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> 原文：Deep Learning based Object Detection using YOLOv3 with OpenCV ( Python / C++ )
>
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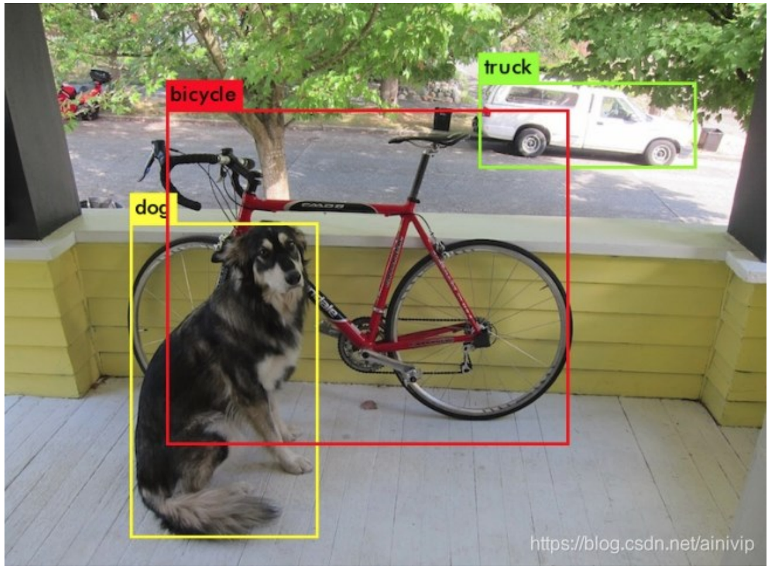
>
> 日期：2018-08-20

这里主要介绍基于 OpenCV 的 YOLOV3 目标检测器的应用.



YOLOV3 是 YOLO-You Only Look Once 目标检测算法的最新变形，其开源的模型能够识别图片和视频中 80 种不同的物体类别，而且最重要的是其速度非常快，并具有与 SSD(Single Shot MultiBox) 相当的精度.

> YOLOv3 Tech Report

OpenCV3.4.2 版本之后，可以很方便地在 OpenCV 应用中采用 YOLOV3 模型.

## 1. YOLO 工作原理

目标检测器可以看作**位置定位器(object locator)**和**目标识别器(object recognitizer)**的组合.

传统 CV 方法中，一般采用滑窗(sliding window) 来寻找不同位置和不同尺度的物体. 但由于其计算算代价较大，通常都会假设物体的长宽比(aspect ratio) 是固定的.

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早期基于深度学习的目标检测算法，如，R-CNN，Fast-RCNN 等，通常 Selective Search 方法来降低算法需要测试的边界框(bounding box) 数量.

另一种方法叫作 Overfeat，其通过采用类似于滑窗的机制，以全卷积的方式对图像进行多尺度的扫描.

后面出现的方法采用 RPN(Region Proposal Network) 来确定需要测试的边界框. 通过精心的 设计，用于识别物体的提取特征，还可以被 RPN 用于提取潜在的边界框，因此节省了大量的计算量.

另一方面，YOLO 等目标检测算法，采用了完全不同的方式来处理目标检测问题，其 只需要对整张图像进行一次网络前向计算. SSD 是另一种只进行一次深度学习网络前向计算的目标检测算法， 但，YOLOV3 比 SDD 具有更快的速度和相当的精度. 再 M40，TitanX 和 1080Ti GPUs 上取得了更快的实时效果.

YOLO 对于给定图像，检测目标物体的工作原理如下：

首先，将图像划分为 13x13 个网格组成. 共169 个单元格，各单元格的尺寸取决于网络的输入尺寸. 比如，实验中，对于 416x416 的输入尺寸，则每个单元格的 尺寸为 32x32.

然后，每个单元格负责预测图像的一些框(boxes).

对于每一个边界框，网络还会预测包含物体的边界框的置信度，以及物体关于特定类别的概率.

由于大部分边界框的置信度都比较低，或者很多边界框是包含相同物体的，只保留最高置信的边界框，因此，大部分边界框都是可以被消除掉的. 这种消除边界框的方法即为 NMS(non-maximum suppression).

YOLOV3 的作者 Joseph Redmon 和 Ali Farhadi, 将精度和速度都比 YOLOV2 进行了提升. YOLOV3 可以更好的处理多尺度. 此外，还通过增大网络和添加跳跃链接(shortcut connections) 的残差网络的方式提升网络能力.

## 2. YOLO 采用 OpenCV 的原因

[1] - **更易于与 OpenCV 应用的整合**

如果已有应用已经采用了 OpenCV，则可以很方便的使用 YOLOV3，而无需担心编译新增的 Darknet 源码.

[2] - **OpenCV CPU 版本速度更快，9x倍提速**

OpenCV 中的 DNN 模块的 CPU 实现是很快的. 例如，采用 OpenMP 的 Darknet 对于单张图片的一次 CPU 推断大约耗时 2s；而 OpenCV 的实现仅仅只需 0.22s.

[3] - **Python 支持**

Darknet 是以 C 构建的，其原声不支持 Python. 而 OpenCV 是原生支持 Python 的. 尽管Darknet 也会有可用的 Python 接口.

## 3. 基于 OpenCV 和 Darknet 的 YOLOV3 速度测试

如下表：

| OS | Framework | CPU/GPU | Time(ms)/Frame |
|---|---|---|---|
| Linux 16.04 | Darknet | 12x Intel Core i7-6850K CPU @ 3.60GHz | 9370 |
| Linux 16.04 | Darknet + OpenMP | 12x Intel Core i7-6850K CPU @ 3.60GHz | 1942 |
| Linux 16.04 | OpenCV [CPU] | 12x Intel Core i7-6850K CPU @ 3.60GHz | 220 |
| Linux 16.04 | Darknet | NVIDIA GeForce 1080 Ti GPU | 23 |
| macOS | DarkNet | 2.5 GHz Intel Core i7 CPU | 7260 |
| macOS | OpenCV [CPU] | 2.5 GHz Intel Core i7 CPU | 400 |

所有测试中，网络输入均为 416x416. 不出意外的，Darknet 的 GPU 版本速度是最快的. 而且，不出意外的还有，采用 OpenMP 的 Darknet 比未采用 OpeMP 的的 Darknet 具有更好的表现，因为 OpenMP 可以支持多核CPU.

采用 OpenCV 的 DNN 的 CPU 实现，比 OpenMP 速度快了 9 倍.

**注**：在采用 OpenCV 的 DNN GPU 实现时遇到了问题. 这里只在 Intel 的 GPUs 上进行了测试，如果没有 intel GPU 则自动切换到 CPU 模型.

## 4. 采用 YOLOV3 进行目标检测(C++/Python)

```
git clone https://github.com/pjreddie/darknet
cd darknet
make
```

> Github - ObjectDetection-YOLO

### 4.1. Step1 - 下载模型

```
wget https://pjreddie.com/media/files/yolov3.weights
wget https://github.com/pjreddie/darknet/blob/master/cfg/yolov3.cfg?raw=true -O ./yolov3.cfg
wget https://github.com/pjreddie/darknet/blob/master/data/coco.names?raw=true -O ./coco.names
```

**yolov3.weights** 文件包含了预训练的网络权重；

**yolov3.cfg** 文件包含 了网络配置；

**coco.names** 文件包含了 COCO 数据集中的 80 个不同类别名.

### 4.2. Step2 - 初始化参数

YOLOV3 算法输出边界框作为预测的检测结果. 每个预测框关联了一个置信度.

在第一阶段，所有低于置信阈值参数的 boxes 被忽略，并不进一步处理.

对于剩余的 boxes，采用 NMS 算法进行处理，以移除冗余的重叠边界框. NMS 由参数 **nmsThreshold** 来控制. 可以通过修改这些参数，来观察输出的预测 boxes 数量的变化.

接着，设置网络的输入图片的默认尺寸 - width(**inpWidth**) 和 height(**inpHeight**). 这里均设置为 416，以便于与 YOLOV3 作者开源的 Darknet C 代码进行对比. 也可以设置为 320 以得到更快的速度，设置为 608 以得到更好的精度.

**Python**：

```
# 参数初始化
confThreshold = 0.5  #Confidence threshold
nmsThreshold = 0.4   #Non-maximum suppression threshold
inpWidth = 416       #Width of network's input image
inpHeight = 416      #Height of network's input image
```

**C++**：

```
// 参数初始化
float confThreshold = 0.5; // Confidence threshold
float nmsThreshold = 0.4;  // Non-maximum suppression threshold
int inpWidth = 416;        // Width of network's input image
int inpHeight = 416;       // Height of network's input image
```

### 4.3. Step3 - 加载模型和类别名

**coco.names** 包含了模型训练时的物体类别名. 首先读取该文件.

然后，加载网络，其包含两部分：

[1] - **yolov3.weights** - 预训练的模型权重

[2] **yolov3.cfg** - 网络配置文件

这里，设置 DNN 后端为 OpenCV， 目标设置为 CPU. 也可以设置为 **cv.dnn.DNN_TARGET_OPENCL** 以在 GPU 上运行. 但要记得，当前 OpenCV 版本只支持 Intel 的 GPUs 测试，如果不是 Intel GPU，则会自动切换到 CPU 运行.

**Python**：

```python
# Load names of classes
classesFile = "coco.names";
classes = None
with open(classesFile, 'rt') as f:
    classes = f.read().rstrip('\n').split('\n')

# Give the configuration and weight files for the model
# and load the network using them.
modelConfiguration = "yolov3.cfg";
modelWeights = "yolov3.weights";

net = cv.dnn.readNetFromDarknet(modelConfiguration, modelWeights)
net.setPreferableBackend(cv.dnn.DNN_BACKEND_OPENCV)
net.setPreferableTarget(cv.dnn.DNN_TARGET_CPU)
```

**C++**：

```cpp
// Load names of classes
string classesFile = "coco.names";
ifstream ifs(classesFile.c_str());
string line;
while (getline(ifs, line)) classes.push_back(line);

// Give the configuration and weight files for the model
String modelConfiguration = "yolov3.cfg";
String modelWeights = "yolov3.weights";

// Load the network
Net net = readNetFromDarknet(modelConfiguration, modelWeights);
net.setPreferableBackend(DNN_BACKEND_OPENCV);
net.setPreferableTarget(DNN_TARGET_CPU);
```

### 4.4. Step4 - 读取输入

这里从图像、视频或摄像头读取输入.

另外，也使用了 Video writer，以视频方式保存带有输出边界框的每一帧图片.

**Python**：

```python
outputFile = "yolo_out_py.avi"
if (args.image):
    # Open the image file
    if not os.path.isfile(args.image):
        print("Input image file ", args.image, " doesn't exist")
        sys.exit(1)
    cap = cv.VideoCapture(args.image)
    outputFile = args.image[:-4]+'_yolo_out_py.jpg'
elif (args.video):
    # Open the video file
    if not os.path.isfile(args.video):
        print("Input video file ", args.video, " doesn't exist")
        sys.exit(1)
    cap = cv.VideoCapture(args.video)
    outputFile = args.video[:-4]+'_yolo_out_py.avi'
else:
    # Webcam input
    cap = cv.VideoCapture(0)

# Get the video writer initialized to save the output video
if (not args.image):
    vid_writer = cv.VideoWriter(
        outputFile,
        cv.VideoWriter_fourcc('M','J','P','G'),
        30,
        (round(cap.get(cv.CAP_PROP_FRAME_WIDTH)),
         round(cap.get(cv.CAP_PROP_FRAME_HEIGHT))))
```

**C++**:

```
outputFile = "yolo_out_cpp.avi";
if (parser.has("image"))
{
    // Open the image file
    str = parser.get<String>("image");
    ifstream ifile(str);
    if (!ifile) throw("error");
    cap.open(str);
    str.replace(str.end()-4, str.end(), "_yolo_out.jpg");
    outputFile = str;
}
else if (parser.has("video"))
{
    // Open the video file
    str = parser.get<String>("video");
    ifstream ifile(str);
    if (!ifile) throw("error");
    cap.open(str);
    str.replace(str.end()-4, str.end(), "_yolo_out.avi");
    outputFile = str;
}
// Open the webcaom
else cap.open(parser.get<int>("device"));

// Get the video writer initialized to save the output video
if (!parser.has("image"))
{
    video.open(outputFile,
               VideoWriter::fourcc('M','J','P','G'),
               28,
               Size(cap.get(CAP_PROP_FRAME_WIDTH),
                    cap.get(CAP_PROP_FRAME_HEIGHT)));
}
```

### 4.5. Step5 - 处理每一帧

神经网络的输入图片需要以 **blob** 的特定格式组织.

当从输入图片或者视频流中读取了一帧图片后，其需要经过 **blobFromImage** 函数的处理，以转换为网络的 **input blob**. 在该处理过程中，图片像素值被采用 1/255 的因子缩放到 [0, 1] 范围；且在不裁剪的情况下，将图片尺寸调整为 (416, 416). **注：** 并未进行任何减均值操作，因此，函数的均值参数采用的是 [0, 0, 0]，并保持 swapRB 为默认值 1.

输入图处理后输出的 blob，被作为网络输入，进行前向计算，以得到输出的预测边界框列表. 网络输出的预测框再进行后处理，以过滤低置信度的边界框. 后面会详细介绍后处理操作. 在左上角打印每一帧图片的推断时间.

图片最终的边界框，会以图片或 video writer 的方式保存到磁盘.

**Python**：

```
while cv.waitKey(1) < 0:
    # get frame from the video
    hasFrame, frame = cap.read()

    # Stop the program if reached end of video
    if not hasFrame:
        print("Done processing !!!")
        print("Output file is stored as ", outputFile)
        cv.waitKey(3000)
        break

    # Create a 4D blob from a frame.
    blob = cv.dnn.blobFromImage(frame,
                                1/255,
                                (inpWidth, inpHeight),
                                [0,0,0],
                                1,
                                crop=False)

    # Sets the input to the network
    net.setInput(blob)

    # Runs the forward pass to get output of the output layers
    outs = net.forward(getOutputsNames(net))

    # Remove the bounding boxes with low confidence
    postprocess(frame, outs)

    # Put efficiency information.
    # The function getPerfProfile returns the overall time for inference(t)
    # and the timings for each of the layers(in layersTimes)
    t, _ = net.getPerfProfile()
    label = 'Inference time: %.2f ms' % (t * 1000.0 / cv.getTickFrequency())
    cv.putText(frame, label, (0, 15), cv.FONT_HERSHEY_SIMPLEX, 0.5, (0, 0, 255))

    # Write the frame with the detection boxes
    if (args.image):
        cv.imwrite(outputFile, frame.astype(np.uint8));
    else:
        vid_writer.write(frame.astype(np.uint8))
```

**C++**：

```
// Process frames.
while (waitKey(1) < 0)
{
    // get frame from the video
    cap >> frame;
    // Stop the program if reached end of video
    if (frame.empty()) {
        cout << "Done processing !!!" << endl;
        cout << "Output file is stored as " << outputFile << endl;
        waitKey(3000);
        break;
    }
    // Create a 4D blob from a frame.
    blobFromImage(frame, blob, 1/255.0, cvSize(inpWidth, inpHeight), Scalar(0,0,0), true, false);

    //Sets the input to the network
    net.setInput(blob);

    // Runs the forward pass to get output of the output layers
    vector<Mat> outs;
    net.forward(outs, getOutputsNames(net));

    // Remove the bounding boxes with low confidence
    postprocess(frame, outs);

    // Put efficiency information. The function getPerfProfile returns the
    // overall time for inference(t) and the timings for each of the layers(in layersTimes)
    vector<double> layersTimes;
    double freq = getTickFrequency() / 1000;
    double t = net.getPerfProfile(layersTimes) / freq;
    string label = format("Inference time for a frame : %.2f ms", t);
    putText(frame, label, Point(0, 15), FONT_HERSHEY_SIMPLEX, 0.5, Scalar(0, 0, 255));

    // Write the frame with the detection boxes
    Mat detectedFrame;
    frame.convertTo(detectedFrame, CV_8U);
    if (parser.has("image")) imwrite(outputFile, detectedFrame);
    else video.write(detectedFrame);
}
```

下面详细的对上面用到的一些函数进行说明.

4.5.1. Step5a - 获取网络输出层名

OpenCV 的 Net 类的 **forward** 函数需要知道网络的最终输出层.

由于要对整个网络进行运行，因此，需要确认网络的最后一层. 可以采用 **getUnconnectedOutLayers()** 函数来获取无连接的输出层的名字，这些层一般都是网络的输出层.

然后，运行网络的 forward 计算，以得到输出层的名字，如代码段 **net.forward(getOutputsNames(net))**.

**Python**:

```python
# Get the names of the output layers
def getOutputsNames(net):
    # Get the names of all the layers in the network
    layersNames = net.getLayerNames()
    # Get the names of the output layers,
    # i.e. the layers with unconnected outputs
    return [layersNames[i[0] - 1] for i in net.getUnconnectedOutLayers()]
```

**C++**:

```cpp
// Get the names of the output layers
vector<String> getOutputsNames(const Net& net)
{
    static vector<String> names;
    if (names.empty())
    {
        // Get the indices of the output layers,
        // i.e. the layers with unconnected outputs
        vector<int> outLayers = net.getUnconnectedOutLayers();

        //get the names of all the layers in the network
        vector<String> layersNames = net.getLayerNames();

        // Get the names of the output layers in names
        names.resize(outLayers.size());
        for (size_t i = 0; i < outLayers.size(); ++i)
        names[i] = layersNames[outLayers[i] - 1];
    }
    return names;
}
```

### 4.5.2. Step5b - 网络输出的后处理

网络输出的每个边界框表示为 类别名 + 5个元素的向量.

向量的前 4 个元素分别为: **center_x** , **center_y** , **width** 和 **height**.

第 5 个元素表示包含物体的边界框的置信度.

其余的元素是与每个类别相关的置信度(概率). 边界框被分配到对应于最高分数的类别. box 的最高分数也被叫作 **置信confidence**. 如果 box 的置信低于给定阈值，则丢弃该边界框，并不进行进一步的后处理.

置信大于或等于给定置信阈值的 boxes，会进行 NMS 进一步处理，以减少重叠 boxes 的数量.

**Python**:

```python
# Remove the bounding boxes with low confidence using nms
def postprocess(frame, outs):
    frameHeight = frame.shape[0]
    frameWidth = frame.shape[1]

    classIds = []
    confidences = []
    boxes = []
    # Scan through all the bounding boxes output from the network and
    # keep only the ones with high confidence scores.
    # Assign the box's class label as the class with the highest score.
    classIds = []
    confidences = []
    boxes = []
    for out in outs:
        for detection in out:
            scores = detection[5:]
            classId = np.argmax(scores)
            confidence = scores[classId]
            if confidence > confThreshold:
                center_x = int(detection[0] * frameWidth)
                center_y = int(detection[1] * frameHeight)
                width = int(detection[2] * frameWidth)
                height = int(detection[3] * frameHeight)
                left = int(center_x - width / 2)
                top = int(center_y - height / 2)
                classIds.append(classId)
                confidences.append(float(confidence))
                boxes.append([left, top, width, height])

    # Perform nms to eliminate redundant overlapping boxes with
    # lower confidences.
    indices = cv.dnn.NMSBoxes(boxes, confidences, confThreshold, nmsThreshold)
    for i in indices:
        i = i[0]
        box = boxes[i]
        left = box[0]
        top = box[1]
        width = box[2]
        height = box[3]
        drawPred(classIds[i], confidences[i], left, top, left + width, top + height)
```

**C++**:

```cpp
// Remove the bounding boxes with low confidence using nms
void postprocess(Mat& frame, const vector<Mat>& outs)
{
    vector<int> classIds;
    vector<float> confidences;
    vector<Rect> boxes;

    for (size_t i = 0; i < outs.size(); ++i)
    {
        // Scan through all the bounding boxes output from the network
        // and keep only the ones with high confidence scores.
        // Assign the box's class label as the class
        // with the highest score for the box.
        float* data = (float*)outs[i].data;
        for (int j = 0; j < outs[i].rows; ++j, data += outs[i].cols)
        {
            Mat scores = outs[i].row(j).colRange(5, outs[i].cols);
            Point classIdPoint;
            double confidence;
            // Get the value and location of the maximum score
            minMaxLoc(scores, 0, &confidence, 0, &classIdPoint);
            if (confidence > confThreshold)
            {
                int centerX = (int)(data[0] * frame.cols);
                int centerY = (int)(data[1] * frame.rows);
                int width = (int)(data[2] * frame.cols);
                int height = (int)(data[3] * frame.rows);
                int left = centerX - width / 2;
                int top = centerY - height / 2;

                classIds.push_back(classIdPoint.x);
                confidences.push_back((float)confidence);
                boxes.push_back(Rect(left, top, width, height));
            }
        }
    }

    // Perform nms to eliminate redundant overlapping boxes with
    // lower confidences
    vector<int> indices;
    NMSBoxes(boxes, confidences, confThreshold, nmsThreshold, indices);
    for (size_t i = 0; i < indices.size(); ++i)
    {
        int idx = indices[i];
        Rect box = boxes[idx];
        drawPred(classIds[idx], confidences[idx], box.x, box.y,
                 box.x + box.width, box.y + box.height, frame);
    }
}
```

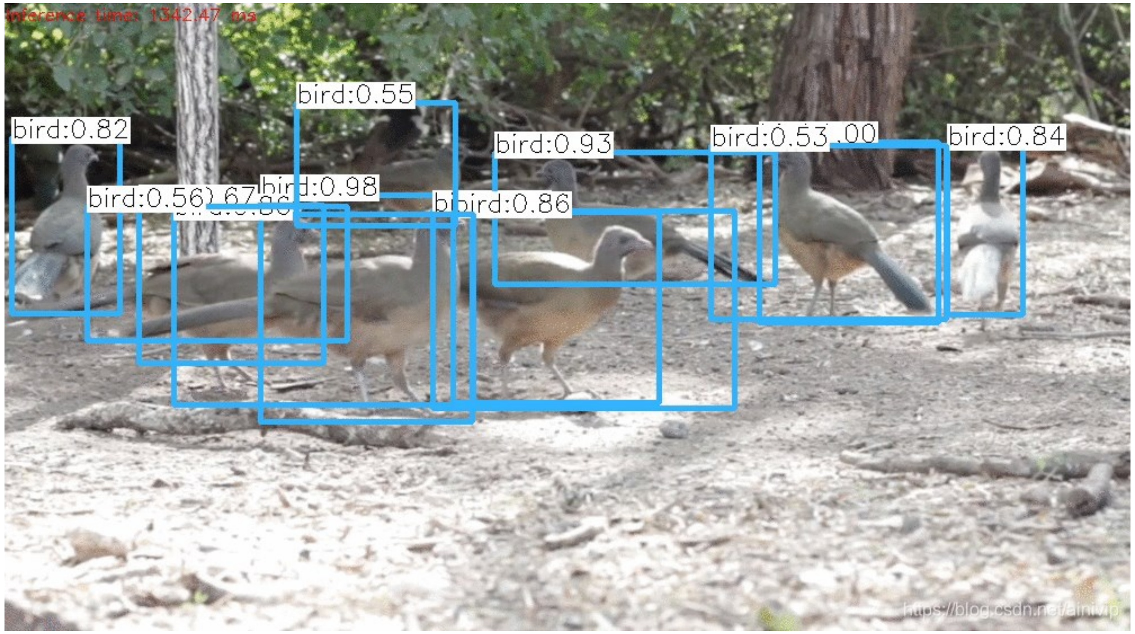
NMS 是由 **nmsThreshold** 参数控制的.

如果 **nmsThreshold** 参数过小，如 0.1，可能检测不到相同或不同类别的重叠物体.

如果 **nmsThreshold** 参数过大，如，1，则会得到同一个物体的多个框.

因此，这里采用了一个中间值 - 0.4.

不同 NMS 阈值效果如图：



https://aiuai.cn/uploads/1905/46a9eedbecd0f8b6.gif

4.5.3. Step5c - 画出预测框

最后，画出输入图片在 NMS 处理后的边界框以及对应的类别标签和置信分数.

**Python**：

```
# Draw the predicted bounding box
def drawPred(classId, conf, left, top, right, bottom):
    # Draw a bounding box.
    cv.rectangle(frame, (left, top), (right, bottom), (0, 0, 255))
```

```python

    label = '%.2f' % conf
    # Get the label for the class name and its confidence
    if classes:
        assert(classId < len(classes))
        label = '%s:%s' % (classes[classId], label)

    #Display the label at the top of the bounding box
    labelSize, baseLine = cv.getTextSize(
        label, cv.FONT_HERSHEY_SIMPLEX, 0.5, 1)
    top = max(top, labelSize[1])
    cv.putText(frame, label, (left, top),
               cv.FONT_HERSHEY_SIMPLEX, 0.5, (255,255,255))
```

**C++**:

```cpp
// Draw the predicted bounding box
void drawPred(int classId, float conf, int left, int top, int right, int bottom, Mat& frame)
{
    //Draw a rectangle displaying the bounding box
    rectangle(frame, Point(left, top), Point(right, bottom), Scalar(0, 0, 255));

    //Get the label for the class name and its confidence
    string label = format("%.2f", conf);
    if (!classes.empty())
    {
        CV_Assert(classId < (int)classes.size());
        label = classes[classId] + ":" + label;
    }

    //Display the label at the top of the bounding box
    int baseLine;
    Size labelSize = getTextSize(label, FONT_HERSHEY_SIMPLEX, 0.5, 1, &baseLine);
    top = max(top, labelSize.height);
    putText(frame, label, Point(left, top), FONT_HERSHEY_SIMPLEX, 0.5, Scalar(255,255,255));
}
```

### 4.6. YOLOV3 完整测试代码(Python)

> object_detection_yolo.py

用法:

```
python3 object_detection_yolo.py --video=run.mp4
python3 object_detection_yolo.py --image=bird.jpg
```

```python
# It is based on the OpenCV project.
import cv2 as cv
import argparse
import sys
import numpy as np
import os.path

# Initialize the parameters
confThreshold = 0.5  #Confidence threshold
```

```
nmsThreshold = 0.4   #Non-maximum suppression threshold
inpWidth = 416       #Width of network's input image
inpHeight = 416      #Height of network's input image

parser = argparse.ArgumentParser(description='Object Detection using YOLO in OPENCV')
parser.add_argument('--image', help='Path to image file.')
parser.add_argument('--video', help='Path to video file.')
args = parser.parse_args()

# Load names of classes
classesFile = "coco.names";
classes = None
with open(classesFile, 'rt') as f:
    classes = f.read().rstrip('\n').split('\n')

# Give the configuration and weight files for the model and load the network using them.
modelConfiguration = "yolov3.cfg";
modelWeights = "yolov3.weights";

net = cv.dnn.readNetFromDarknet(modelConfiguration, modelWeights)
net.setPreferableBackend(cv.dnn.DNN_BACKEND_OPENCV)
net.setPreferableTarget(cv.dnn.DNN_TARGET_CPU)

# Get the names of the output layers
def getOutputsNames(net):
    # Get the names of all the layers in the network
    layersNames = net.getLayerNames()
    # Get the names of the output layers,
    # i.e. the layers with unconnected outputs
    return [layersNames[i[0] - 1] for i in net.getUnconnectedOutLayers()]

# Draw the predicted bounding box
def drawPred(classId, conf, left, top, right, bottom):
    # Draw a bounding box.
    cv.rectangle(frame, (left, top), (right, bottom), (255, 178, 50), 3)

    label = '%.2f' % conf

    # Get the label for the class name and its confidence
    if classes:
        assert(classId < len(classes))
        label = '%s:%s' % (classes[classId], label)

    #Display the label at the top of the bounding box
    labelSize, baseLine = cv.getTextSize(label, cv.FONT_HERSHEY_SIMPLEX, 0.5, 1)
    top = max(top, labelSize[1])
    cv.rectangle(frame, (left, top - round(1.5*labelSize[1])), (left + round(1.5*labelSize[0]), top + baseLine),
    cv.putText(frame, label, (left, top), cv.FONT_HERSHEY_SIMPLEX, 0.75, (0,0,0), 1)

# Remove the bounding boxes with low confidence using nms
def postprocess(frame, outs):
    frameHeight = frame.shape[0]
    frameWidth = frame.shape[1]

    classIds = []
    confidences = []
    boxes = []
    # Scan through all the bounding boxes output from the network and
    # keep only the ones with high confidence scores.
    # Assign the box's class label as the class with the highest score.
    classIds = []
```

```python
    confidences = []
    boxes = []
    for out in outs:
        for detection in out:
            scores = detection[5:]
            classId = np.argmax(scores)
            confidence = scores[classId]
            if confidence > confThreshold:
                center_x = int(detection[0] * frameWidth)
                center_y = int(detection[1] * frameHeight)
                width = int(detection[2] * frameWidth)
                height = int(detection[3] * frameHeight)
                left = int(center_x - width / 2)
                top = int(center_y - height / 2)
                classIds.append(classId)
                confidences.append(float(confidence))
                boxes.append([left, top, width, height])

    # Perform nms to eliminate redundant overlapping boxes with
    # lower confidences.
    indices = cv.dnn.NMSBoxes(boxes, confidences, confThreshold, nmsThreshold)
    for i in indices:
        i = i[0]
        box = boxes[i]
        left = box[0]
        top = box[1]
        width = box[2]
        height = box[3]
        drawPred(classIds[i], confidences[i], left, top, left + width, top + height)

# Process inputs
winName = 'Deep learning object detection in OpenCV'
cv.namedWindow(winName, cv.WINDOW_NORMAL)

outputFile = "yolo_out_py.avi"
if (args.image):
    # Open the image file
    if not os.path.isfile(args.image):
        print("Input image file ", args.image, " doesn't exist")
        sys.exit(1)
    cap = cv.VideoCapture(args.image)
    outputFile = args.image[:-4]+'_yolo_out_py.jpg'
elif (args.video):
    # Open the video file
    if not os.path.isfile(args.video):
        print("Input video file ", args.video, " doesn't exist")
        sys.exit(1)
    cap = cv.VideoCapture(args.video)
    outputFile = args.video[:-4]+'_yolo_out_py.avi'
else:
    # Webcam input
    cap = cv.VideoCapture(0)

# Get the video writer initialized to save the output video
if (not args.image):
    vid_writer = cv.VideoWriter(outputFile, cv.VideoWriter_fourcc('M','J','P','G'), 30, (round(cap.get(cv.CAP_PRO

while cv.waitKey(1) < 0:

    # get frame from the video
    hasFrame, frame = cap.read()

    # Stop the program if reached end of video
    if not hasFrame:
        print("Done processing !!!")
        print("Output file is stored as ", outputFile)
        cv.waitKey(3000)
        # Release device
        cap.release()
        break

    # Create a 4D blob from a frame.
    blob = cv.dnn.blobFromImage(frame, 1/255, (inpWidth, inpHeight), [0,0,0], 1, crop=False)

    # Sets the input to the network
    net.setInput(blob)
    # Runs the forward pass to get output of the output layers
    outs = net.forward(getOutputsNames(net))
    # Remove the bounding boxes with low confidence
    postprocess(frame, outs)

    # Put efficiency information.
    # The function getPerfProfile returns the overall time for inference(t)
    # and the timings for each of the layers(in layersTimes)
    t, _ = net.getPerfProfile()
    label = 'Inference time: %.2f ms' % (t * 1000.0 / cv.getTickFrequency())
    cv.putText(frame, label, (0, 15), cv.FONT_HERSHEY_SIMPLEX, 0.5, (0, 0, 255))

    # Write the frame with the detection boxes
    if (args.image):
        cv.imwrite(outputFile, frame.astype(np.uint8));
    else:
        vid_writer.write(frame.astype(np.uint8))
    cv.imshow(winName, frame)
```

### 4.7. YOLOV3 完整测试代码(C++)

> object_detection_yolo.cpp

用法：

```
./object_detection_yolo.out --video=run.mp4
./object_detection_yolo.out --image=bird.jpg
```

```cpp
// It is based on the OpenCV project.
#include <fstream>
#include <sstream>
#include <iostream>

#include <opencv2/dnn.hpp>
#include <opencv2/imgproc.hpp>
#include <opencv2/highgui.hpp>

const char* keys =
"{help h usage ? | | Usage examples: \n\t\t./object_detection_yolo.out --image=dog.jpg \n\t\t./object_detection_y
"{image i        |<none>| input image   }"
"{video v       |<none>| input video   }"
```

```
;
using namespace cv;
using namespace dnn;
using namespace std;

// Initialize the parameters
float confThreshold = 0.5; // Confidence threshold
float nmsThreshold = 0.4;  // Non-maximum suppression threshold
int inpWidth = 416;  // Width of network's input image
int inpHeight = 416; // Height of network's input image
vector<string> classes;

// Remove the bounding boxes with low confidence using nms
void postprocess(Mat& frame, const vector<Mat>& out);

// Draw the predicted bounding box
void drawPred(int classId, float conf, int left, int top, int right, int bottom, Mat& frame);

// Get the names of the output layers
vector<String> getOutputsNames(const Net& net);

int main(int argc, char** argv)
{
    CommandLineParser parser(argc, argv, keys);
    parser.about("Use this script to run object detection using YOLO3 in OpenCV.");
    if (parser.has("help"))
    {
        parser.printMessage();
        return 0;
    }
    // Load names of classes
    string classesFile = "coco.names";
    ifstream ifs(classesFile.c_str());
    string line;
    while (getline(ifs, line)) classes.push_back(line);

    // Give the configuration and weight files for the model
    String modelConfiguration = "yolov3.cfg";
    String modelWeights = "yolov3.weights";

    // Load the network
    Net net = readNetFromDarknet(modelConfiguration, modelWeights);
    net.setPreferableBackend(DNN_BACKEND_OPENCV);
    net.setPreferableTarget(DNN_TARGET_CPU);

    // Open a video file or an image file or a camera stream.
    string str, outputFile;
    VideoCapture cap;
    VideoWriter video;
    Mat frame, blob;

    try {
        outputFile = "yolo_out_cpp.avi";
        if (parser.has("image"))
        {
            // Open the image file
            str = parser.get<String>("image");
            ifstream ifile(str);
            if (!ifile) throw("error");
            cap.open(str);
            str.replace(str.end()-4, str.end(), "_yolo_out_cpp.jpg");
            outputFile = str;
        }
        else if (parser.has("video"))
        {
            // Open the video file
            str = parser.get<String>("video");
            ifstream ifile(str);
            if (!ifile) throw("error");
            cap.open(str);
            str.replace(str.end()-4, str.end(), "_yolo_out_cpp.avi");
            outputFile = str;
        }
        // Open the webcaom
        else cap.open(parser.get<int>("device"));

    }
    catch(...) {
        cout << "Could not open the input image/video stream" << endl;
        return 0;
    }

    // Get the video writer initialized to save the output video
    if (!parser.has("image")) {
        video.open(outputFile, VideoWriter::fourcc('M','J','P','G'), 28, Size(cap.get(CAP_PROP_FRAME_WIDTH), cap.
    }

    // Create a window
    static const string kWinName = "Deep learning object detection in OpenCV";
    namedWindow(kWinName, WINDOW_NORMAL);

    // Process frames.
    while (waitKey(1) < 0)
    {
        // get frame from the video
        cap >> frame;

        // Stop the program if reached end of video
        if (frame.empty()) {
            cout << "Done processing !!!" << endl;
            cout << "Output file is stored as " << outputFile << endl;
            waitKey(3000);
            break;
        }
        // Create a 4D blob from a frame.
        blobFromImage(frame, blob, 1/255.0, cvSize(inpWidth, inpHeight), Scalar(0,0,0), true, false);
        //Sets the input to the network
        net.setInput(blob);
        // Runs the forward pass to get output of the output layers
        vector<Mat> outs;
        net.forward(outs, getOutputsNames(net));

        // Remove the bounding boxes with low confidence
        postprocess(frame, outs);

        // Put efficiency information.
        // The function getPerfProfile returns the overall time for inference(t)
        // and the timings for each of the layers(in layersTimes)
        vector<double> layersTimes;
        double freq = getTickFrequency() / 1000;
        double t = net.getPerfProfile(layersTimes) / freq;
        string label = format("Inference time for a frame : %.2f ms", t);
```

```cpp
        putText(frame, label, Point(0, 15), FONT_HERSHEY_SIMPLEX, 0.5, Scalar(0, 0, 255));

        // Write the frame with the detection boxes
        Mat detectedFrame;
        frame.convertTo(detectedFrame, CV_8U);
        if (parser.has("image")) imwrite(outputFile, detectedFrame);
        else video.write(detectedFrame);

        imshow(kWinName, frame);
    }
    cap.release();
    if (!parser.has("image")) video.release();

    return 0;
}

// Remove the bounding boxes with low confidence using nms
void postprocess(Mat& frame, const vector<Mat>& outs)
{
    vector<int> classIds;
    vector<float> confidences;
    vector<Rect> boxes;

    for (size_t i = 0; i < outs.size(); ++i)
    {
        // Scan through all the bounding boxes output from the network and
        // keep only the ones with high confidence scores.
        // Assign the box's class label as the class
        // with the highest score for the box.
        float* data = (float*)outs[i].data;
        for (int j = 0; j < outs[i].rows; ++j, data += outs[i].cols)
        {
            Mat scores = outs[i].row(j).colRange(5, outs[i].cols);
            Point classIdPoint;
            double confidence;
            // Get the value and location of the maximum score
            minMaxLoc(scores, 0, &confidence, 0, &classIdPoint);
            if (confidence > confThreshold)
            {
                int centerX = (int)(data[0] * frame.cols);
                int centerY = (int)(data[1] * frame.rows);
                int width = (int)(data[2] * frame.cols);
                int height = (int)(data[3] * frame.rows);
                int left = centerX - width / 2;
                int top = centerY - height / 2;

                classIds.push_back(classIdPoint.x);
                confidences.push_back((float)confidence);
                boxes.push_back(Rect(left, top, width, height));
            }
        }
    }

    // Perform nms to eliminate redundant overlapping boxes with
    // lower confidences
    vector<int> indices;
    NMSBoxes(boxes, confidences, confThreshold, nmsThreshold, indices);
    for (size_t i = 0; i < indices.size(); ++i)
    {
        int idx = indices[i];
        Rect box = boxes[idx];
        drawPred(classIds[idx], confidences[idx], box.x, box.y,
                 box.x + box.width, box.y + box.height, frame);
    }
}

// Draw the predicted bounding box
void drawPred(int classId, float conf, int left, int top, int right, int bottom, Mat& frame)
{
    //Draw a rectangle displaying the bounding box
    rectangle(frame, Point(left, top), Point(right, bottom), Scalar(255, 178, 50), 3);

    //Get the label for the class name and its confidence
    string label = format("%.2f", conf);
    if (!classes.empty())
    {
        CV_Assert(classId < (int)classes.size());
        label = classes[classId] + ":" + label;
    }

    //Display the label at the top of the bounding box
    int baseLine;
    Size labelSize = getTextSize(label, FONT_HERSHEY_SIMPLEX, 0.5, 1, &baseLine);
    top = max(top, labelSize.height);
    rectangle(frame, Point(left, top - round(1.5*labelSize.height)), Point(left + round(1.5*labelSize.width), top
    putText(frame, label, Point(left, top), FONT_HERSHEY_SIMPLEX, 0.75, Scalar(0,0,0),1);
}

// Get the names of the output layers
vector<String> getOutputsNames(const Net& net)
{
    static vector<String> names;
    if (names.empty())
    {
        // Get the indices of the output layers,
        // i.e. the layers with unconnected outputs
        vector<int> outLayers = net.getUnconnectedOutLayers();

        //get the names of all the layers in the network
        vector<String> layersNames = net.getLayerNames();

        // Get the names of the output layers in names
        names.resize(outLayers.size());
        for (size_t i = 0; i < outLayers.size(); ++i)
        names[i] = layersNames[outLayers[i] - 1];
    }
    return names;
}
```

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最近在用yolo做人脸识别的时候发现使用 CV2.dnn.readNetFromDarknet(config_path, weights_path) 经常会出现错误 cv2.error: OpenCV(4.5.3) C:\Users...

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文章目录说明介绍blobFromImage 的工作流程深度学习和均值减法blobFromImage 和 blobFromImages使用blobFromImage 方法深度学习结果展示总结源...

用python实现目标检测与手势识别的原理简单总结 最新发布 m0_63626366的博客 381
一、 目标检测 目标检测属于分类和回归的综合问题。 目标检测是借助于计算机和软件系统在图像/场景中，定位目标并识别出每个目标的类别的技术。 基...

Opencv+C++之身份证识别（一） weixin_34104341的博客 1050
五月份各种课程，也是最后一个学期了，所以就没有跟大家分享自己的一些所学。现在课程终于结束了，即将开始下一阶段的项目开发，所以趁这个间隙...

基于opencv的车牌识别解析与代码 热门推荐 LinJM-机器视觉 5万+
车牌识别太出名了，我也就花几天来了解下这个系统，并结合opencv进行实现。下面是一些介绍： 车辆牌照识别（License Plate Recognition，LPR）技...

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