

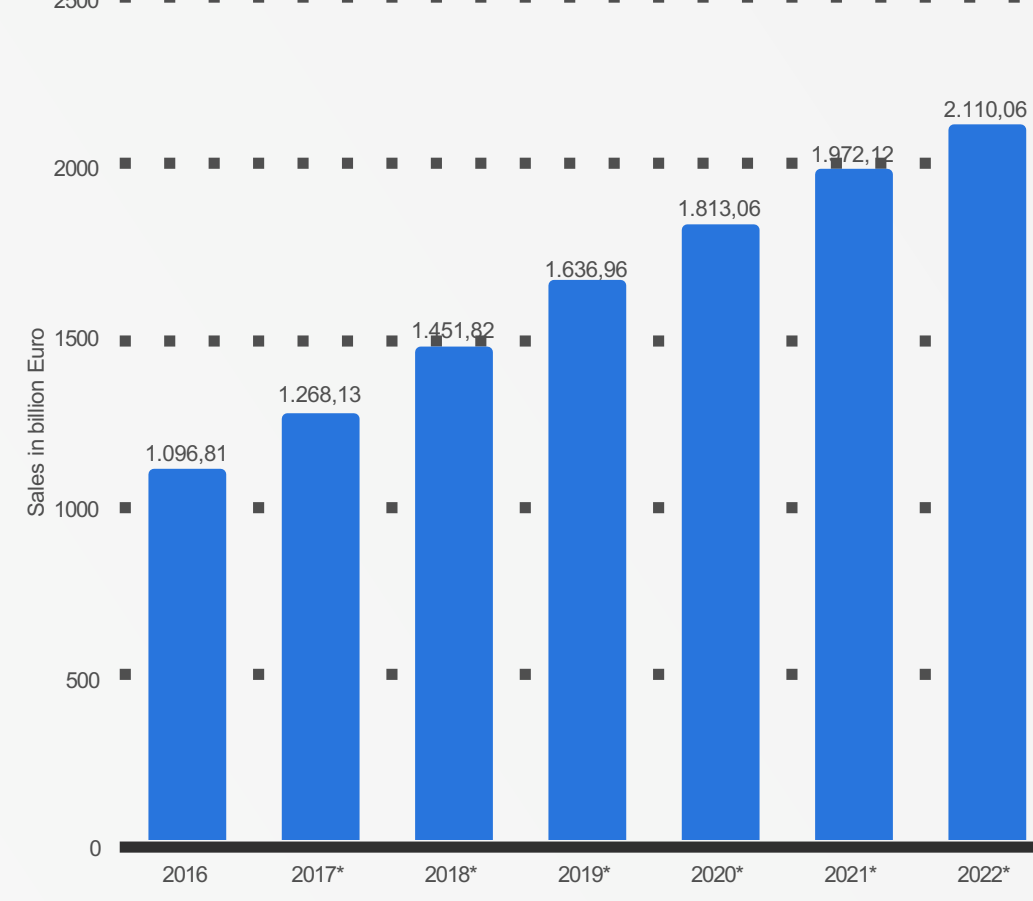
Progress in Autonomous Picking as demonstrated by the Amazon Robotics Challenge

Dominik Colling, Jonathan Dziedzitz, Kai Furmans, Patric Hopfgarten, Kai Markert

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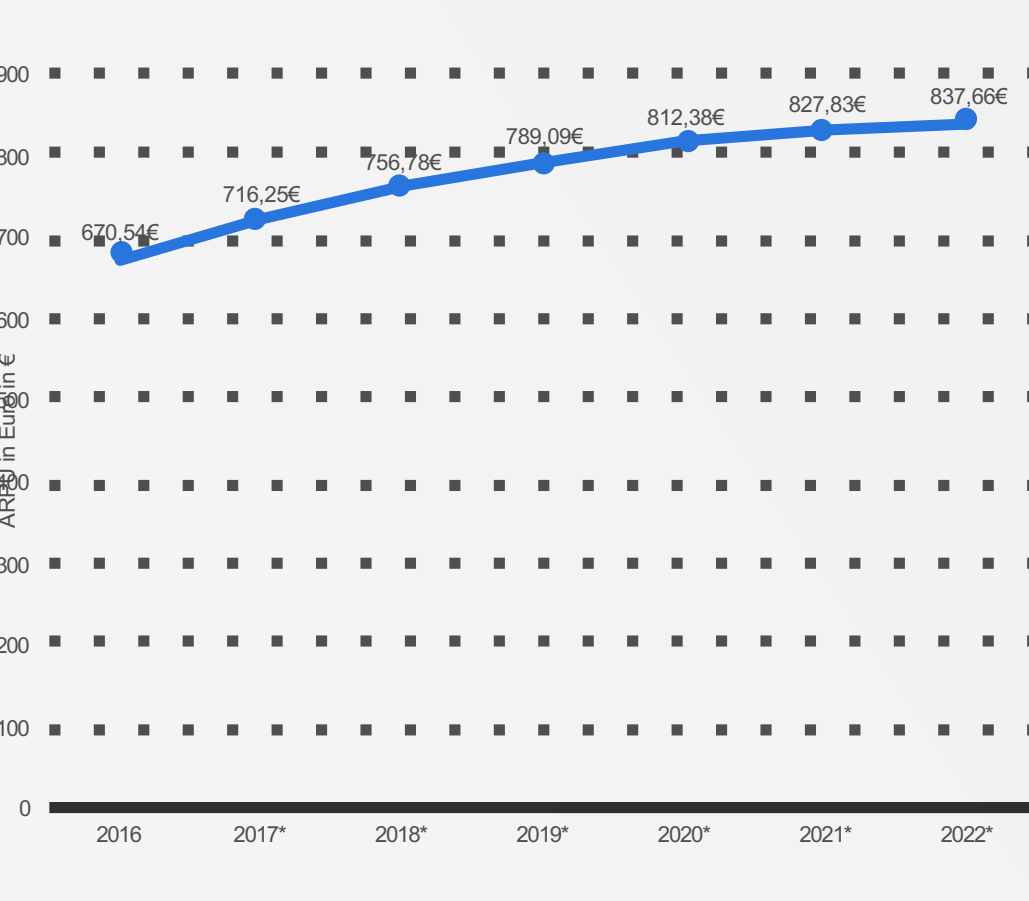
Motivation

E-Commerce Sales Worldwide
in 2016 and forecast until 2022



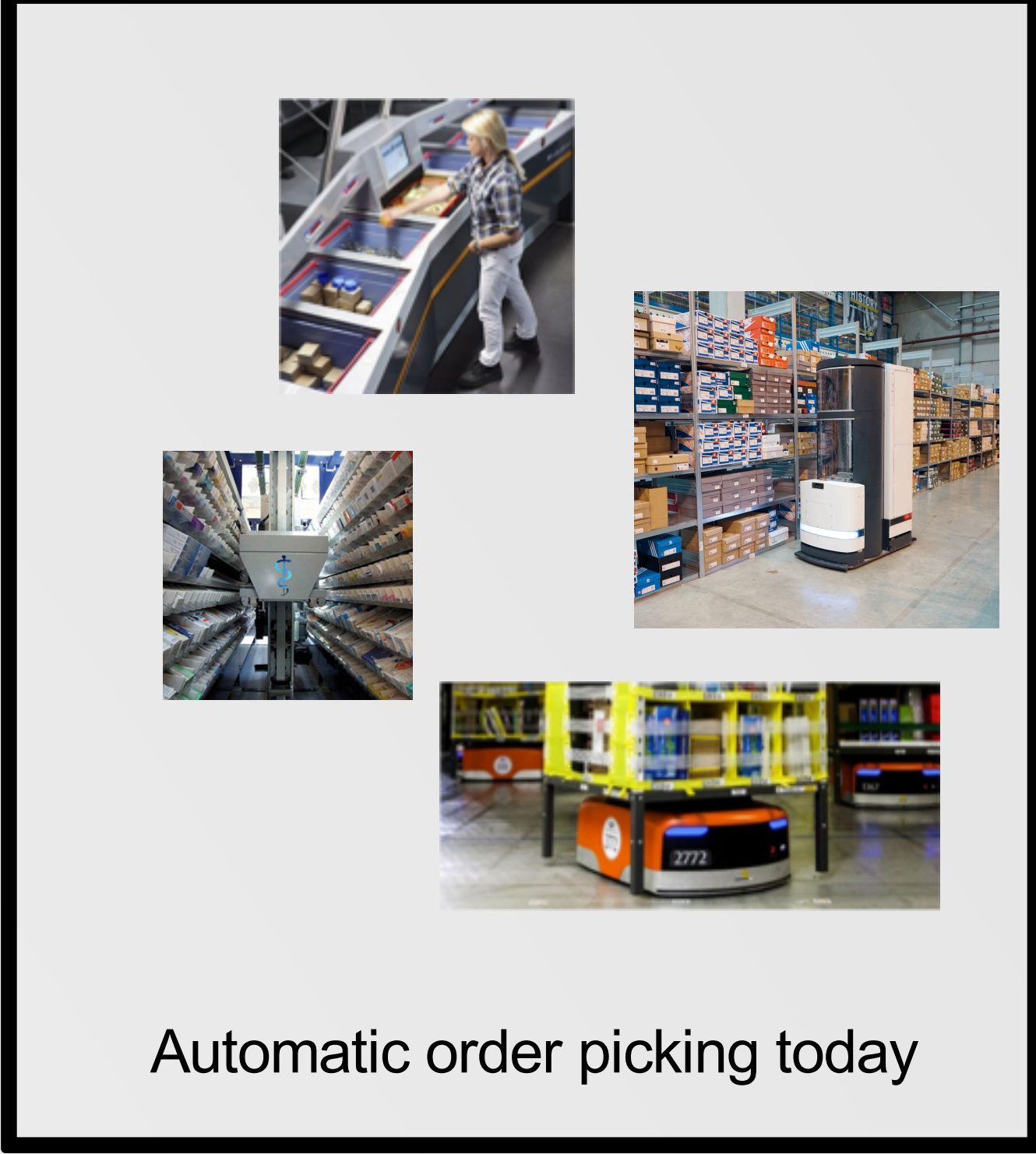
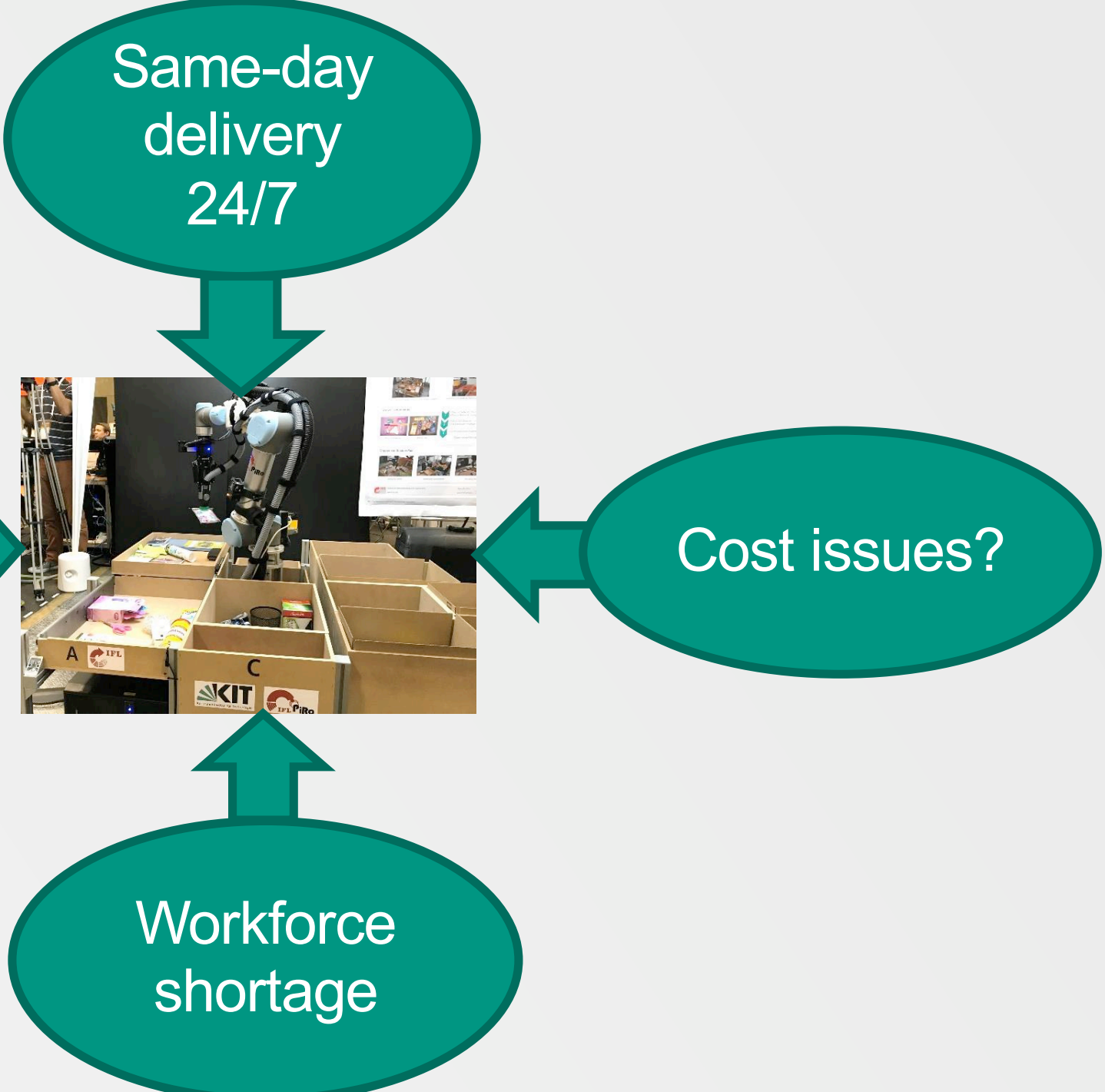
Source: statista.de, June 15th, 2018

Average Revenue Per User in
2016 and forecast until 2022



Source: Statista, DAX, Statista (2018)

E-commerce
drives single-piece
picking in locations
with large number
of items at one
place



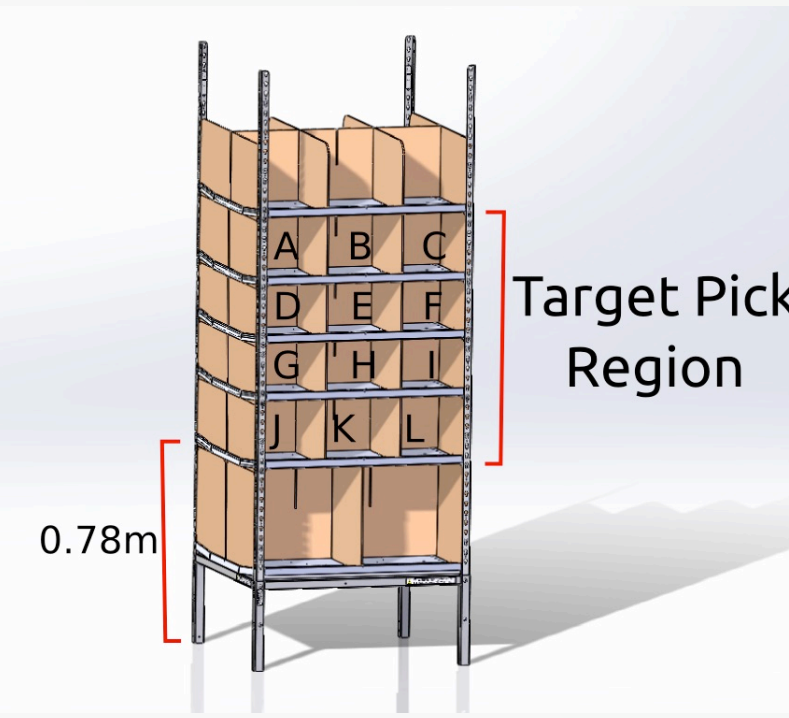
Amazon Picking / Robotics Challenge

The Everything Store

- Inhomogeneous products
- No predefined locations
- No defined orientation
- occlusions

Seattle 2015

Amazon Picking Challenge 2015
Kiva-Regal und Team RBO



Kiva-Regal, Quelle Amazon Robotics, Rules 2015



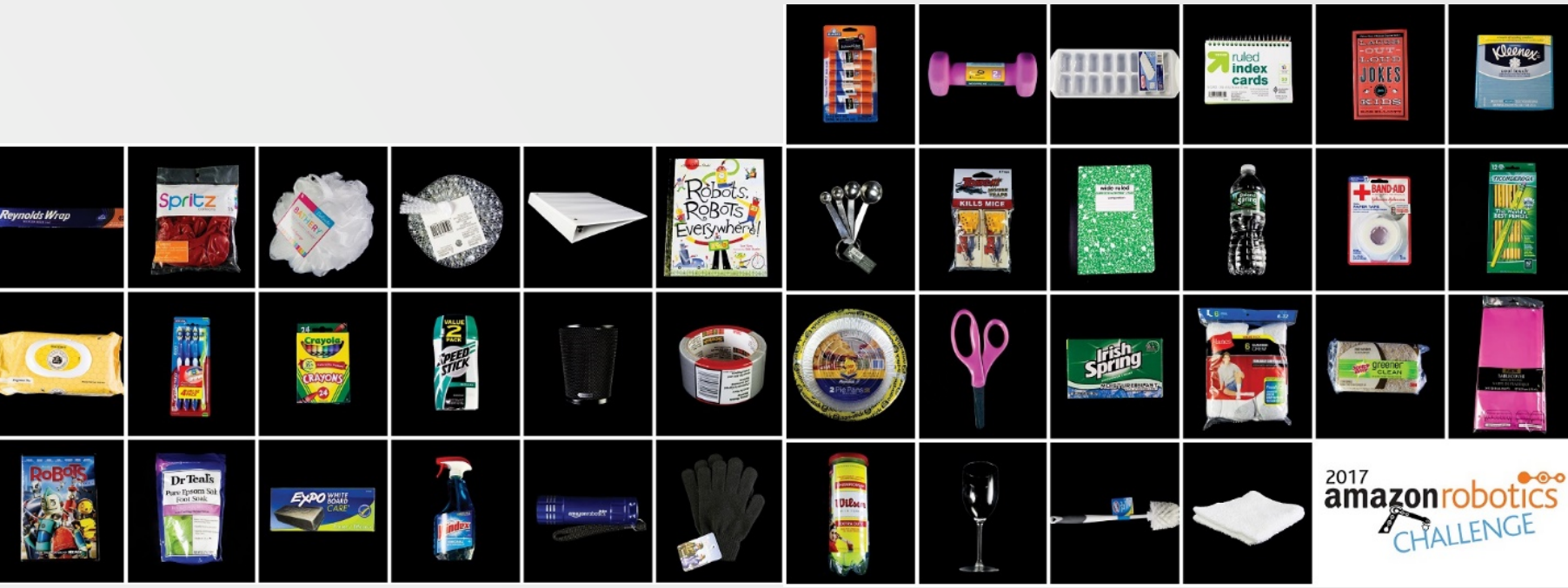
Team RBO Berlin, Quelle: Youtube

Development of the Amazon Robotics Challenge

Task	rack	shelves	Items in rack	Items known	orders	Size of order	time [min]	Teams
APC 2015 Seattle								
Pick Task	Amazon Kiva	12	24	alle	1	12	20	26
APC 2016 Leipzig								
Pick Task	Amazon Kiva	12	50	alle	1	12	15	16
Stow Task	Kiva	12	40	alle	1	12	15	
ARC 2017 Nagoya								
Pick Task	open	1-3-partitions 125cm 5.000cm ² 95.000cm ³ 2 bis 10	32	50%	3	2 + 3 + 5	15	16
Stow Task	1-3-partitions		0	50%	1	20	15	
Final Round Stow	1-3-partitions		16	50%	1	16	30	8
Final Round Pick	1-3-partitions		32	50%	3	2 + 3 + 5		

Some parameters of the APC 2015 – ARC 2017

Nagoya 2017



- Only 50% of the items previously available
- Other items available for 30 minutes before the start of the task

source: Amazon Robotics Challenge 2017

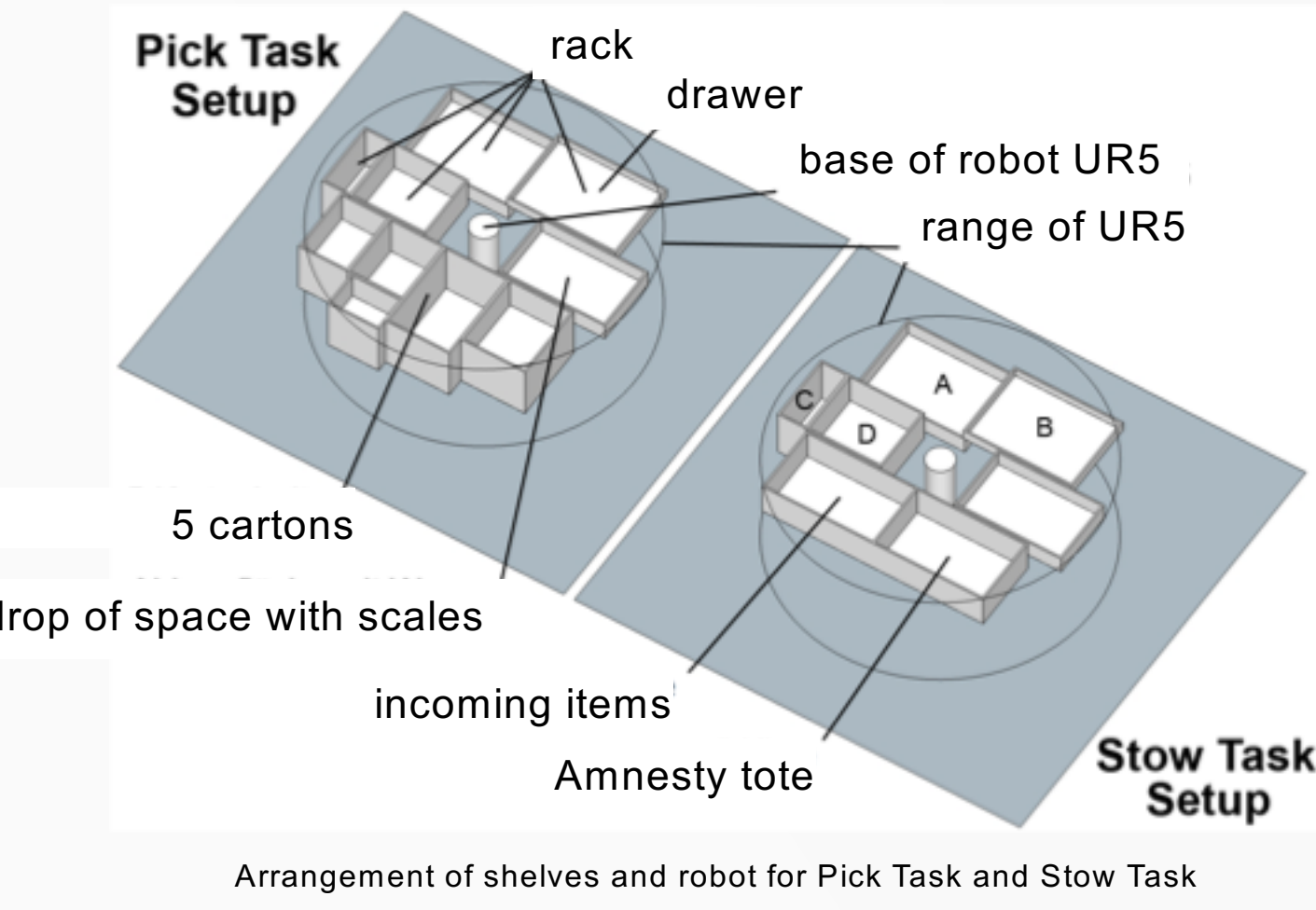
Elements of a Solution

Robot Ergonomics

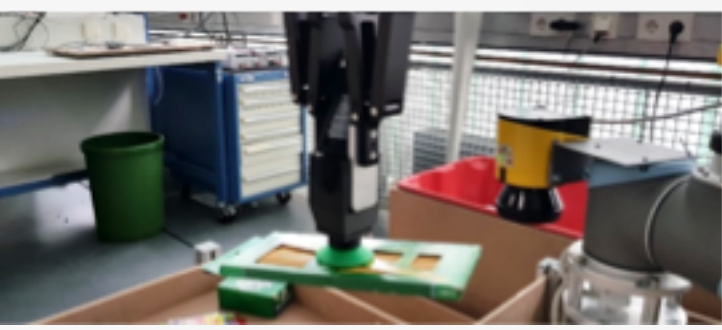
Grasping and Suction Gripping

3D-Imaging

Computing Power



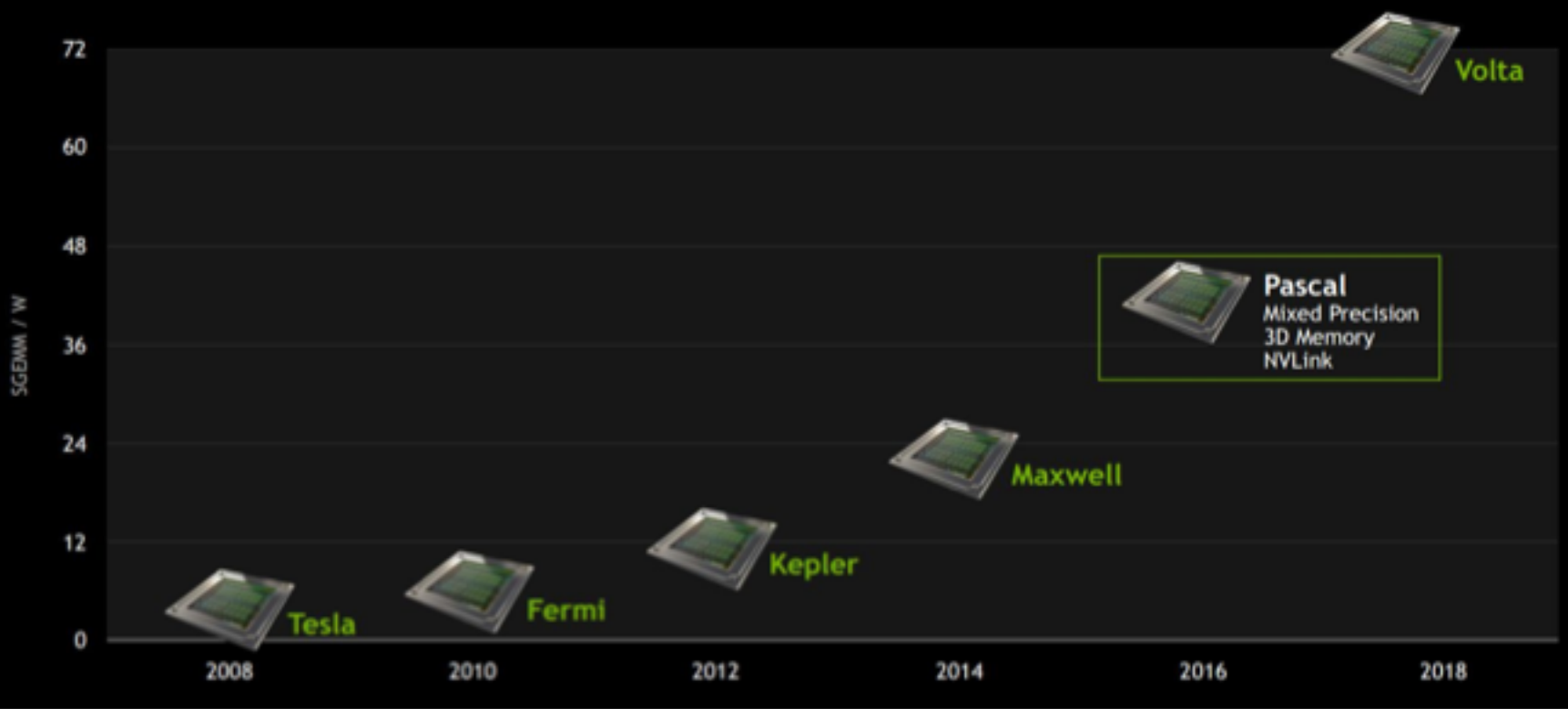
Gripper gets suction device



Laser scanner supervision of grasping results and moving range



Intel RealSense Depth Camera D415 and D435
Quelle: Intel Corporation, 2017. "Intel® RealSense™ Depth Camera D400-Series".
<https://www.intel.com/content/www/us/en/programmable/realsense-d400-series.html> (seen14.12.2017).

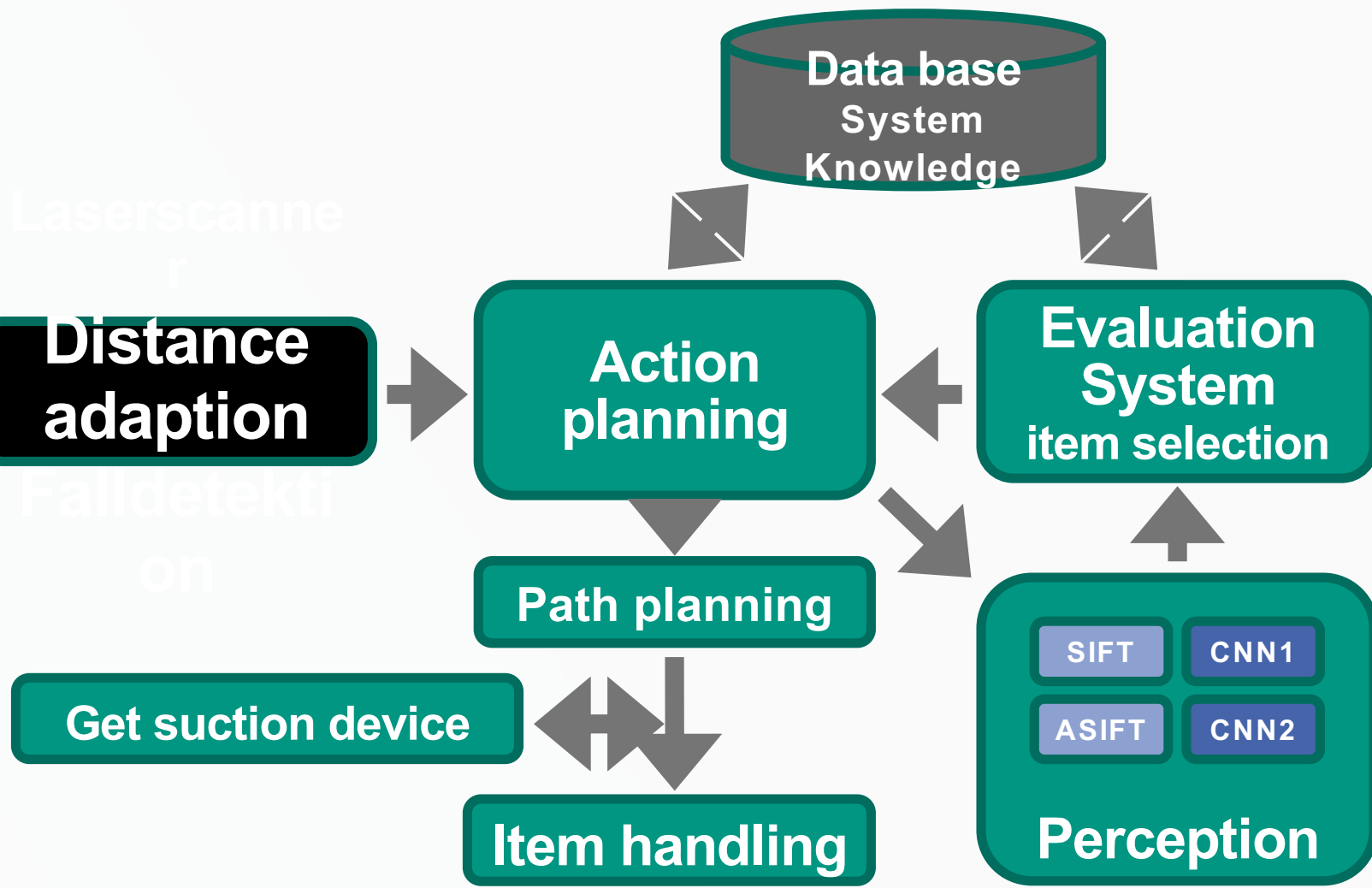


Single precision floating General Matrix Multiply (SGEMM) per Watt for different NVIDIA architectures, Quelle: Huang, Jen-Hsun, 2015. "Leaps in visual computing". In Proceedings GTC, <http://on-demand.gputechconf.com/gtc/2015/presentation/S5715-Keynote-Jen-Hsun-Huang.pdf> (seen14.12.2017).

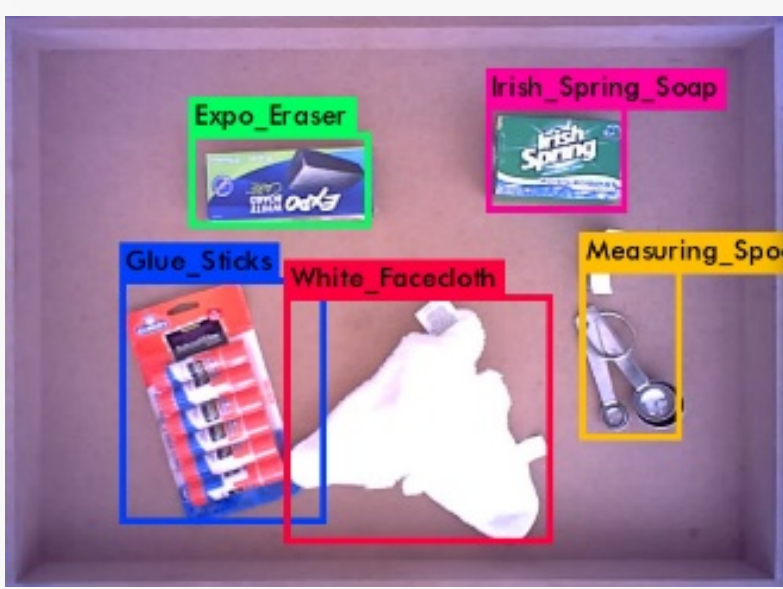
Decision Making

Perception

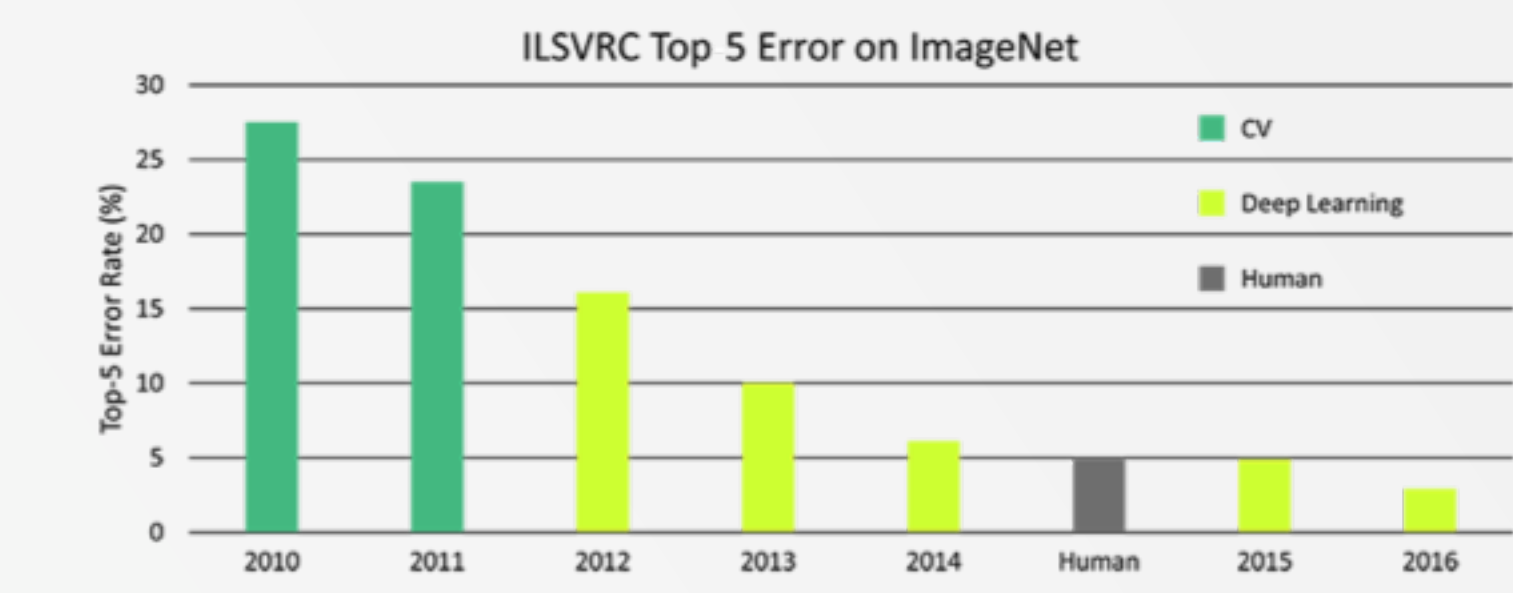
Performance of ANN



ASIFT with Bounding-Boxes, Suction and Gripping Points

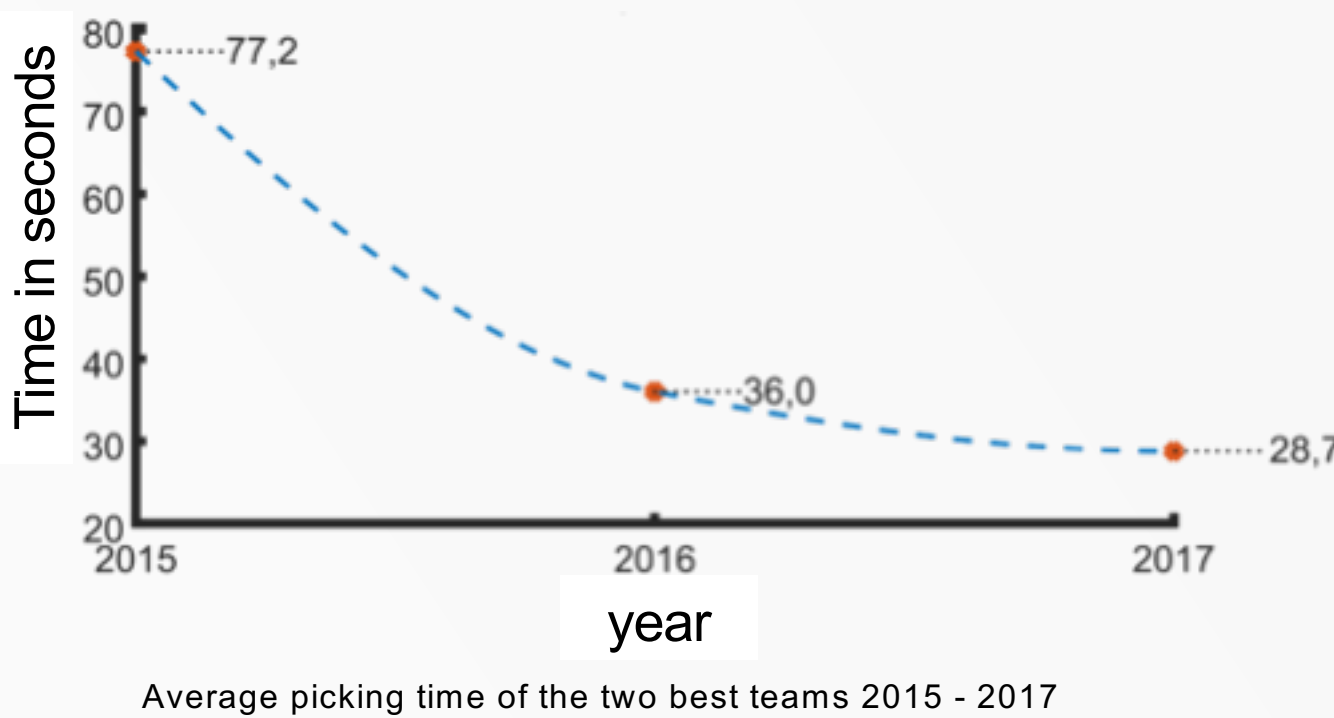


CNN yolo v2 (right) with Bounding-Boxes



Rating of ILSVRC der letzten sechs Jahre. Quelle: Service Engineering Company, 2017. "DSIAC".
<https://www.dsiaac.com/wordpress/wp-content/uploads/2017/volumes/submitting/submitting-to-dsiac.pdf> (seen 5.8.2018).


Results




Average picking time of the two best teams 2015 - 2017

FINAL ROUND SCHEDULE

	STOW	PICK	FINALS		STOW	PICK	FINALS		
9:30	Applied Robotics	5	140	20	1300	IITK-TCS	105	160	170
10:15	IFL PiRo	25	130	30	1345	MIT-Princeton	160	125	115
11:00	ACRV	55	150	272	1430	Nanyang	125	237	225
11:45	NAIST-Panasonic	110	80	90	1515	Nimbro Picking	20	245	235



robotics
CHALLENGE



Results