Automated Threat Detection In X-Ray Imagery For Advanced Security Applications

Presentation

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Harmful Object Detection : XRay Images

- Limited Dataset
- Accuracy Improvement
- Speed Improvement

Limited Dataset & X-Ray Images differs from normal Images

Popular Datasets available For Training mostly contains only 4 classes of Objects: Knife, Razor/Blade, Shuriken and Gun. But actual machines used at site need to identify more than 12 classes of objects : Gun, Knife, Bomb, Scissor, Blade, Spanner, Tools, GunParts, Mobile, BatteryBank, Charger, Battery etc. Each of these classes can have different object types and orientations

Limited Data : Normal Data Augmentations

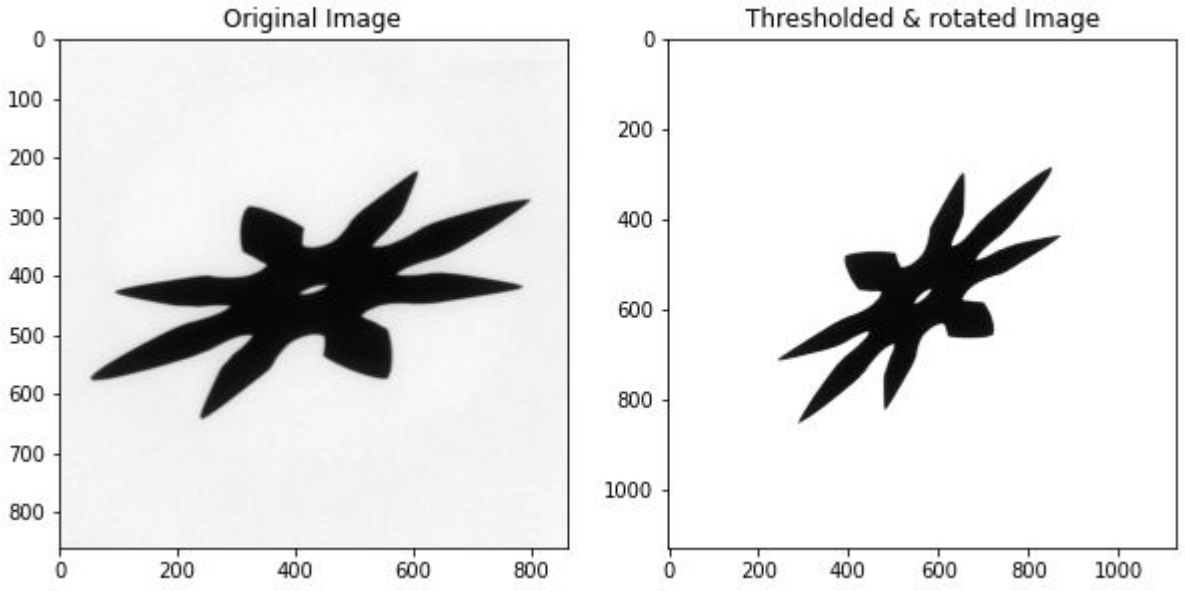
Synthetic Image Generation

- Guns

- Shuriken

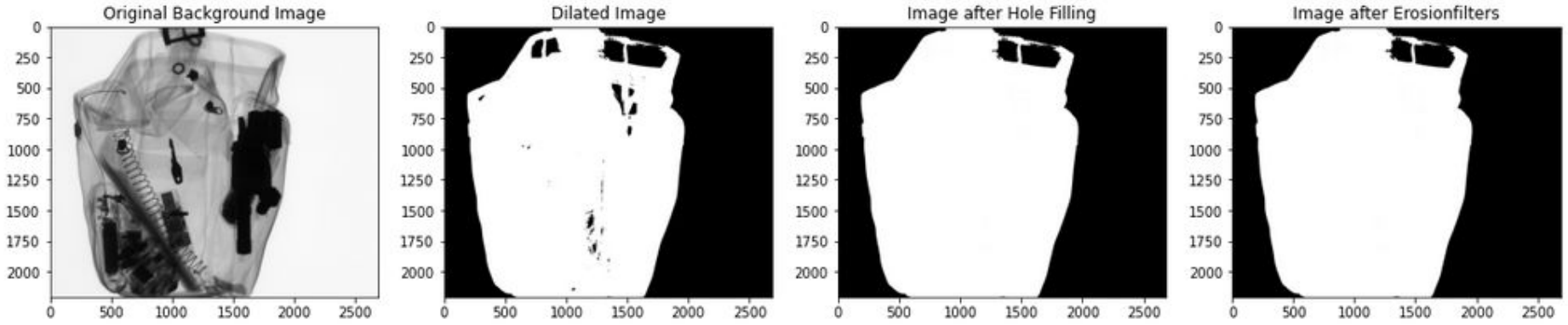
Synthetic Image Generation

1. Threat Signature Transformation



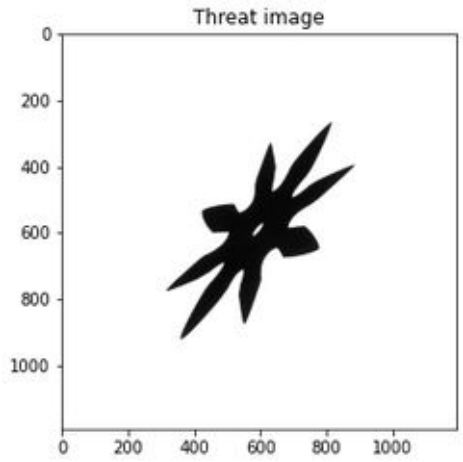
Synthetic Image Generation

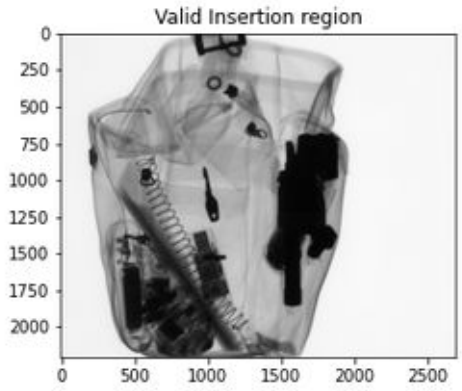
2. Image position determination

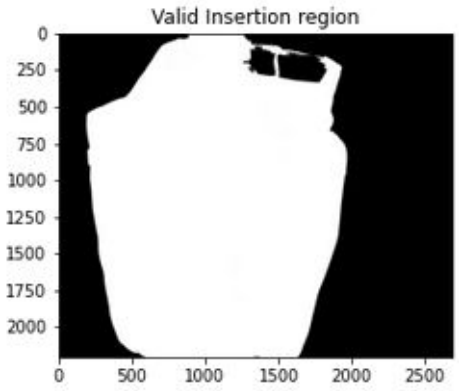


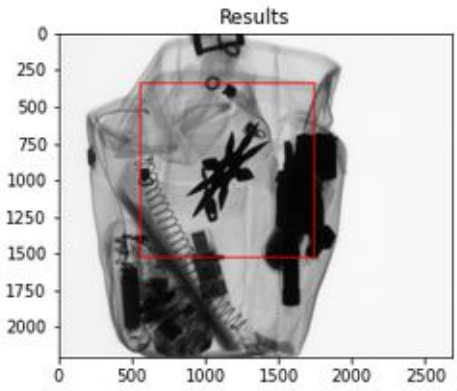
Synthetic Image Generation

3. Image compositing

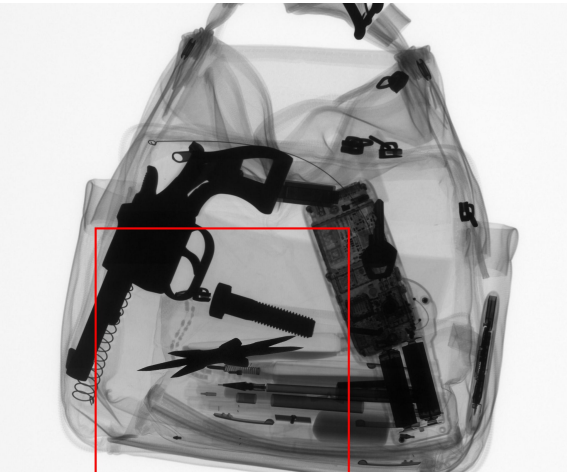








Sample Results



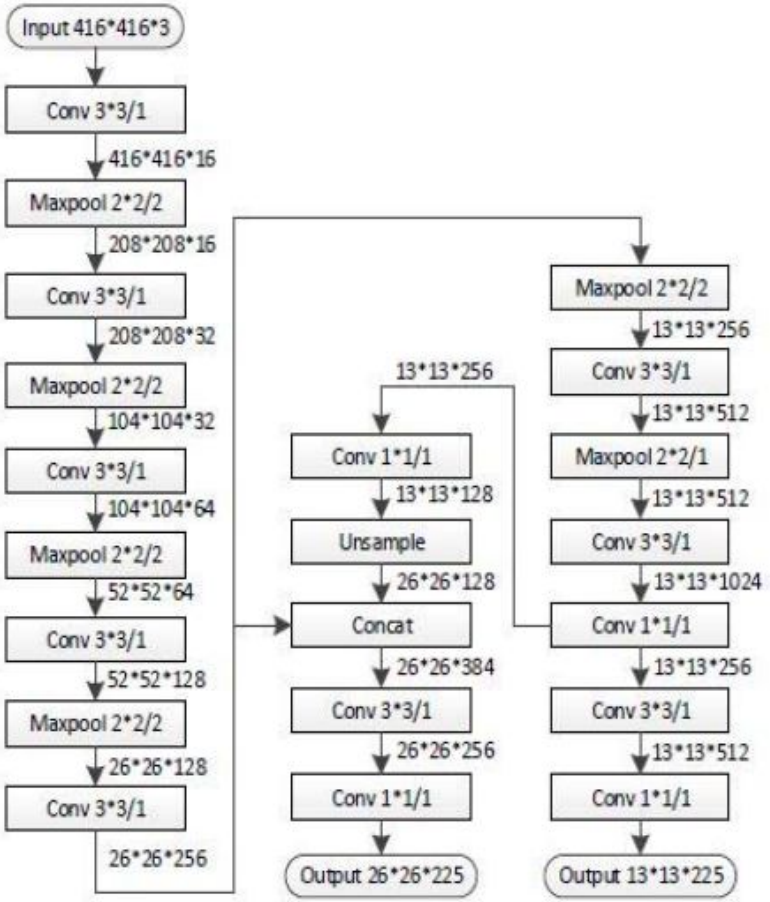
Modelling : Yolov3-tiny

- Decreased depth of the convolutional layer in Yolov3
- 10 times Faster than Yolov3, provides low accuracies

https://www.researchgate.net/publication/340893960_YOLO_v3-Tiny_Object_Detection_and_Recognition_using_one_stage_improved_model

Architecture : Yolov3-tiny

Prediction of bounding boxes occurs at two different feature map scales, which are 13×13, and 26×26 merged with an upsampled 13×13 feature map.



https://www.researchgate.net/publication/340893960_YOLO_v3-Tiny_Object_Detection_and_Recognition_using_one_stage_improved_model

Choose & Label Dataset for training :

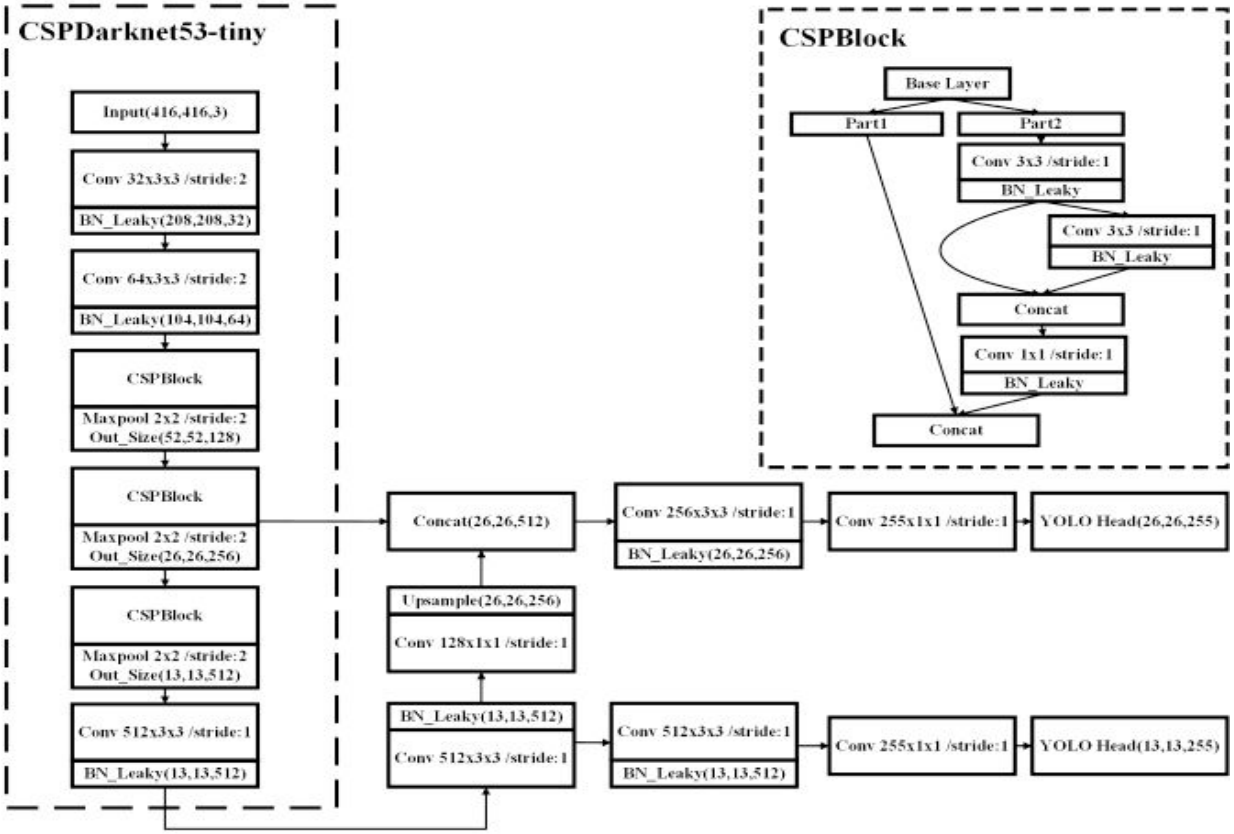
`Set	GDXRay	Baggage Data
Training	Series	B0046
	Images	1-200
	Series	B0047
	Images	1-10
Testing	Series	B0047
	Images	11-90

Real Data [GDXRay] : 210 Training Data & 90 Testing Data
Synthetic Data : 1600 Training Data & 400 Testing Data

Results of Real Dataset :

Classes	Testing Accuracy (mAP)	
	Real Model(on Real Dataset)	Synthetic Modell(on Real Dataset)
Guns	93.59	79.26
Shuriken	86.59	12.37

Yolov4 Architecture :



Accurracy & Speed Improvement : Model Comparision

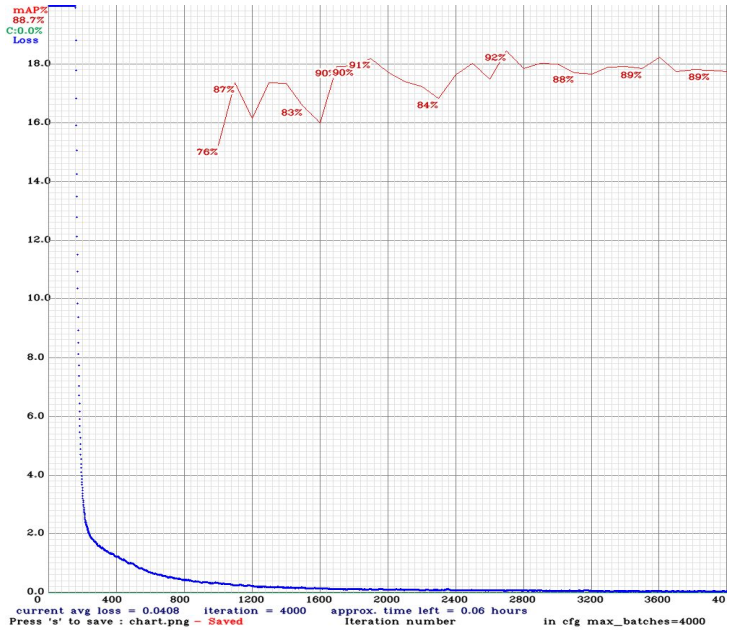
- Transfer Learning : Using Pre-Trained Weights and fine tune the model.
- Batch & Subdivision - Control no of images to be send for processing. Appropriate number can improve GPU utilization.
- Reduce no of filters in architecture as we need less no of classes (5+classes)*3
- Check model is trained properly using the graph
- Save the weights after several iterations, we are saving after every 1000 iterations.

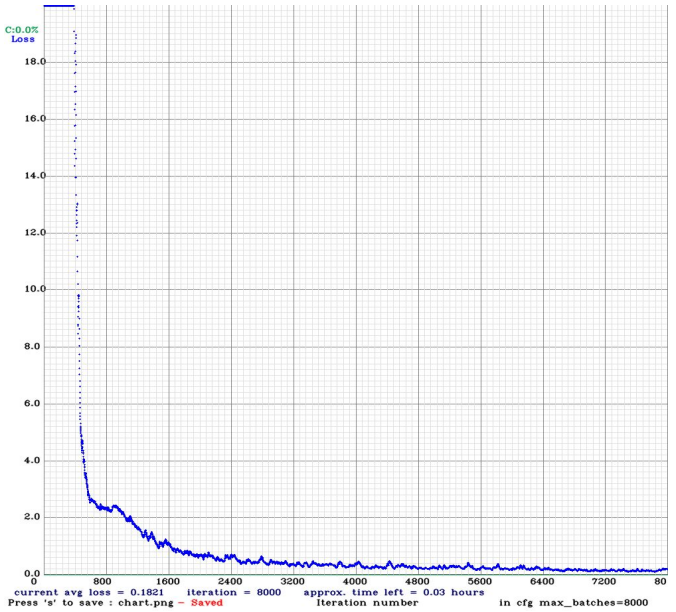
The Yolov4-tiny method uses CSPDarknet53-tiny network as backbone network which uses CSPBlock module in cross stage partial network instead of the ResBlock module in residual network.

The CSPBlock module divides the feature map into two parts, and combines the two parts by cross stage residual edge. This makes the gradient flow can propagate in two different network paths to increase the correlation difference of gradient information. The CSPBlock module can enhance the learning ability of convolution network comparing with ResBlock module. Although this increase computation by 10%-20%, it improves the accuracy.

To reduce the amount of calculation, it removes the computational bottlenecks that have higher amount of calculation in CSPBlock module. It improves the accuracy of Yolov4-tiny method in the case of constant or even reduced computation.

Training Graphs :

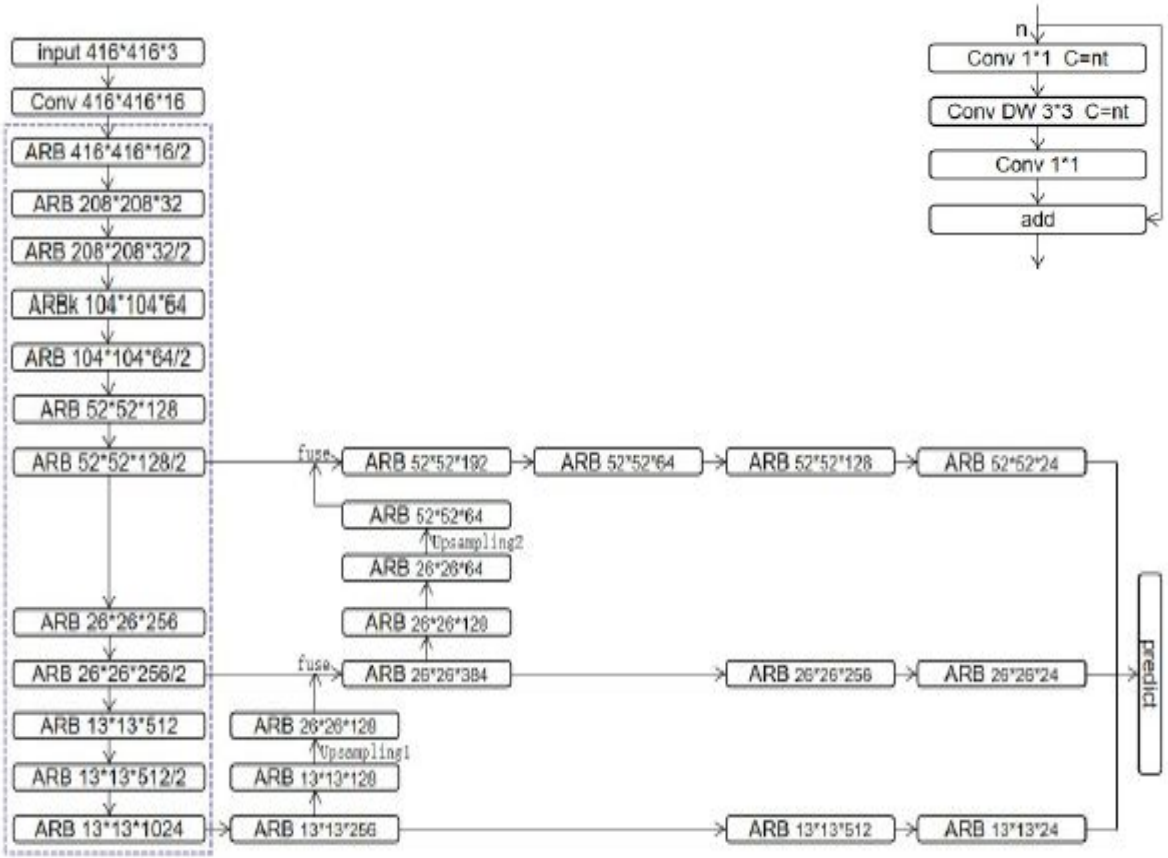




Comparison Metrics : IOU = 50%

MODEL	YOLOV3-Tiny	YOLOV4-Tiny
Gun (AP)	93.59	96.95
Knife (AP)	94.82	93.95
Razor (AP)	55.05	84.62
Shuriken (AP)	86.59	79.26
Mean Average Precision	82.52	88.69
Average IOU	72.37	70.46
BFLOPS	5.452	6.792
FPS	400	263
Per Frame Inference	2.5 ms	3.8ms

Improved YoloTinyV3 Model



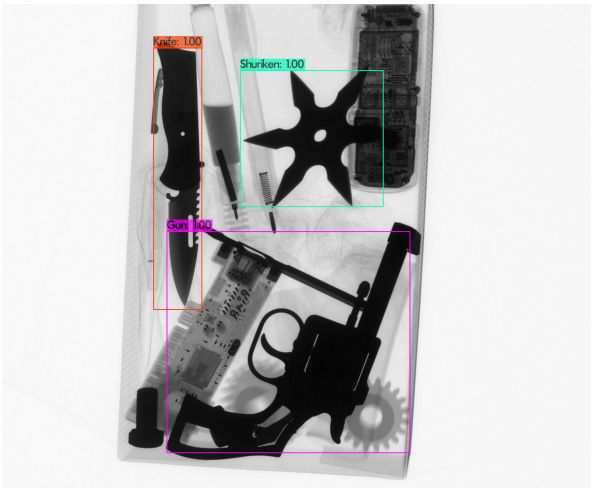
Speed Improvement :

Future Step , increase the speed of model using pruning techniques

Gan for Data Generation :

- Time Consuming but may offer better results.
- Comparative analysis of GAN DataGeneration and synthetic image generation.

Sample Results :



Summary and Discussion?

- Train the model on new objects
- Good accuracy for gun data
- Add Diversity & Save Human Cost
- Smaller Objects improving or changing yolov3-tiny model may give some accuracies
- Increase synthetic train dataset from 100 to 500, increases accuracy from 8.1% to 12%
- Need further analysis on real data & synthetic data
- Limitation single background/target image and few threat images per classes.
- Compare GANS and Synthetic Data Creation Approach

Questions?