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PIDray: A Large-Scale X-ray Benchmark for Real-World Prohibited Item Detection

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Abstract

Automatic security inspection relying on computer vision technology is a challenging task in real-world scenarios due to many factors, such as intra-class variance, class imbalance, and occlusion. Most previous methods rarely touch the cases where the prohibited items are deliberately hidden in messy objects because of the scarcity of large-scale datasets, hindering their applications. To address this issue and facilitate related research, we present a large-scale dataset, named **PIDray**, which covers various cases in real-world scenarios for prohibited item detection, especially for deliberately hidden items. In specific, PIDray collects 124, 486 X-ray images for 12 categories of prohibited items, and each image is manually annotated with careful inspection, which characterizes it, to our best knowledge, with the largest volume and varieties of annotated images with prohibited items to date. Meanwhile, we propose a general divide-and-conquer pipeline to develop baseline algorithms on PIDray. Specifically, we adopt the tree-like structure to suppress the influence of the long-tailed issue in the PIDray dataset, where the first course-grained node is tasked with the binary classification to alleviate the influence of head category, while the subsequent fine-grained node is dedicated to the specific tasks of the tail categories. Based on this simple yet effective scheme, we offer strong task-specific baselines across object detection, instance segmentation, and multi-label classification tasks and verify the generalization ability on common datasets (*e.g.*, COCO and PASCAL VOC). Extensive experiments on PIDray demonstrate that the proposed method performs favorably against current state-of-the-art methods, especially for deliberately hidden items. Our benchmark and codes are available at https://github.com/lutao2021/PIDray.

Keywords Prohibited item dataset · Object detection · Instance segmentation · Multi-label classification

1 Introduction

Security inspection is tasked with checking packages against specific criteria and reveals any potential risks to ensure public safety, which is widely applied in real-world scenarios, such as public transportation and sensitive departments. In recent years, a set of surveys provide an in-depth review of developments in this field (Akcay & Breckon, 2022; Mery et al., 2020; Velayudhan et al., 2022). In practice, there is an ever-increasing demand for inspectors to monitor the scanned X-ray images generated by the security inspection machine to specify potentially prohibited items, such as guns, ammunition, explosives, corrosive substances, and toxic and radioactive substances. But unfortunately, it is highly challenging for inspectors to localize prohibited items hidden in messy objects accurately and efficiently, which poses a great threat to safety.

Deep learning technologies have sparked tremendous progress in the computer vision community (Ren et al., 2015;

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