Should I say hello?

The very basics of human-robot interaction

- Who should I greet? Not all persons might be interested in a conversation.
- As humans we do not have to think about this.
- The robot should be able to start the interaction.
- It needs intelligence to do so!
- Social AI comes into play.

How smart am I?

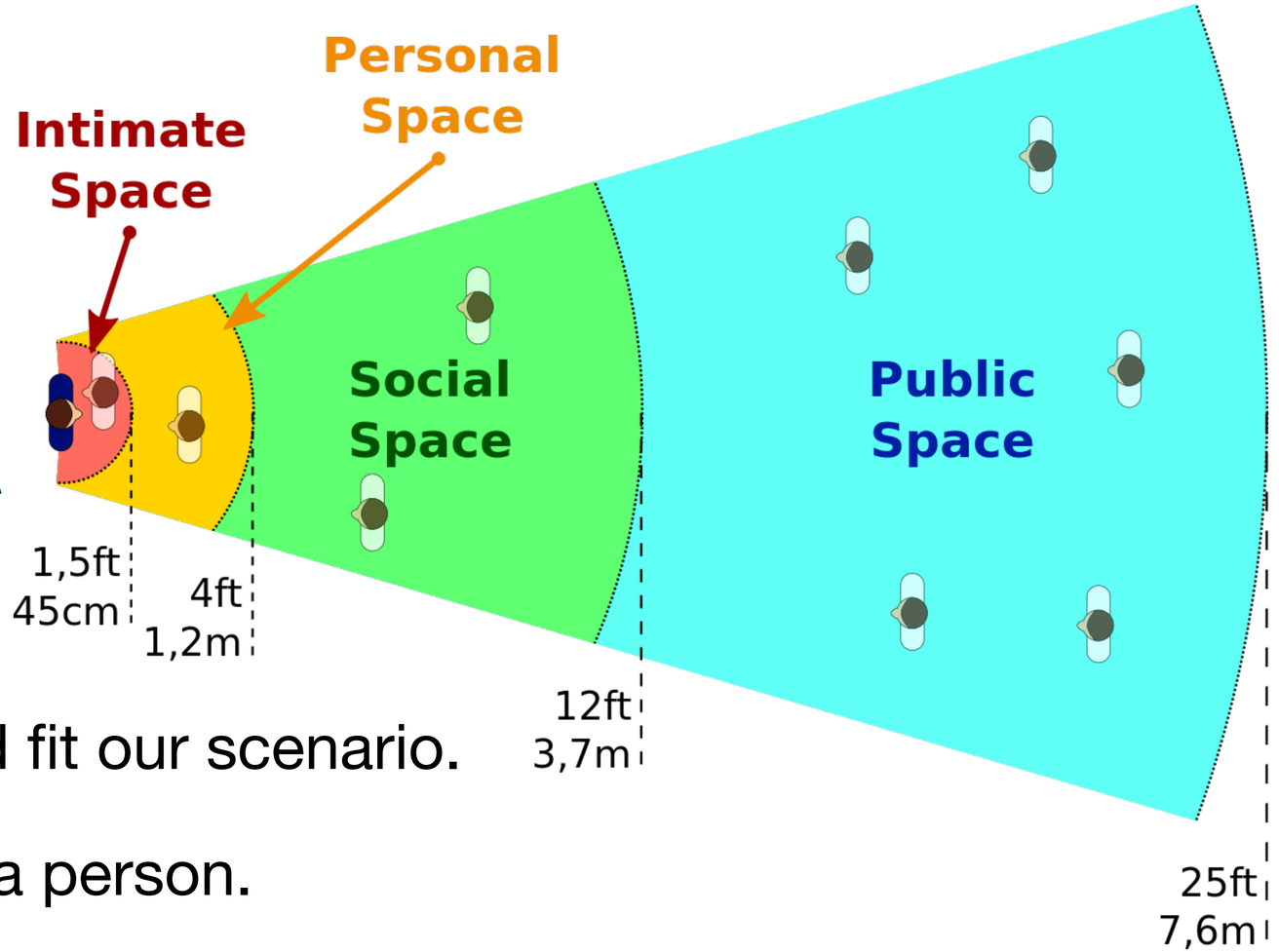
The requirements for greeting

- Detect the presence of a person.
  - How many persons are there?
- Locate and identify the person(s).
- Decide to greet a person or not
  - Which person do I greet?
  - When?
- Do the actual greeting action within an appropriate timespan.

Shall I greet this person?

Theoretical foundation from social psychology

- Hall's Proxemic Theory[1]
- *Intimate relationship; e.g. lovers*
- *Good friends, family*
- *Impersonal business; acquaintances*
- *Public speaking*
- Social space / personal space could fit our scenario.
- <u>Additional requirement</u>: distance to a person.




Person 1
at 2.12m

How to perceive depth from 2D images?

A human-inspired approach

- We as humans need the signal from both eyes to perceive depth —> use stereo images instead of mono images with robots!

- Objects closer to camera ‘move’ more between two images.
- Basic technique, cost-efficient and fast.

Pipeline for stereo depth

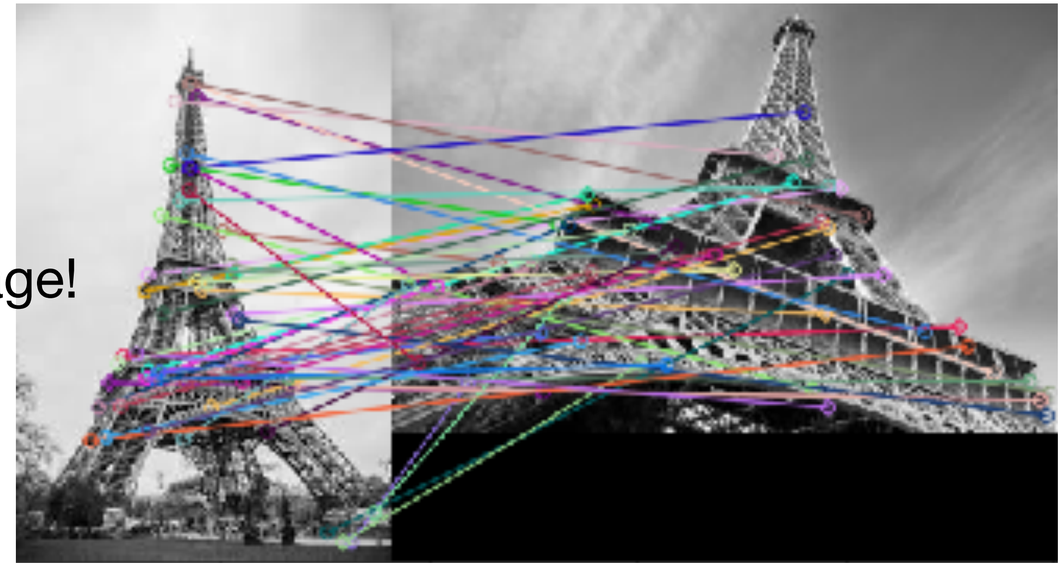
The devil is in the details

- Calibrate the camera (checkerboard)
- Take stereo image
- Split image into two separate images
- Align both images with calibration matrices
- Match every pixel in left image with a pixel in right image (occlusion is a problem)
- Create disparity map to obtain per-pixel depth information: $$z = \frac{f \times b}{x_l - x_r} = \frac{f \times b}{d}$$
- Calibration and alignment are great challenges. Use more points for calibration!

SIFT² for calibration

Distinctive Image Features from Scale-Invariant Keypoints

- Checkerboard ± 70 points, but not uniformly spread across the image!
- Keypoint descriptor based on local image gradients.
- Very robust descriptor due to invariance to rotation and scale.
  - Also robust to changes in lighting, affine distortion, and noise.
- Match keypoints from both images and find the transformation matrix.
- Can use hundreds of keypoints, across the whole image!

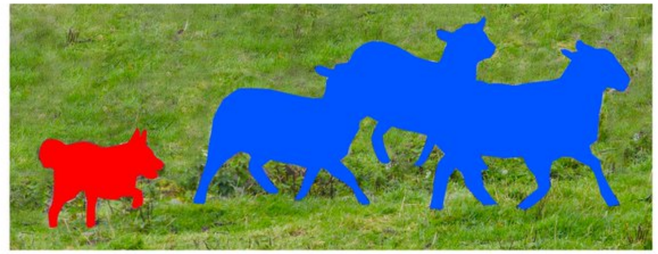


Depth is cool, but what is a person?

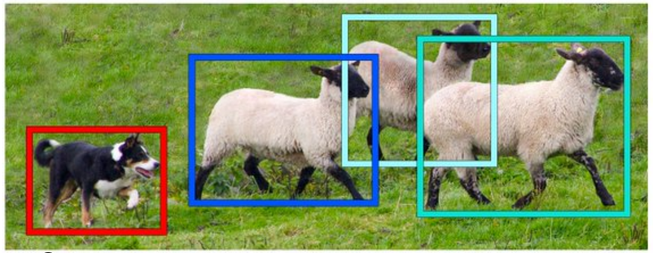
Instance segmentation in a nutshell

- From image recognition to instance segmentation.
- We need to be able to distinguish between people.
- Object instance detection not sufficient; why not?
- Use the instance mask for depth.
- But, what if the mask is not perfect?

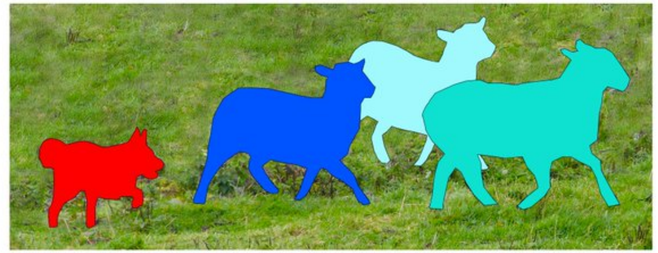
Image Recognition



Semantic Segmentation



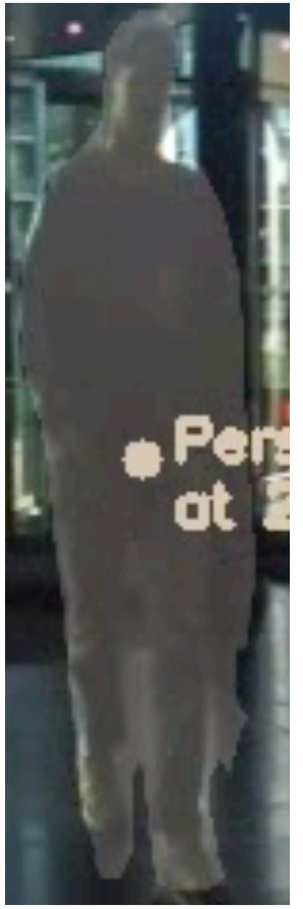
Object Detection



Instance Segmentation

What metric to use?

A: Mean
B: Mode
C: Maximum



What metric to use?

A: Mean

B: Mode

C: Maximum

How to do instance segmentation?

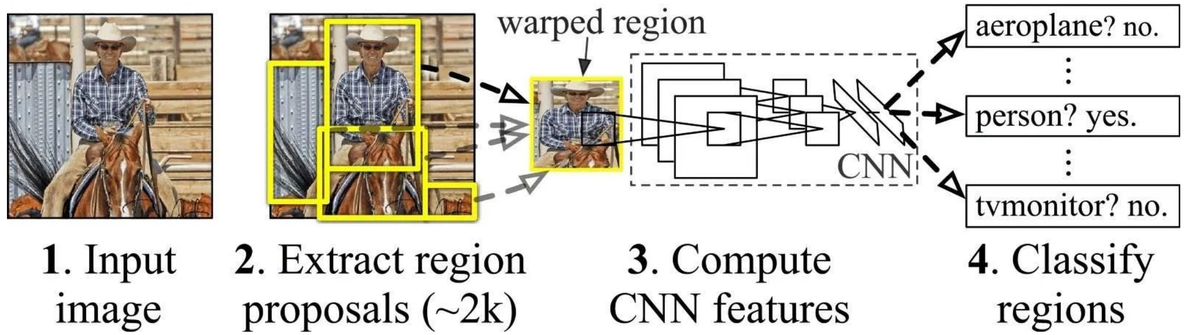
Lots of research done in CV field

- Detecron2[3] library from Facebook Research.
- Mask-RCNN[4] structure with ResNet50[5] backbone.
- Many pertained models are available.

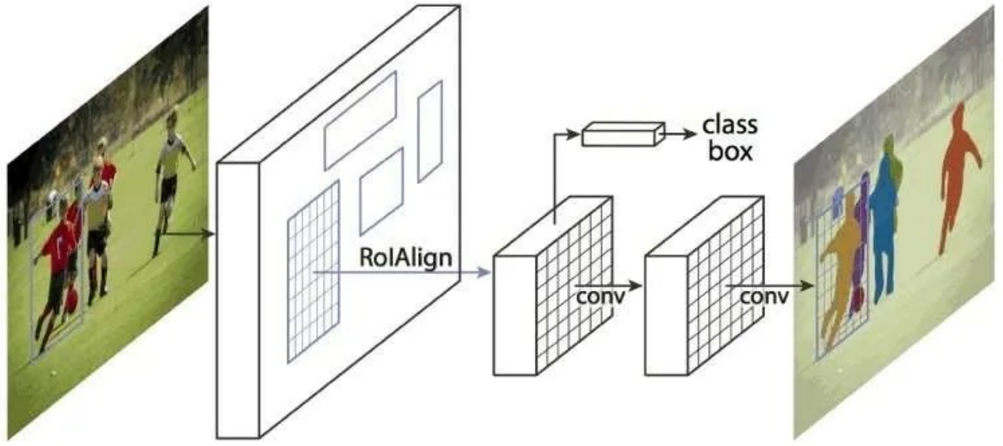
A little dive into Mask-RCNN

It is all based on Convolutional Neural Networks

- R-CNN[6] foundation of Mask-RCNN.
- Many forward passes make it slow.



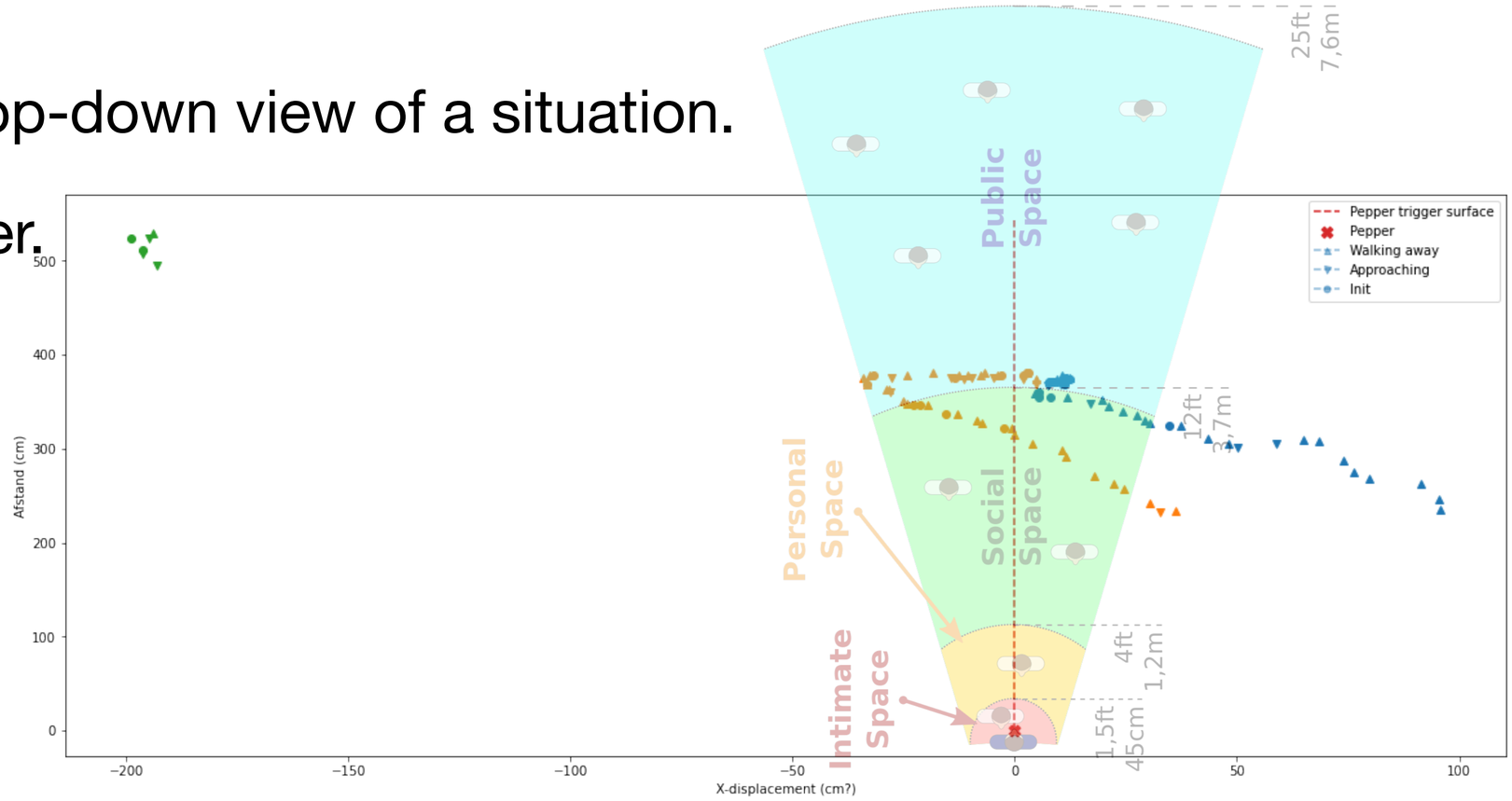
- Re-use features from conv layers + RPN.
- Additional branch for mask prediction.
- RoIAlign is crucial for pixel-level accuracy.



Combining it all

Depth, instance segmentation, Hall's Proxemic…

- We can now generate a top-down view of a situation.
- Distance relative to Pepper.
- Distinguish persons.
- Approaching or not.
- Hall's spaces.
- Path prediction.
- <u>Shall I say hello?</u>



Remaining challenges

We have still some work to do

- What happens when more people (e.g. 5+) enter the frame?
- How reliable is the pipeline?
- How can we track people better?
- How can we make the whole pipeline fast enough to run in real-time?

References

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