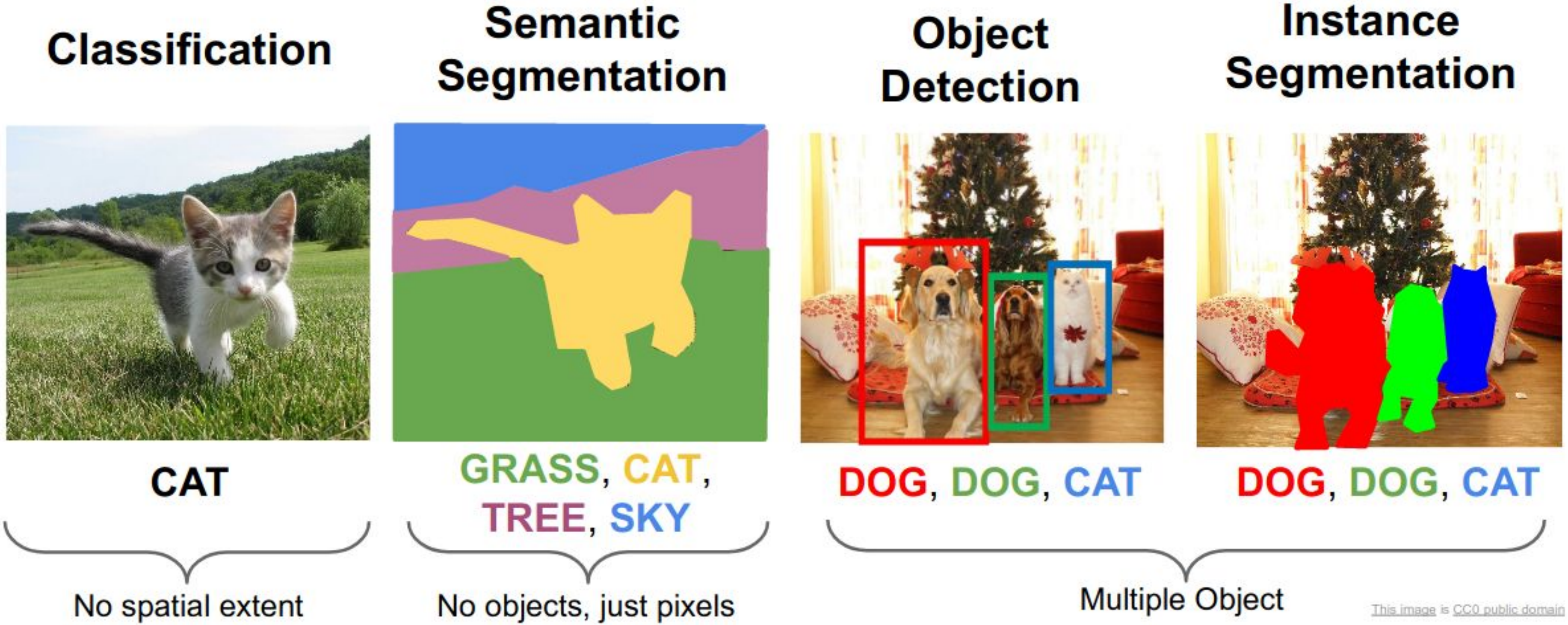
Mask R-CNN

MLRG 2021 @ UBC
Victor Sanches Portella

The task: **instance segmentation**



http://cs231n.stanford.edu/slides/2020/lecture_12.pdf

The full story

Looking **only** at the Mask R-CNN paper is not helpful, looks like magics

Looking at the **series** of work leading-up to Mask R-CNN is more interesting

- Region CNN (R-CNN)
- Fast R-CNN
- Faster R-CNN
- Mask R-CNN

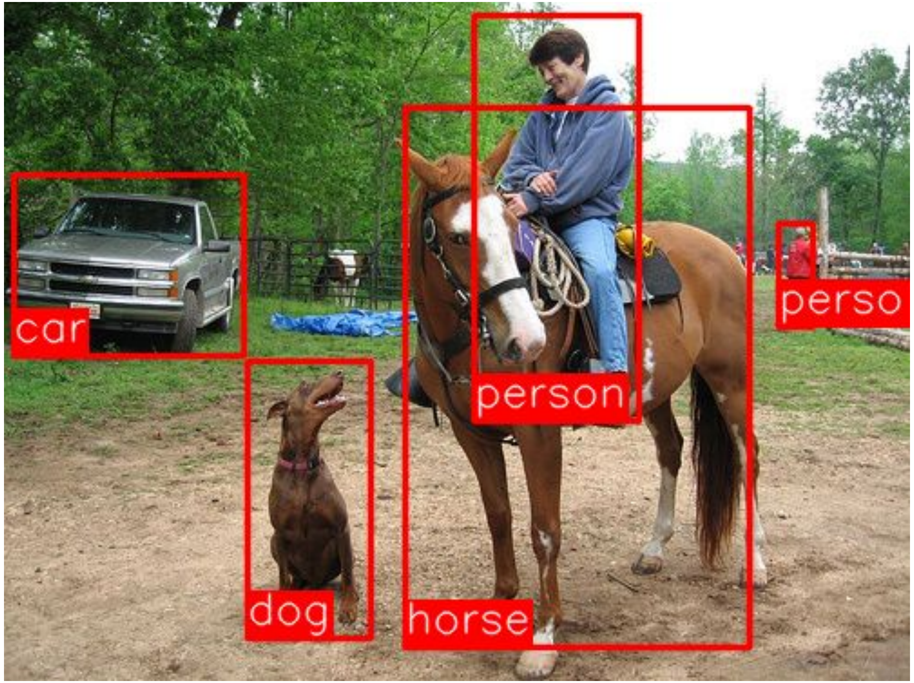
Object detection

Instance Segmentation

Region CNN

Ross Girshick, Jeff Donahue, Trevor Darrell, Jitendra Malik

Object classification vs Object detection



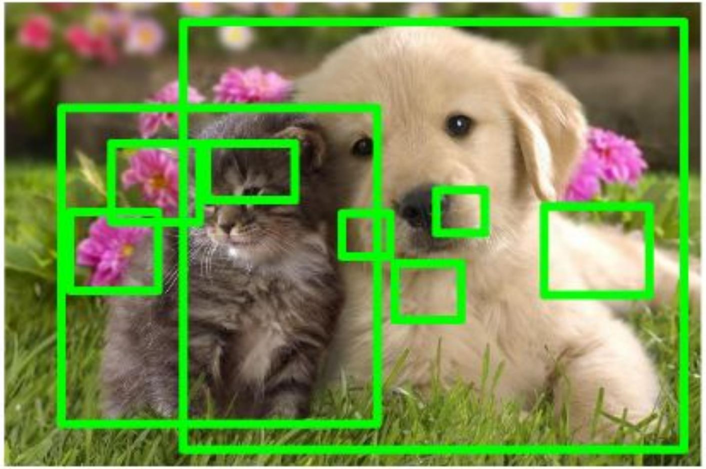
Are the results from **image classification** transferable to **image detection**?

Fixed # of outputs **VS** Varying # of outputs

Given a region/box of interest, we could run classification

How to propose regions?

Selective Search



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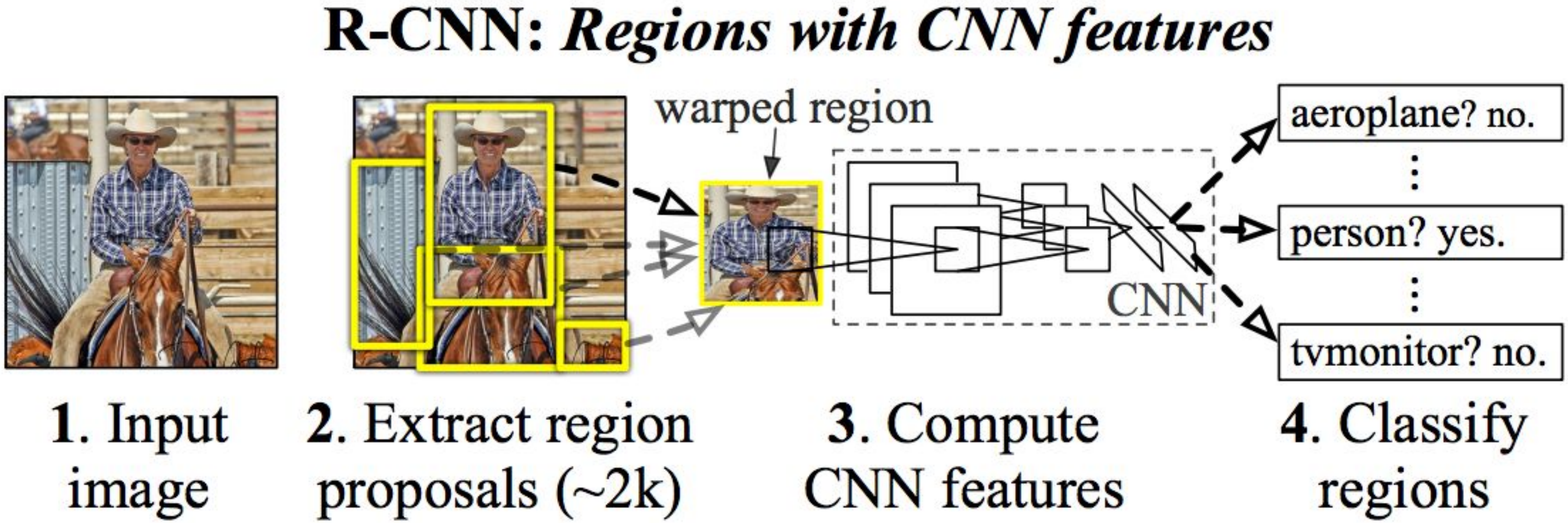
In the original paper, it proposes around **2k regions per image**

For each region, we can run classification (with a CNN)!



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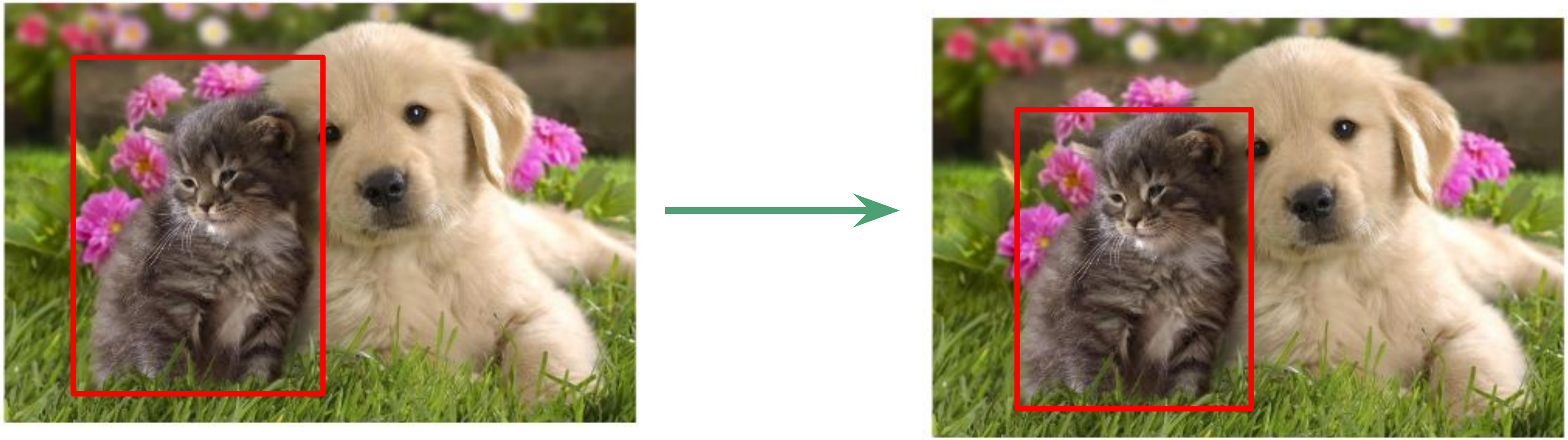
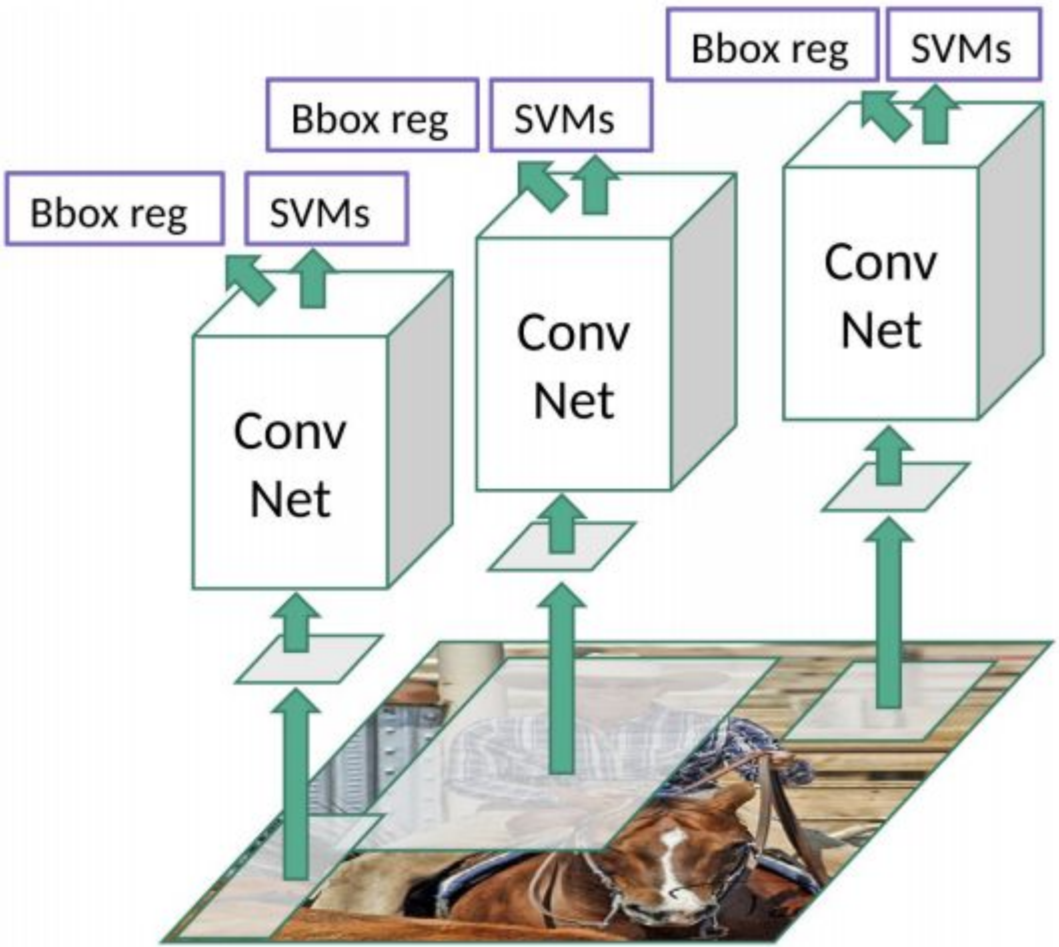
Improving bounding boxes

Proposed boxes may not be well-fitted to the object

We can tighten these boxes using linear regression (*details skipped*)





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Three models to be trained

SVM vs Softmax

Features are extracted for **each** RoI

SLOW

Fast R-CNN

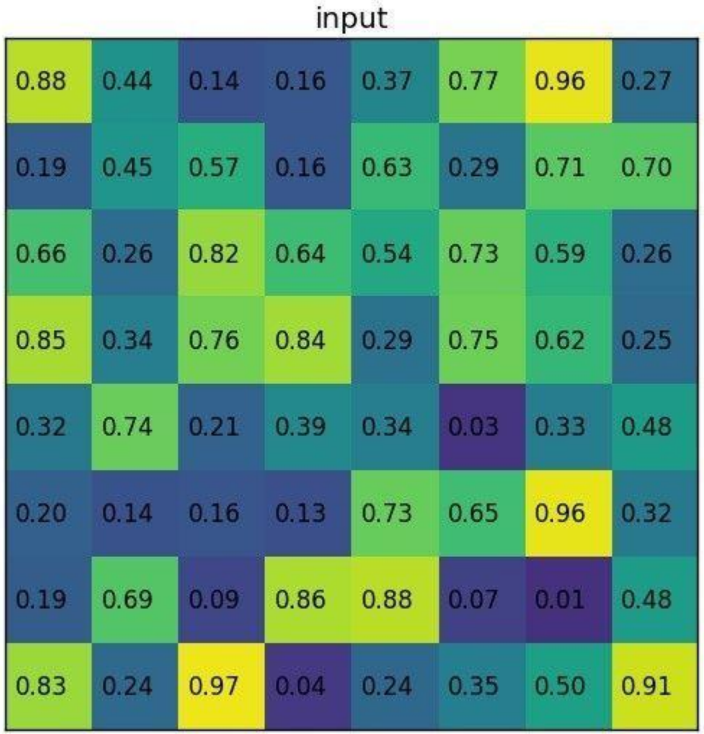
Ross Girshick

Key insights to speed-up R-CNN

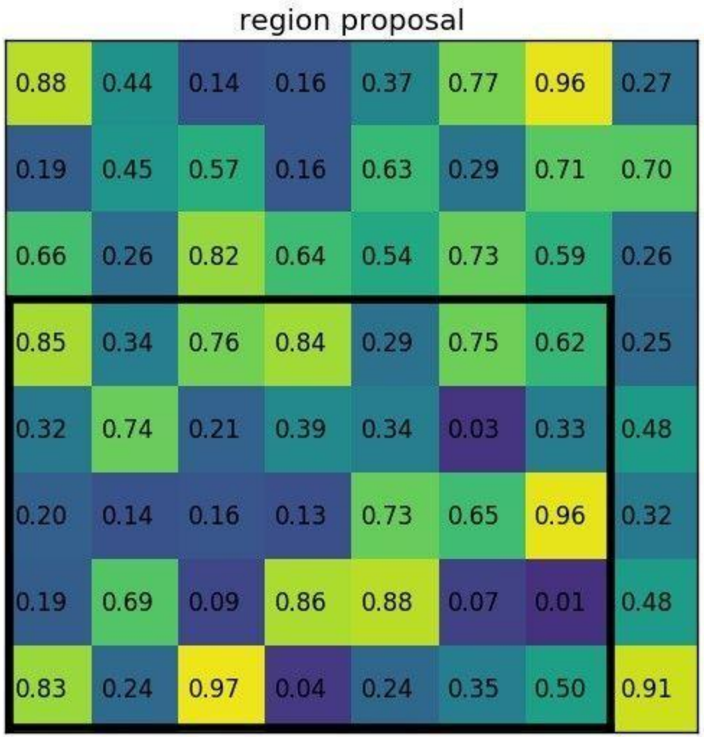
- Extract features first, select regions of interest later
  - A lot of proposed regions for a image overlap
  - Use RoIPool to share features!

- One network to rule them all
  - Instead of stacking models, make one network to do everything

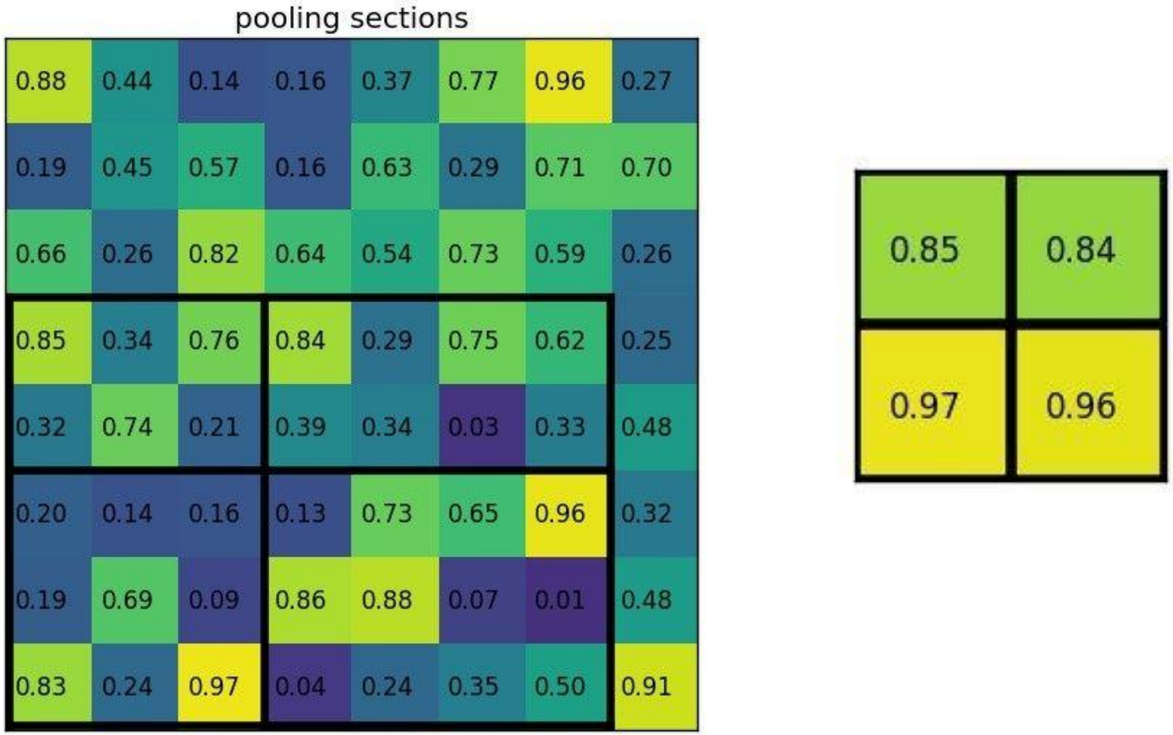
Region of Interest (RoI) Pooling



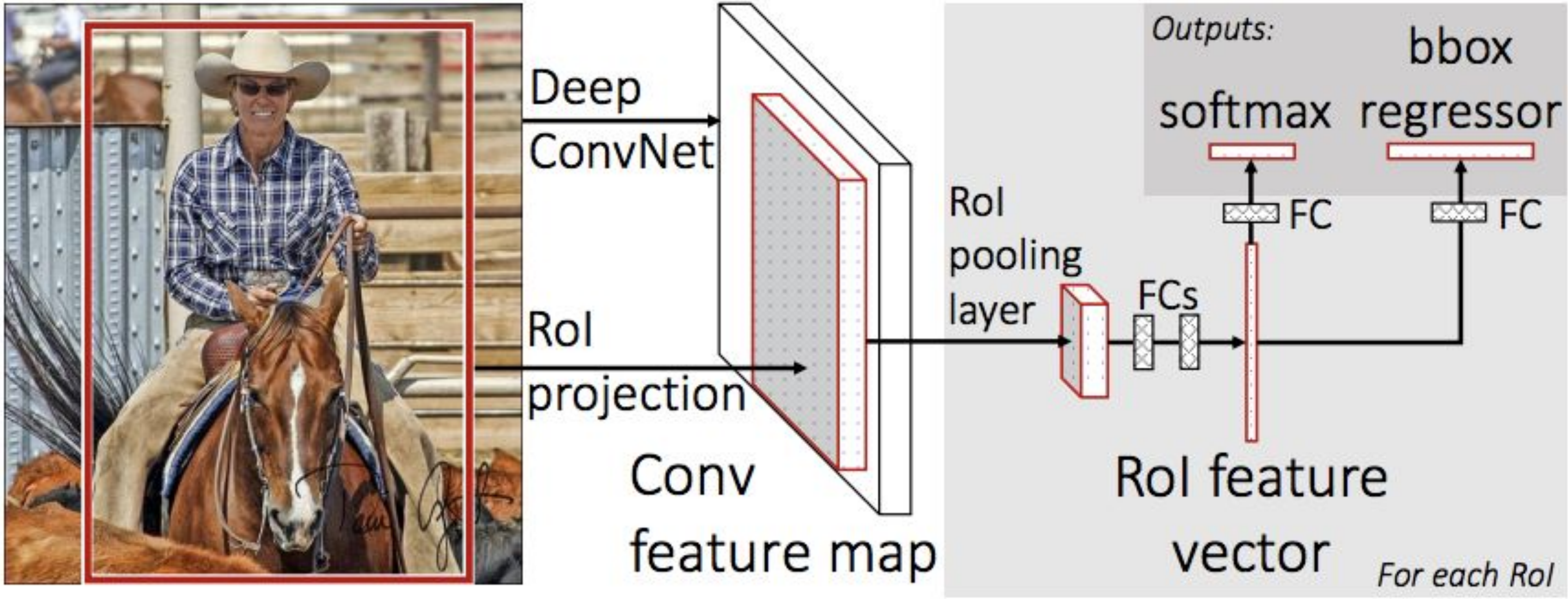
Region of Interest (RoI) Pooling



Region of Interest (RoI) Pooling

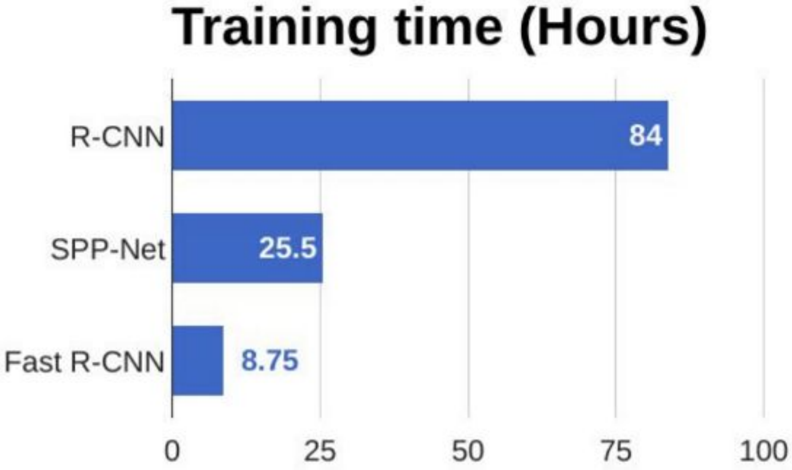


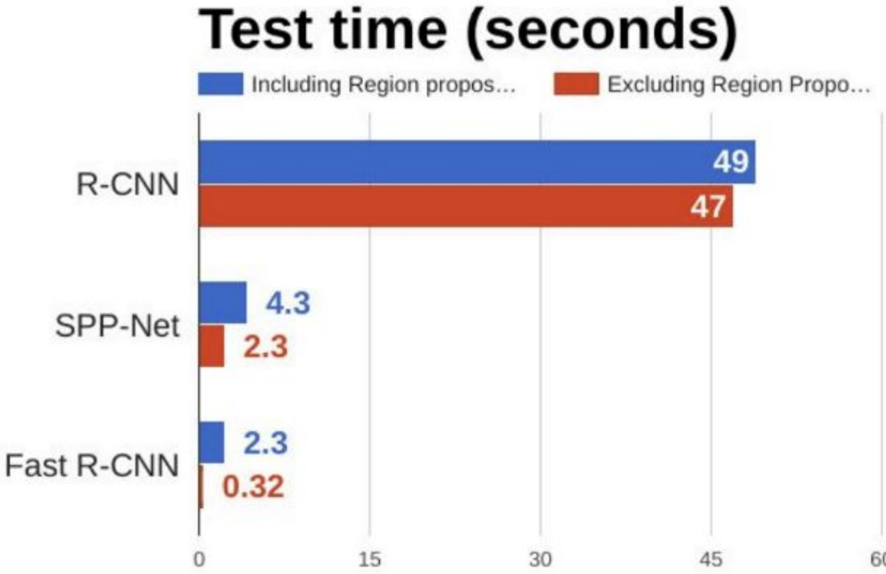
Putting everything together into a NN



https://arxiv.org/abs/1504.08083

Performance gains





Remark: The efficiency bottleneck of Fast R-CNN is region proposal via Selective Search

Fast**er** R-CNN

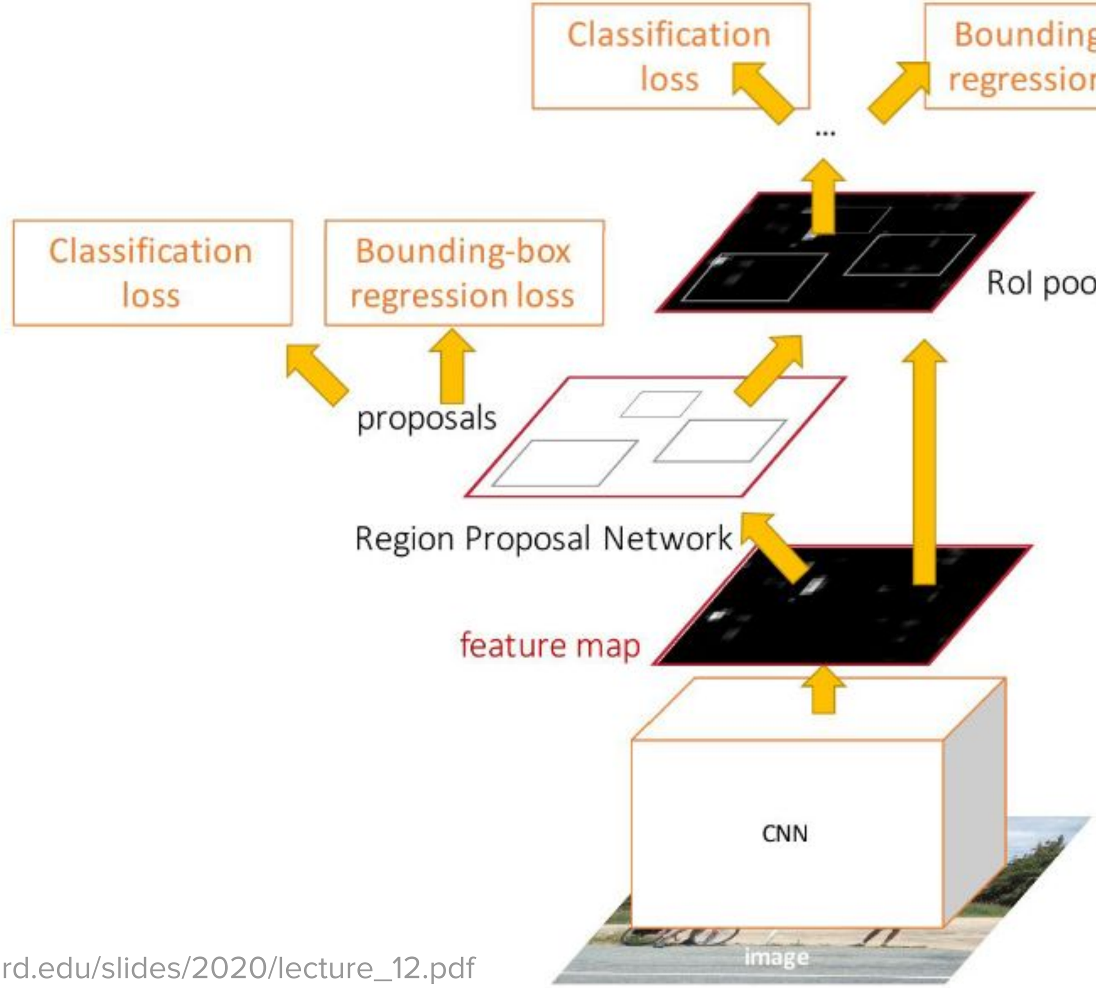
Shaoqing Ren, Kaiming He, Ross Girshick, Jian Sun

Region proposal in Fast R-CNN

- Selective Search became the main bottleneck for prediction

- RoI selection depends on features computed by a CNN

- **Idea:** Pass features through yet another NN, the **Region Proposal Network**



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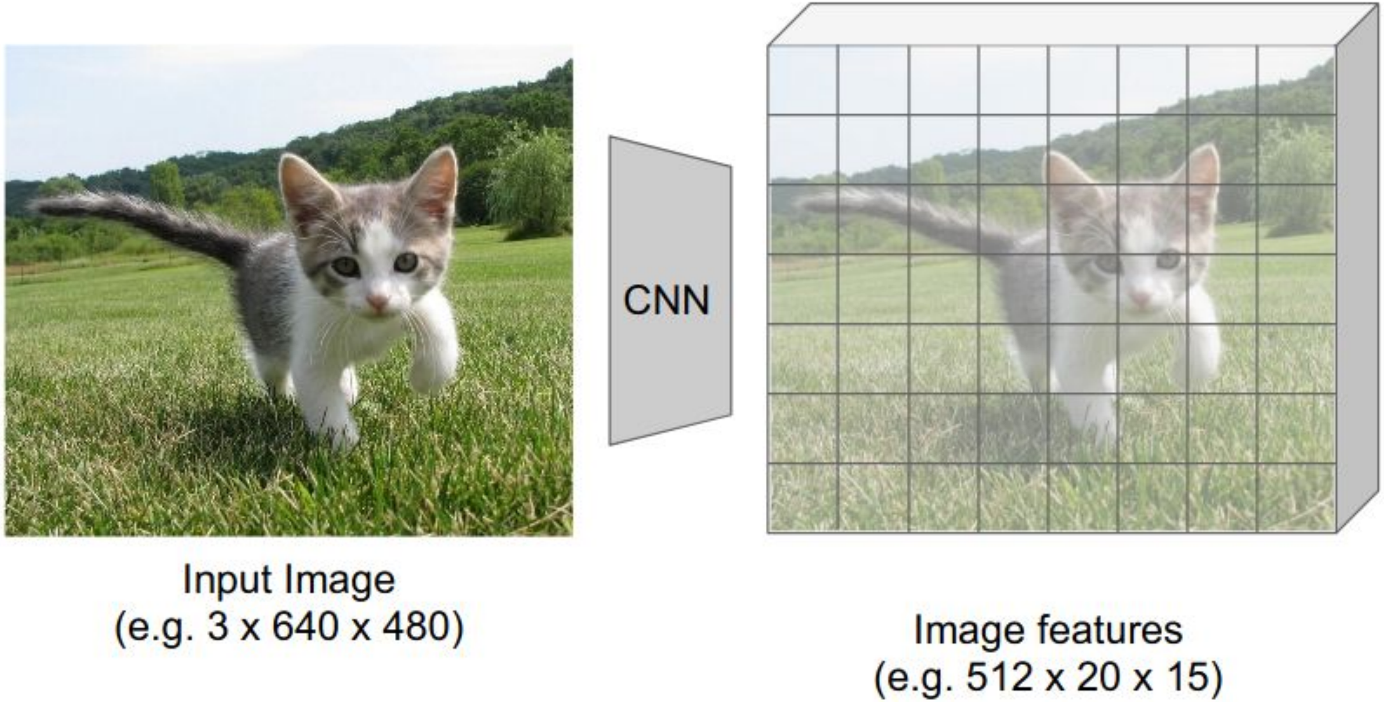
Region Proposal Network (RPN)



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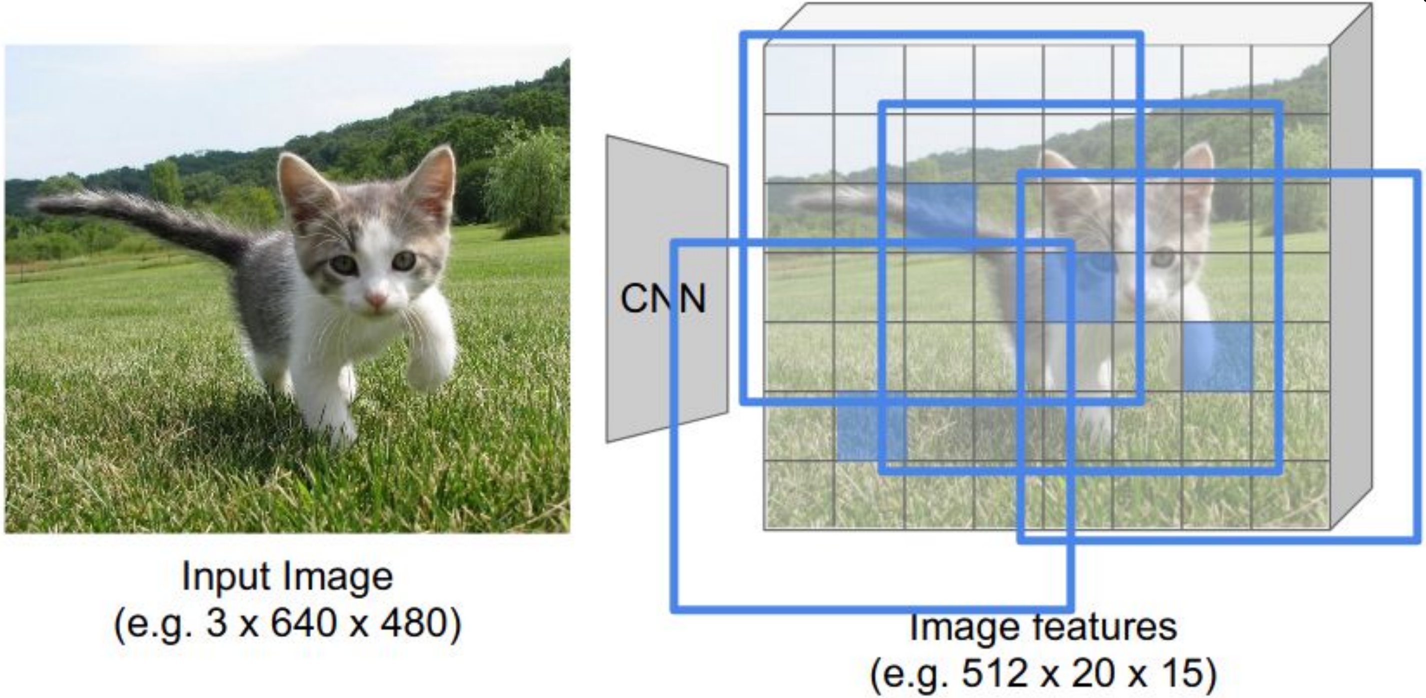
Region Proposal Network (RPN)

Slide an **anchor box** to generate candidates



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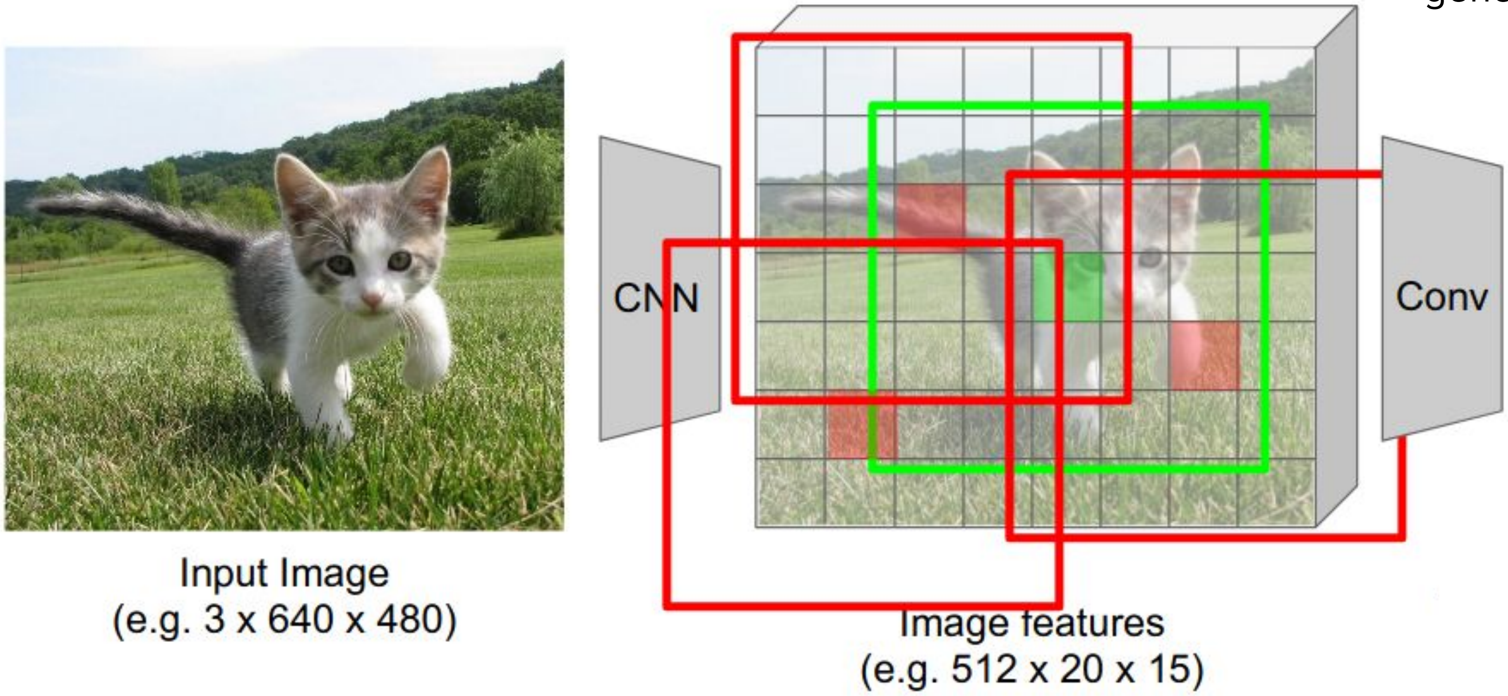

→ Is **box** an object?

→ **Box** warping

http://cs231n.stanford.edu/slides/2020/lecture_12.pdf

Region Proposal Network (RPN)

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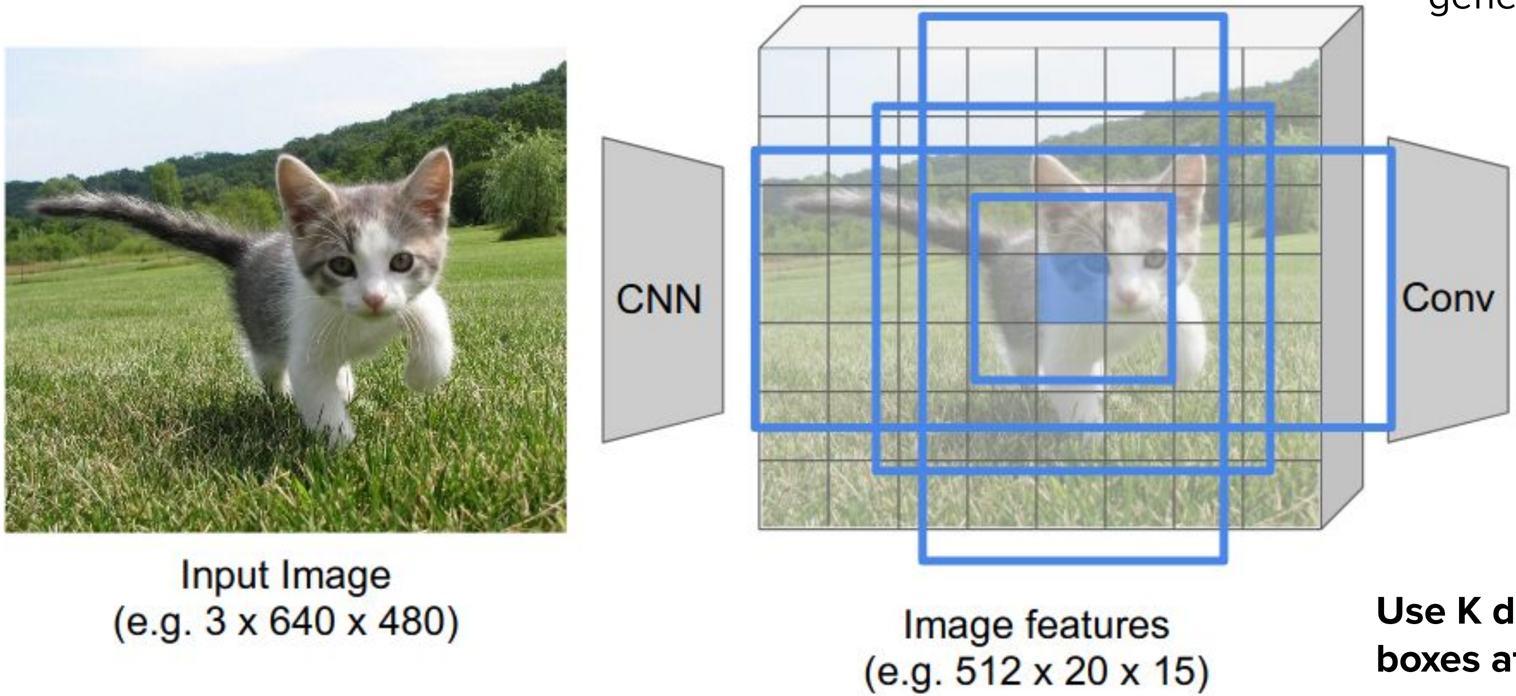
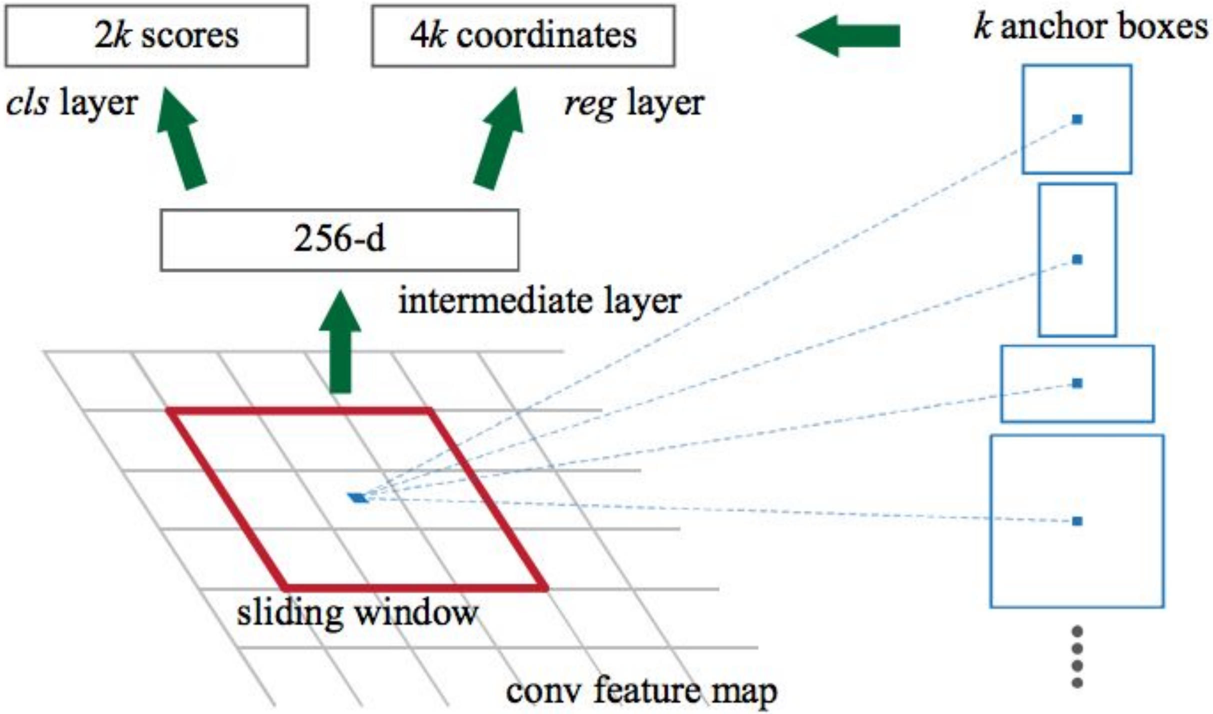


→ Is **box** an object?

→ **Box** warping

Use K different achor boxes at each point!

Region Proposal Network (RPN)



https://arxiv.org/pdf/1506.01497.pdf

How to train Faster R-CNN?

- **Option 1:** Alternating training (used in the paper)
    - Train RPN, then train Fast R-CNN, then fix the shared CNN, train RPN again, and then train Fast R-CNN again

- **Option 2:** Train the whole network simultaneously
    - By ignoring the derivative of the box coordinates, one can (approximately) train the whole network at once. Apparently it works without affecting efficiency by much.

Mask R-CNN

Kaiming He, Georgia Gkioxari, Piotr Dollár, Ross Girshick

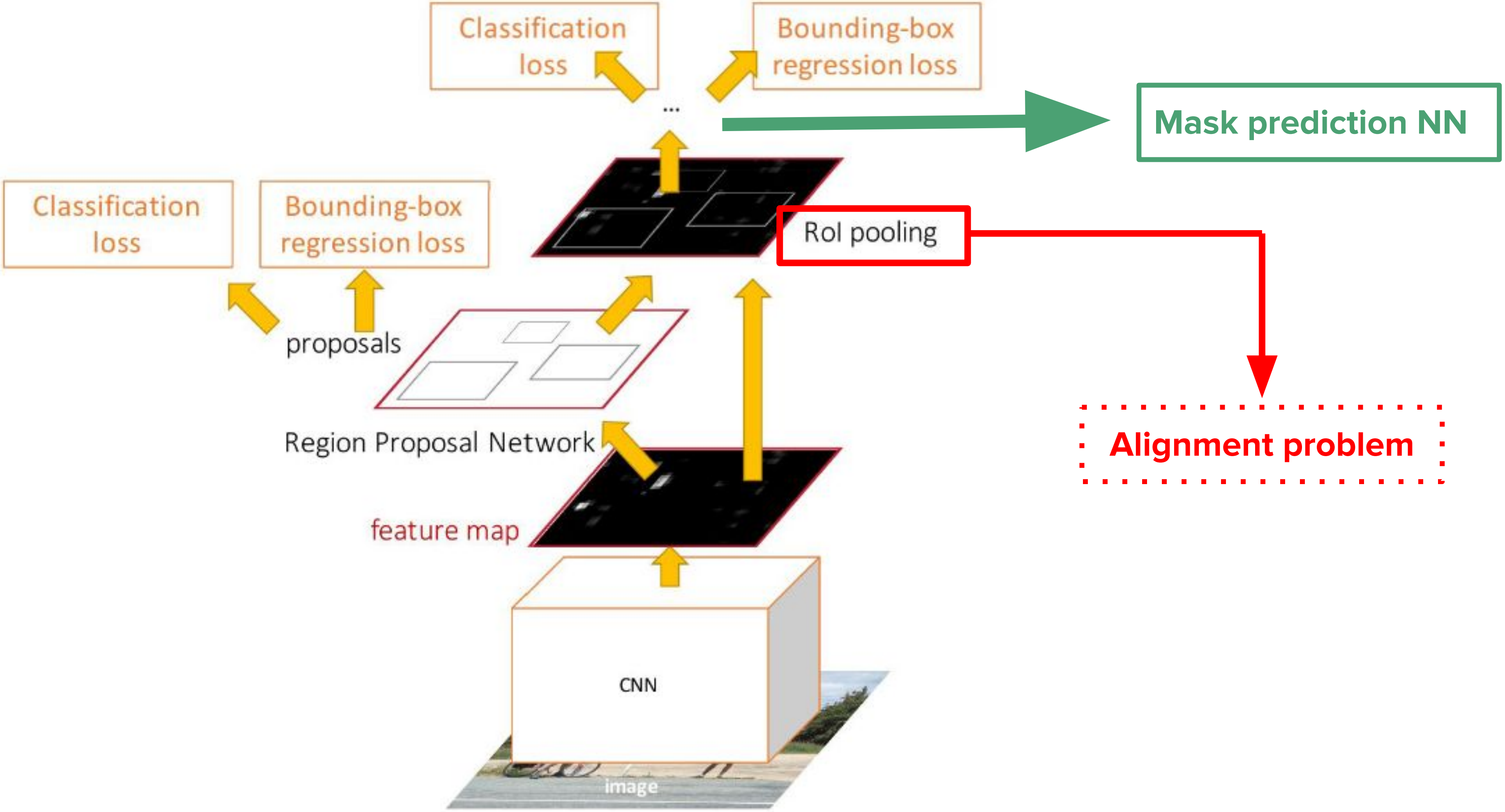
Adapt Faster R-CNN to do segmentation?

- Can we in some way adapt Faster R-CNN to do segmentation?

- **Idea:** For each RoI box, have a separate network to predict pixel mask

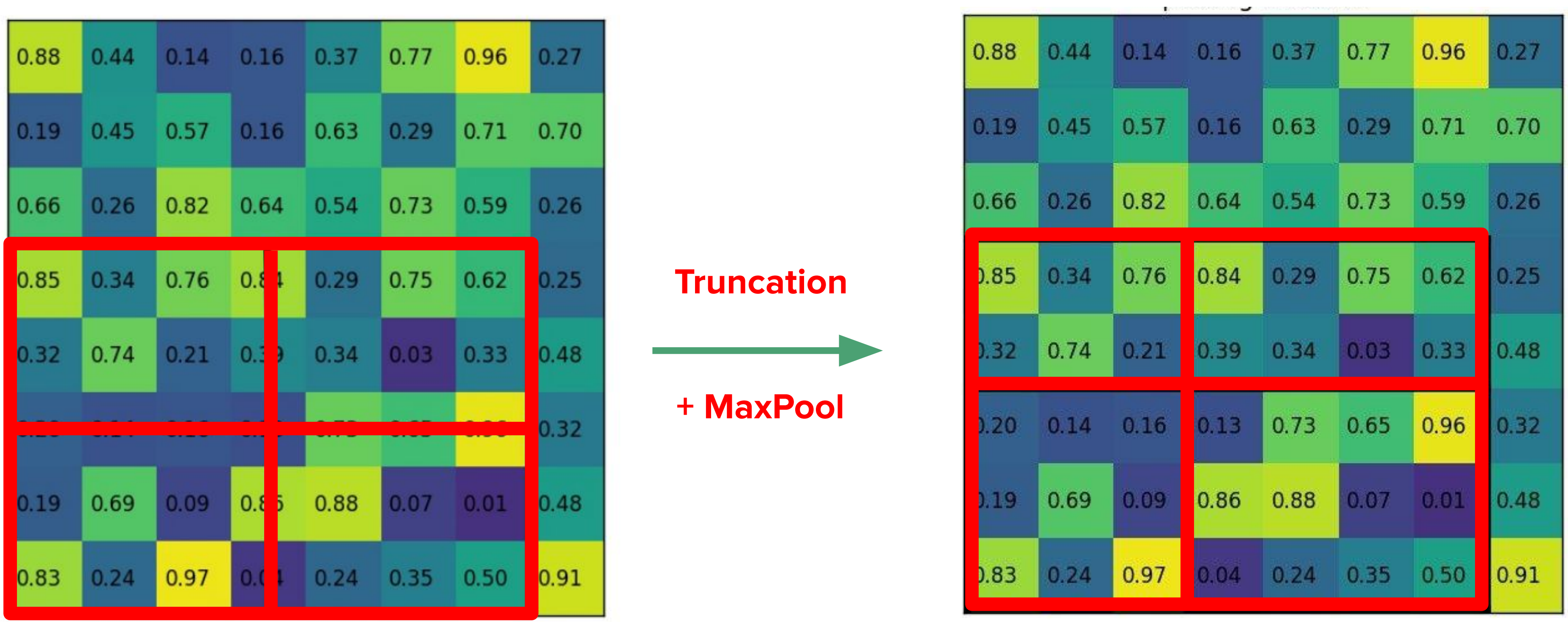
- Add this as a branch to Faster R-CNN and perform end-to-end training

- Some tweaks are needed to the Faster R-CNN architecture


Classification loss
Bounding-box regression loss
...
Mask prediction NN
Classification loss
Bounding-box regression loss
RoI pooling
proposals
Region Proposal Network
Alignment problem
feature map
CNN
image

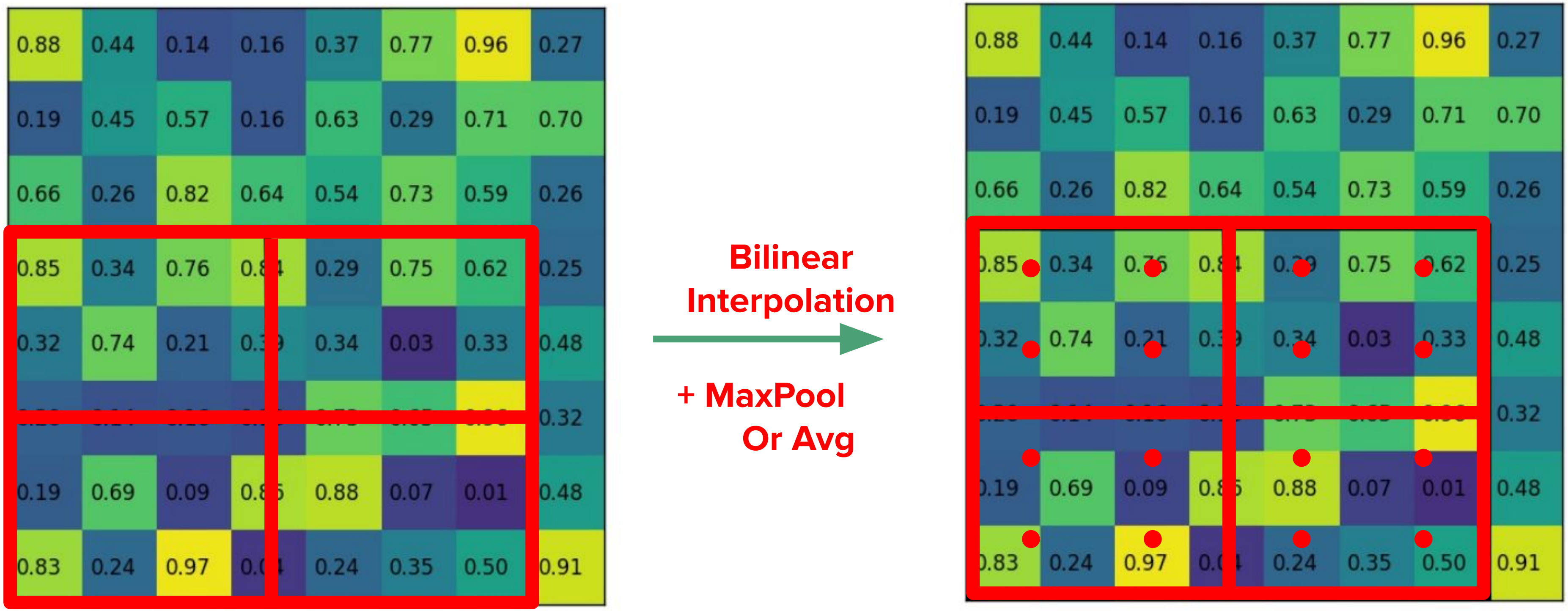
RoI Pool vs RoI Align

RoI **Pool**



RoI Pool vs RoI Align

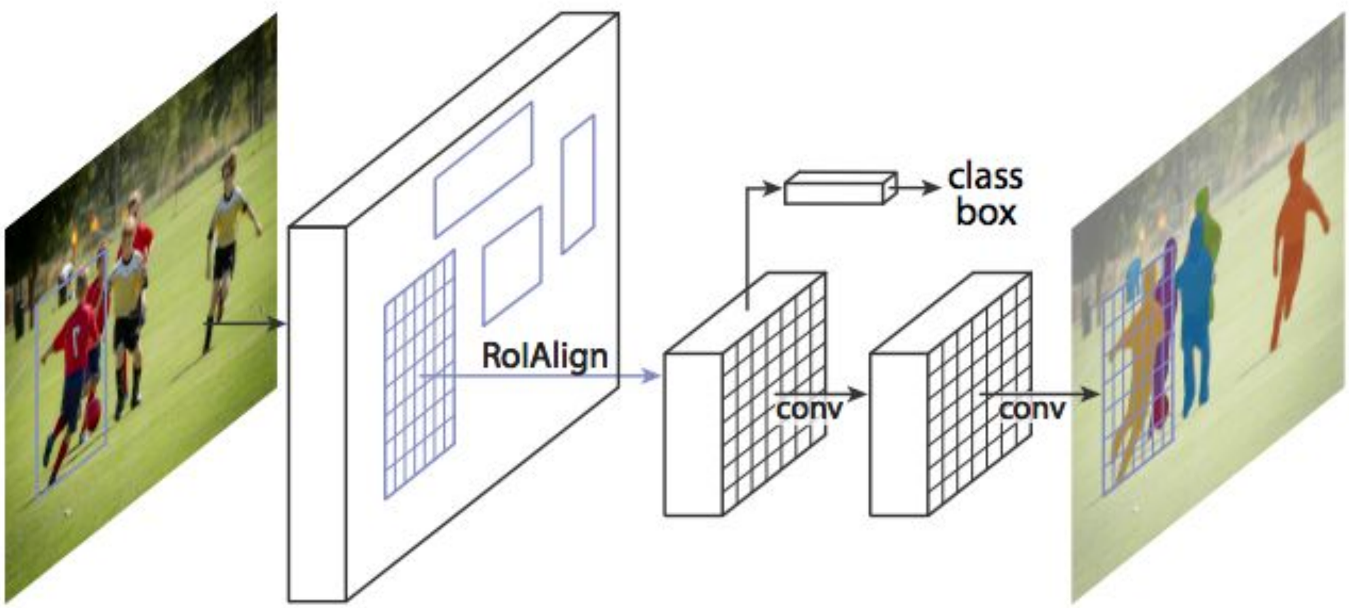
RoI **Align**



Mask prediction branch

- Fully convolutional network (2 or 4 layers depending on the backbone)
- Outputs, **for each class,** a small binary mask (14x14 ou 28x28)
    - In the end uses only one of these masks depending on the class prediction
- Mask loss is given by cross-entropy
- Upsampling technique of the mask not clearly stated (I think)

Network architecture



https://arxiv.org/pdf/1703.06870v3.pdf

Segmentation examples

https://arxiv.org/pdf/1703.06870v3.pdf

Using Mask R-CNN for pose estimation

- Task: for each region, predict K keypoints types (left shoulder, right elbow, etc.)
- Each keypoint is represented by a 1-hot bitmap
- Cross-entropy loss

Using Mask R-CNN for pose estimation

https://arxiv.org/pdf/1703.06870v3.pdf