MOVING OBJECT DETECTION (YOLO)

1.Dependencies

To build Yolo we're going to need Tensorflow (deep learning), NumPy (numerical computation) and Pillow (image processing) libraries. Also we're going to use seaborn's color palette for bounding boxes colors. Finally, let's import IPython function display()to display images in the notebook.

```
import tensorflow as tf
tf.reset_default_graph()
import numpy as np
from PIL import Image, ImageDraw, ImageFont
from IPython.display import display
from seaborn import color_palette
import cv2
```

2.Model hyperparameters

Next, we define some configurations for Yolo.

```
_BATCH_NORM_DECAY = 0.9
_BATCH_NORM_EPSILON = 1e-05
_LEAKY_RELU = 0.1
_ANCHORS = [(10, 13), (16, 30), (33, 23),
            (30, 61), (62, 45), (59, 119),
            (116, 90), (156, 198), (373, 326)]
_MODEL_SIZE = (416, 416)
```

3.Model definition

```
def batch_norm(inputs, training, data_format):
    """Performs a batch normalization using a standard set of
parameters."""
    return tf.layers.batch_normalization(
        inputs=inputs, axis=1 if data_format == 'channels_first' else
3,
```

```
        momentum=_BATCH_NORM_DECAY, epsilon=_BATCH_NORM_EPSILON,
        scale=True, training=training)


def fixed_padding(inputs, kernel_size, data_format):
    """ResNet implementation of fixed padding.

    Pads the input along the spatial dimensions independently of input
size.

    Args:
        inputs: Tensor input to be padded.
        kernel_size: The kernel to be used in the conv2d or
max_pool2d.
        data_format: The input format.
    Returns:
        A tensor with the same format as the input.
    """
    pad_total = kernel_size - 1
    pad_beg = pad_total // 2
    pad_end = pad_total - pad_beg

    if data_format == 'channels_first':
        padded_inputs = tf.pad(inputs, [[0, 0], [0, 0],
                                        [pad_beg, pad_end],
                                        [pad_beg, pad_end]])
    else:
        padded_inputs = tf.pad(inputs, [[0, 0], [pad_beg, pad_end],
                                        [pad_beg, pad_end], [0, 0]])
    return padded_inputs


def conv2d_fixed_padding(inputs, filters, kernel_size, data_format,
strides=1):
    """Strided 2-D convolution with explicit padding."""
    if strides > 1:
        inputs = fixed_padding(inputs, kernel_size, data_format)

    return tf.layers.conv2d(
        inputs=inputs, filters=filters, kernel_size=kernel_size,
        strides=strides, padding=('SAME' if strides == 1 else
'VALID'),
        use_bias=False, data_format=data_format)

def darknet53_residual_block(inputs, filters, training, data_format,
                             strides=1):
    """Creates a residual block for Darknet."""
    shortcut = inputs

    inputs = conv2d_fixed_padding(
```

```
        inputs, filters=filters, kernel_size=1, strides=strides,
        data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs = conv2d_fixed_padding(
        inputs, filters=2 * filters, kernel_size=3, strides=strides,
        data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs += shortcut

    return inputs


def darknet53(inputs, training, data_format):
    """Creates Darknet53 model for feature extraction."""
    inputs = conv2d_fixed_padding(inputs, filters=32, kernel_size=3,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)
    inputs = conv2d_fixed_padding(inputs, filters=64, kernel_size=3,
                                  strides=2, data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs = darknet53_residual_block(inputs, filters=32,
training=training,
                                      data_format=data_format)

    inputs = conv2d_fixed_padding(inputs, filters=128, kernel_size=3,
                                  strides=2, data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    for _ in range(2):
        inputs = darknet53_residual_block(inputs, filters=64,
                                          training=training,
                                          data_format=data_format)

    inputs = conv2d_fixed_padding(inputs, filters=256, kernel_size=3,
                                  strides=2, data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
```

```
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    for _ in range(8):
        inputs = darknet53_residual_block(inputs, filters=128,
                                          training=training,
                                          data_format=data_format)

    route1 = inputs

    inputs = conv2d_fixed_padding(inputs, filters=512, kernel_size=3,
                                  strides=2, data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    for _ in range(8):
        inputs = darknet53_residual_block(inputs, filters=256,
                                          training=training,
                                          data_format=data_format)

    route2 = inputs

    inputs = conv2d_fixed_padding(inputs, filters=1024, kernel_size=3,
                                  strides=2, data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    for _ in range(4):
        inputs = darknet53_residual_block(inputs, filters=512,
                                          training=training,
                                          data_format=data_format)

    return route1, route2, inputs

def yolo_convolution_block(inputs, filters, training, data_format):
    """Creates convolution operations layer used after Darknet."""
    inputs = conv2d_fixed_padding(inputs, filters=filters,
kernel_size=1,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs = conv2d_fixed_padding(inputs, filters=2 * filters,
kernel_size=3,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)
```

```
    inputs = conv2d_fixed_padding(inputs, filters=filters,
kernel_size=1,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs = conv2d_fixed_padding(inputs, filters=2 * filters,
kernel_size=3,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    inputs = conv2d_fixed_padding(inputs, filters=filters,
kernel_size=1,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    route = inputs

    inputs = conv2d_fixed_padding(inputs, filters=2 * filters,
kernel_size=3,
                                  data_format=data_format)
    inputs = batch_norm(inputs, training=training,
data_format=data_format)
    inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)

    return route, inputs

def yolo_layer(inputs, n_classes, anchors, img_size, data_format):
    """Creates Yolo final detection layer.

    Detects boxes with respect to anchors.

    Args:
        inputs: Tensor input.
        n_classes: Number of labels.
        anchors: A list of anchor sizes.
        img_size: The input size of the model.
        data_format: The input format.

    Returns:
        Tensor output.
    """
    n_anchors = len(anchors)
```

```
    inputs = tf.layers.conv2d(inputs, filters=n_anchors * (5 +
n_classes),
                              kernel_size=1, strides=1, use_bias=True,
                              data_format=data_format)

    shape = inputs.get_shape().as_list()
    grid_shape = shape[2:4] if data_format == 'channels_first' else
shape[1:3]
    if data_format == 'channels_first':
        inputs = tf.transpose(inputs, [0, 2, 3, 1])
    inputs = tf.reshape(inputs, [-1, n_anchors * grid_shape[0] *
grid_shape[1],
                                 5 + n_classes])

    strides = (img_size[0] // grid_shape[0], img_size[1] //
grid_shape[1])

    box_centers, box_shapes, confidence, classes = \
        tf.split(inputs, [2, 2, 1, n_classes], axis=-1)

    x = tf.range(grid_shape[0], dtype=tf.float32)
    y = tf.range(grid_shape[1], dtype=tf.float32)
    x_offset, y_offset = tf.meshgrid(x, y)
    x_offset = tf.reshape(x_offset, (-1, 1))
    y_offset = tf.reshape(y_offset, (-1, 1))
    x_y_offset = tf.concat([x_offset, y_offset], axis=-1)
    x_y_offset = tf.tile(x_y_offset, [1, n_anchors])
    x_y_offset = tf.reshape(x_y_offset, [1, -1, 2])
    box_centers = tf.nn.sigmoid(box_centers)
    box_centers = (box_centers + x_y_offset) * strides

    anchors = tf.tile(anchors, [grid_shape[0] * grid_shape[1], 1])
    box_shapes = tf.exp(box_shapes) * tf.to_float(anchors)

    confidence = tf.nn.sigmoid(confidence)

    classes = tf.nn.sigmoid(classes)

    inputs = tf.concat([box_centers, box_shapes,
                        confidence, classes], axis=-1)

    return inputs

def upsample(inputs, out_shape, data_format):
    """Upsamples to `out_shape` using nearest neighbor
interpolation."""
    if data_format == 'channels_first':
        inputs = tf.transpose(inputs, [0, 2, 3, 1])
        new_height = out_shape[3]
        new_width = out_shape[2]
```

```
    else:
        new_height = out_shape[2]
        new_width = out_shape[1]

    inputs = tf.image.resize_nearest_neighbor(inputs, (new_height,
new_width))

    if data_format == 'channels_first':
        inputs = tf.transpose(inputs, [0, 3, 1, 2])

    return inputs
```

4.Non-max suppression

The model is going to produce a lot of boxes, so we need a way to discard the boxes with low confidence scores. Also, to avoid having multiple boxes for one object, we will discard the boxes with high overlap as well using non-max suppresion for each class.

```
def build_boxes(inputs):
    """Computes top left and bottom right points of the boxes."""
    center_x, center_y, width, height, confidence, classes = \
        tf.split(inputs, [1, 1, 1, 1, 1, -1], axis=-1)

    top_left_x = center_x - width / 2
    top_left_y = center_y - height / 2
    bottom_right_x = center_x + width / 2
    bottom_right_y = center_y + height / 2

    boxes = tf.concat([top_left_x, top_left_y,
                       bottom_right_x, bottom_right_y,
                       confidence, classes], axis=-1)

    return boxes


def non_max_suppression(inputs, n_classes, max_output_size,
iou_threshold,
                        confidence_threshold):
    """Performs non-max suppression separately for each class.

    Args:
        inputs: Tensor input.
        n_classes: Number of classes.
        max_output_size: Max number of boxes to be selected for each
class.
        iou_threshold: Threshold for the IOU.
        confidence_threshold: Threshold for the confidence score.
    Returns:
        A list containing class-to-boxes dictionaries
            for each sample in the batch.
```

```
    """
    batch = tf.unstack(inputs)
    boxes_dicts = []
    for boxes in batch:
        boxes = tf.boolean_mask(boxes, boxes[:, 4] >
confidence_threshold)
        classes = tf.argmax(boxes[:, 5:], axis=-1)
        classes = tf.expand_dims(tf.to_float(classes), axis=-1)
        boxes = tf.concat([boxes[:, :5], classes], axis=-1)

        boxes_dict = dict()
        for cls in range(n_classes):
            mask = tf.equal(boxes[:, 5], cls)
            mask_shape = mask.get_shape()
            if mask_shape.ndims != 0:
                class_boxes = tf.boolean_mask(boxes, mask)
                boxes_coords, boxes_conf_scores, _ =
tf.split(class_boxes,
                                                                    [4, 1, -
1],
                                                                   axis=-1)
                boxes_conf_scores = tf.reshape(boxes_conf_scores, [-
1])
                indices = tf.image.non_max_suppression(boxes_coords,

boxes_conf_scores,

max_output_size,
                                                       iou_threshold)
                class_boxes = tf.gather(class_boxes, indices)
                boxes_dict[cls] = class_boxes[:, :5]

        boxes_dicts.append(boxes_dict)

    return boxes_dicts

class Yolo_v3:
    """Yolo v3 model class."""

    def __init__(self, n_classes, model_size, max_output_size,
iou_threshold,
                 confidence_threshold, data_format=None):
        """Creates the model.

        Args:
            n_classes: Number of class labels.
            model_size: The input size of the model.
            max_output_size: Max number of boxes to be selected for
each class.
            iou_threshold: Threshold for the IOU.
```

```
            confidence_threshold: Threshold for the confidence score.
            data_format: The input format.

        Returns:
            None.
        """
        if not data_format:
            if tf.test.is_built_with_cuda():
                data_format = 'channels_first'
            else:
                data_format = 'channels_last'

        self.n_classes = n_classes
        self.model_size = model_size
        self.max_output_size = max_output_size
        self.iou_threshold = iou_threshold
        self.confidence_threshold = confidence_threshold
        self.data_format = data_format

    def __call__(self, inputs, training):
        """Add operations to detect boxes for a batch of input images.

        Args:
            inputs: A Tensor representing a batch of input images.
            training: A boolean, whether to use in training or
inference mode.

        Returns:
            A list containing class-to-boxes dictionaries
                for each sample in the batch.
        """
        with tf.variable_scope('yolo_v3_model'):
            if self.data_format == 'channels_first':
                inputs = tf.transpose(inputs, [0, 3, 1, 2])

            inputs = inputs / 255

            route1, route2, inputs = darknet53(inputs,
training=training,

data_format=self.data_format)

            route, inputs = yolo_convolution_block(
                inputs, filters=512, training=training,
                data_format=self.data_format)
            detect1 = yolo_layer(inputs, n_classes=self.n_classes,
                                 anchors=_ANCHORS[6:9],
                                 img_size=self.model_size,
                                 data_format=self.data_format)
```

```
            inputs = conv2d_fixed_padding(route, filters=256,
kernel_size=1,

data_format=self.data_format)
            inputs = batch_norm(inputs, training=training,
                                data_format=self.data_format)
            inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)
            upsample_size = route2.get_shape().as_list()
            inputs = upsample(inputs, out_shape=upsample_size,
                              data_format=self.data_format)
            axis = 1 if self.data_format == 'channels_first' else 3
            inputs = tf.concat([inputs, route2], axis=axis)
            route, inputs = yolo_convolution_block(
                inputs, filters=256, training=training,
                data_format=self.data_format)
            detect2 = yolo_layer(inputs, n_classes=self.n_classes,
                                 anchors=_ANCHORS[3:6],
                                 img_size=self.model_size,
                                 data_format=self.data_format)

            inputs = conv2d_fixed_padding(route, filters=128,
kernel_size=1,

data_format=self.data_format)
            inputs = batch_norm(inputs, training=training,
                                data_format=self.data_format)
            inputs = tf.nn.leaky_relu(inputs, alpha=_LEAKY_RELU)
            upsample_size = route1.get_shape().as_list()
            inputs = upsample(inputs, out_shape=upsample_size,
                              data_format=self.data_format)
            inputs = tf.concat([inputs, route1], axis=axis)
            route, inputs = yolo_convolution_block(
                inputs, filters=128, training=training,
                data_format=self.data_format)
            detect3 = yolo_layer(inputs, n_classes=self.n_classes,
                                 anchors=_ANCHORS[0:3],
                                 img_size=self.model_size,
                                 data_format=self.data_format)

            inputs = tf.concat([detect1, detect2, detect3], axis=1)

            inputs = build_boxes(inputs)

            boxes_dicts = non_max_suppression(
                inputs, n_classes=self.n_classes,
                max_output_size=self.max_output_size,
                iou_threshold=self.iou_threshold,
                confidence_threshold=self.confidence_threshold)

            return boxes_dicts
```

5.Utility functions

Here are some utility functions that will help us load images as NumPy arrays, load class names from the official file and draw the predicted boxes.

```
def load_images(img_names, model_size):
    """Loads images in a 4D array.

    Args:
        img_names: A list of images names.
        model_size: The input size of the model.
        data_format: A format for the array returned
            ('channels_first' or 'channels_last').

    Returns:
        A 4D NumPy array.
    """
    imgs = []

    for img_name in img_names:
        img = Image.open(img_name)
        img = img.resize(size=model_size)
        img = np.array(img, dtype=np.float32)
        img = np.expand_dims(img, axis=0)
        imgs.append(img)

    imgs = np.concatenate(imgs)

    return imgs


def load_class_names(file_name):
    """Returns a list of class names read from `file_name`."""
    with open(file_name, 'r') as f:
        class_names = f.read().splitlines()
    return class_names


def draw_boxes(img_names, boxes_dicts, class_names, model_size):
    """Draws detected boxes.

    Args:
        img_names: A list of input images names.
        boxes_dict: A class-to-boxes dictionary.
        class_names: A class names list.
        model_size: The input size of the model.

    Returns:
```

```
        None.
    """
    colors = ((np.array(color_palette("hls", 80)) *
255)).astype(np.uint8)
    for num, img_name, boxes_dict in zip(range(len(img_names)),
img_names,
                                         boxes_dicts):
        img = Image.open(img_name)
        draw = ImageDraw.Draw(img)
        font = ImageFont.truetype(font='/kaggle/input/data-for-yolo-
v3-kernel/futur.ttf',
                                  size=(img.size[0] + img.size[1]) //
100)
        resize_factor = \
            (img.size[0] / model_size[0], img.size[1] / model_size[1])
        for cls in range(len(class_names)):
            boxes = boxes_dict[cls]
            if np.size(boxes) != 0:
                color = colors[cls]
                for box in boxes:
                    xy, confidence = box[:4], box[4]
                    xy = [xy[i] * resize_factor[i % 2] for i in
range(4)]
                    x0, y0 = xy[0], xy[1]
                    thickness = (img.size[0] + img.size[1]) // 200
                    for t in np.linspace(0, 1, thickness):
                        xy[0], xy[1] = xy[0] + t, xy[1] + t
                        xy[2], xy[3] = xy[2] - t, xy[3] - t
                        draw.rectangle(xy, outline=tuple(color))
                    text = '{} {:.1f}%'.format(class_names[cls],
                                               confidence * 100)
                    text_size = draw.textsize(text, font=font)
                    draw.rectangle(
                        [x0, y0 - text_size[1], x0 + text_size[0],
y0],
                        fill=tuple(color))
                    draw.text((x0, y0 - text_size[1]), text,
fill='black',
                              font=font)

        display(img)
```

6.Converting weights to Tensorflow format

Now it's time to load the official weights. We are going to iterate through the file and gradually create tf.assignoperations.

```
def load_weights(variables, file_name):
    """Reshapes and loads official pretrained Yolo weights.

    Args:
        variables: A list of tf.Variable to be assigned.
        file_name: A name of a file containing weights.

    Returns:
        A list of assign operations.
    """
    with open(file_name, "rb") as f:
        # Skip first 5 values containing irrelevant info
        np.fromfile(f, dtype=np.int32, count=5)
        weights = np.fromfile(f, dtype=np.float32)

        assign_ops = []
        ptr = 0

        # Load weights for Darknet part.
        # Each convolution layer has batch normalization.
        for i in range(52):
            conv_var = variables[5 * i]
            gamma, beta, mean, variance = variables[5 * i + 1:5 * i +
5]
            batch_norm_vars = [beta, gamma, mean, variance]

            for var in batch_norm_vars:
                shape = var.shape.as_list()
                num_params = np.prod(shape)
                var_weights = weights[ptr:ptr +
num_params].reshape(shape)
                ptr += num_params
                assign_ops.append(tf.assign(var, var_weights))

            shape = conv_var.shape.as_list()
            num_params = np.prod(shape)
            var_weights = weights[ptr:ptr + num_params].reshape(
                (shape[3], shape[2], shape[0], shape[1]))
            var_weights = np.transpose(var_weights, (2, 3, 1, 0))
            ptr += num_params
            assign_ops.append(tf.assign(conv_var, var_weights))

        # Loading weights for Yolo part.
        # 7th, 15th and 23rd convolution layer has biases and no batch
norm.
        ranges = [range(0, 6), range(6, 13), range(13, 20)]
        unnormalized = [6, 13, 20]
        for j in range(3):
            for i in ranges[j]:
                current = 52 * 5 + 5 * i + j * 2
```

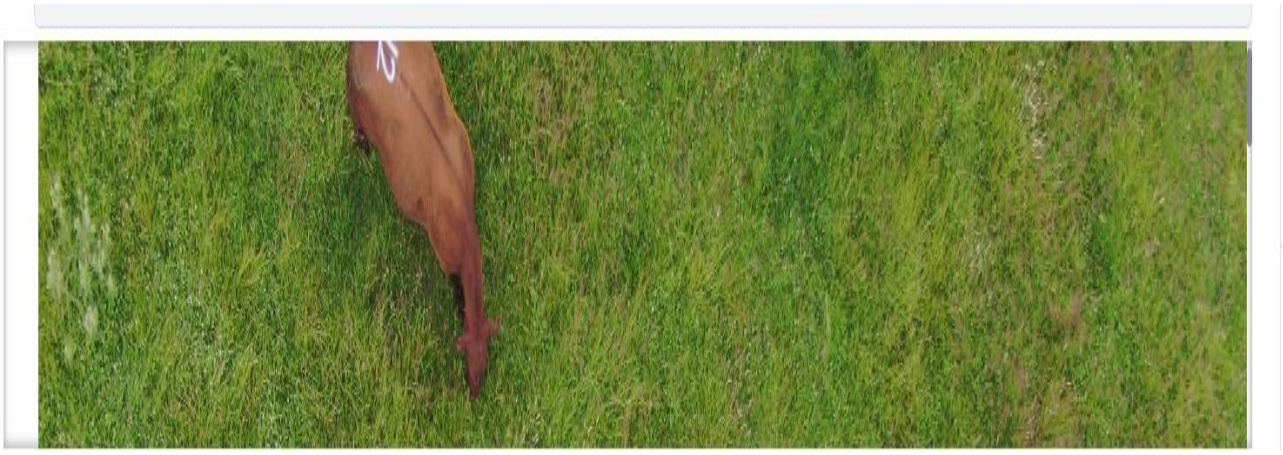
```
                conv_var = variables[current]
                gamma, beta, mean, variance =  \
                    variables[current + 1:current + 5]
                batch_norm_vars = [beta, gamma, mean, variance]

                for var in batch_norm_vars:
                    shape = var.shape.as_list()
                    num_params = np.prod(shape)
                    var_weights = weights[ptr:ptr +
num_params].reshape(shape)
                    ptr += num_params
                    assign_ops.append(tf.assign(var, var_weights))

                shape = conv_var.shape.as_list()
                num_params = np.prod(shape)
                var_weights = weights[ptr:ptr + num_params].reshape(
                    (shape[3], shape[2], shape[0], shape[1]))
                var_weights = np.transpose(var_weights, (2, 3, 1, 0))
                ptr += num_params
                assign_ops.append(tf.assign(conv_var, var_weights))

            bias = variables[52 * 5 + unnormalized[j] * 5 + j * 2 + 1]
            shape = bias.shape.as_list()
            num_params = np.prod(shape)
            var_weights = weights[ptr:ptr + num_params].reshape(shape)
            ptr += num_params
            assign_ops.append(tf.assign(bias, var_weights))

            conv_var = variables[52 * 5 + unnormalized[j] * 5 + j * 2]
            shape = conv_var.shape.as_list()
            num_params = np.prod(shape)
            var_weights = weights[ptr:ptr + num_params].reshape(
                (shape[3], shape[2], shape[0], shape[1]))
            var_weights = np.transpose(var_weights, (2, 3, 1, 0))
            ptr += num_params
            assign_ops.append(tf.assign(conv_var, var_weights))

    return assign_ops
```

7.Running the model

Now we can run the model using some sample images.

```
img_names = ['/kaggle/input/beef-data/DJI_20230627141645_0046_Z.JPG']
for img in img_names: display(Image.open(img))
```

output:



8.Detections

Testing the model with IoU (Interception over Union ratio used in non-max suppression) threshold and confidence threshold both set to 0.5).

```
batch_size = len(img_names)
batch = load_images(img_names, model_size=_MODEL_SIZE)
class_names = load_class_names('/kaggle/input/data-for-yolo-v3-
kernel/coco.names')
n_classes = len(class_names)
max_output_size = 10
iou_threshold = 0.5
confidence_threshold = 0.5

model = Yolo_v3(n_classes=n_classes, model_size=_MODEL_SIZE,
                max_output_size=max_output_size,
                iou_threshold=iou_threshold,
                confidence_threshold=confidence_threshold)

inputs = tf.placeholder(tf.float32, [batch_size, 416, 416, 3])

detections = model(inputs, training=False)

model_vars = tf.global_variables(scope='yolo_v3_model')
assign_ops = load_weights(model_vars, '/kaggle/input/data-for-yolo-v3-
kernel/yolov3.weights')

with tf.Session() as sess:
    sess.run(assign_ops)
    detection_result = sess.run(detections, feed_dict={inputs: batch})

draw_boxes(img_names, detection_result, class_names, _MODEL_SIZE)
```

output:

9.Video processing

I also applied the same algorithm to video detections. Here is an example of applying Yolo to a video I found on YouTube. (A Street Walk in Shinjuku,Tokyo, Japan)

```
from IPython.display import Image
with open('/kaggle/input/data-for-yolo-v3-kernel/detections.gif','rb')
as f:
    display(Image(data=f.read(), format='png'))
```