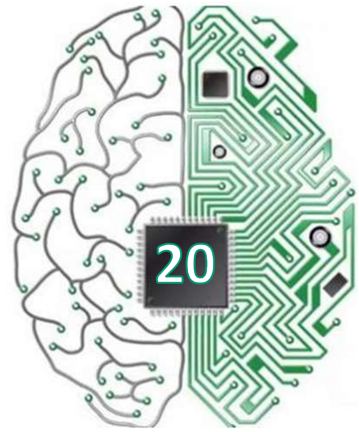
Open Elective Course [OE]
Course Code: CSO507
Winter 2023-24

Lecture#



Deep Learning

Unit-4: Convolutional Neural Networks (Part-VIII)

Unit-5: Sequence Modeling

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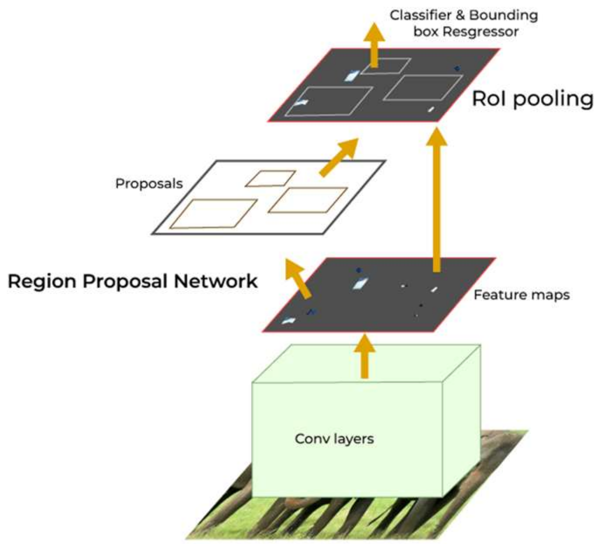
YOLO Model for Object Detection

YOLO: You Only Look Once

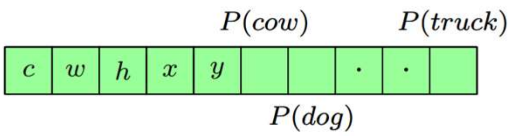


- The approaches that we have seen so far are two stage approaches
- They involve a region proposal stage followed by separate classification and regression stage
- Can we have an end-to-end architecture which does both proposal and classification simultaneously ?
- This is the idea behind YOLO
  - **You Only Look Once.**

Key Insights

- Previous Approaches
  - more complicated model pipeline
  - expensive computation
  - lacks contextual information for detection
- YOLO Algorithm
  - less complicated pipeline
  - efficient computation
  - has contextual information for detection

YOLO: You Only Look Once

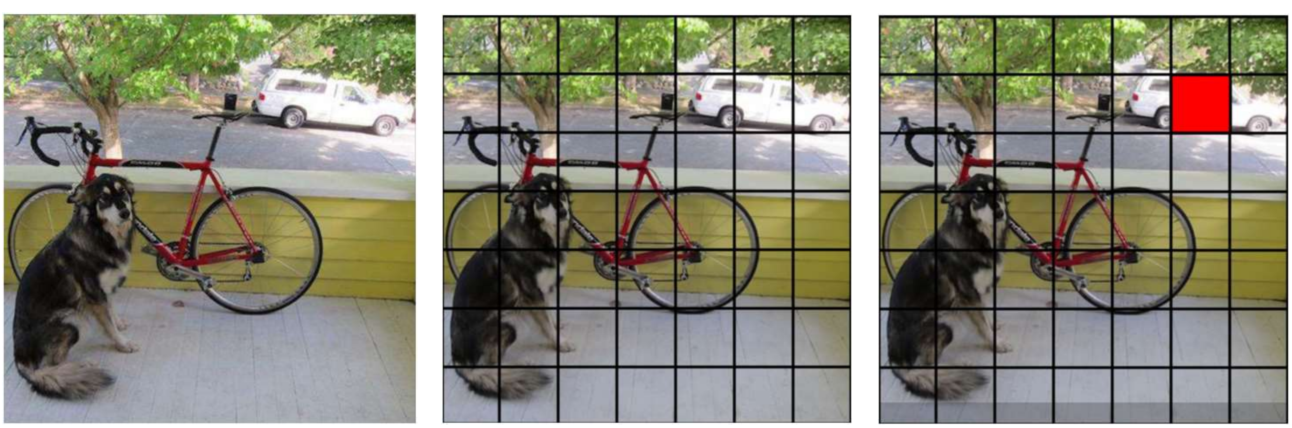



S × S grid on input

Considering only 1 bounding box per cell

- Divide an image into S × S grids
- For each such cell we are interested in predicting 5 + k quantities
  - Confidence
  - Width of the bounding box
  - Height of the bounding box
  - Center (x,y) of the bounding box
  - Probability of the object in the bounding box belonging to the k-th class (k - values)
- The output layer thus contains S × S × (5 + k) elements

YOLO: You Only Look Once



YOLO: You Only Look Once

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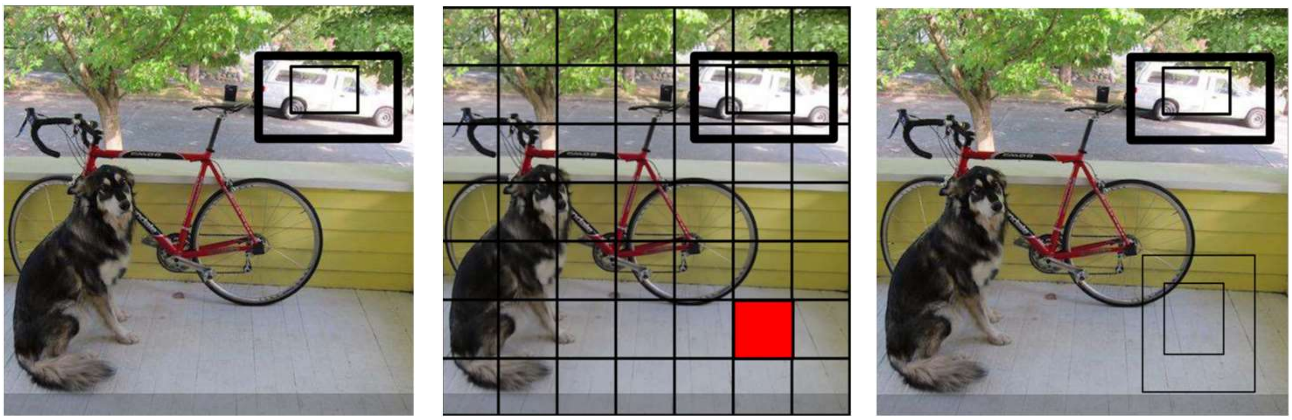

YOLO: You Only Look Once

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Considering B number of bounding boxes per cell, the output layer dimension would be: $\boldsymbol{S \times S \times (B * 5 + k)}$

YOLO: You Only Look Once

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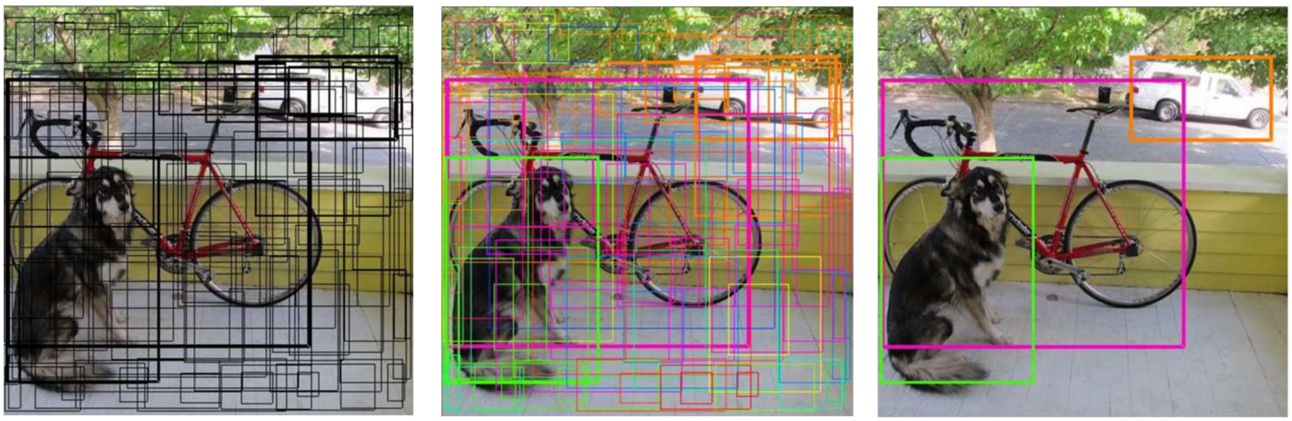
Class-specific Confidence

After applying Non-Maximum Suppression (NMS)



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

IoU: Intersection over Union

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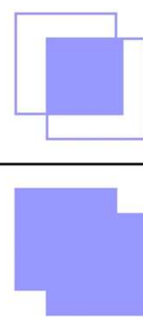
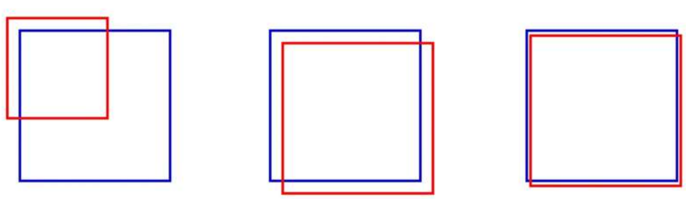
$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}}$$

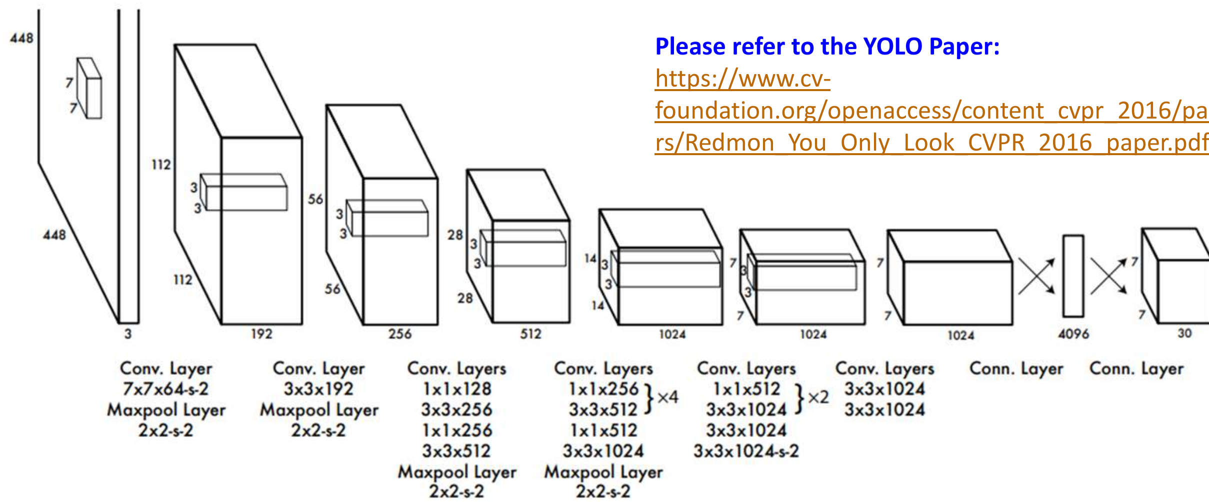




Poor Good Excellent

Network Design

Please refer to the YOLO Paper:
https://www.cv-foundation.org/openaccess/content_cvpr_2016/papers/Redmon_You_Only_Look_CVPR_2016_paper.pdf



Inspired from GoogLeNet, however does not use Inception layer

YOLO Objective Function

$$
\lambda_{\textbf{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2 \right]
$$

$$
+ \lambda_{\textbf{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[\left(\sqrt{w_i} - \sqrt{\hat{w}_i} \right)^2 + \left(\sqrt{h_i} - \sqrt{\hat{h}_i} \right)^2 \right]
$$

$$
+ \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left(C_i - \hat{C}_i \right)^2
$$

$$
+ \lambda_{\text{noobj}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{noobj}} \left(C_i - \hat{C}_i \right)^2
$$

$$
+ \sum_{i=0}^{S^2} \mathbb{1}_{i}^{\text{obj}} \sum_{c \in \text{classes}} \left(p_i(c) - \hat{p}_i(c) \right)^2
$$

Please refer to the YOLO Paper:
https://www.cv-foundation.org/openaccess/content_cvpr_2016/papers/Redmon_You_Only_Look_CVPR_2016_paper.pdf

YOLO Objective Function

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$$\lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[(x_i - \hat{x}_i)^2 + (y_i - \hat{y}_i)^2 \right]$$
$$+ \lambda_{\text{coord}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left[\left(\sqrt{w_i} - \sqrt{\hat{w}_i} \right)^2 + \left(\sqrt{h_i} - \sqrt{\hat{h}_i} \right)^2 \right]$$

Coordinate Loss: Minimize the difference between x,y,w,h pred and x,y,w,h ground truth. ONLY IF object exists in grid box and if bounding box is resp for pred

$$+ \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{obj}} \left(C_i - \hat{C}_i \right)^2$$

Confidence Loss: Loss based on confidence ONLY IF there is object

$$+ \lambda_{\text{noobj}} \sum_{i=0}^{S^2} \sum_{j=0}^{B} \mathbb{1}_{ij}^{\text{noobj}} \left(C_i - \hat{C}_i \right)^2$$

No Object Loss: based on confidence if there is no object

$$+ \sum_{i=0}^{S^2} \mathbb{1}_{i}^{\text{obj}} \sum_{c \in \text{classes}} (p_i(c) - \hat{p}_i(c))^2$$

Class loss, minimize loss between true class of object in grid box

Advantages of YOLO

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- Pipeline comprised of a single network
- Learns general representation of the objects
- Extremely fast
- Reasons globally

Drawbacks of YOLO

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- More localization error
- Loss function

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Unit-5: Introduction (Sequence Modelling)

Sequential Data Examples

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- Often arise through measurement of time series
  - Acoustic features at successive time frames in speech recognition
  - Sequence of characters in an English sentence
  - Parts of speech of successive words
  - Snowfall measurements on successive days
  - Rainfall measurements on successive days
  - Daily values of currency exchange rate
  - Nucleotide base pairs in a strand of DNA

Example

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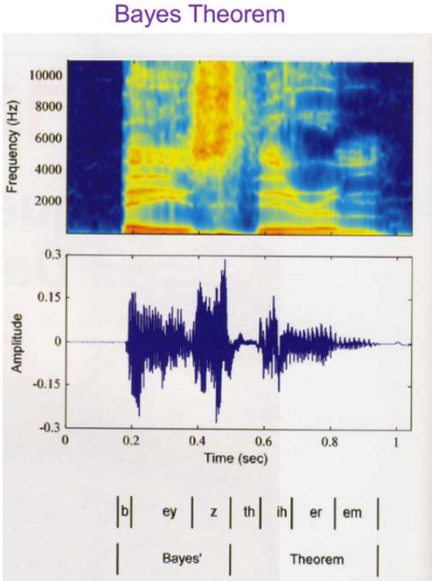
Bayes Theorem



- Decompose sound waves into frequency, amplitude using Fourier transforms
- Plot of the intensity of the spectral coefficients versus time index

Types of Sequential Data

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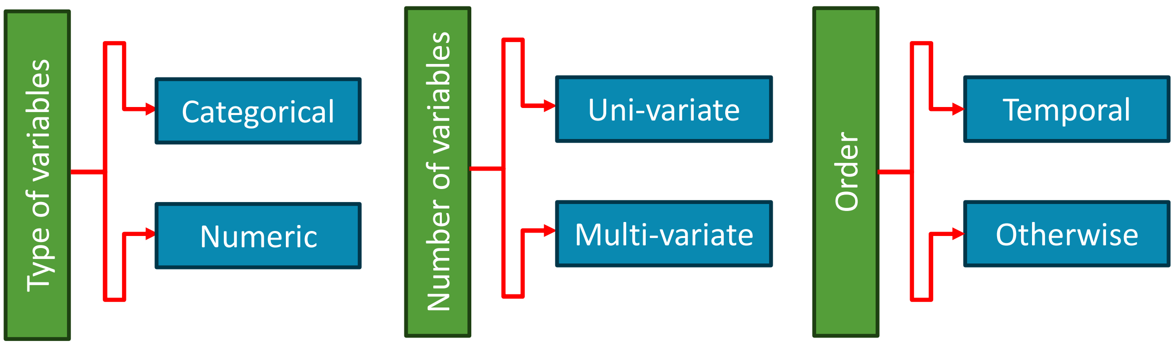

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Two common tasks with sequential data

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- **1. Sequence-to-sequence**
  - Named Entity Recognition
    - Input: Jim bought 300 shares of Acme Corp. in 2006
    - NER: [Jim]Person bought 300 shares of [Acme Corp.]Organization in [2006]Time
  - Machine Translation: Echte dicke kiste → Awesome sauce
- **2. Sequence-to-symbol**
  - Sentiment:
    - Best movie ever → Positive
  - Speaker recognition
    - Sound spectrogram → Harry

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Traditional NN & Sequence Data

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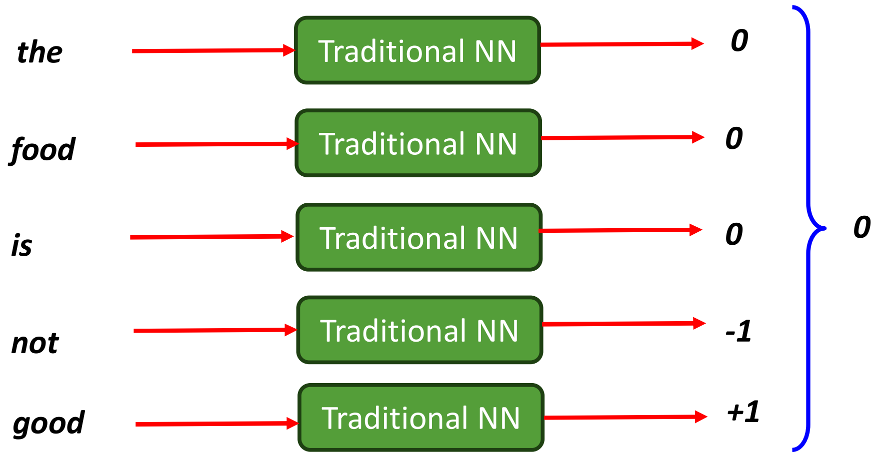
- Categorizing a piece of text: *“**the food is not good**”*



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Questions?

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