X-Ray Object Recognition using Machine Learning / Interactive Visualization

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So What? Who Cares?

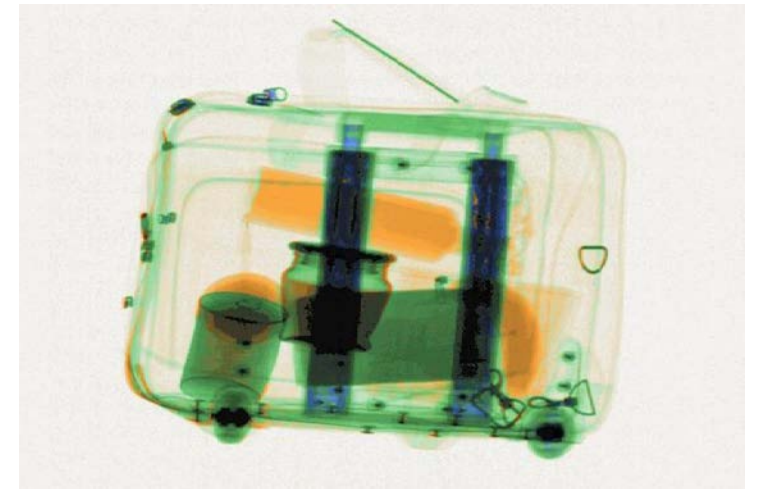Space: *(semi-)automated threat detection in luggage/cargo*

Problem: *threats (e.g. organics, weapons, people) difficult to detect with high PD and low PFA*

Solution: *Algorithms for dual-view, dual-energy X-ray machines to automatically detect and label for operators*

Results: *In development, early results promising*

TRL: 4

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Our Approach

Most machine learning systems try to do everything at once
- ◦ ML as the universal solution

Our background: image processing and understanding
- ◦ ML is a tool, but not the only one
- ◦ Works much better with better data
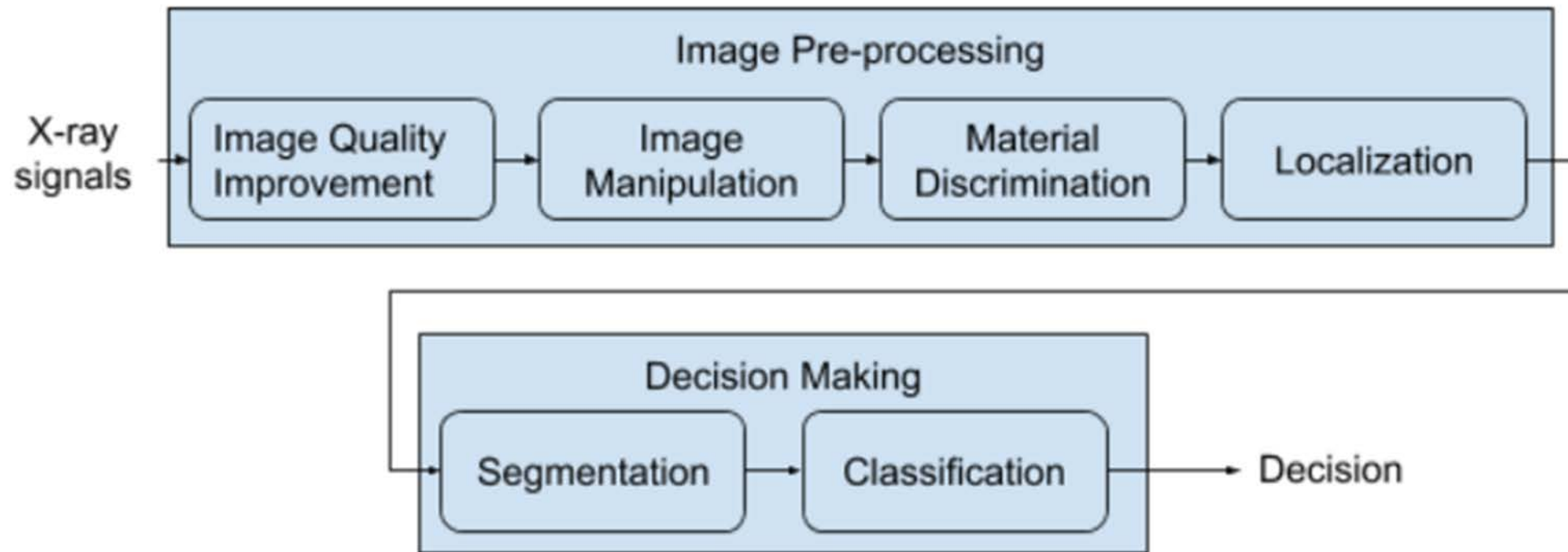
Problem space requires several steps
- ◦ Modular design for experimentation

Typical source data: Rapiscan 620DV

https://www.rapiscansystems.com/en/products/rapiscan-620dv

Processing Pipeline for
Object Recognition in X-Ray Images
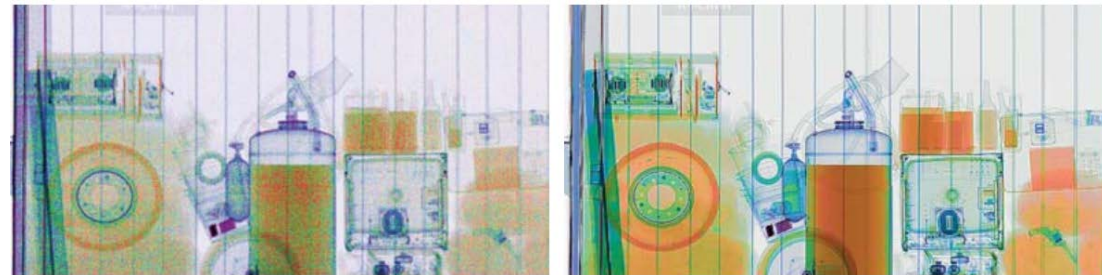
Sample Algorithms: Image Enhancement

Mumford-Shah: Edge detection and denoising

- Denoising preserves edges
- Can be used in denoising, image manipulation, or localization
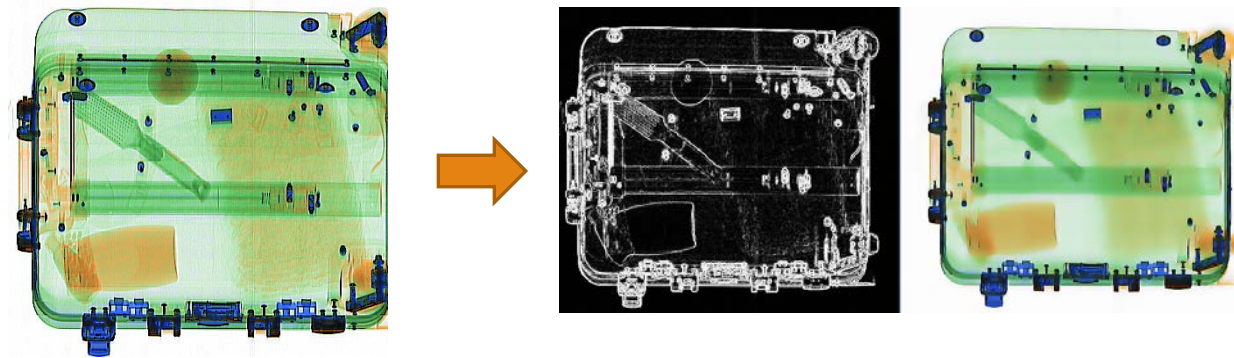
Material Discrimination

- Scanners often include large amount of noise
- Focus on spatial regions rather than individual pixels

S. Ogorodnikov and V. Petrunin. Processing of interlaced images in 4–10 MeV dual energy customs system for material recognition. Physical Review Special Topics – Accelerator and Beams, 5(10):67–77, 2002
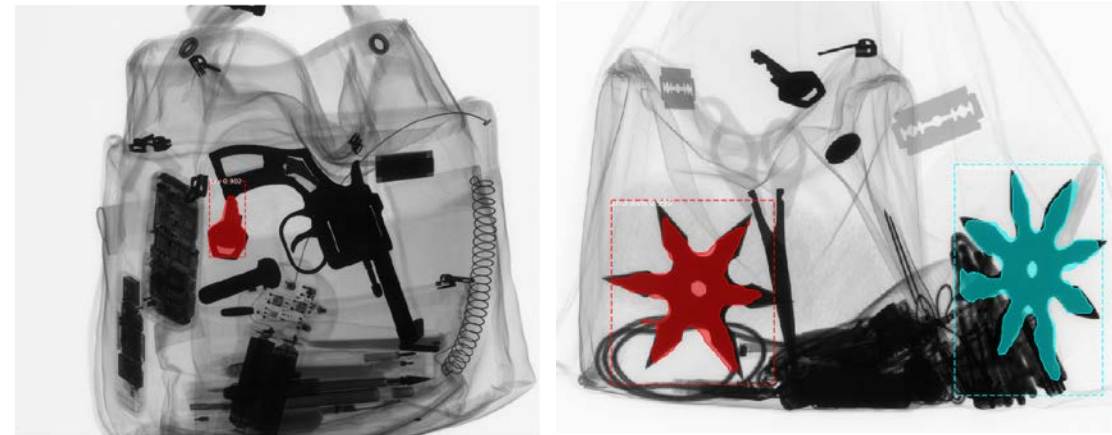
Sample Algorithms: Segmentation/Identification

Active Contours

◦ Performs segmentation from localization

◦ Reshapes to fit objects

◦ Can be used for labeling and segmentation

Mask R-CNN

◦ High-quality image object detection method

◦ Identifies objects in the image

◦ Recognizes distinct objects

◦ Can operate even with small or hard to see objects

Status

Project recently started, funded by DHS S&T (David Taylor)

Collaborative project with Sandia National Labs and our group

Generating test image sets for luggage
- First round received, working on manual labeling to run and verify learning

Basic pipeline functional, adding modules based on needs
- Putting pieces together, adding Mask R-CNN

Starting learning based on labeled training sets

Next Steps

Add more modules for pipeline
◦ Image preprocessing, material detection, …

Label more images for learning

Add multi-view (top+side or more generic) processing and correlation

Add cargo/container images and processing
◦ Partners/Users sought, please contact us

About Us

Emerging Analytics Center (EAC) at UA Little Rock

Center of Expertise in Interactive Visualization, Virtual and Augmented Reality, Visual Data Analytics and Visual Cybersecurity
◦ Core team with more than 20 years of experience each

Focus: Applied Research in Software and (if necessary) Hardware

Largest Center of its kind in the US
◦ >4000 sq ft lab space, ~25 staff/students, >$2M research/year
◦ "One of each" approach to hardware: choose most appropriate platform, not the one available

http://eac.ualr.edu   eacinfo@ualr.edu

Interactive Large Data Visualization

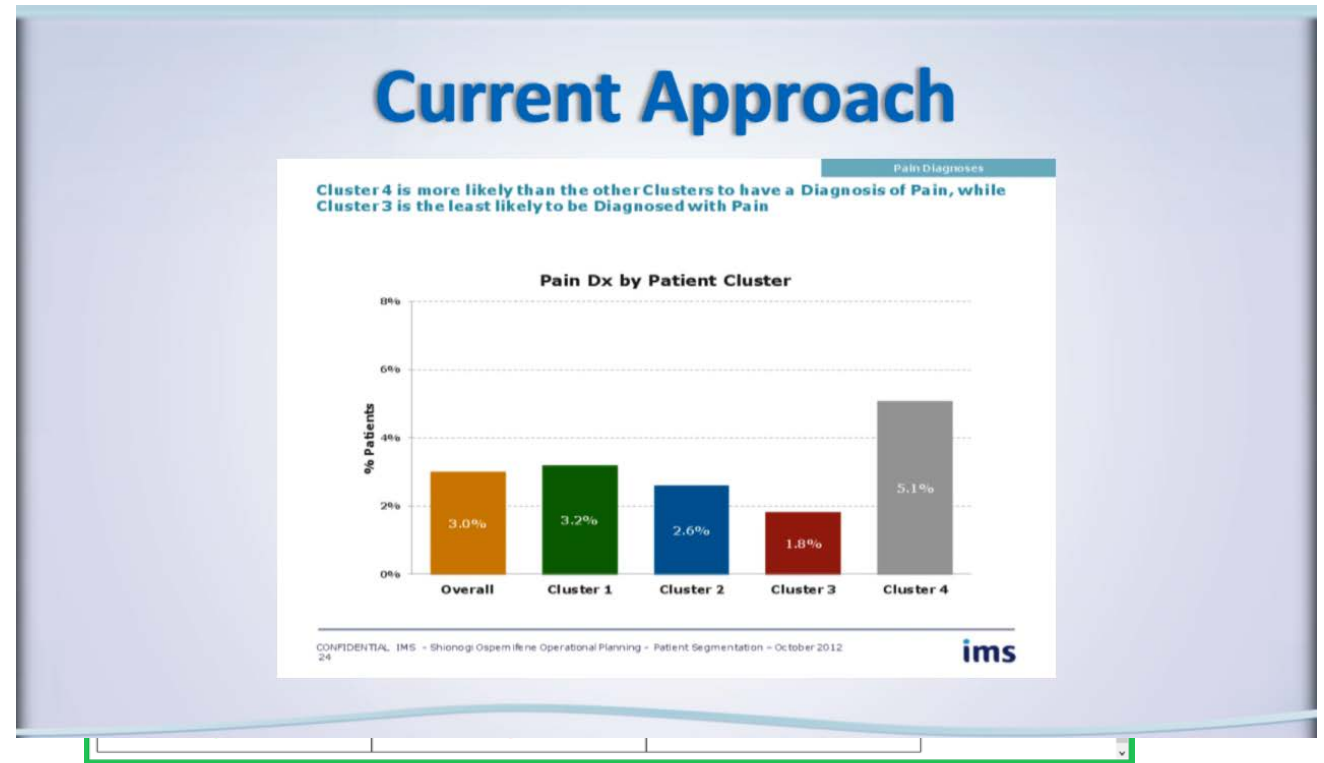**Different Application Areas**
- Medical, Sales, Social Nets, …

Goal: High Density, Interactive, Exploratory Visualizations
- Often custom most effective

From Mobile to Web to VR
- Whatever is most appropriate

Emerging Analytics Center

Questions? Comments?
Contact us at dpreiners@ualr.edu, +1 501 569 8140
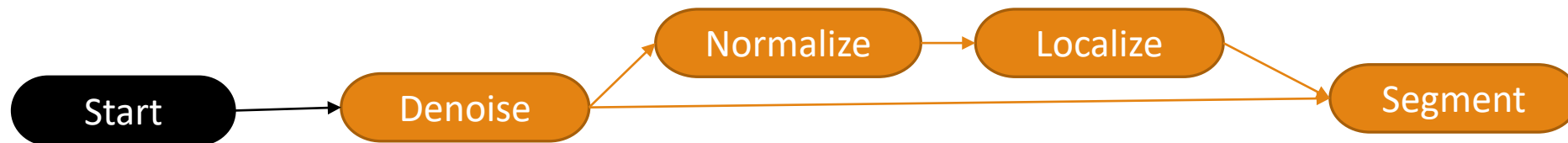
Add-on Materials

Our Modular Pipeline

Code once, test diversely

Separate problem into steps, then explore diverse solutions to these steps

Simple example command:

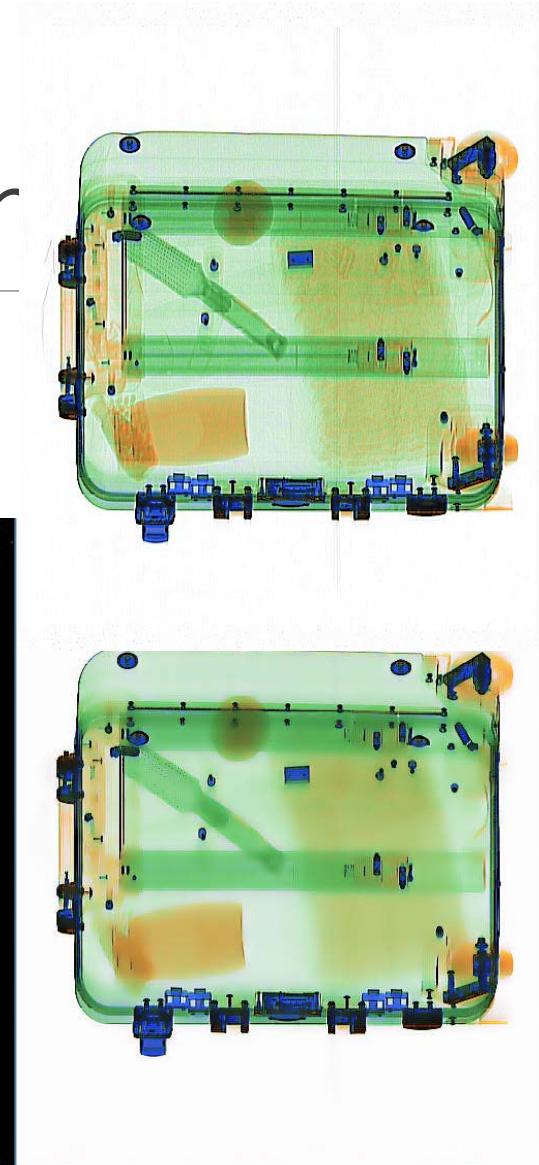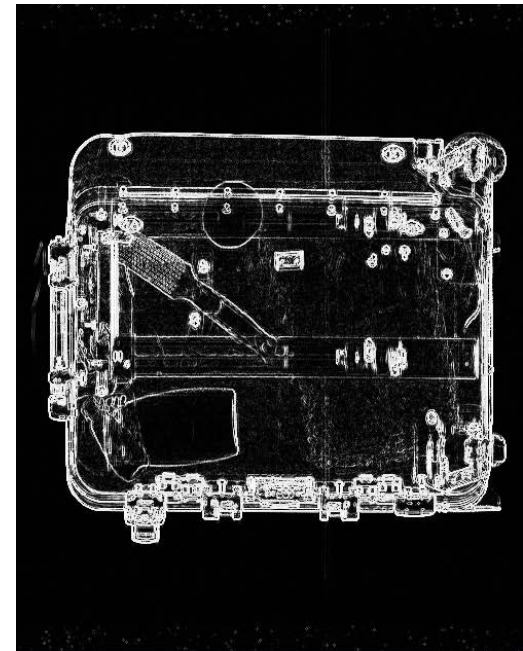- ◦ c>mumfordShah() : c>equalizeHistogram() : 1>applyMask(invertImage(c>binaryThreshold(40)))

Sample Algorithms: Mumford-Shah

Performs edge detection and denoising

Denoising preserves edges

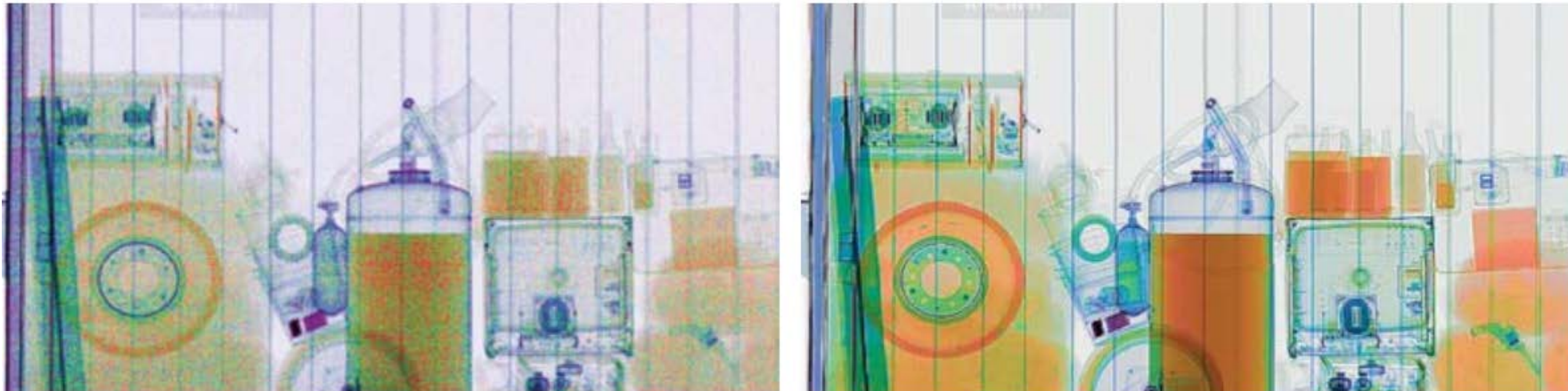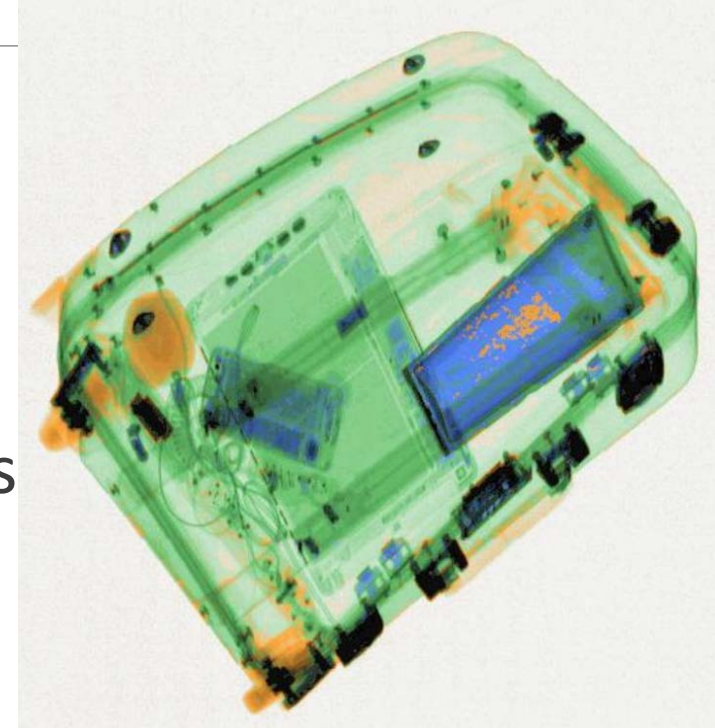Can used in denoising,

image manipulation, or localization

Sample Algorithms: Material Discrimination

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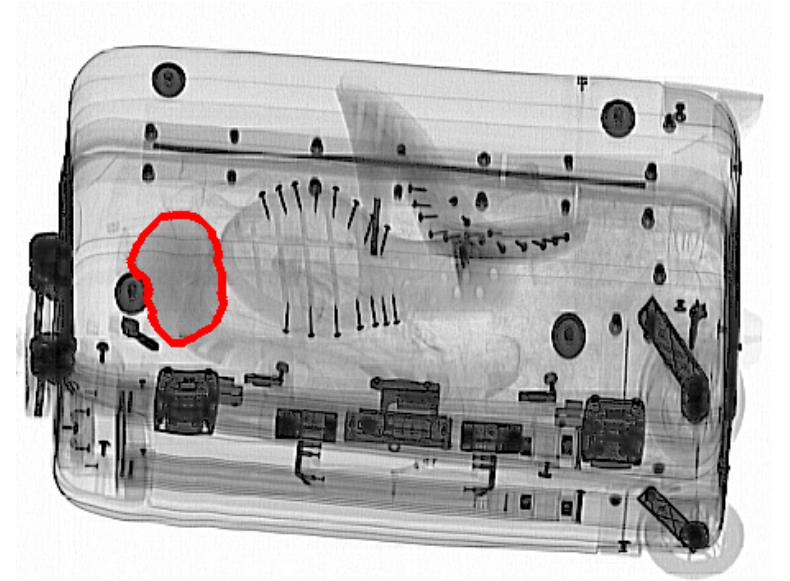
Sample Algorithms: Active Contour

Performs segmentation from localization

Reshapes to fit objects

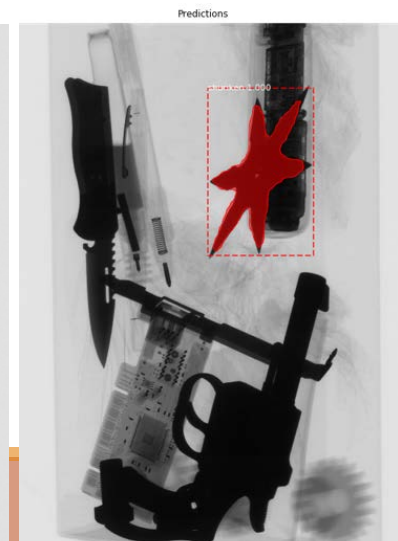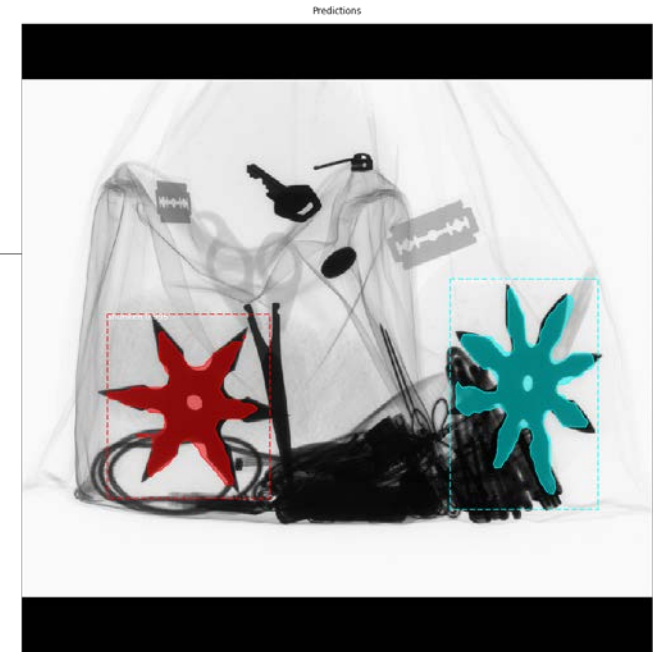Can be used for labeling and segmentation

Sample Algorithms: Mask R CNN

Identifies objects in the image

Recognizes distinct objects

Can operate even with small or hard to see objects

Goals

The goal of our solution is to provide full instance segmentation
◦ This would give number, location, and type of objects

If unable to realize, various other types of output can still provide value to operators

Transfer to other application areas, specifically containers

Classification   Semantic Segmentation
Object Detection   Instance Segmentation