电子科技大学
University of Electronic Science and Technology of China

Neural network-based military aircraft identification

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Catalogue

Background

The supervision of pictures and videos of confidential military aircraft on the Internet is an important part of the protection of state confidential military information. Before the relevant photos and videos of confidential military aircraft are uploaded to the Internet, technical means need to be taken to identify and intercept them.

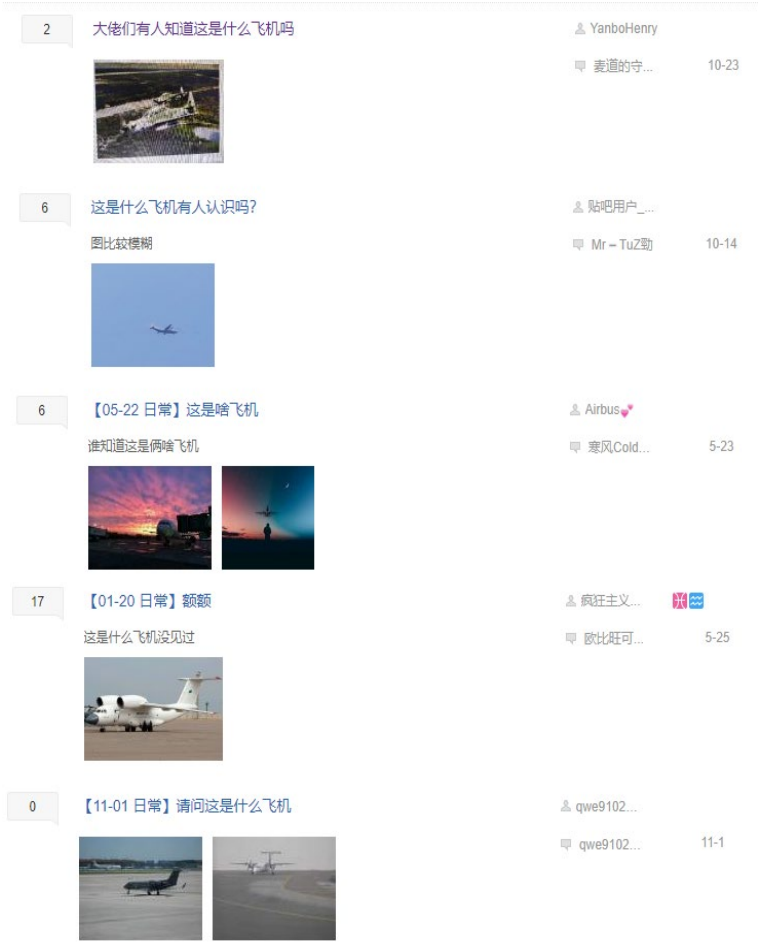
偷拍军机视频获刑

发布时间：2012-05-01 05:55　来源：　进入电子报

楚天金报讯 据《福州晚报》报道 福建一名男子拍下军用飞机视频并上传至网络，日前被法院以故意泄露国家秘密罪判处缓刑。

2009年8月，福州市永泰县残疾人黄某驾驶残疾人代步车来到福州市仓山区探望儿子。途经义序机场时，他用数码相机拍摄了义序路标、机场设施及几架军用飞机的视频。拍摄时，一名路人提醒他“不能拍，会抓”，他未予理会，仍拍摄了1分多钟。随后，黄某把这段视频上传到网上，直至被有关部门制止时，此段视频已播放1.5万多次。

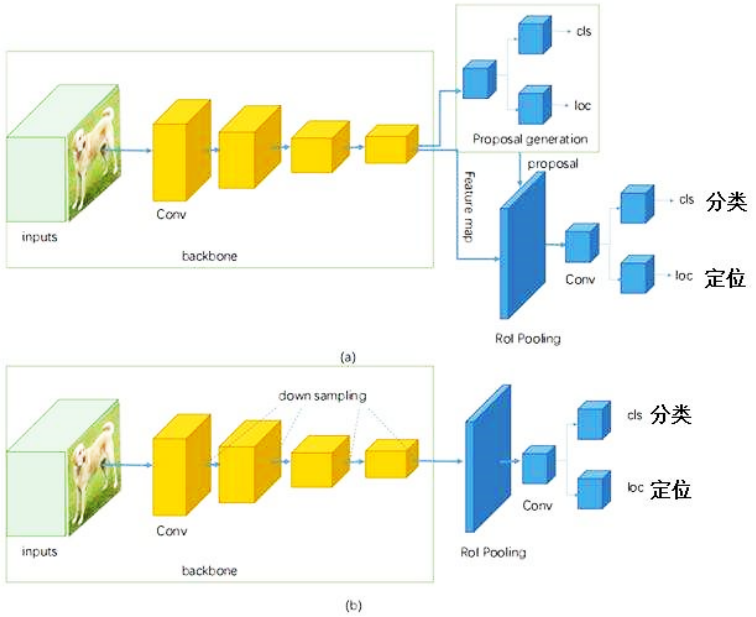
经空军福州指挥所保密委员会鉴定，这段视频中3项为机密级，3项为秘密级。



Background

The purpose of our research is to select an appropriate target detection model to identify the aircraft and make the model as lightweight as possible, so that it can be deployed to life scenes for application.

Two-stage Detectors & One-stage Detectors



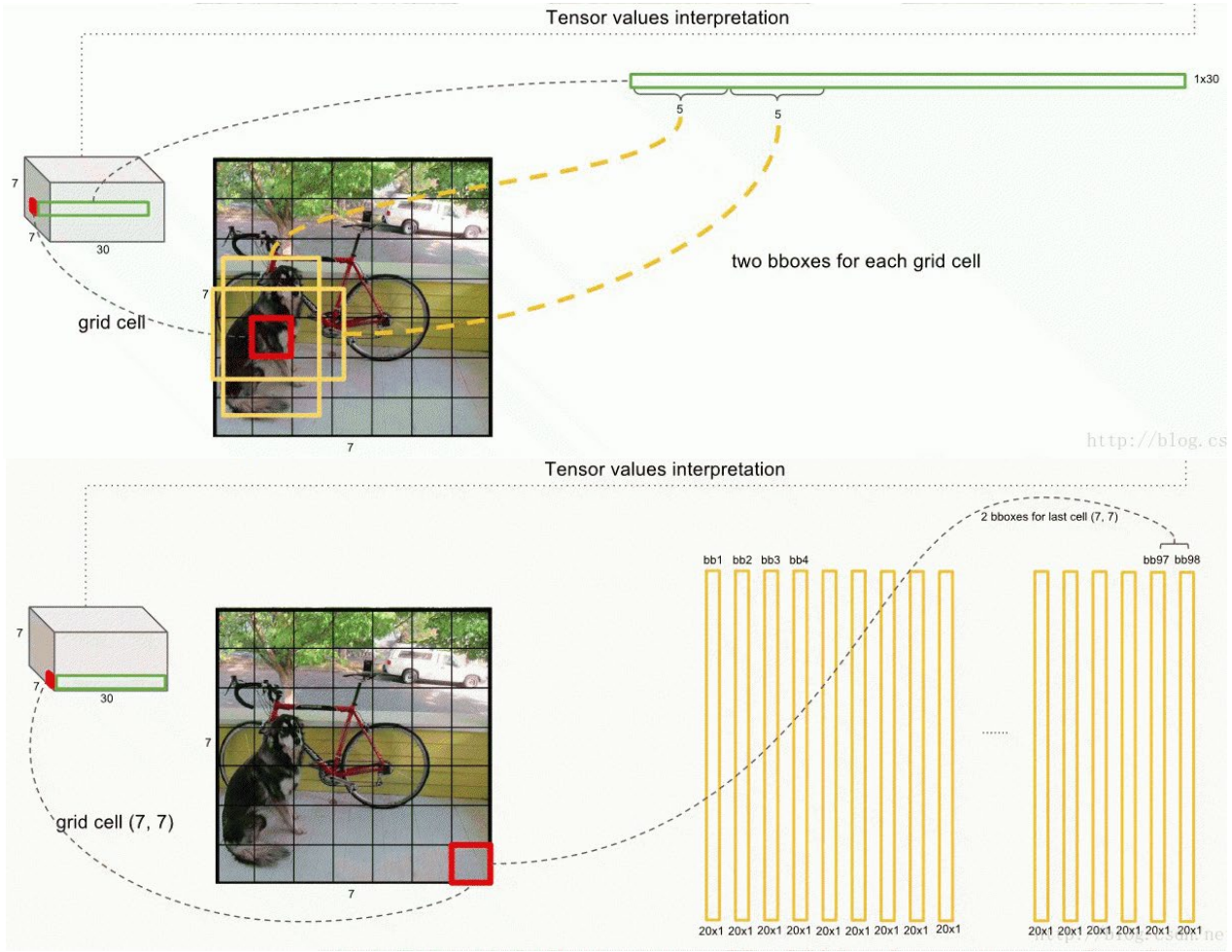
A. Two-stage Detectors
R-CNN、Fast R-CNN、
Faster R-CNN、Mask R-CNN

Lightweight

B. One-stage Detectors
YOLO、YOLO v2、YOLO v3、
Retinanet、SSD、DSSD、RefineDet

Faster

Background



$$\Pr(\text{Class}_i|\text{Object}) * \Pr(\text{Object}) * \text{IOU}_{\text{pred}}^{\text{truth}} = \Pr(\text{Class}_i) * \text{IOU}_{\text{pred}}^{\text{truth}}$$

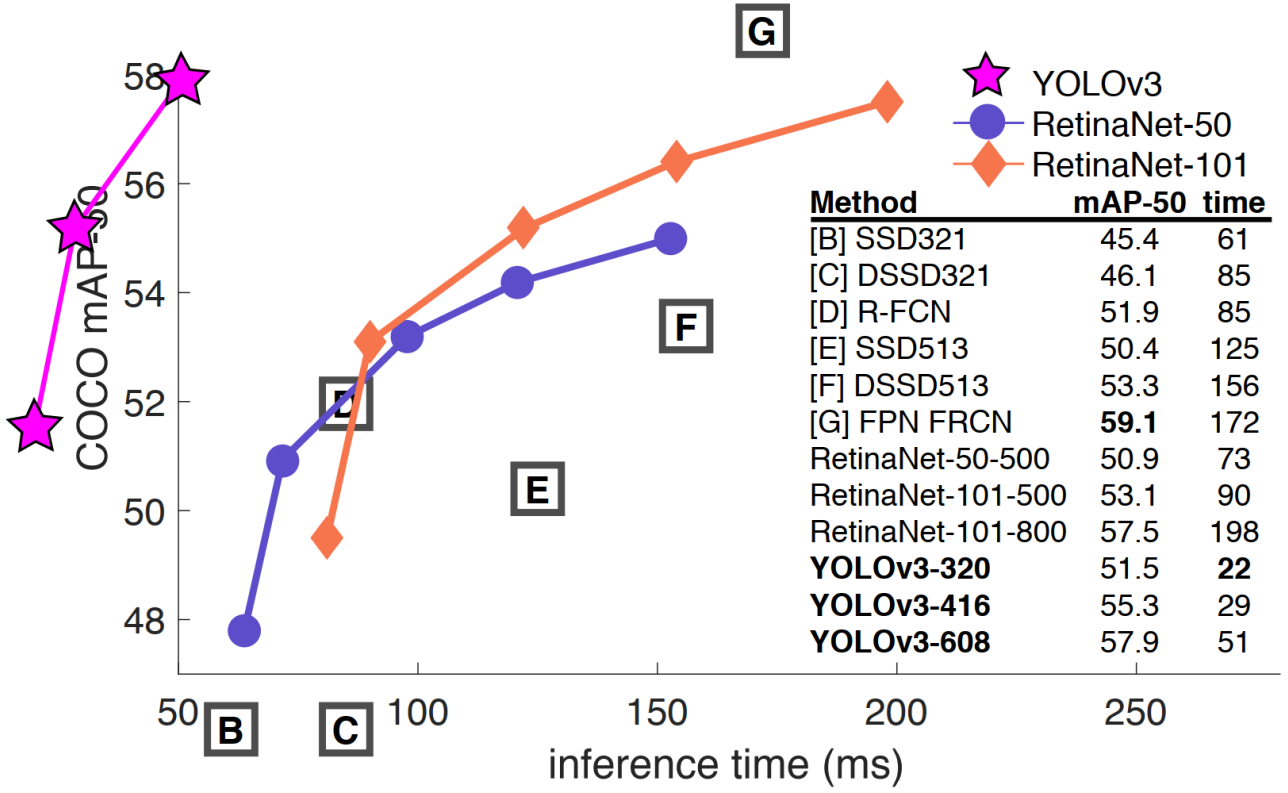
Many methods have been proposed in military aircraft detection and recognition at home and abroad.

In 2016, Redmon et al. Proposed the Yolo algorithm, which integrates the classification, positioning and detection functions into a neural network. After only one calculation, the bounding box and category probability of the target in the image can be directly obtained.

Background

In 2018, Redmon et al. Proposed the yolov3 algorithm, which built a 53 layer benchmark network called darnet-53 by using the idea of jump connection in the residual network for reference.

The network only uses 3 × 3 and 1 × 1, which has the same classification accuracy as resnet-152, but greatly reduces the amount of calculation.

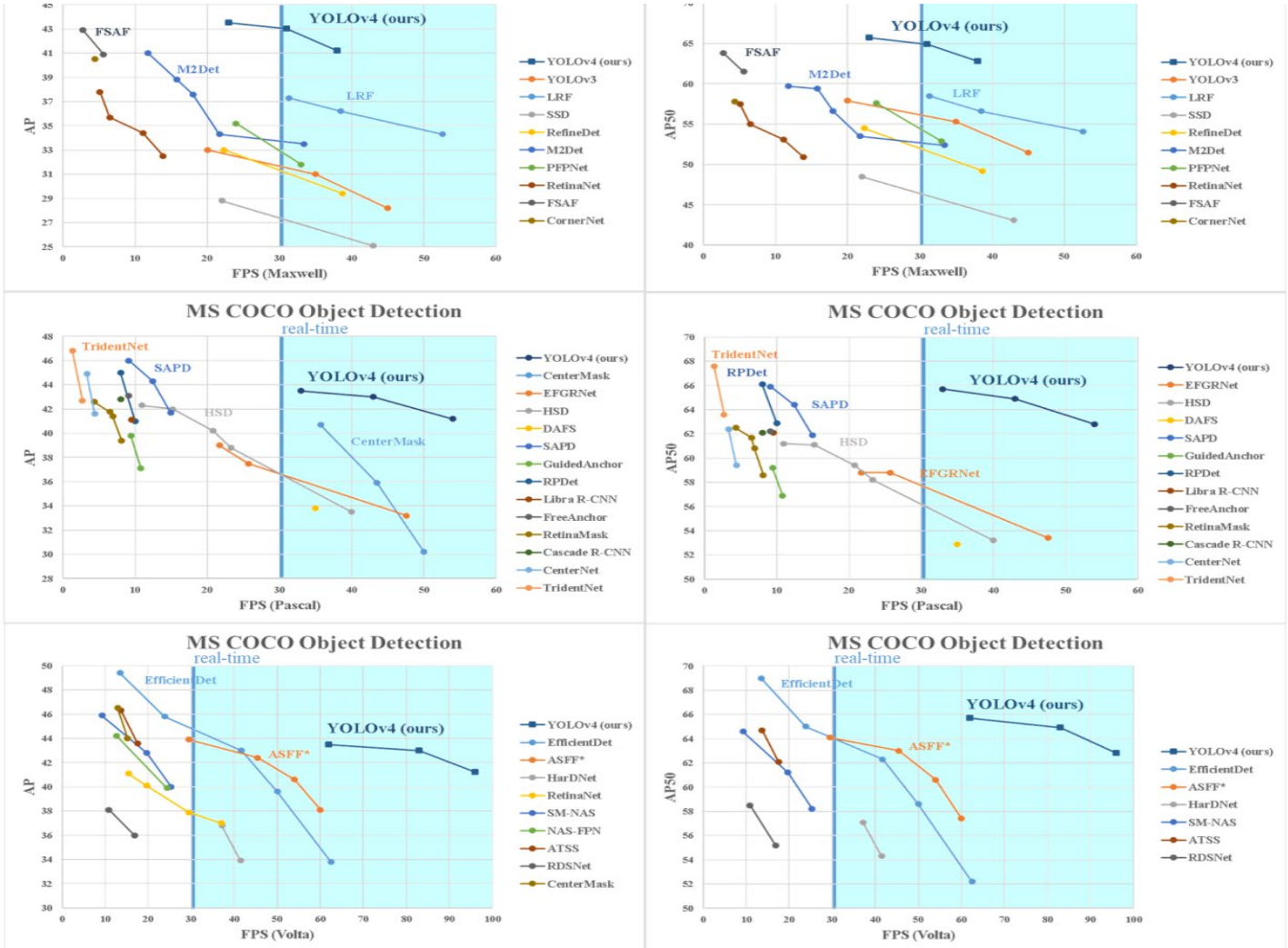


Method	mAP-50	time
[B] SSD321	45.4	61
[C] DSSD321	46.1	85
[D] R-FCN	51.9	85
[E] SSD513	50.4	125
[F] DSSD513	53.3	156
[G] FPN FRCN	**59.1**	172
RetinaNet-50-500	50.9	73
RetinaNet-101-500	53.1	90
RetinaNet-101-800	57.5	198
YOLOv3-320	51.5	**22**
YOLOv3-416	55.3	29
YOLOv3-608	57.9	51

YOLOv3: An Incremental Improvement.

Joseph Redmon, Ali Farhadi. University of Washington

Background



YOLOv4: Optimal Speed and Accuracy of Object Detection.

Alexey Bochkovskiy∗ , Chien-Yao Wang∗ . Hong-Yuan Mark Liao.

In 2020, bochkovskiy et al. proposed yolov4 algorithm, which is continuously improved and developed on the basis of yolov3. Yolov4 can use traditional GPU for training and testing, and can obtain real-time and high-precision detection results.

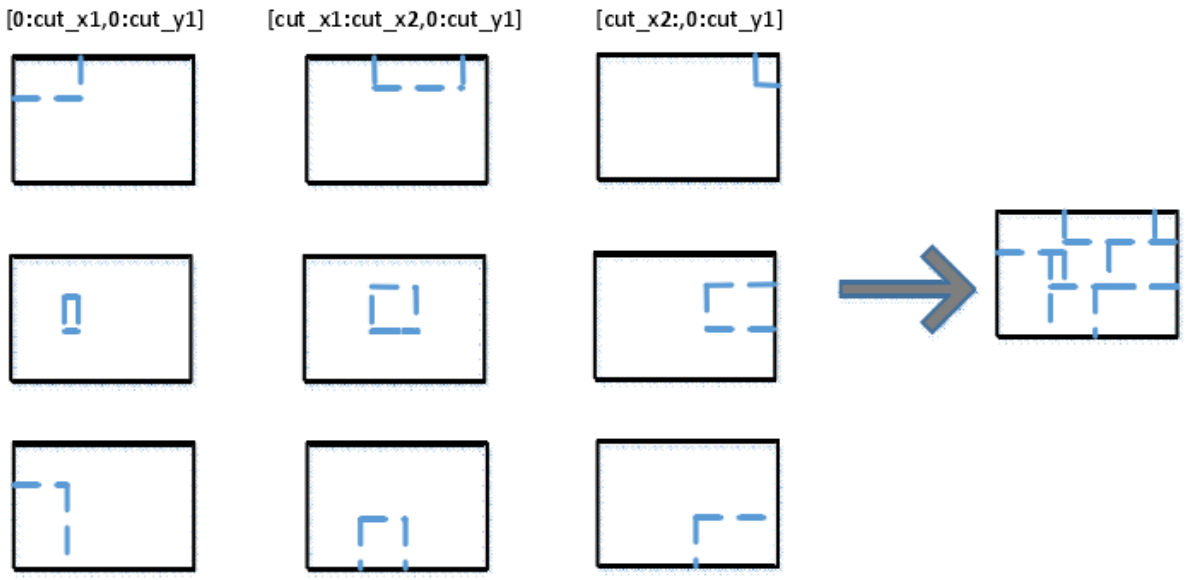
Catalogue

- Background
- Method
- Improvement
- Result

Method

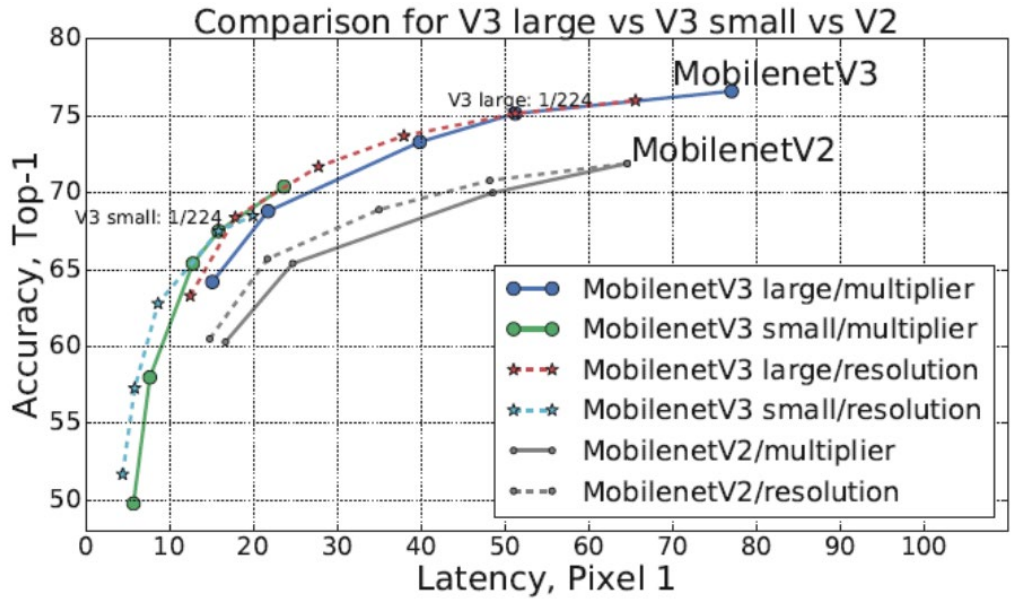
Taking yolov5 model as the prototype, we propose the following five improved methods to improve the training and detection speed of the model.

Firstly, mosaic-9 data enhancement method is adopted, that is, 9 pictures are randomly cut, randomly scaled and randomly arranged to form a new picture, and the picture is introduced into the neural network for learning, which is equivalent to 9 pictures at one time, which greatly enriches the background of the detected object.



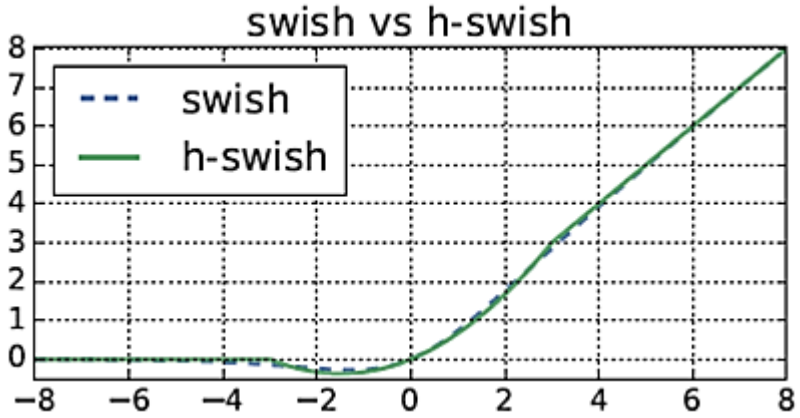
Method

The second is to use the lightweight model mobilenet V3 small to replace the backbone feature extraction network of yolov5 for feature extraction, which can greatly reduce the model complexity without reducing the network accuracy.



$$h-swish[x] = \frac{x \cdot (\mathrm{Re}LU6(x+3))}{6}$$

$$\mathrm{swish}(x) = x \cdot \sigma(x)$$



Searching for MobileNetV3: 2019 IEEE/CVF INTERNATIONAL CONFERENCE ON COMPUTER

Howard A, Sandler M, Chu G, et al.

Method

The third is to prune the channel of deep convolutional neural network (CNN). Channel pruning can reduce the size of the model, reduce the memory occupation at runtime, and reduce the computational operands without affecting the accuracy.

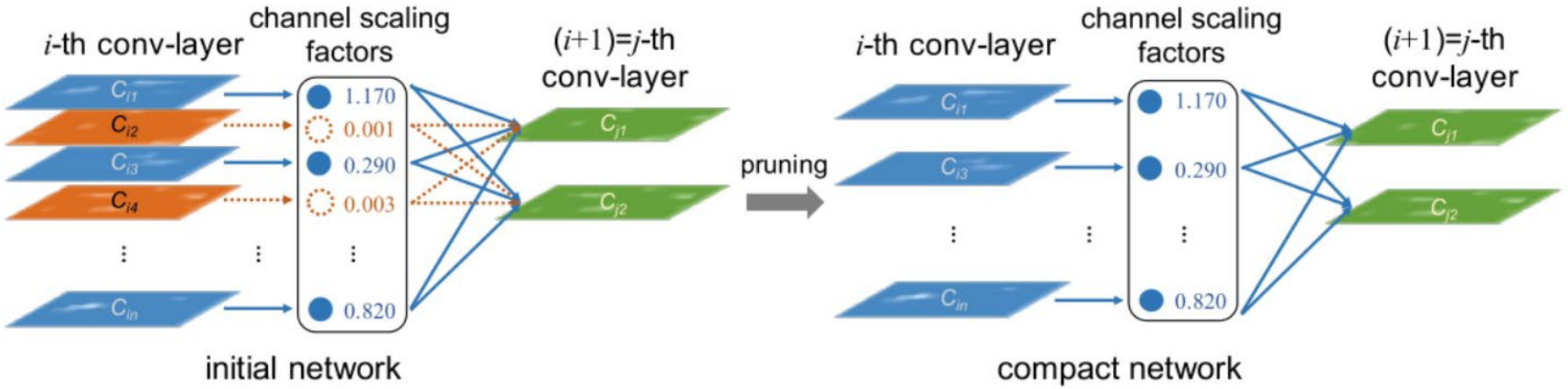


Figure 1: We associate a scaling factor (reused from a batch normalization layer) with each channel in convolutional layers. Sparsity regularization is imposed on these scaling factors during training to automatically identify unimportant channels. The channels with small scaling factor values (in orange color) will be pruned (left side). After pruning, we obtain compact models (right side), which are then fine-tuned to achieve comparable (or even higher) accuracy as normally trained full network.

Learning Efficient Convolutional Networks through Network Slimming

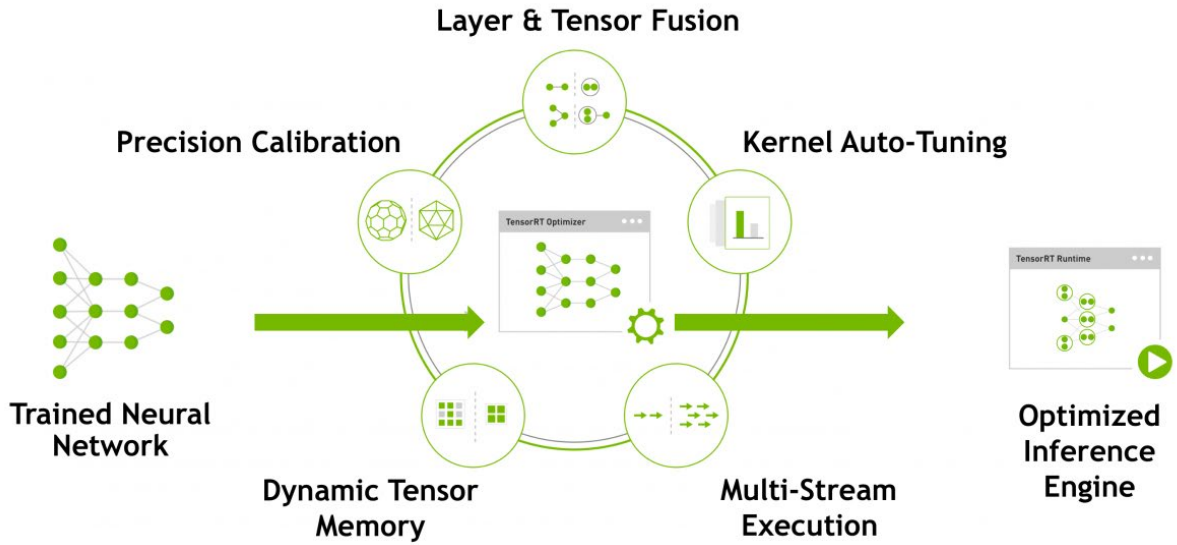
Zhuang Liu, Jianguo Li, Zhiqiang Shen, et al.

Method

The fourth is to introduce the label smoothing method into the prediction layer of yolov5. Label smoothing will help the model train around the wrong label data, so as to improve its robustness and performance.

$$q_i' = (1-\varepsilon)q_i + \frac{\varepsilon}{K}$$

Finally, the Yolo trained model is sent to TensorRT to optimize the engine, and then applied to GPU reasoning to further lighten the model.



https://developer.nvidia.cn/zh-cn/tensorrt

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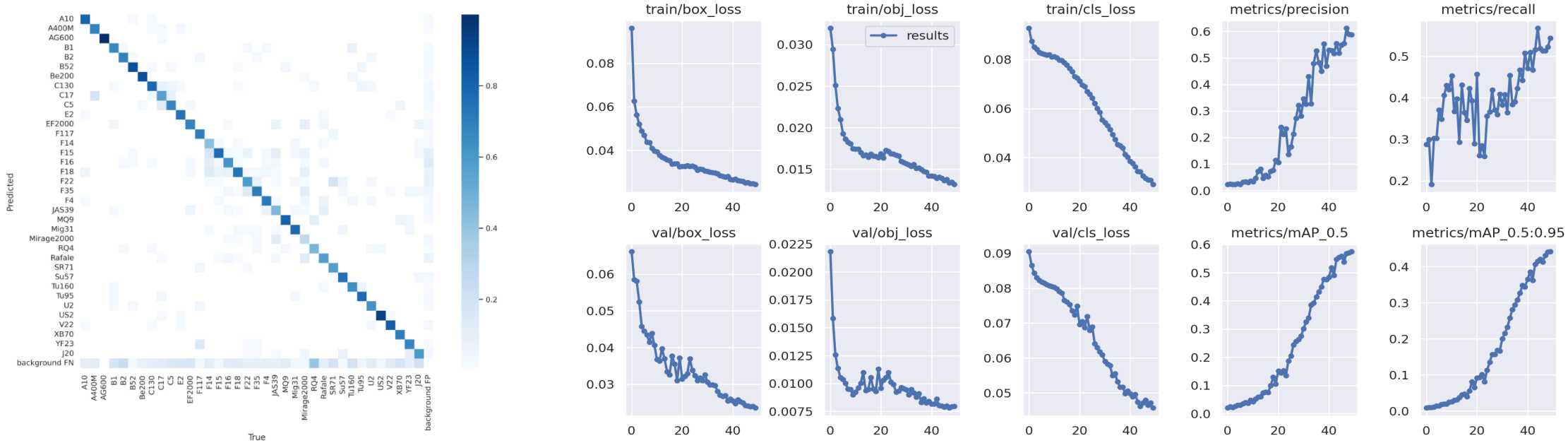
Improvement

Our experiment is based on military aircraft detectiondataset1, which contains 36 kinds and 5062 pictures of military aircraft, including popular models in China, the United States, Russia, Europe and other countries. Finally, although the model accelerated by TensorRT will lose some accuracy, the detection speed has been greatly improved.

Improvement

After 50 iterations, the final loss and map value of the model are shown in Figure 8. It can be seen from the figure that after many training, the map value of the model gradually stabilized at about 0.6, which proves that the optimized model has good accuracy.



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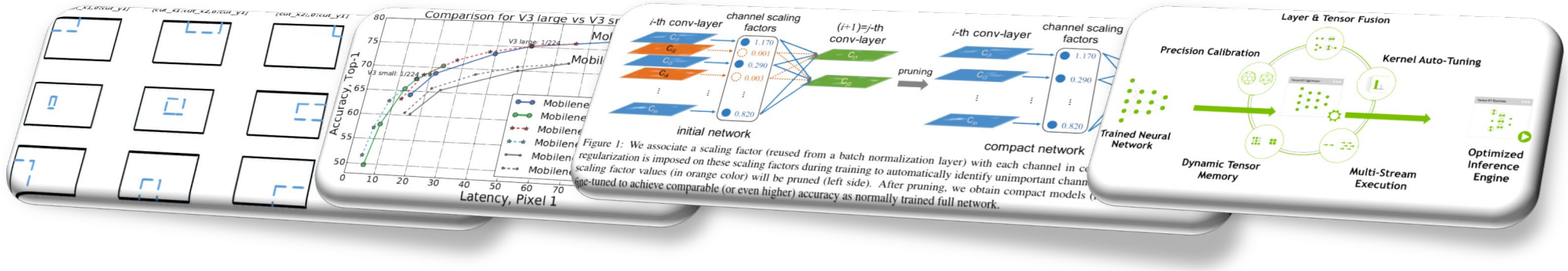
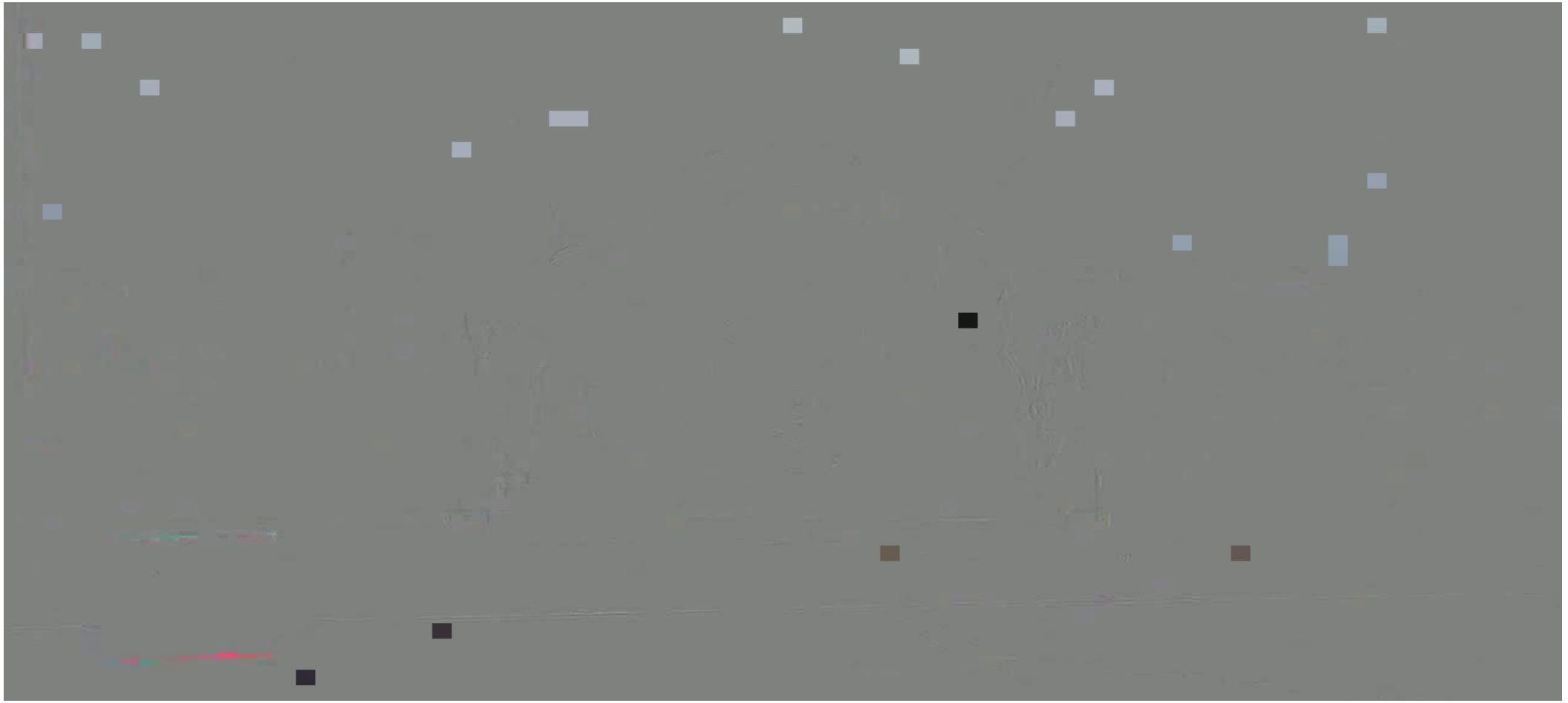
Result

We propose a fast detection method of military aircraft based on improved yolov5 network. The main improvements are as follows:

1. Using mosaic-9, small target samples are added to improve the speed of network training.
2. Use mobilenet V3 small to replace the backbone feature extraction network of yolov5s.
3. Channel pruning to improve the comprehensive performance of the network.
4. Introduce label smoothing method. Noise is added through soft one hot to suppress over fitting.
5. Use TensorRT to optimize GPU hardware resources.



Result



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THANK YOU