A Novel Incremental Learning Driven Instance Segmentation Framework to Recognize Highly Cluttered Instances of the Contraband Items

Supplementary Material

Datasets Detail:

This supplementary material reports the detailed description of the datasets which we used to evaluate the proposed framework:

GDXray [1], introduced in 2015, is a public X-ray dataset designed for non-destructive testing (NDT) purposes. It contains scans for different NDT categories like *castings*, *welds*, *baggage*, *nature*, and *settings*. In the proposed study, we only considered the *baggage* category because it is the only category within the GDXray [1] dataset that contains scans for detecting baggage threats. The total scans within the *baggage* category are 8,150, which contains one or more suspicious items like *guns*, *shuriken*, *knives*, and *razors*. Moreover, the dataset contains box-level annotations for these suspicious items (which we used for evaluating the proposed framework). Furthermore, since the proposed study deals with the instance segmentation (in an incremental fashion), we also marked the mask-level annotations for the suspicious items (using the MATLAB Image Labeler Application) and used them for further validating the proposed framework. We have also publicly released these annotations for the research community, and they are available within the source code repository on GitHub[1]. Apart from this, to make the data more challenging, we have also identified and added the *chip* category in the GDXray [1] dataset and trained the proposed framework to extract it as well.

SIXray [2] is a large-scale baggage X-ray imagery dataset that has been recently introduced to develop computer-aided screening systems capable of detecting suspicious items such as *guns*, *knives*, *wrenches*, *pliers*, *scissors*, and *hammers*. We also want to highlight that SIXray [2] dataset contains extremely overlapping and occluded contraband items and is the most challenging baggage X-ray imagery dataset to date [2]. SIXray [2] contains a total of 8,929 positive scans (containing one or more contraband items), 1,050,302 negative scans (which do not contain any contraband item), and it has been designed to generate real-life class imbalance scenarios.

Moreover, the dataset also contains bounding box annotations for all the 8,929 scans recorded in XML files. As with the GDXray [1], we have also generated (and publicly released) the mask annotations for the suspicious items in SIXray [2] using the MATLAB Image Labeler Application and evaluated our proposed incremental instance segmentation framework (on the SIXray dataset) using both box-level and mask-level annotations.

Combined Dataset: We also evaluated the proposed framework's performance on the combined dataset by merging the GDXray [1] and SIXray [2]. Such a dataset contains multi-vendor X-ray scans to assess the proposed framework's robustness towards baggage threat detection for various items and occlusions.

In the combined dataset, there are a total of 1,067,381 scans, from which 17,079 contains suspicious items (and so are termed as positives), whereas 1,050,302 scans contain normal items (negatives). Furthermore, there are nine suspicious item classes in the combined dataset, namely, *shuriken*, *razors*, *wrenches*, *pliers*, *hammers*, *guns* (*handguns*), *scissors*, *chips*, and *knives*. Moreover, the total number of

[1] The complete source code and its documentation is available at https://github.com/taimurhassan/inc-inst-seg.

iterations on the combined dataset to obtain an instance-aware model is six since the dataset contains a maximum of six instances of the same item in the input scan.

References:

[1] D. Mery, V. Riffo, U. Zscherpel, G. Mondrag´on, I. Lillo, I. Zuccar, H. Lobel, and M. Carrasco, “GDXray: The Database of X-ray Images for Nondestructive Testing,” Journal of Nondestructive Evaluation, Volume 34, Issue: 4, 2015.

[2] C. Miao, L. Xie, F. Wan, C. Su, H. Liu, J. Jiao, and Q. Ye, “SIXray: A Large-scale Security Inspection X-ray Benchmark for Prohibited Item Discovery in Overlapping Images,” in IEEE International Conference on Computer Vision and Pattern Recognition (CVPR), pp. 2119–2128, 2019.