## Supplementary materials

The following supplementary materials provide more details of our proposed method and experimental setups, which are omitted in the main paper due to space limitation.

### A.2.2. Additional Color X-ray Security Images

The color of objects in the X-ray security image varies differently according to the materials, thickness, viewpoint and complex background, as shown in Figure 10.

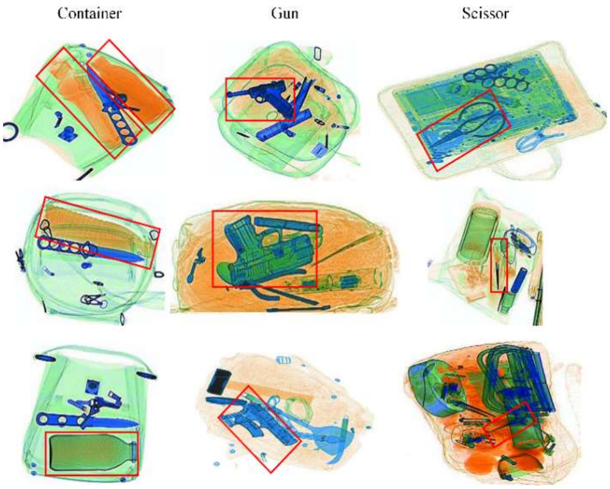


Figure 10. Examples of the X-ray security image. The appearance of item varies for different materials, thickness, viewpoint and background. The prohibited items are marked with a red box.

### A.3.3 Additional Details of Loss Function

We develop a Luminance loss in Logarithmic form ($LL$) $\mathcal{L}_{LL}$ as follows:

$$\mathcal{L}_{LL} = 1-\left[\log \ell(I_f, I_{fb}, w_1) + \log \ell(I_b, I_{fb}, w_2)\right] \quad (19)$$

where $\ell(x,y,w) = \frac{2\mu_x\mu_y}{\mu_x^{4w} + \mu_y^{2}}$, then we could deduce:

$$\begin{aligned}\mathcal{L}_{LL} &= 1\text{-}\left[\log \ell(I_f, I_{fb}, w_1) + \log \ell(I_b, I_{fb}, w_2)\right] \\ &= 1\text{-}\log \frac{2\mu_f\mu_{fb}}{\mu_f^{4w_1} + \mu_{fb}^2} \bullet \frac{2\mu_b\mu_{fb}}{\mu_b^{4w_2} + \mu_{fb}^2} \\ &= 1\text{-}\log \frac{4(\mu_f\mu_b)\mu_{fb}^2}{\mu_f^{4w_1}\mu_b^{4w_2} + (\mu_f^{4w_1} + \mu_b^{4w_2})\mu_{fb}^2 + \mu_{fb}^4} \\ &= 1\text{-}\log \frac{4\mu_f\mu_b}{\frac{\mu_f^{4w_1}\mu_b^{4w_2}}{\mu_{fb}^2} + \mu_{fb}^2 + (\mu_f^{4w_1} + \mu_b^{4w_2})}\end{aligned} \quad (20)$$

where $\mu_f$, $\mu_b$ and $\mu_{fb}$ respectively represent the local mean of the prohibited item $I_f$ the baggage image $I_b$ and the fused image $I_{fb}$. When the function is optimized to the minimum, the fusion result $\mu_{fb}$ is expected to converge to be $\mu_f^{w1} \cdot \mu_b^{w2}$. Meanwhile, given the $\mu_f$ of non-overlapping region is 1, the non-overlapping region of fused image $I_{fb}$ could retain its own information in the background and avoid the influence of the prohibited item.

In practice, we use $\ell(x,y,w) = \frac{2\mu_x\mu_y + \varepsilon}{\mu_x^{4w} + \mu_y^{2} + \varepsilon}$, adding a tiny constant $\varepsilon$ to relieve an abnormal zero value.

The power weights $w_1$ and $w_2$ denote the preservation degree. We automatically estimate the weights $w_1$ and $w_2$ from the feature of R, G and B component of the prohibited item and the baggage image independently, to get different power weights $w_1$ and $w_2$ for R, G and B component. To be specific, we first activate the features by using the Softmax function, and then multiply the result by 2 to ensure the sum of $w_1$ and $w_2$ is 2.

### A.4.1 Additional Details of SIXray Dataset

SIXray dataset contains six kinds of prohibited items: guns, knives, wrenches, pliers, scissors and hammers. These items have great diversity in terms of scale, viewpoint and overlapping. The statistical information of SIXray dataset is shown in Table 6. The distribution of these prohibited items is similar to the real-world security inspection scenario, where the occurrence of prohibited items is rather rare. This dataset consists of SIXray10, SIXray100 and SIXray1000 dataset, which involves 10×, 100× and 1000× negative images without prohibited items.

Table 6 The distribution of the public SIXray dataset.

| The SIXray Dataset (1,059,231) | | | | | | |
|---|---|---|---|---|---|---|
| Positive (8929) | | | | | | Negative |
| Gun | Knife | Wrench | Plier | Scissor | Hammer | |
| 3131 | 1943 | 2199 | 3961 | 983 | 60 | 1,050,302 |

### A.4.5. Additional evaluation experiments

We prepare 12 different groups of prohibited X-ray security datasets, each consisting of 40 real prohibited X-ray security images and 60 synthetic prohibited X-ray security images from the proposed model. Then, 12 experienced X-ray security inspectors judge the true and false of the 100 images. The correct number of each inspector is listed in Table 7, and the average mis-judgement ratio of all inspectors is 53 among 100. This result demonstrates that our synthetic prohibited X-ray security images are realistic enough to fool the inspectors.

Table 7 The subjective evaluation score of each inspector judging between the real and synthetic images.

| id | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Score | 57 | 71 | 46 | 30 | 53 | 36 | 57 | 46 | 44 | 68 | 28 | 32 | 47.3 |