Large-Scale Object Detection in the Wild from Imbalanced Multi-Labels

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Abstract

Training with more data has always been the most stable and effective way of improving performance in deep learning era. As the largest object detection dataset so far, Open Images brings great opportunities and challenges for object detection in general and sophisticated scenarios. However, owing to its semi-automatic collecting and labeling pipeline to deal with the huge data scale, Open Images dataset suffers from label-related problems that objects may explicitly or implicitly have multiple labels and the label distribution is extremely imbalanced. In this work, we quantitatively analyze these label problems and provide a simple but effective solution. We design a concurrent softmax to handle the multi-label problems in object detection and propose a soft-sampling methods with hybrid training scheduler to deal with the label imbalance. Overall, our method yields a dramatic improvement of 3.34 points, leading to the best single model with 60.90 mAP on the public object detection test set of Open Images. And our ensembling result achieves 67.17 mAP, which is 4.29 points higher than the best result of Open Images public test 2018.

1. Introduction

Data is playing a primary and decisive role in deep learning. With the advent of ImageNet dataset, deep neural network becomes well exploited for the first time, and an unimaginable number of works in deep learning sprung up. Some recent works also prove that larger quantities of data with labels of low quality like hashtags could surpass the state-of-the-art methods by a large margin. Throughout the history of deep learning, it could be easily learned that the development of an area is closely related to the data.

In the past years, great progresses have also been achieved in the field of object detection. Some generic object detection datasets with annotations of high quality like Pascal VOC and MS COCO greatly boost the development of object detection, giving birth to plenty of amazing methods. However, these datasets are quite small in today’s view, and begin to limit the advancement of object detection area to some degree. Attempts are frequently made to focus on atomic problems on these datasets instead of exploring object detection in harder scenarios.

Recently, Open Images dataset is published in terms of 1.7 million images with 12.4 million boxes annotated of 500 categories. This unseals the limits of data-hungry methods and may stimulate research to bring object detection to more general and sophisticated situations. However, accurately annotating data of such scale is labor intensive that manual labeling is almost infeasible. The annotating procedure of Open Images dataset is completed with strong assistance of deep learning that candidate labels are generated by models and verified by humans. This inevitably weakens the quality of labels because of the uncertainty of models and the knowledge limitation of human individuals, which leads to several major problems.

Objects in Open Image dataset may explicitly or implicitly have multiple labels, which differs from the traditional object detection. The object classes in Open Images form a hierarchy that most objects may hold a leaf label and all the corresponding parent labels. However, due to the annotation quality, there are cases that objects are only labeled as parent classes and leaf classes are absent. Apart from hierarchical labels, objects in Open Images dataset may also hold several leaf classes like and toy. Another annoying case is that objects of similar classes are frequently ano-
Figure 1: Example of multi-label annotations in Open Images dataset. (a)(b) are cases that objects are explicitly annotated with multiple labels. In (a), a car toy is labeled as car and toy at the same time. In (b), an apple is hierarchically labeled as apple and fruit. (c)(d) are cases that objects implicitly have multiple labels. In (c), apples are only labeled as fruit. In (d), flashlights are always randomly labeled as torch or flashlight.

However, most works are still exploring in datasets like Pascal VOC and MS COCO, which are small by modern standards. Only a few works [25, 38, 10] have been proposed to deal with large-scale object detection dataset like Open Images [10]. Wu et al. [38] proposes a soft box-sampling method to cope with the partial label problem in large scale dataset. In [25], a part-aware sampling method is designed to capture the relations between entity and parts to help recognize part objects.

2. Related Works

Object Detection. Generic object detection is a fundamental and challenging problem in computer vision, and plenty of works [29, 28, 22, 20, 7, 23, 5, 19, 27] in this area come out in recent years. Faster-RCNN [29] first proposes an end-to-end two-stage framework for object detection and lays a strong foundation for successive methods. In [7], deformable convolution is proposed to adaptively sample input features to deal with objects of various scales and shapes. [19, 27] utilize dilated convolutions to enlarge the effective receptive fields of detectors to better recognize objects of large scale. [3, 23] focus on predicting boxes of higher quality to accommodate the COCO metric.

Imbalanced Label Distribution. There have been many efforts on handling long-tailed label distribution through data based resampling strategies [31, 10, 26, 41, 24] or loss-based methods [6, 14, 35]. In [31, 10, 26], class-aware sampling is applied that each mini-batch is filled as uniform as possible with respect to different classes. [4, 41] expand samples of minor classes through synthesizing new data. Dhruv et al. [24] computes a replication factor for each image based on the distribution of hashtags and duplicates images the prescribed number of times.

As for loss-based methods, loss weights are assigned to samples of different classes to match the imbalanced label distribution. In [14, 35], samples are re-weighted by inverse class frequency, while Yin et al. [6] calculates the effective
number of each class to re-balance the loss. In OHEM [32]
and focal loss [20], difficulty of samples are evaluated in
term of losses and hard samples are assigned higher loss
weights.

3. Problem Setting

Open Images dataset is currently the largest released ob-
ject detection dataset to the best of our knowledge. It con-
tains 12 million annotated instances for 500 categories on
1.7 million images. Considering its large size, it is unfea-
sible to manually annotate such huge number of images on
500 categories. Owing to its scale size and annotation styles,
we argue that there are three major problems regarding this
kind of dataset, apart from the missing annotation problem
which has been discussed in [38,25].

**Objects may explicitly have multiple labels.** As objects in
physical world always contain rich categorical attributes on
different levels, the 500 categories in Open Images dataset
form a class hierarchy of 5 levels, with 443 of the nodes
as leaf classes and 57 of the nodes as parent classes. It is
likely that some objects hold multiple labels including leaf
labels and parent labels, like apple and fruit as shown in
Figure 1b. Another case is that an object could easily have
multiple leaf labels. For instance, a car-toy is labeled as toy
and car at the same time as shown in Figure 1a. This hap-
pens frequently in dataset and all leaf labels are requested
to be predicted during evaluation. Different from previous
single-label object detection, how to deal with multiple la-
beles is one of the crucial factors for object detection in this
dataset.

**Objects may implicitly have multiple labels.** Other than
the explicit multi-label problem, there is also the implicit
multi-label problem caused by the limited and inconsistent
knowledge of human annotators. There remain many pairs
of leaf categories that are hard to distinguish, and labels of
these pairs are mixed up randomly. We analyze the propor-
tion that an object of a leaf class is labeled as another, and
find that there are at least 115 pairs of severely confused
categories (confusion ratio ≥ 0.1). We display the top-55
confused pairs in Figure 3a and find many categories heav-
ily confused. For instance, nearly 65% of the torches are
labeled as flashlight and 50% of the leopards are labeled as
cheetah.

Besides, labels of leaf and parent classes are always not
complete so that a large amount of objects are only an-
notated with parent labels without leaf label. As shown
in Figure 1c, an apple is sometimes labeled as apple
and sometimes labeled as fruit without the leaf annotation.
We demonstrate the ratio of leaf annotations and parent anno-
tations lacking leaf annotations in Figure 3b. This implicit co-
existence phenomenon also happens frequently and needs
to be taken into consideration, otherwise the detectors may
learn the false signals.

**Imbalanced label distribution.** To build such a huge
dataset, images are collected from open source in the wild.
As on can expect, Open Images dataset suffers from ex-
tremely imbalanced label distribution that both infrequent
and very frequent categories are included. As shown in Fig-
ure 2, the most frequent category owns nearly 30k times
the training images of the most infrequent category. Naive
re-balance strategy, such as widely used class-aware sam-
ping [10] which uniformly samples training images of dif-
ferent categories could not cope with such extreme imbal-
ance, and may lead to two consequences:
1) For frequent categories, they are not trained sufficiently,
for the reason that most of their training samples have never
been seen and are wasted.
2) For infrequent categories, the excessive over-sampling on
them may cause severe over-fitting and degrade the gener-
alisability of recognition on these classes.

Once adopting the class-aware sampling, category like
person is extremely undersampled that 99.13% of the in-
stances are neglected, while category like pressure cooker
is immensely oversampled that each instance is seen for 252
more times averagely within an epoch.

4. Methodology

In this part, we explore methods to deal with the la-
el related problems in large scale object detection. First,
we design a **concurrent softmax** to handle both the explicit
and implicit multi-label issues jointly. Second, we pro-
pose a **soft-balance sampling** together with a **hybrid train-
ing scheduler** to deal with the extremely imbalanced label
distribution.

4.1. Multi-Label Object Detection

As one of the most widely used loss function in deep
learning, the form of softmax loss about a bounding box b
is presented as follows:

\[ L_{cls}(b) = - \sum_{i=1}^{C} \sigma_{i} \log(\phi_{i}), \quad \text{with} \quad \sigma_{i} = \frac{e^{z_{i}}}{\sum_{j=1}^{C} e^{z_{j}}}, \quad (1) \]

where \( z_{i} \) denotes the response of the \( i \)-th class, \( y_{i} \) denotes
the label and \( C \) means the number of categories. It behaves
well in single label recognition where \( \sum y_{i} = 1 \). However,
things are different when it comes to multi-label recogni-
tion.

In the conventional object detection training scheme,
each bounding box is assigned only one label during train-
ing ignoring other ground-truth labels. If we force to as-
sign all the \( m (m \geq 1) \) ground-truth labels that belongs to
\( K = \{ k \mid k \in C, y_{k} = 1 \} \) to bounding box during training,
scores of multiple labels would restrain each other. When
computing the gradient of each ground-truth label, it looks
Number of instances

10

10

10

10

10

Imbalance magnitude

0

0

4

2

2

Figure 2: The imbalance magnitude of Open Images and MS COCO dataset. Imbalance magnitude means the number of the images of the largest category divided by the smallest. (best viewed on high-resolution display)

Figure 3: Implicit multi-label problem caused by confused categories and absence of leaf classes.

(a) We select the top-55 confused category pairs and show their concurrent rates.

(b) We show the ratio of parent annotations without leaf label and total parent annotations.

Figure 3: Implicit multi-label problem caused by confused categories and absence of leaf classes.

4.1.1 Concurrent Softmax

The concurrent softmax is designed to help solve the problem of recognizing objects with multiple labels in object detection. During training, the concurrent softmax loss of a predicted box \( b \) is presented as follows:

\[
L_{\text{clss}}^*(b) = - \sum_{i=1}^{C} y_i \log \sigma_i^* ,
\]

\[
\text{with } \sigma_i^* = \frac{e^{z_i}}{\sum_{j=1}^{C} (1 - y_j)(1 - r_{ij})e^{z_j} + e^{z_i}},
\]

where \( y_i \) denotes the label of class \( i \) regarding the box \( b \), and \( r_{ij} \) denotes the concurrent rate of class \( i \) to class \( j \). And output of concurrent softmax during training is defined as:

\[
\frac{\partial L_{\text{clss}}^*}{\partial z_i} = \begin{cases} 
\sigma_i^* - 1, & \text{if } i \in K; \\
\sum_{j \in K} (1 - r_{ij})\sigma_i^* , & \text{if } i \notin K.
\end{cases}
\]

Unlike in softmax that responses of the ground-truth categories are suppressing all the others, we remove the suppression effects between explicitly coexisting categories in concurrent softmax. For instance, a bounding box is assigned multiple ground-truth labels \( K = \{ k | k \in C, y_k = 1 \} \) during training. When computing the score of class \( i \in K \), influences of all the other ground-truth classes \( j \in K \setminus \{ i \} \) are neglected because of the \((1 - y_j)\) term, and the score of each correct class is boosted. This avoids the unnecessary large losses due to the multi-label problem, and the gradients could focus on more valuable knowledge.

Apart from the explicit co-existence cases, there are still implicit concurrent relationships remain to be settled. We define a concurrent rate \( r_{ij} \) as the probability that an object of class \( i \) is labeled as class \( j \). The \( r_{ij} \) is calculated based on the class annotations of training set and Figure 3a shows the concurrent rates of confusion pairs. For hierarchical relationships, \( r_{ij} \) is set 0 when \( i \) is leaf node with \( j \) as its parent, and vice versa. With the \((1 - r_{ij})\) term, suppression effects between confusing pairs are weakened.

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The influence of multi-label object detection is also prominent during inference. Different from the conventional multi-label recognition tasks, the evaluation metric of object detection is mean average precision (mAP). For each category, detection results of all images are firstly collected and ranked by scores to form a precision-recall curve, and the average area of precision-recall curve is defined as the mAP. In this way, the absolute value of box score matters, because it may influence the rank of predicted box over the entire dataset. Thus we also apply the concurrent softmax during inference, and present it as follows:

$$\sigma^\dagger_i = \frac{e^{z_i}}{\sum_{j=1}^{C} (1 - y_{ij}) e^{z_j}},$$

(5)

where we abandon the $(1 - y_{ij})$ term and keep the concurrent rate term. Scores of categories in a hierarchy and scores of similar categories would not suppress each other, and are boosted effectively, which is desirable in object detection task.

4.1.2 Compared with BCE loss

BCE is always a popular solution to multi-label recognition, but it does not work well on multi-label detection task. We argue that sigmoid function fails to normalize scores and declines the suppression effect between categories which is desired when evaluated with mAP metric. We have tried BCE loss and focal loss, but it turns out that they yield much worse result even than the original softmax cross-entropy.

4.2. Soft-balance Sampling with Hybrid Training

As detailedly illuminated in [3], Open Images dataset suffers from severely imbalanced label distribution. We denote by $C$ the number of categories, $N$ the number of total training images, and $n_i$ the number of images containing objects of the $i$-th class. Conventionally, images are sampled in sequence without replacement for training in each epoch, and the original probability $P_o$ of class $i$ being sampled is denoted as $P_o(i) = \frac{n_i}{N}$, which may greatly degrade the recognition capability of model for infrequent classes. A widely used technique, i.e., class-aware sampling mentioned in [31][10][26] is a naive solution to handle the class imbalance problem, in which categories are sampled uniformly in each batch. The class-aware sampling probability $P_c$ of class $i$ becomes $P_c(i) = \frac{1}{C}$. Yet this may cause heavy over-fitting on infrequent categories and insufficient training on frequent categories as aforementioned.

To alleviate the problems above, we firstly adjust the sampling probability based on number of samples, which we call soft-balance sampling. We first define the $P_o(i) = \frac{n_i}{\sum_{i=1}^{C} n_i}$ as the approximation of non-balance sampling probability $P_o(i)$ for convenience. Then the sampling probability of class-aware balance can be reformulated as:

$$P_s(i) = \frac{1}{C} = \frac{1}{CP_o(i)} P_n(i) = \alpha P_n(i),$$

(6)

where the $\alpha = \frac{1}{CP_o(i)}$ can be regarded as a balance factor that is inversely proportional to the number of categories and the original sampling probability.

To reconcile the frequent and infrequent categories, we introduce soft-balance sampling by adjusting the balance factor with a new hyper-parameter $\lambda$:

$$P_s(i) = \alpha^\lambda P_n(i) = P_n(i)^\lambda P_n(i)^{(1-\lambda)}.$$

(7)

Note that $\lambda = 0$ corresponds to non-balance sampling and $\lambda = 1$ corresponds to class-aware balance. The normalized probability is:

$$P_s^*(i) = \frac{P_s(i)}{\sum_{j=1}^{C} P_s(j)}.$$  

(8)

This sampling strategy guarantees more sufficient training on dominate categories and decreases the excessive sampling frequency of infrequent categories.

Even with the soft-balance method, there are still many samples of the frequent categories that are not sampled. Thus we propose a hybrid training scheduler to further mitigate this problem. We firstly train detector using the conventional strategy, which is sampling training images in sequence without replacement, and the equivalent sampling probability is $P_o$. Then we finetune the model with soft-balance strategy to cover categories with very few samples. This hybrid training schema exploits the effectiveness of pretrained model for object detection task from Open Images itself rather than ImageNet. It ensures that all the images have been seen during training, and endows the model with a better generalization ability.

5. Experiments

5.1. Dataset

To analyze the proposed concurrent softmax loss and soft-balance with hybrid training, we conduct experiment on Open Images challenge 2019 dataset. As an object detection dataset in the wild, it contains 1.7 million images with 12.4 million boxes of 500 categories in its challenge split. The scale of training images is 15 times of the MS COCO [21] and 3 times of the second largest object detection dataset Object365 [30].

Considering the huge size of Open Images dataset, we split a mini Open Images dataset for our ablation study. The mini Open Images dataset contains 115K training images and 5K validation images named as mini-train and mini-val.
All the images are sampled from Open Images challenge 2019 dataset with the ratio of each category unchanged. Final results on full-val and public test-challenge in Open Images challenge 2019 dataset are also reported. We follow the metric used in Open Images challenge which is a variant mAP at IoU 0.5, as all false positives not existing in image-level labels are ignored.

5.2. Implementation Details

We train our detector with ResNet-50 backbone armed with FPN. For the network configuration, we follow the setting mentioned in Detectron. We use SGD with momentum 0.9 and weight decay 0.0001 to optimize parameters. The initial learning rate is set to 0.00125 × batch size, and then decreased by a factor of 10 at 4 and 6 epoch for 1× schedule which has total 7 epochs. The input images are scaled so that the length of the shorter edge is 800 and the longer side is limited to 1333. Horizontal flipping is used as data augmentation and sync-BN is adopted to speed up the convergence.

5.3. Concurrent Softmax

We explore the influence of concurrent softmax in training and testing stage respectively in this ablation study. All models are trained with mini-train and evaluated on mini-val.

The impacts of concurrent softmax during training. Table 1 shows the results of the proposed concurrent softmax compared with the vanilla softmax and other existing methods during training stage. Concurrent softmax could outperform softmax by 1.13 points with class-aware sampling and 0.98 points with non-balance sampling. It is also found that sigmoid with BCE and focal loss behaves poorly in this case. We guess that they are incompatible with the mAP metric in object detection as mentioned in 4.1.2. Our method also outperforms dist-CE loss [24] and Co-BCE loss [1].

The impacts of concurrent softmax during testing. We also show results to demonstrate the effectiveness of concurrent softmax in testing stage in Table 2. Solely applying concurrent softmax brings 0.36 mAP improvement during inference, while applying it in both training and testing stage yields 1.50 points improvement totally. This also proves the fact that suppression effects between leaf and parent categories or confusing categories are harming the performance of object detection in Open Images.

5.4. Soft-balance Sampling

Results. Table 3 presents the results of the proposed soft-balance sampling and other balance method. As Open Images is a long-tailed dataset, many categories have few samples, so that non-balance training only achieves 38.16 mAP. Class-aware sampling simply samples all categories data uniformly at random, it remedy the data imbalance problem to a great extent and boost the performance to 55.45. The effective number [6] is used to re-weight the classification loss with the purpose of harmonizing the gradient contribution from different categories. Comparing to the non-balance method, the effective number improves the results by 7.56 points, but is worse than the class-aware sampling. We argue that it is because the balance strategy applied on data level is more efficient than that of loss level. Soft-balance with hyper-parameter $\lambda$ allows us to transfer from non-balance ($\lambda = 0$) to class-aware sampling ($\lambda = 1$). Thus, we can find a point at which sufficient infrequent cat-

| Loss Type               | Balance | mAP  |
|-------------------------|---------|------|
| Focal Loss [20]         | ✓       | 50.18|
| BCE Loss                | ✓       | 54.29|
| Co-BCE Loss [11]        | ✓       | 55.74|
| dist-CE Loss [24]       | ✓       | 55.90|
| Softmax Loss            |         | 38.16|
| Concurrent Softmax Loss | ✓       | 39.14|
| Softmax                 | ✓       | 55.45|
| Concurrent Softmax Loss | ✓       | 56.58|

| Train Method            | Test Method         | mAP  |
|-------------------------|---------------------|------|
| Softmax                 | Softmax             | 55.45|
| Softmax                 | Concurrent Softmax  | 55.77|
| Concurrent Softmax      | Softmax             | 56.58|
| Concurrent Softmax      | Concurrent Softmax  | 56.95|

| Methods                 | $\lambda$ | mAP  |
|-------------------------|-----------|------|
| Non-balance             |           | 38.16|
| Class-aware Sampling    |           | 55.45|
| Effective Number        | 0.3       | 50.69|
|                        | 0.5       | 56.19|
|                        | 0.7       | 57.04|
|                        | 1.0       | 55.45|
|                        | 1.5       | 52.41|

1In Open Images dataset, image-level labels consist of verified-exist labels and verified-not-exist labels. The unverified categories are ignored.
The impacts of soft-balance during training. To investigate why soft-balance is better, we show the training curves of soft-balance with different $\lambda$ in Figure 4. We can learn that the small $\lambda = 0.3$ is hard to achieve a good performance due to the data imbalance problem. But too large $\lambda = 1.5$ also fails on accomplishing the best performance comparing with the relatively smaller $\lambda$ setting. Note that the mAP of $\lambda = 1.5$ is much higher than that of $\lambda = 0.5$ in the first learning rate stage (before epoch 4), but this situation reverses in subsequent train progress. This comparison proves that $\lambda = 1.5$ provides more sufficient rare categories data to train the model and achieve better performance in the beginning, however, it run into a severe over-fitting in the convergence stage. The results of $\lambda = 1.0$ and $\lambda = 0.7$ validate this rules again.

The impacts of soft-balance among categories. We further study the performance of $\lambda = 0.0$, $\lambda = 0.7$, and $\lambda = 1.0$ among categories in Figure 5, in which the challenge validation results of 500 categories are arranged from large to few by their number of images. As shown in Figure 5a, the $\lambda = 1.0$ (orange line) outperforms the $\lambda = 0.0$ (blue line) on the later half categories which have few image samples. Although $\lambda = 1.0$ solves the data insufficiency of infrequent categories, it under-samples the frequent categories and causes the performance dropping on the former half categories. Figure 5b shows that $\lambda = 0.7$ (orange line) alleviates the excessive under-sampling of the major categories comparing to $\lambda = 1.0$ (blue line). On the other hand, it mitigates the over-fitting problem of infrequent categories. Therefore, the performance of $\lambda = 0.7$ is almost always better than $\lambda = 1.0$ on the full category space.

### 5.5. Hybrid Training Scheduler

Table 4 summarizes the results of ResNeXt152 on Open Images Challenge dataset trained with different training scheduler. For the non-balance setting, the more epochs the model trained, the better performance the model achieves. And training a model from scratch yields better results than finetuning from ImageNet pretrained model. These observations match similar conclusion in [12].

While class-aware sampling significantly boosts the performance by 8.62 points using the ImageNet pretrained in 7 epochs setting, it suffers from over-fitting problem, as the mAP of model trained with 14 epochs is lower than that of 7 epochs. And frequent categories are still intensely under-sampled even applying the balance sampling. With hybrid training, class-aware sampling can achieve better performance in both non-balance ImageNet pretraining and non-balance scratch pretraining setting. Note that these improvements are not caused by more training epochs, because longer training schedule will decreases the performance if with only ImageNet pretraining. By further using soft-balance strategy, the hybrid training with non-balance scratch is improved from 65.92 to 67.09 mAP.

### 5.6. Extension Results on Test-challenge Set

With the proposed concurrent softmax, soft-balance and hybrid training scheduler, we achieve 67.17 mAP and 4.29 points absolute improvement compared to the first place en-
(a) Non-balance (blue) versus Class-aware Sampling (orange) sorted by the number of images for most frequent 100 categories (left) and most infrequent 100 categories (right).

(b) Class-aware Sampling (blue) versus Soft-balance with \( \lambda = 0.7 \) (orange) sorted by the number of images for most frequent 100 categories (left) and most infrequent 100 categories (right).

Figure 5: The comparison of sampling strategy among categories. (Best viewed on high-resolution display)

Table 5: Results with bells and whistles on Open Images public test-challenge set.

| Methods                        | Ensemble | Public Test |
|--------------------------------|----------|-------------|
| 2018 1st [1]                   |          | 55.81       |
| Ours                           |          | **60.90**   |
| 2018 1st [1]                   | ✓        | 62.88       |
| 2018 2nd [10]                  | ✓        | 62.16       |
| 2018 3rd                       | ✓        | 61.70       |
| Ours                           | ✓        | **67.17**   |
| Baseline (ResNeXt-152)         |          | 53.88       |
| +Class-aware Sampling          |          | 57.56       |
| +Concurrent Softmax Loss       |          | 58.60       |
| +Soft-balance                  |          | 59.86       |
| +Hybrid Training Scheduler     |          | 60.90       |
| +Other Tricks                  |          | 62.34       |
| +Ensemble                      | ✓        | **67.17**   |

We train a ResNeXt-152 FPN with multi-scale training and testing as our baseline which achieves 53.88 mAP. After using class-aware balance, the performance is boosted to 57.56. With the help of proposed concurrent softmax, the model achieves 58.60 mAP. The soft-balance and the hybrid training scheduler lead to mAP gains of 1.26 and 1.04 points, respectively. By further using other tricks including data augmentation, loss function search, and heavier head, we achieve a best single model with a mAP of 62.34. We use ResNeXt-101, ResNeXt-152, and EfficientNet-B7 with various tricks for model ensembling. The final mAP on Open Images public test-challenge set is 67.17.

6. Conclusion

In this paper, we investigate the multi-label problem and the imbalanced label distribution problem in large-scale object detection dataset, and introduce a simple but powerful solution. We propose the concurrent softmax function to deal with explicit and implicit multi-label problem in both training and testing stage. Our soft-balance method together with hybrid training scheduler could effectively deal with the extremely imbalanced label distribution.

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