Lecture 13
Robot Learning

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Review of data-driven grasping papers

- Dexnet
- Learning hand-eye coordination for robotic grasping with deep learning and large scale data collection
- Yolo

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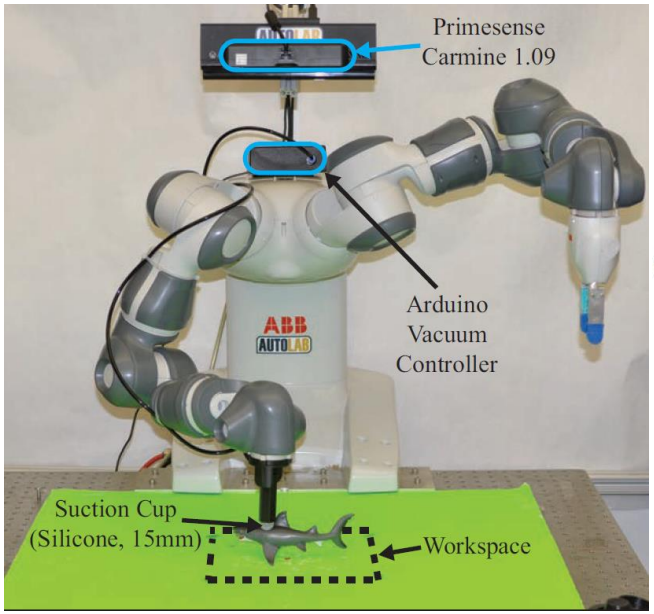
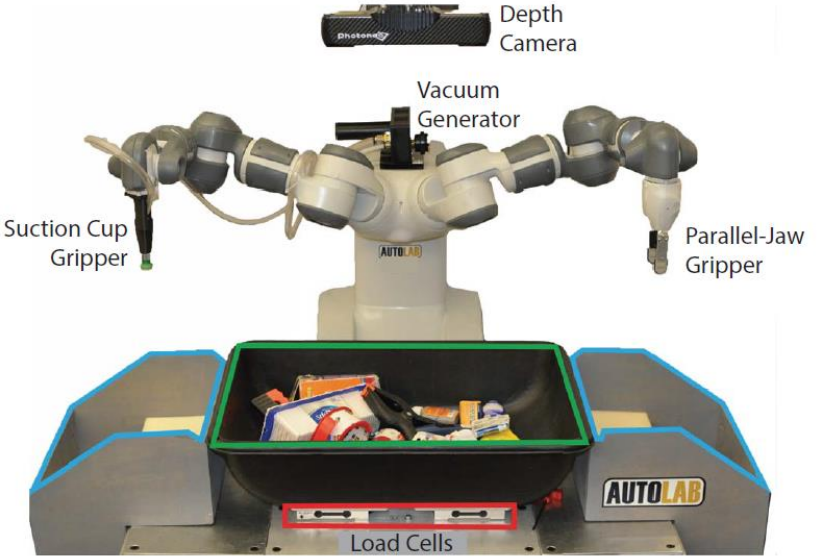
Dexnet

- Dexnet 2.0: Two finger gripper
- Dexnet 3.0: Suction cup end-effector
- Dexnet 4.0: Dual arm with one gripper and one suction cup end-effector

Executed Grasp

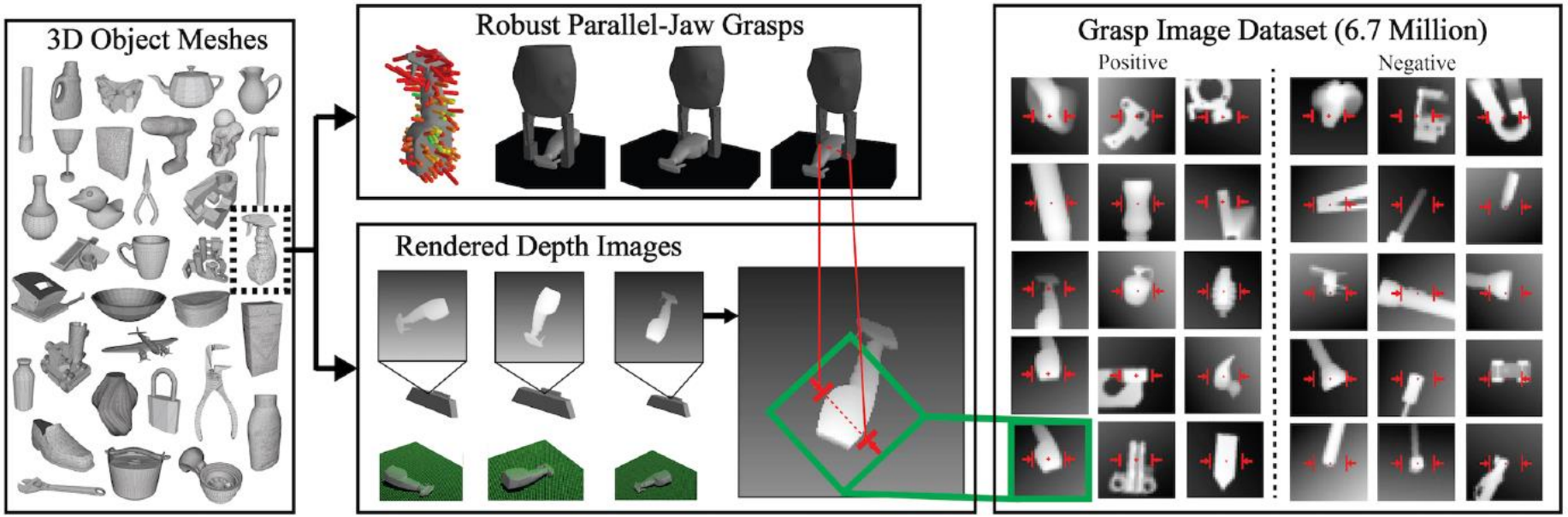




Dexnet 2.0

Dataset

- Dexnet 2.0 is a dataset associating 6.7 million point clouds and analytic grasp quality metrics with parallel-jaw grasps planned using robust quasi-static GWS analysis on a dataset of 1,500 3D object models



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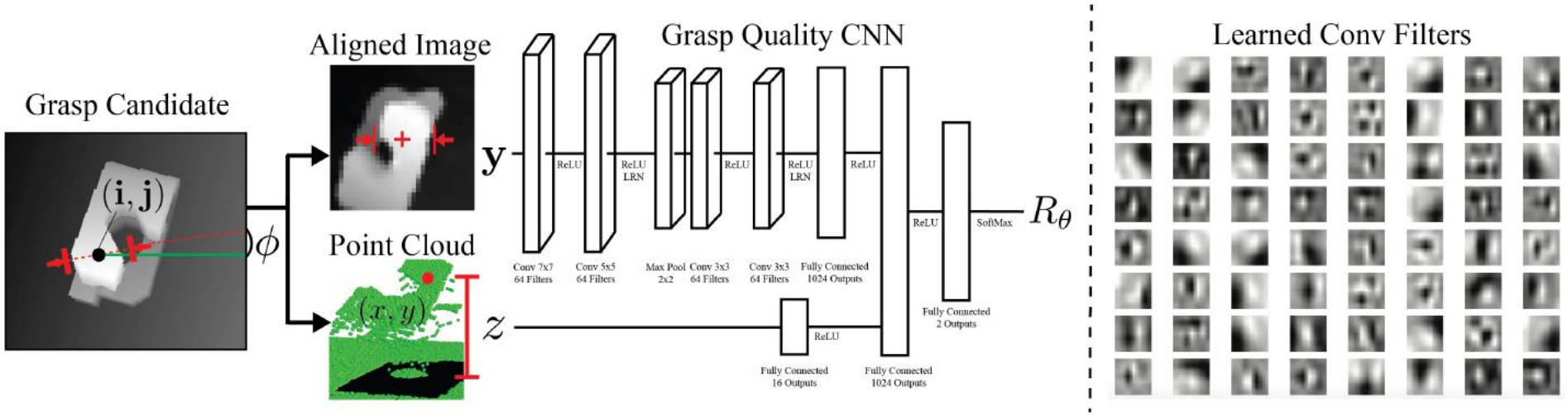
Dexnet 2.0

Grasp Quality Convolutional Neural Network (GQ-CNN).

- Planar grasp candidates u = (i, j, φ, z) are generated from a depth image and transformed to align the image with the grasp center pixel (i, j) and orientation φ.



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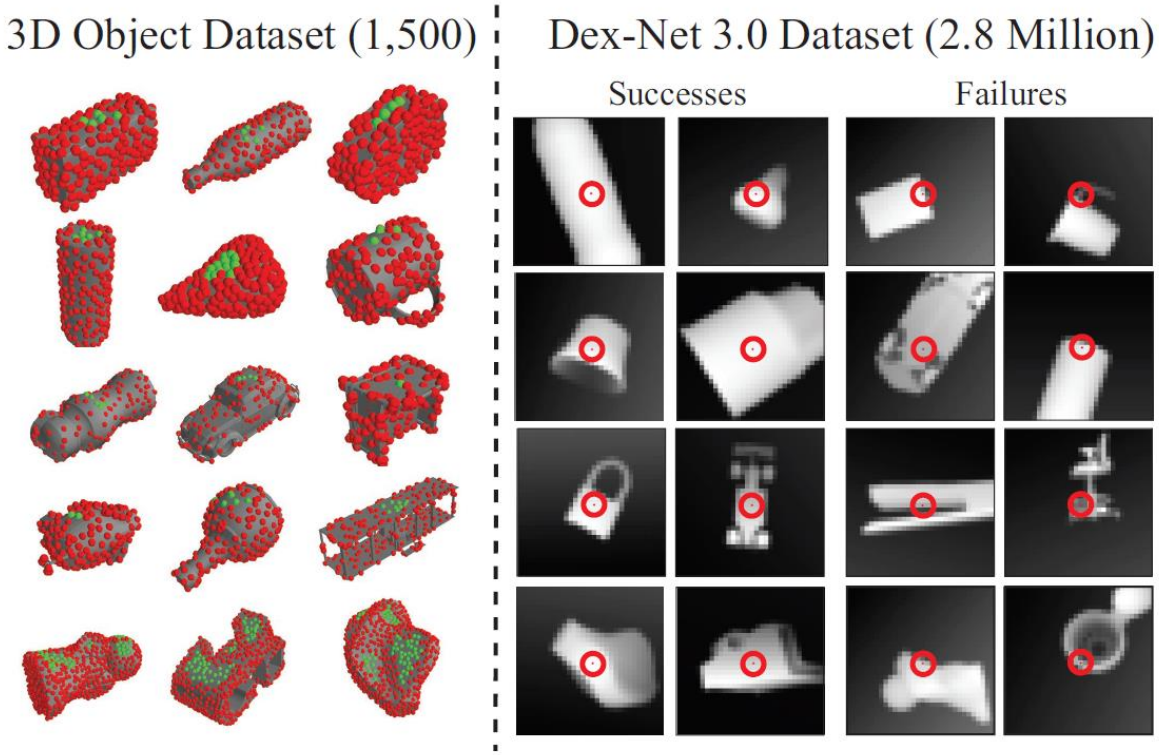
Dexnet 3.0

Dataset

- The Dex-Net 3.0 point cloud dataset contains approx. 2.8 million tuples of point clouds and suction grasps with robustness labels



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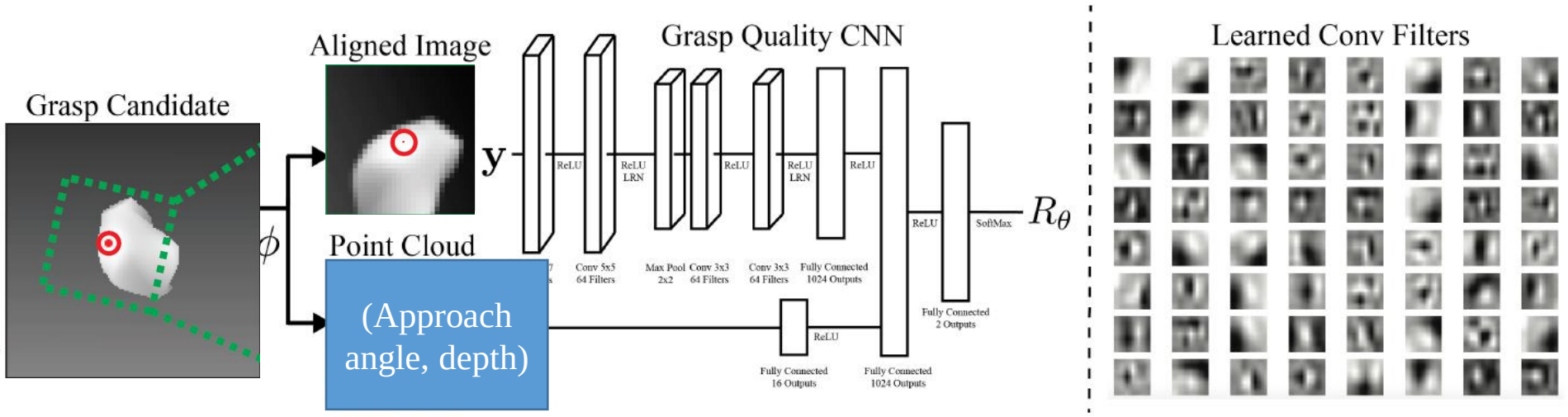
Dexnet 3.0

policy

- Uniform random sampling of candidate grasp from surface and use CEM to optimize sampling process.
- GQCNN takes the end-effector depth from the camera and orientation as input to a fully connected layer in a separate pose stream.



Dexnet 4.0

- the Dex-Net 4.0 policy consistently clears bins of up to 25 novel objects with reliability greater than 95% at a rate of more than 300 mean picks per hour.

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Learning hand-eye coordination

Dataset

- large-scale data collection setup, consisting of 14 robotic manipulators collected over 800,000 grasp attempts to train the CNN grasp prediction model.

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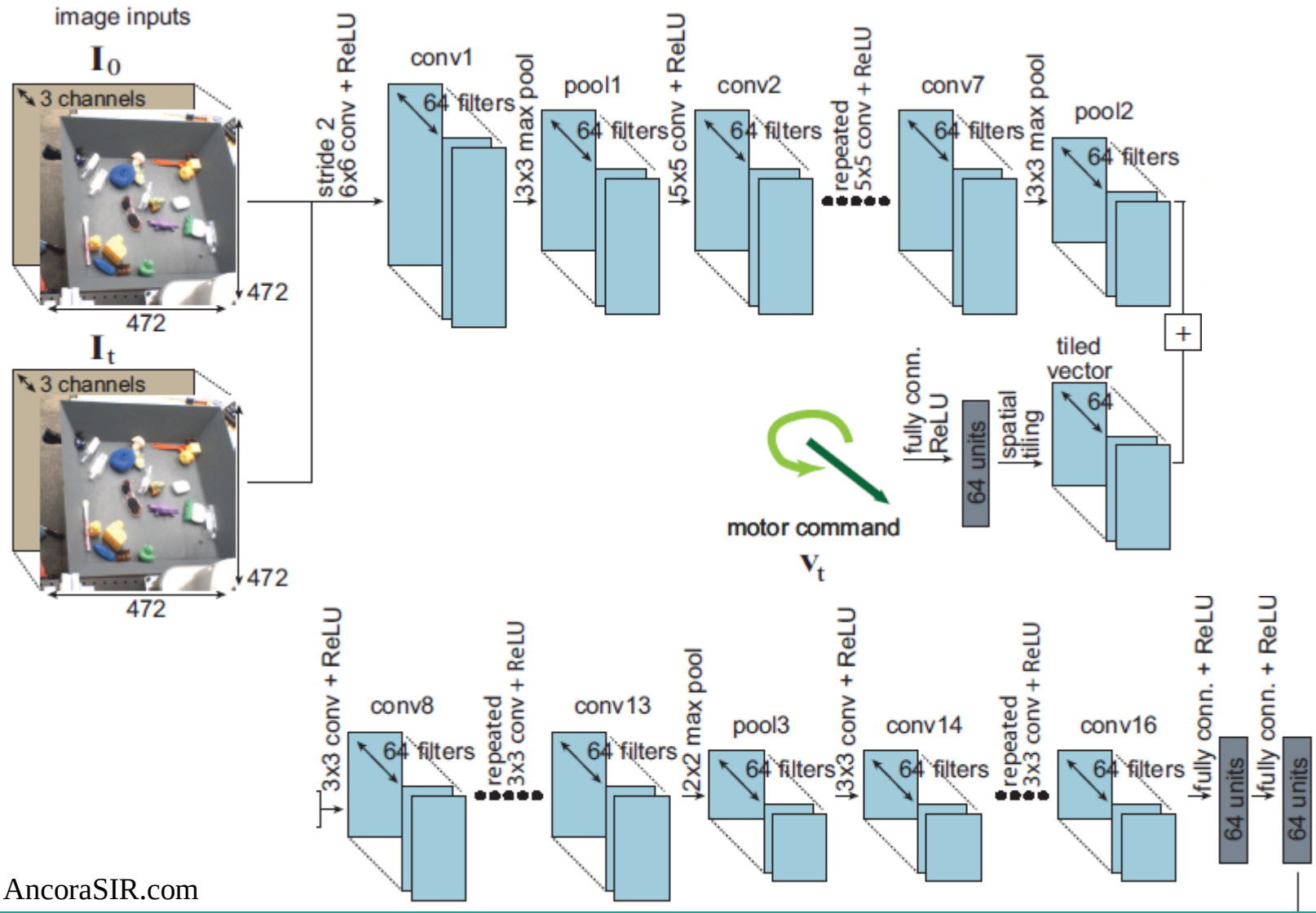
Learning hand-eye coordination



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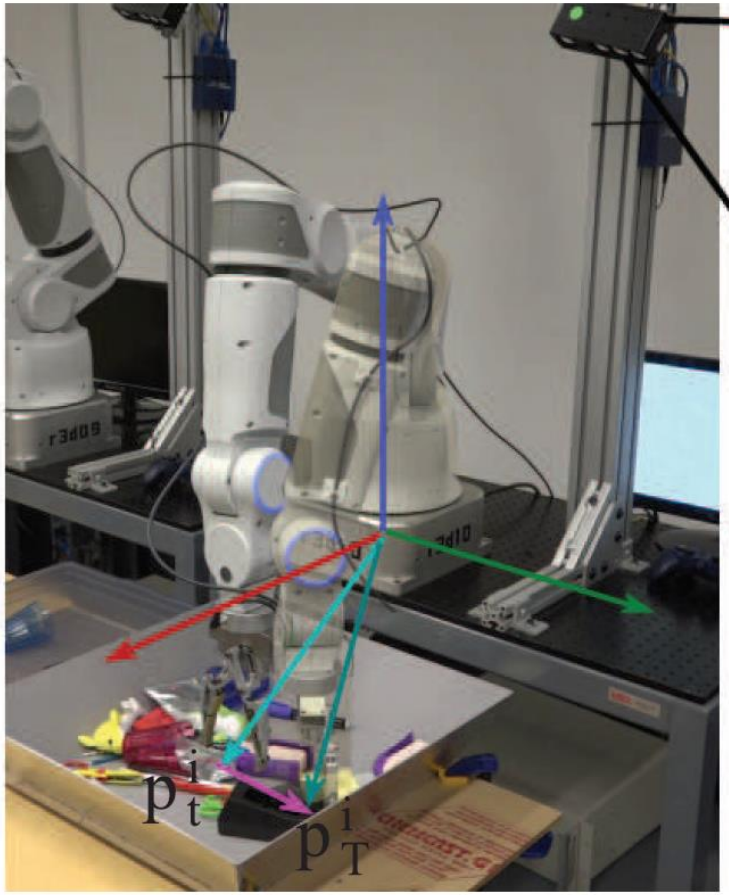
Learning hand-eye coordination

- Model predict motor command directly
- No hand eye calibration needed



I_t^i

samples $(\mathbf{I}_t^i, \mathbf{p}_T^i - \mathbf{p}_t^i, \ell_i)$

$\rightarrow \mathbf{p}_t^i$

$\rightarrow \mathbf{p}_T^i$

$\rightarrow \mathbf{v}_t^i$

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Learning hand-eye coordination

Transferability

- Failure rates with Kuka IIWA robots

Training data	Average failure rate	Bin 1	Bin 2	Bin 3	Bin 4	Bin 5	Bin 6
Random policy	89.79 ± 5.8%	88.24%	94.12%	91.18%	79.90%	88.73%	96.57%
2.7m non-Kuka images	76.80 ± 12.3%	87.25%	89.22%	75.49%	84.31%	60.29%	64.22%
3k Kuka images	84.80 ± 3.6%	82.35%	91.18%	82.84%	85.29%	81.37%	85.78%
30k Kuka images	74.75 ± 6.5%	75.49%	87.25%	73.04%	69.12%	71.08%	72.55%
300k Kuka images	41.50 ± 7.3%	50.00%	49.51%	42.65%	39.78%	32.35%	35.29%
3m Kuka images	34.31 ± 9.5%	46.08%	42.16%	31.86%	30.88%	19.12%	35.78 %
8m Kuka images	32.84 ± 13.8%	52.94%	38.24%	24.02%	30.88%	12.75%	38.24%
2.7m non-Kuka images and 3k Kuka images (finetuned)	70.92 ± 10.8%	76.96%	74.51%	76.47%	73.53%	49.02%	75.00%
2.7m non-Kuka images and 30k Kuka images (finetuned)	62.34 ± 8.4%	75.49%	60.29%	62.25%	66.18%	50.00%	59.80%
2.7m non-Kuka images and 300k Kuka images (finetuned)	35.62 ± 14.6%	43.63%	34.31%	36.27%	70.49%	29.90%	39.22%
2.7m non-Kuka images and 3m Kuka images (finetuned)	32.19 ± 10.3%	50.98%	24.02%	31.37%	25.00%	25.49%	36.27%
2.7m non-Kuka images and 8m Kuka images (finetuned)	25.65 ± 10.5%	46.57%	**25.00%**	**19.12** %	22.55%	18.14%	22.55%
2.7m non-Kuka images and 3k Kuka images (joint)	70.26 ± 13.4%	67.16%	60.78%	76.96%	76.96%	50.98%	88.73%
2.7m non-Kuka images and 30k Kuka images (joint)	48.45 ± 12.2%	58.82%	55.88%	59.80%	47.55%	28.92%	39.71%
2.7m non-Kuka images and 300k Kuka images (joint)	35.62 ± 16.6%	60.29%	48.04%	37.75%	29.41%	15.69%	22.55%
2.7m non-Kuka images and 3m Kuka images (joint)	27.61 ± 6.6%	30.39%	35.78%	31.37%	27.94%	23.04%	17.16%
2.7m non-Kuka images and 8m Kuka images (joint)	**22.82 ± 5.3%**	**30.39%**	27.12%	24.18%	**19.61%**	**17.65%**	**17.97%**

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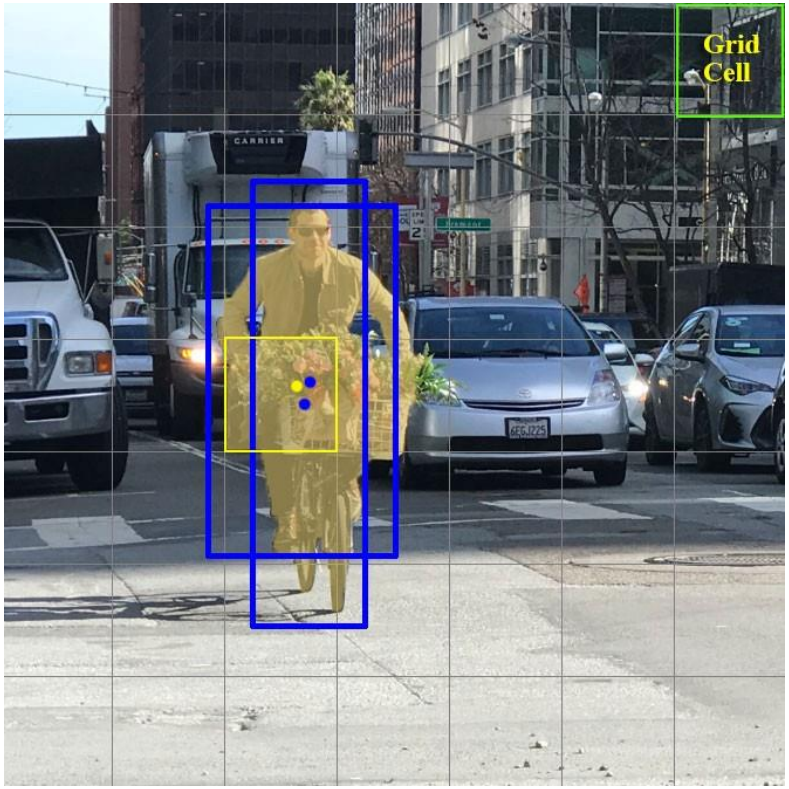
YOLO v3

You only look once

YOLO

Bounding Box Prediction

- Split an image into S×S cells. Each cell predicts only one object and
  - the coordinates of B bounding boxes (center x-coord, center y-coord, width, height) — (x,y,w,h)
  - a confidence score indicates the likelihood that the cell contains an object
  - a probability of object class conditioned on the existence of an object in the bounding box
  - The total prediction values for one image is S×S×(5B+C),



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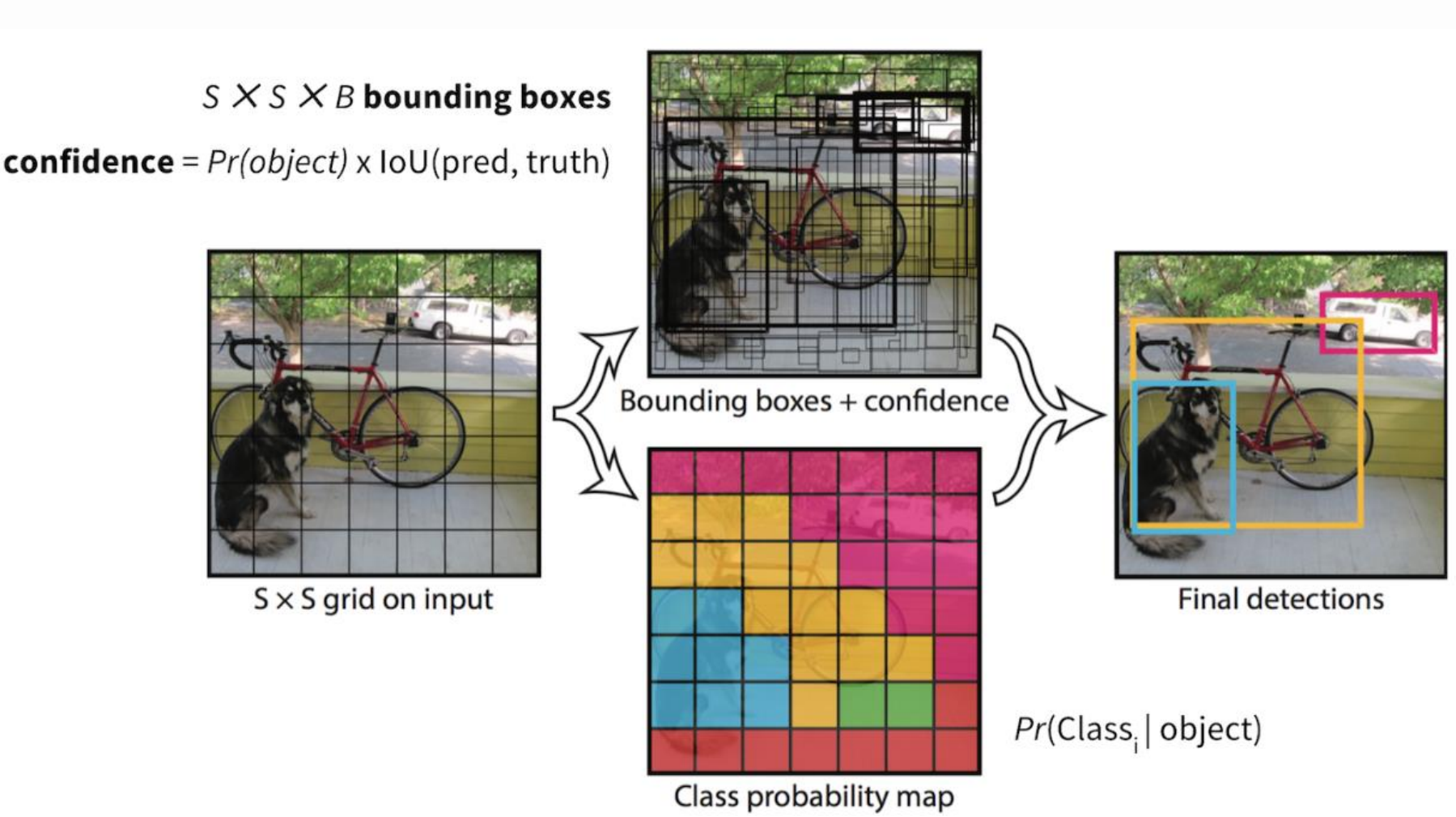
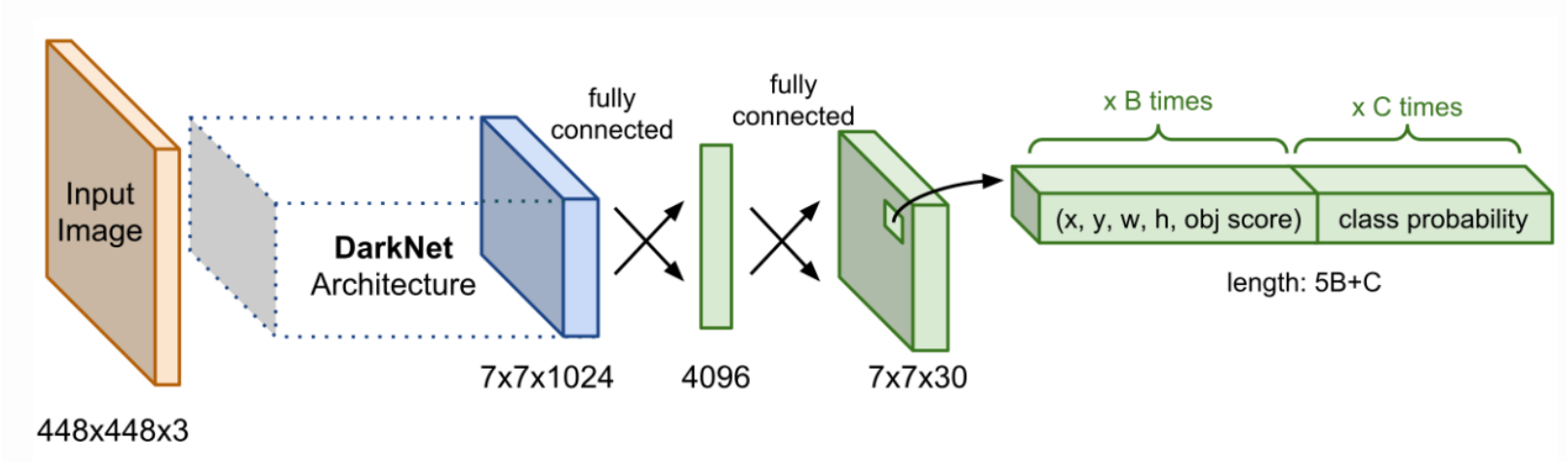
YOLO

Bounding Box Prediction



YOLO

Network Architecture



Website: https://github.com/YunYang1994/tensorflow-yolov3
https://github.com/srp-31/Data-Augmentation-for-Object-Detection-YOLO-

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