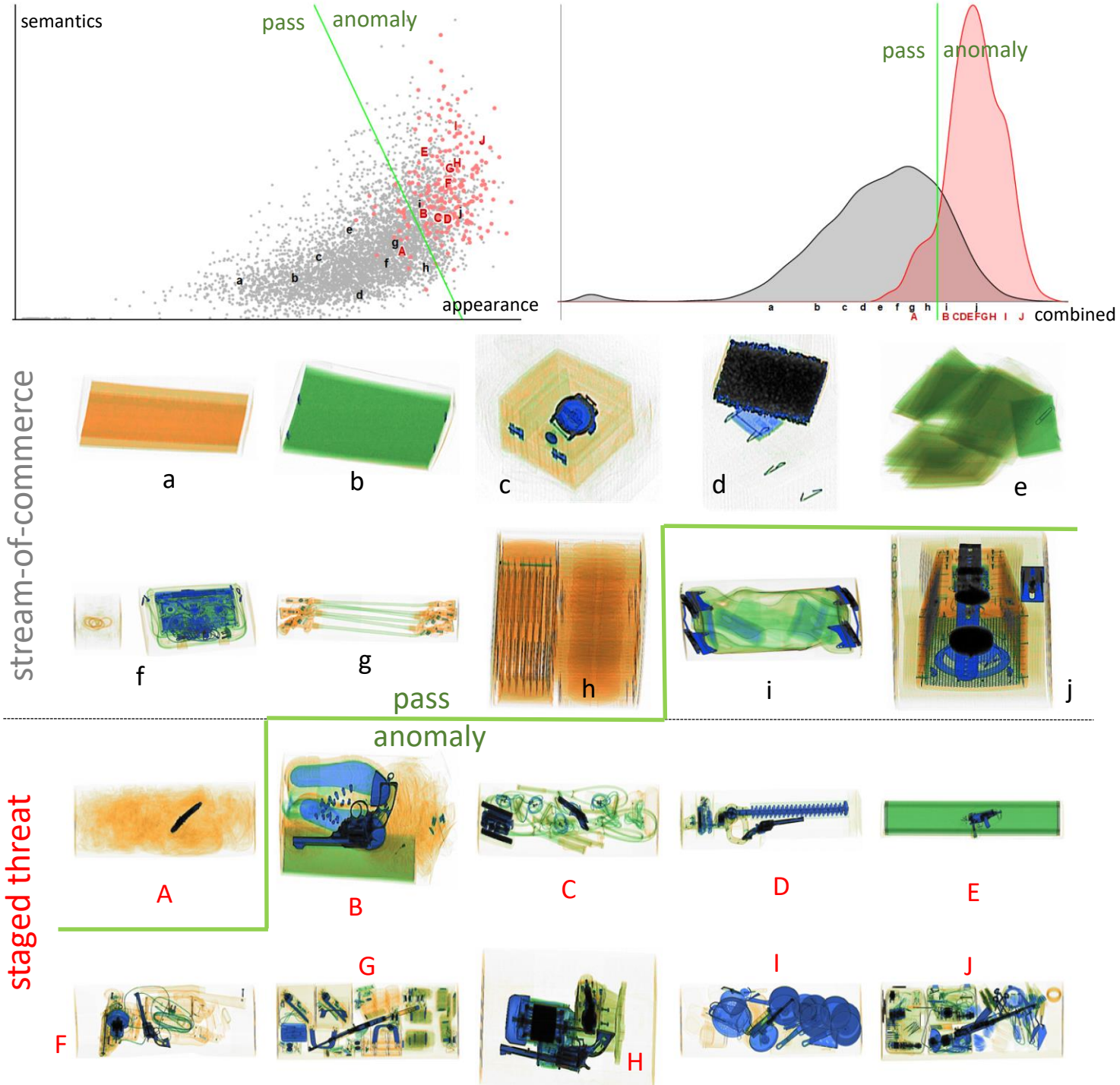
Most common categories in parcel images according to network

SoC	Threat
Rule (7.3%)	Rule (5.9%)
Envelope (6.1%)	Volleyball net (4.2%)
Stratus (3.6%)	Envelope (33%)
Fluorescent lamp (2.5%)	Compass (3.3%)
Long sleeve (2.2%)	Graffiti (2.9%)
Snowdrift (2.0%)	File folder (2.2%)
Dune (1.9%)	Awning (2.0%)
Art (1.9%)	Windshield wiper (2.0%)
Map (1.6%)	Circuitry (2.0%)
Compass (1.6%)	Art (2.0%)
Volleyball net (1.6%)	Shopping cart (1.6%)
File folder (1.5%)	Ridge rope (1.5%)
Organdy (1.4%)	Dish rack (1.4%)
Herringbone pattern (1.3%)	Goalpost (1.4%)
Graffiti (1.3%)	Slide rule (1.4%)
Bookmark (1.2%)	Fluorescent lamp (1.3%)
Ocean (1.1%)	Map (1.2%)
Toothpick (1.0%)	Automatic pistol (1.2%)

Threat Detection using appearance representation



A: semantics poorly, appearance better.


semantics
pass
anomaly
appearance
pass
anomaly
combined
stream-of-commerce
a
b
c
d
e
f
g
h
i
j
pass
anomaly
staged threat
A
B
C
D
E
F
G
H
I
J

Summary & Conclusions

1. **Anomaly Detection has a role alongside Threat Detection**.

2. Described Anomaly Detection approach based on:
   i. **transfer of representations** from object identification in photographs
   ii. parametric modelling of the density of normal data

3. Detected 90% of firearms as anomalies while raising false alarms on 18% of SoC parcels.

4. A more X-ray ‘aware’ network is needed.

5. But never enough data.

6. Learning a ‘translation’ between photo and X-ray appearance could help.

NB. All X-ray images are from a dataset provided for algorithm development by CAST, Home Office, UK. Scanner models were not disclosed for this dataset.