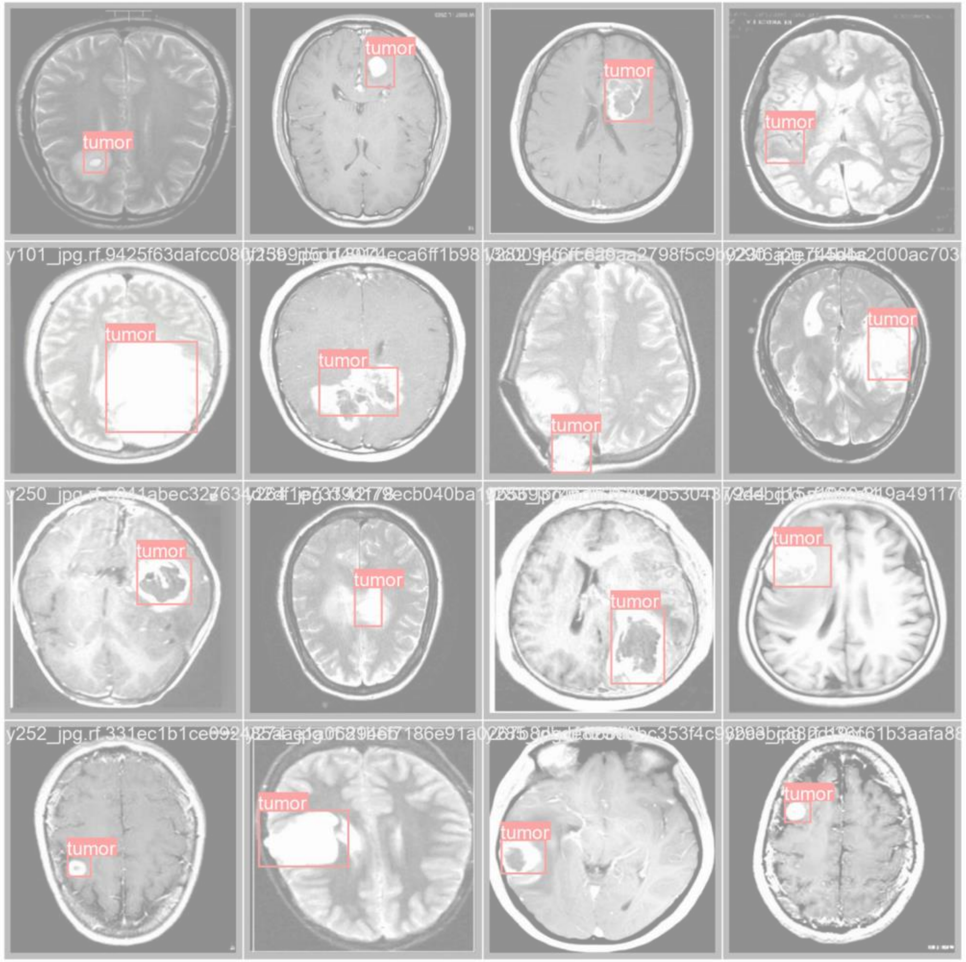


YOLO object detection model

Journal Club : October 4,2024

Commentator

Ekapob Sangariyavanich, MD.

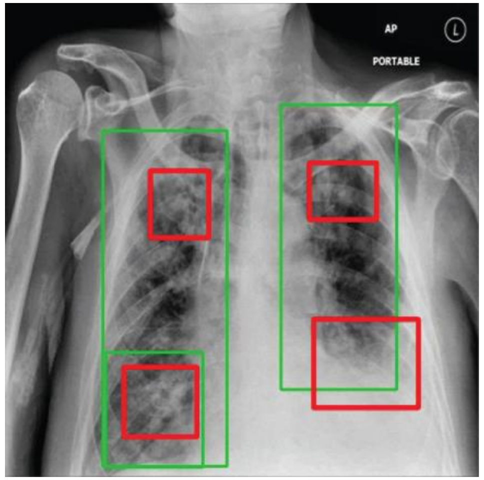
Outline

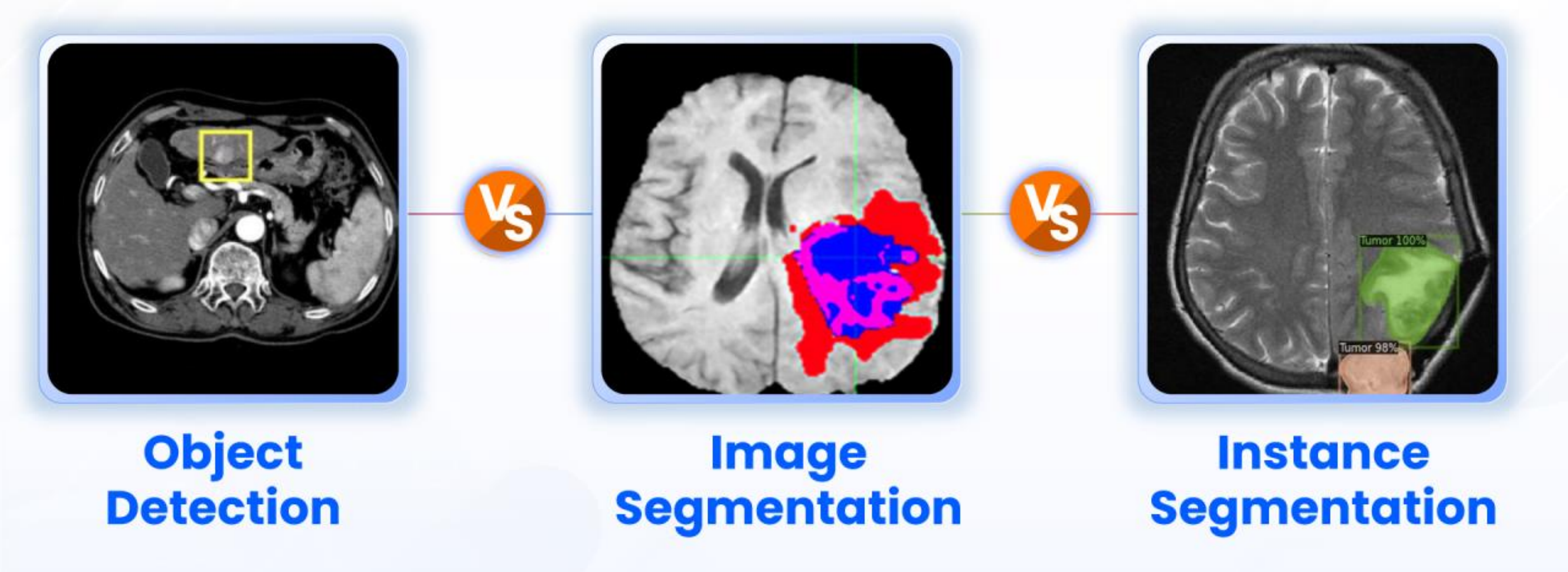
- Object detection model
- Object detection metrics
- Example use of YOLO in medical images

Object detection VS Image classification

Advantage of object detection

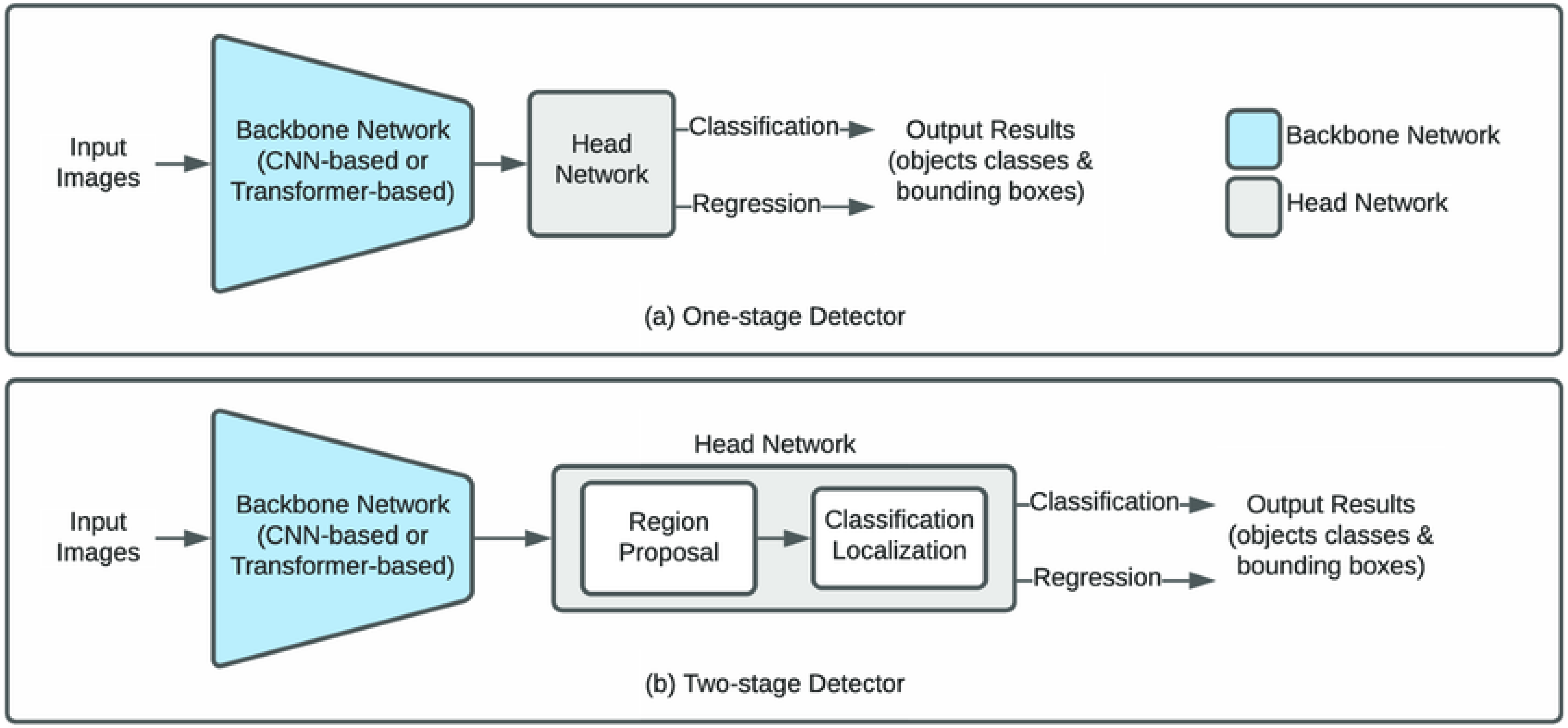
- Localization
- Detail orientation
- Contextual understanding
- Dynamic monitoring





Advantage	Speed	Comprehensive understanding	Detail and precision
Application	Identify fracture in ER	Brain MRI scan	lung CT scans for detecting lung nodules

Object detection model



1.Single stage e.g.

- YOLO (You Only Look Once)
- SSD (Single Shot Multibox Detector)
- RetinaNet

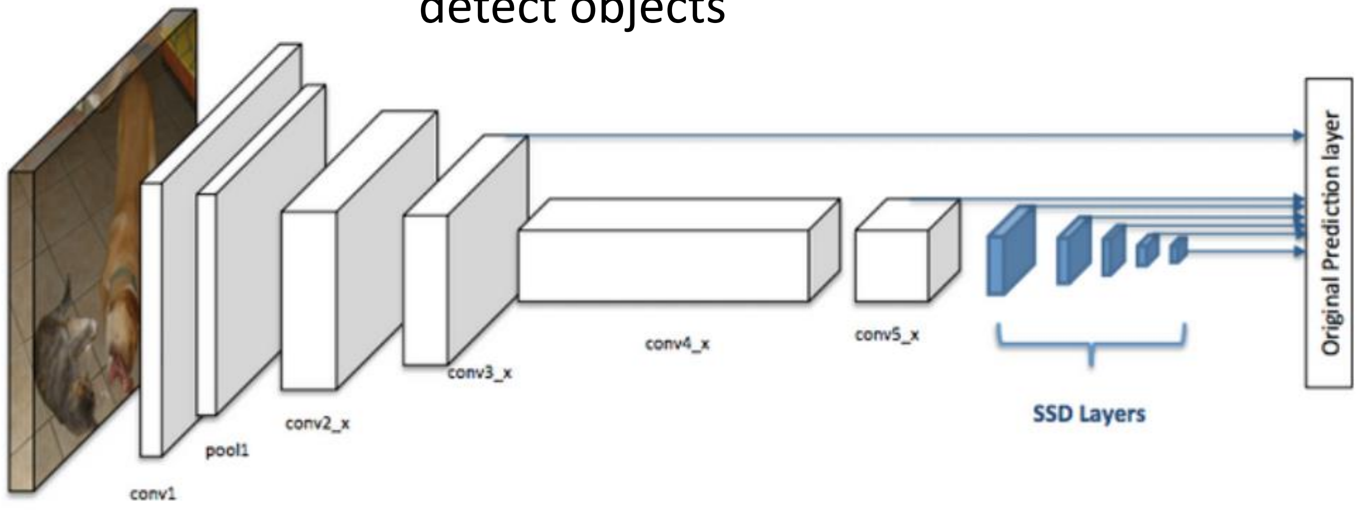
2. Two stage e.g.

- RCNN (Region-based Convolution Neural Network)
- Fast RCNN , Faster RCNN
- SPP (Spatial Pyramid Pooling networks)

Kang, Junhyung & Tariq, Shahroz & Oh, Han & Woo, Simon. (2022). A Survey of Deep Learning-Based Object Detection Methods and Datasets for Overhead Imagery. IEEE Access. 10. 1-1. 10.1109/ACCESS.2022.3149052.

SSD (2016)

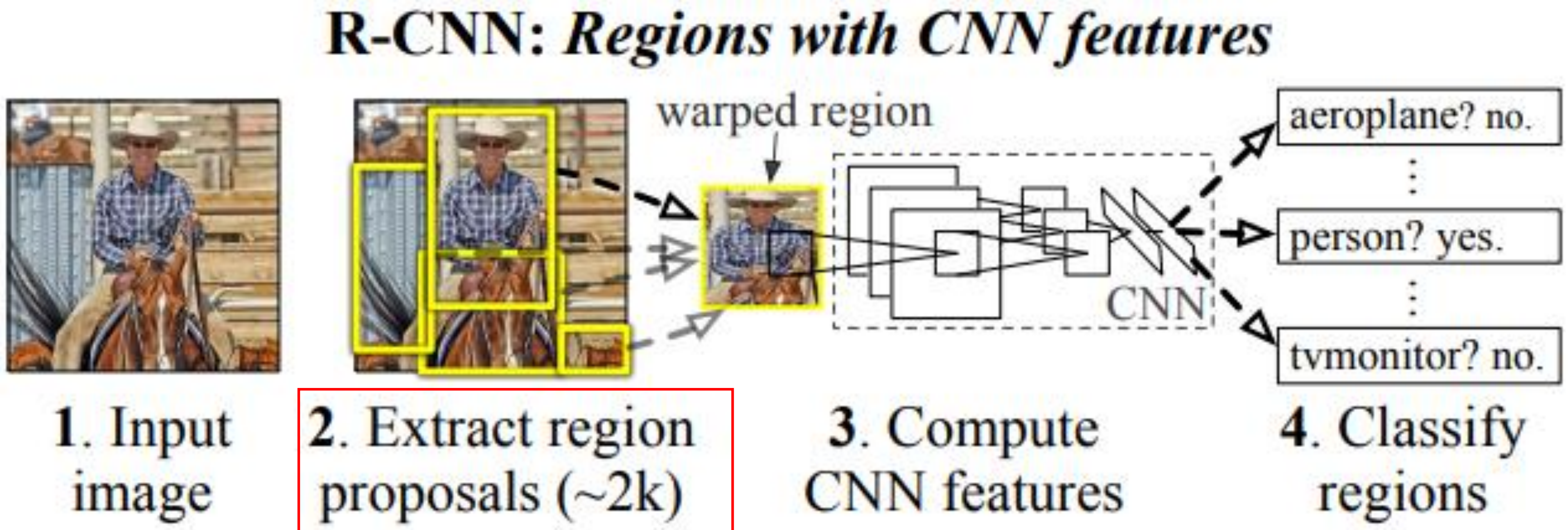
- Backbone : Conv. network for feature extraction
- SSD head : Apply multi-scale feature map for detect objects



- Fast but slightly slower than YOLO
- SSD usually performs badly for small objects comparing with other detection methods.
- Good accuracy than YOLO

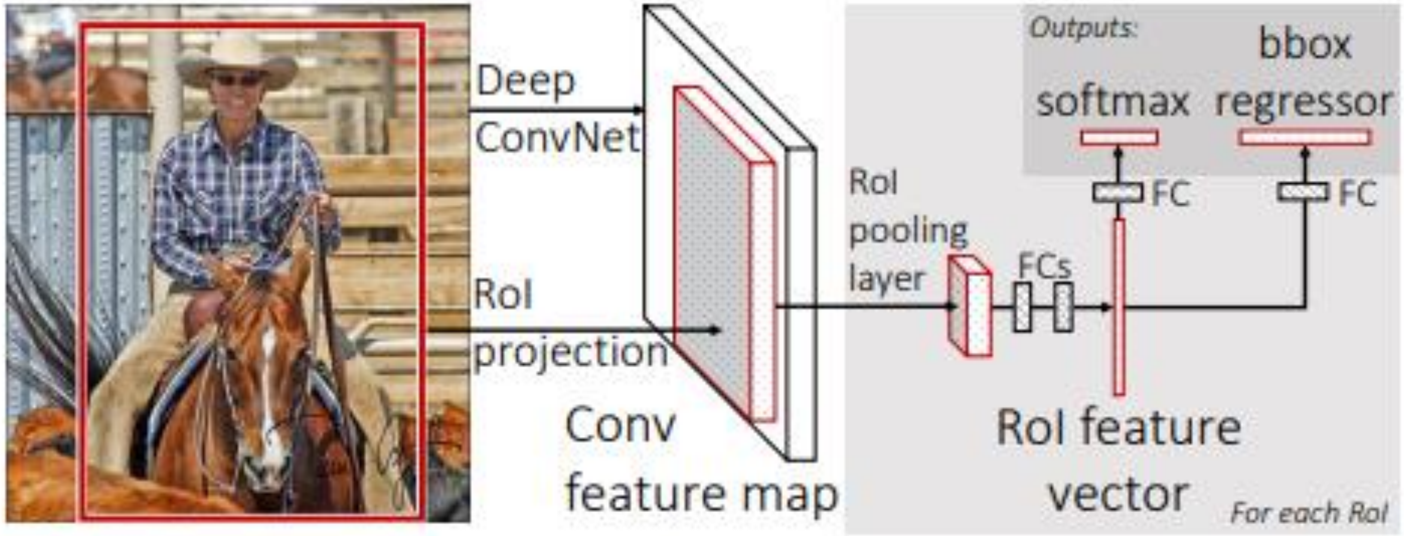
Figure 3. Architecture of a convolutional neural network with a SSD detector [2]

R-CNN (2013)



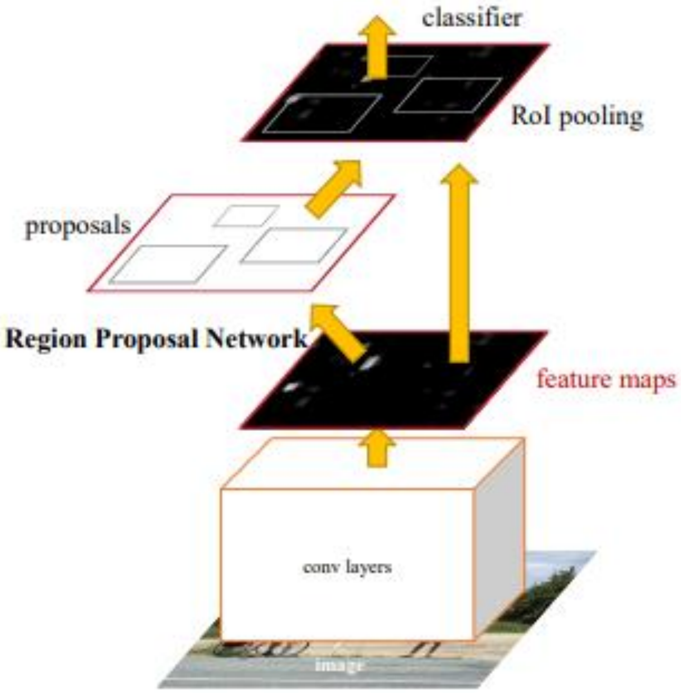
Selective search

Fast R-CNN (2015)



-Girshick, Ross B.. "Fast R-CNN." (2015).
-Ren, Shaoqing, et al. "Faster R-CNN: Towards real-time object detection with region proposal networks." *IEEE transactions on pattern analysis and machine intelligence* 39.6 (2016): 1137-1149.

Faster R-CNN (2015)

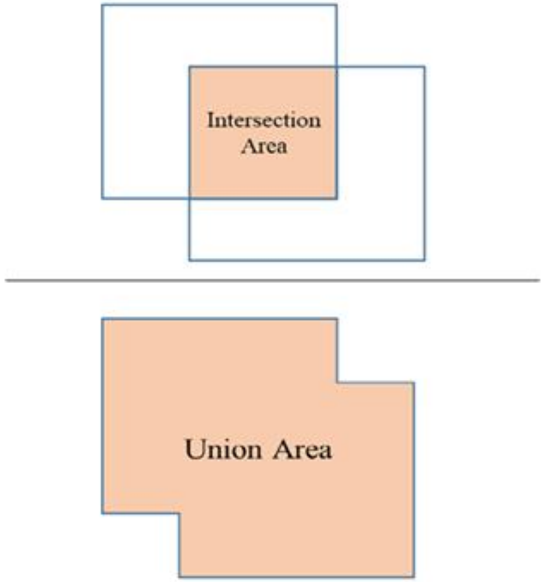


- **Region proposal network**
  predicting whether there is an object or not and also predicting the bounding box of those objects.
- **ROI pooling layer**
  reshape RPN region to fixed size for classification and bound box regression

Object detection performance metrics

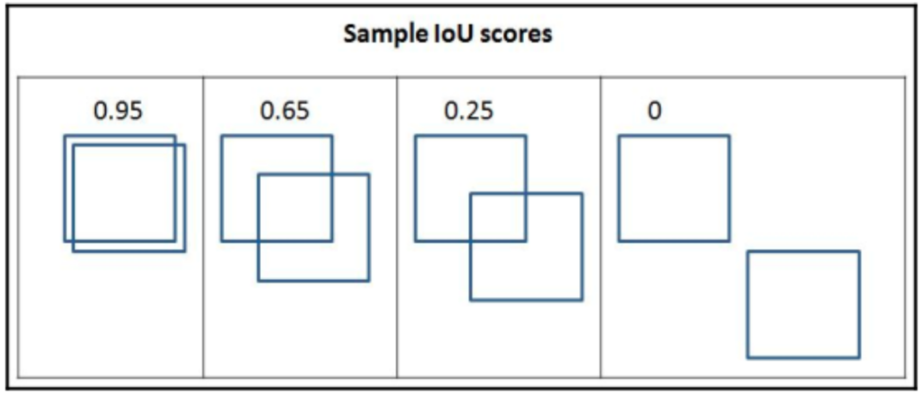
- Intersection over Union (IoU)

$$IoU = \frac{overlapping\ area}{union\ area} =$$



\> 0.5 Acceptable
\> 0.7 Good
\> 0.95 Excellent

- Class prediction :
  Positive if IoU >= IoU threshold
  Negative if IoU < IoU threshold



True Positive

IoU = 0.922

False Positive

- Incorrect localization
- Incorrect classification

IoU = 0.258

IoU Threshold = 0.5

False Negative

IoU = 0.00

True Positives [TP]

Object detections with IoU >= IoU threshold

False Positives [FP]

Object detections with IoU < IoU threshold

False Negatives [FN]

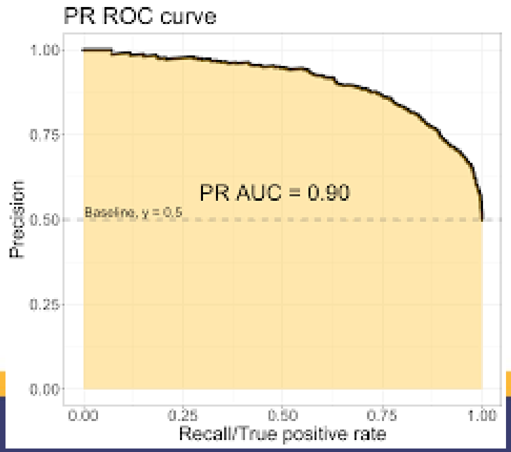
No objects detected

Object detection performance metrics

- Accuracy, Precision, F1-score, Recall, Specificity
- Average Precision (AP)

  = AUC for precision-recall curve (AUPRC)

  - PR Curve is plot between precision and recall with varying IOU threshold



- Precision $(P) = TP\ /\ (TP + FP)$
- Recall $(R) = TP\ /\ (TP + FN)$

- Mean average precision(mAP)

-The mAP is calculated by finding Average Precision(AP) for each class and then average over a number of classes.

$$mAP = \frac{1}{n}\sum_{k=1}^{k=n} AP_k$$

$$AP_k = \text{ the AP of class } k$$

$$n = \text{ the number of classes}$$

- mAP50 calculates AP at an IoU of 0.5 .

- mAP50-95 averages AP calculated at IoU thresholds from 0.5 to 0.95 with a step size of 0.05 .

- Detection speed (FPS)

$$\text{FPS} = \frac{\text{Number of frames processed}}{\text{Total time taken (seconds)}}$$

- real-time detector → at least 30 frames per second (FPS)

- smooth performance → at least 60 frames per second (FPS)

Example use of YOLO in medical images

STBi-YOLO: A Real-Time Object Detection Method for Lung Nodule Recognition

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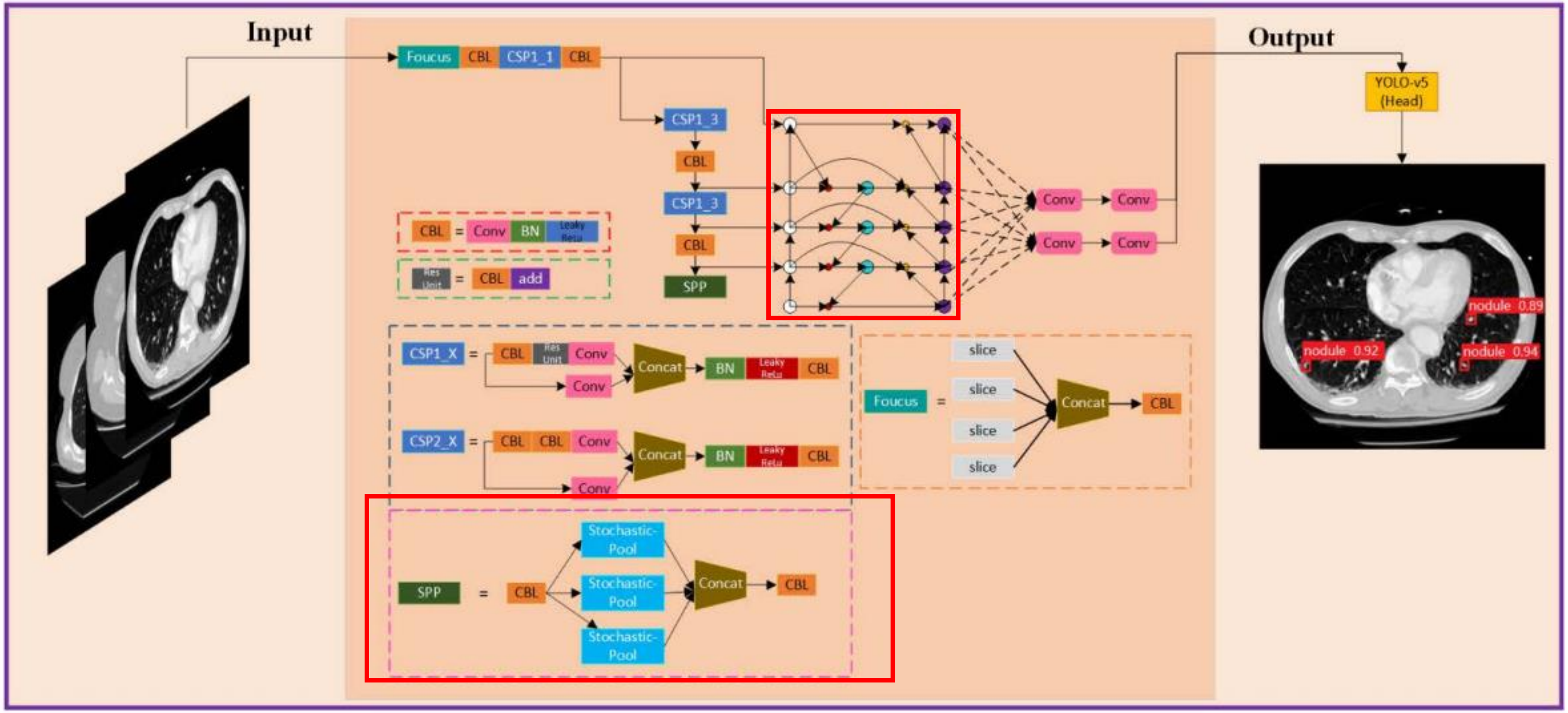
K. Liu, "STBi-YOLO: A Real-Time Object Detection Method for Lung Nodule Recognition," in *IEEE Access*, vol. 10, pp. 75385-75394, 2022, doi: 10.1109/ACCESS.2022.3192034

Introduction

- Lung nodules, which can indicate early-stage lung cancer, typically appear as small, round shadows on CT scans, measuring up to 3 cm in diameter.
- Tiny size nodules are similar to blood vessels.
- This complicates accurate diagnosis, making the screening process inefficient and increasing the risk of misdiagnosis.
- When applying the YOLO-v5 algorithm to lung CT images, it performs with poor detection accuracy and low processing speed.

Lung nodule detection based on STBi-YOLO



Experimental settings

- Tensorflow deep learning network
- GPU:NVIDIA Tesla K80; accelerated using CUDAv11.0 and CuDNNv8.0
- The programming language of this model is Python.
- Train proposed model (STBI-YOLO), YOLO-v3,YOLO -v4, and YOLO-v5 with the same parameter settings.
- Model parameter settings

Parameters	Values
weight decay	0.0005
batch size	4
learning rate	0.01
epoch	300

Experimental dataset

- LUNA16 (high quality lung nodule CT image dataset launched in 2016)
- This dataset contains a total of 888 3D lung CT image, 1,186 lung nodules and 36,378 annotated information by four professional radiologists.
- The dataset consists of four main parts:

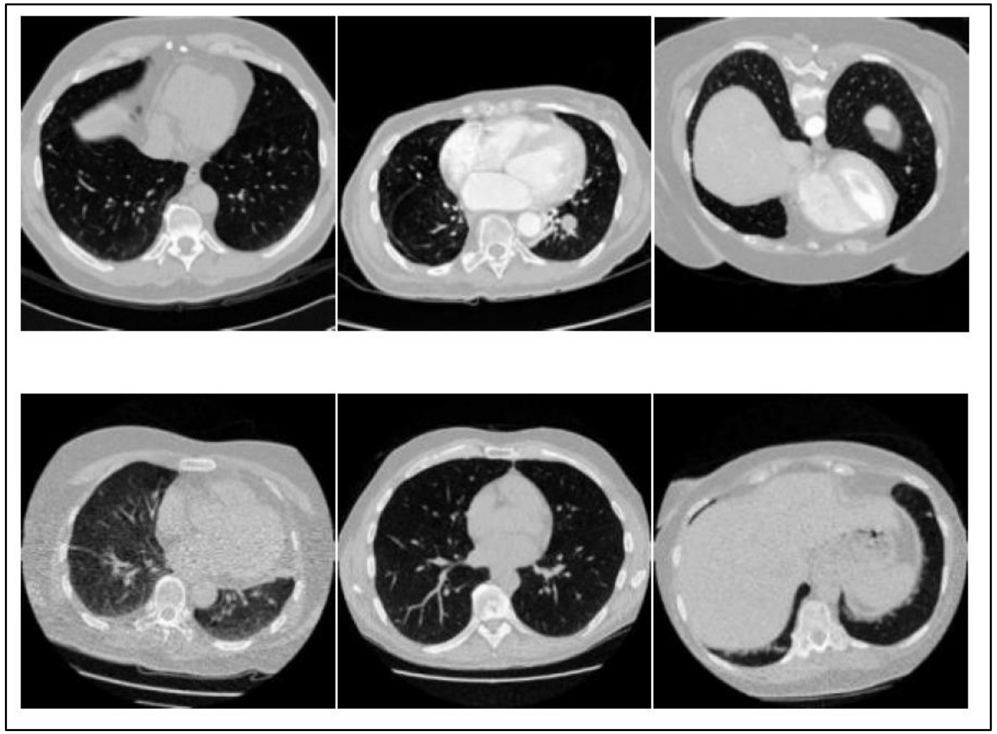
  1) the original CT images

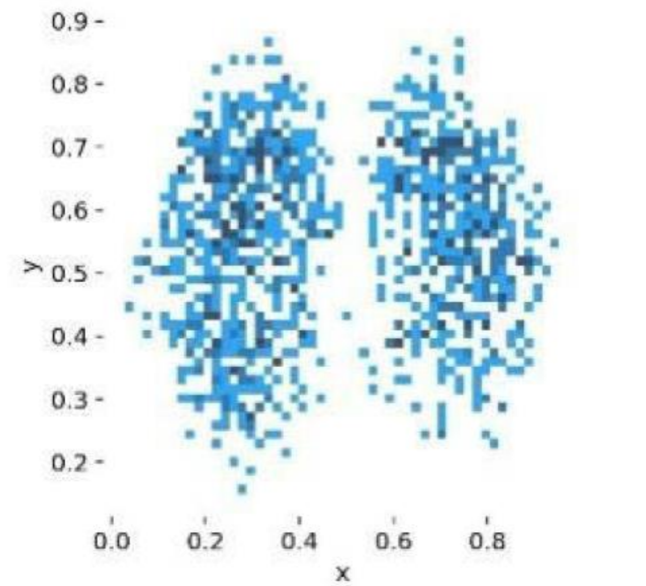
  2) the annotation files of lung nodule locations

  3) the original CT lung regional segmentation files

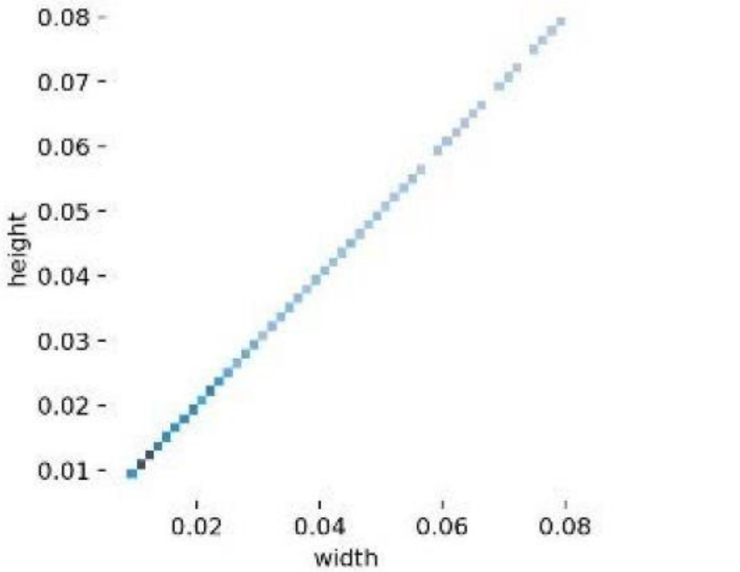
  4) the diagnosis result files
- Train-test-validation = 70% : 15% : 15%

https://luna16.grand-challenge.org/





(a) Distribution of lung nodules



(b) Lung nodule size distribution

Dataset analysis

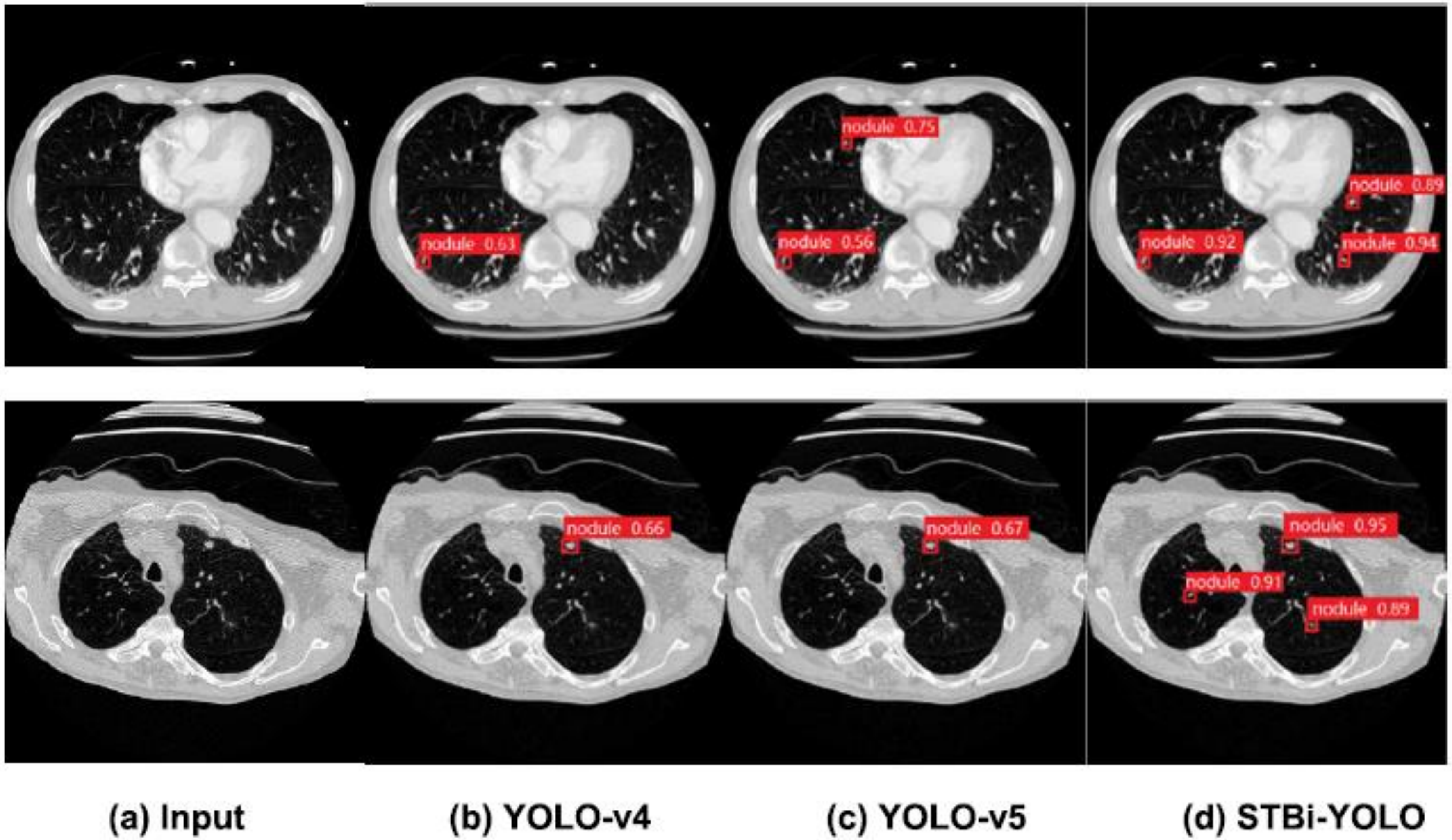


FIGURE 10. Experimental results.

Experimental results

Model	Weights/MB	mAP/%	Recall/%	Detection speed/FPS
Faster R-CNN	159	91.9	92.5	191
Mask R-CNN	121	73.65	78.3	54
SSD	100.2	75.2	77.0	98
YOLO-v3	235	81.3	82.9	59
YOLO-v4	246	88.4	90.0	41
YOLO-v5s	41.9	90.8	91.1	25
STBi-YOLO	43.6	95.9	96.7	27

Thank you for your attention