IntellAct (2011-14): Intelligent observation and execution of **Act**ions and manipulations

SDU (co-ordinator)

MMI

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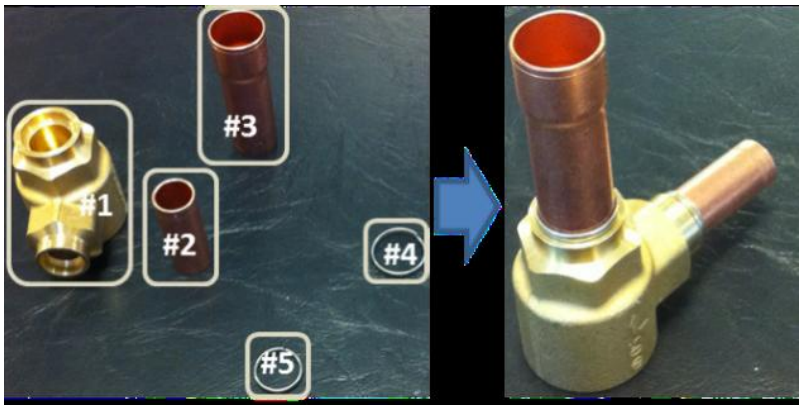
SEVENTH FRAMEWORK PROGRAMME, ICT-2009.2.1, COGNITIVE SYSTEMS AND ROBOTICS

Status on Production in Europe

- Only ca. 15% of production is performed by robots
- Robots are used primarily for large batch size production
- Set-up times for automated robot solutions are still long and therefore are robot solutions expensive
- In particular SMEs avoid the use of robots because of these complexities and costs
- Assembly is done by hand

  →Production moves to ‘low wage countries’

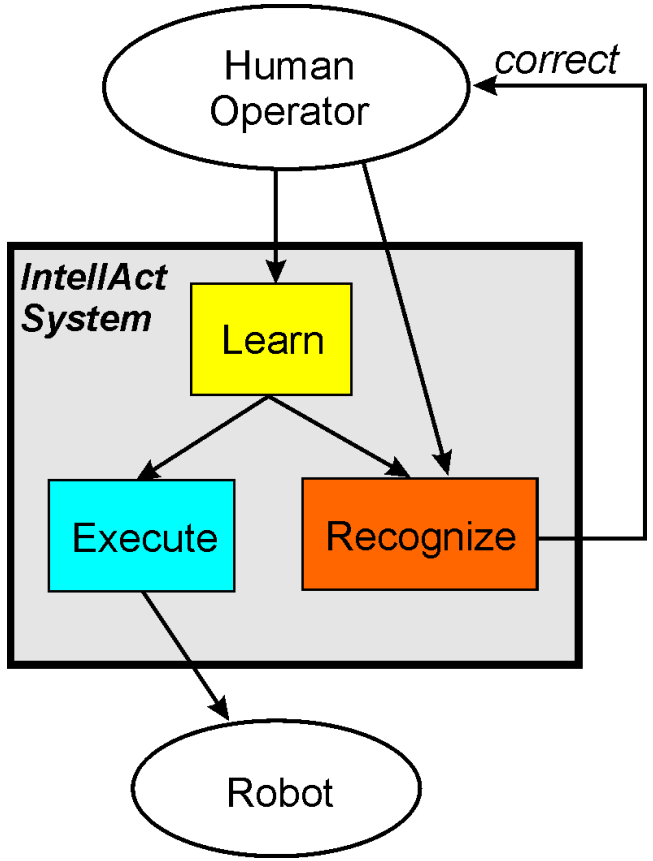


Typical industrial assembly problem

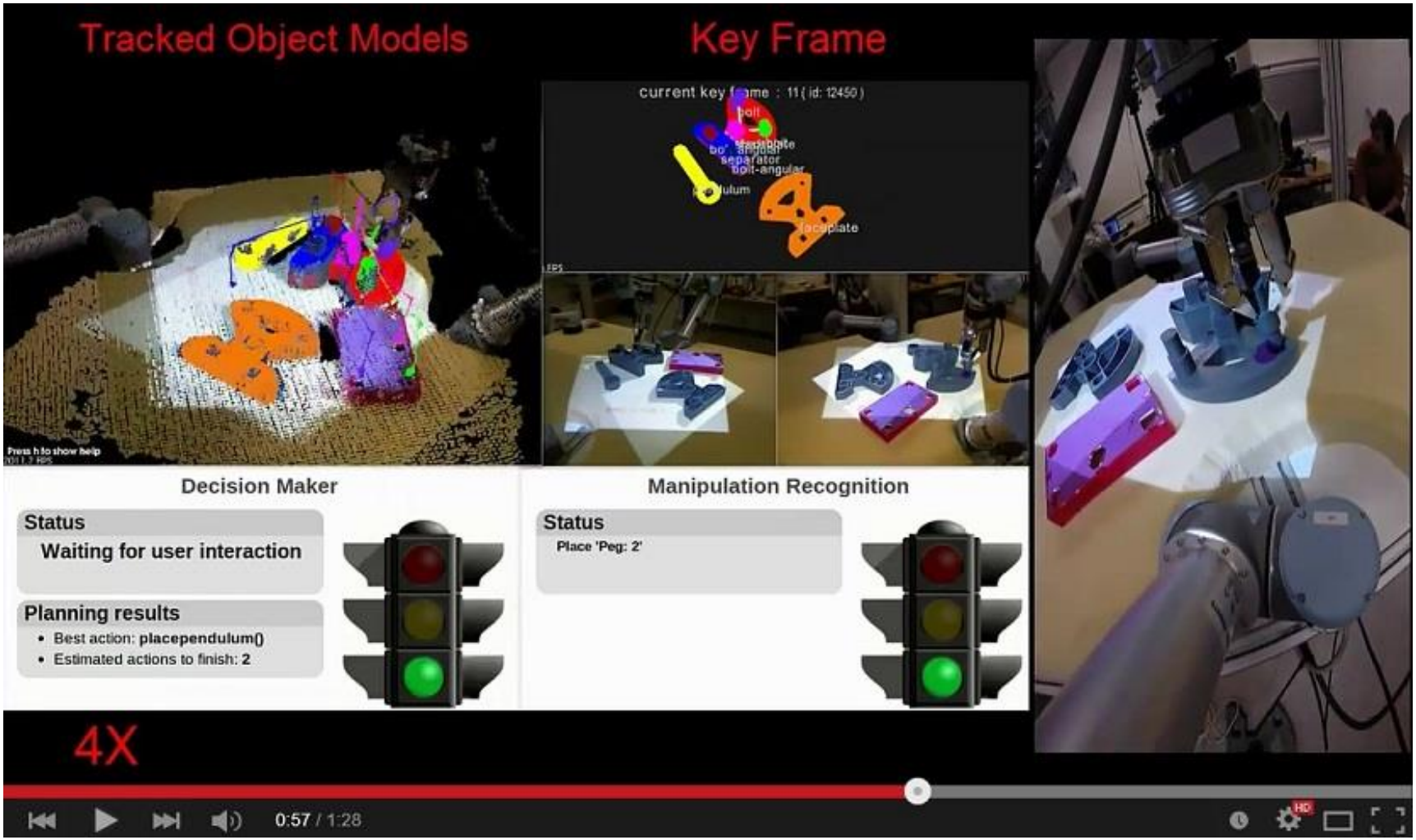
IntellAct Objectives

- Learning to
  - execute robot actions
  - monitor human and robot actions

  Programming by Demonstration (PbD)
- Learning takes place on a semantic level not only on a trajectory/motor level!
- Requires *scene and action understanding*!

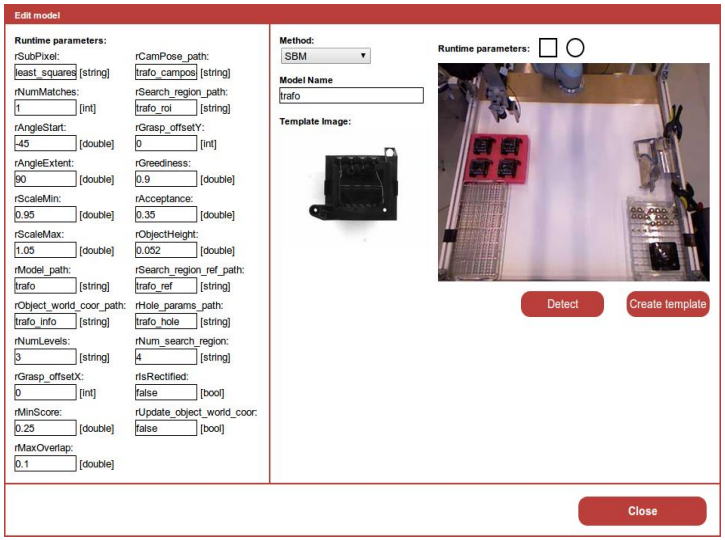


Demo


Tracked Object Models
Key Frame
current key frame : 11 (id: 12450)
bolt
separator
bolt-angular
baseplate
Decision Maker
Status
Waiting for user interaction
Planning results
Best action: placependulum()
Estimated actions to finish: 2
Manipulation Recognition
Status
Place 'Peg: 2'
4X
0:57 / 1:28

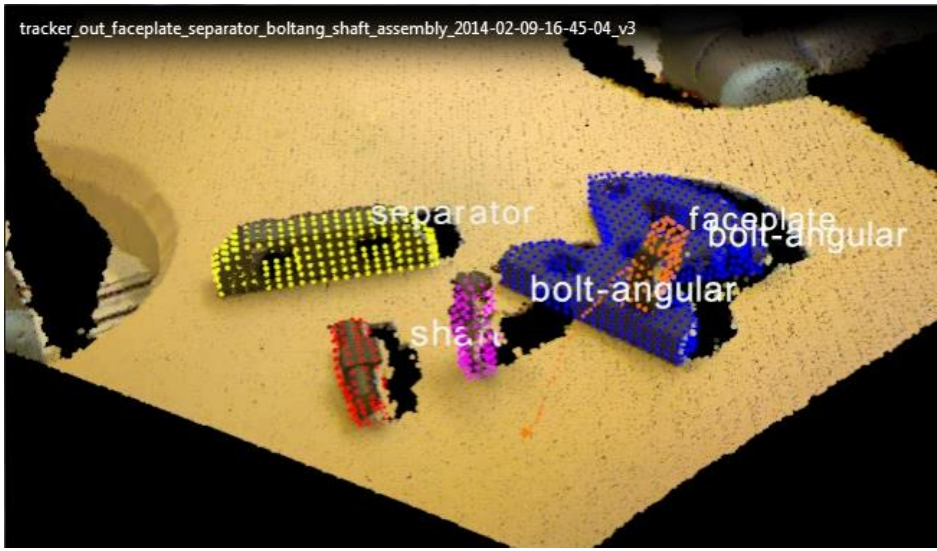
Computer Vision in Production

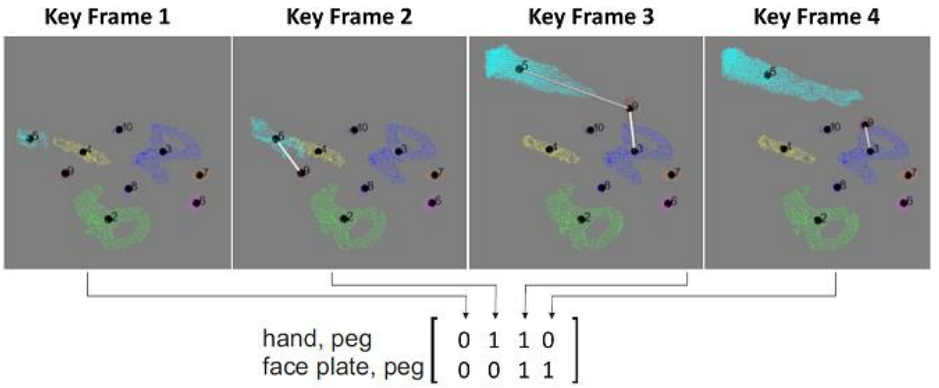
- Vision can substitute positioning hardware
- 2D vision increases complexity
  - Vision does not work!



Contributions of IntellAct

- 3D Object recognition, pose estimation and tracking in a controlled environment
- Mid-level representations that bridges towards action understanding



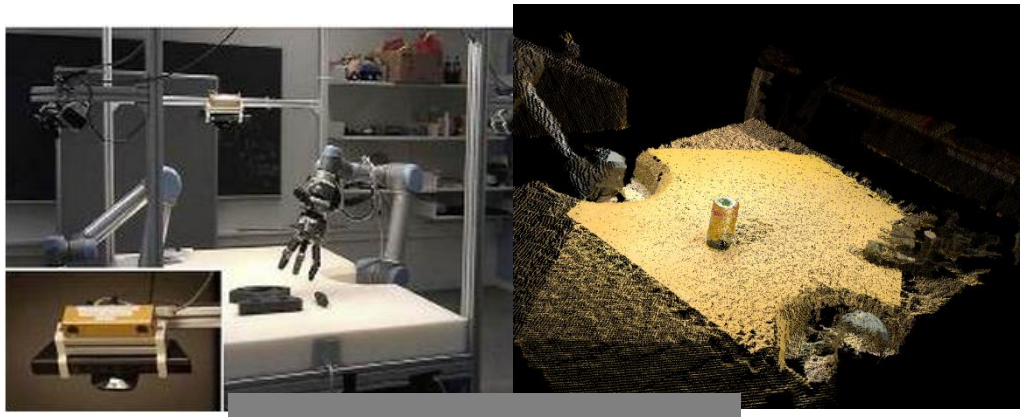


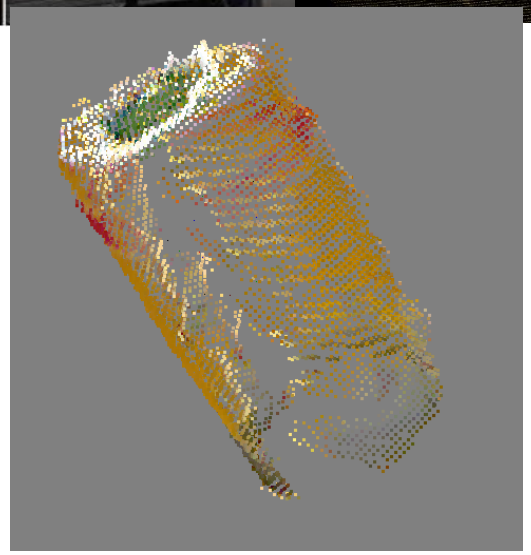
Aksoy, E. E., Abramov, A., Dörr, J., Kejun, N., Dellen, B. & Wörgötter, F. (2011). *Learning the semantics of object-action relations by observation*. The International Journal of Robotics Research, *30*, 1229-1249.

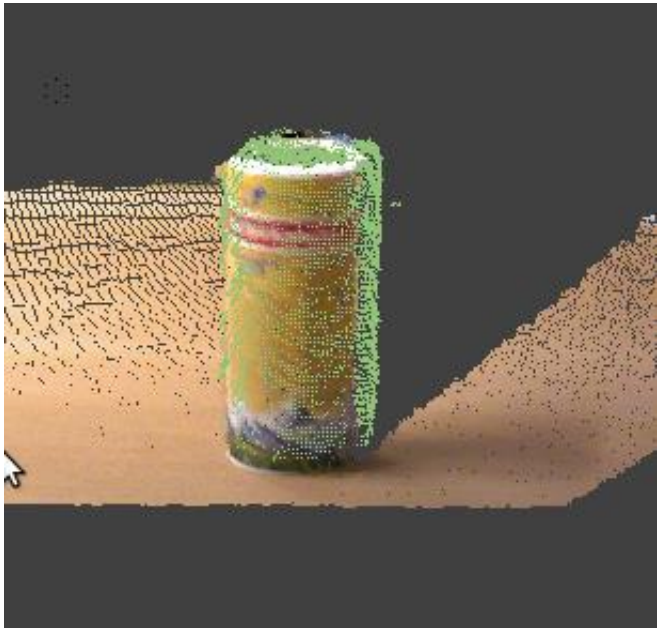
Buch, A. G.; Yang, Y; Krüger, N.; Petersen, H. G. "In Search of Inliers: 3D Correspondence by Local and Global Voting". IEEE Conference on Visual Pattern Recognition (CVPR), 2014.

One Shot Object Learning as alternative to CAD models

Object Learning



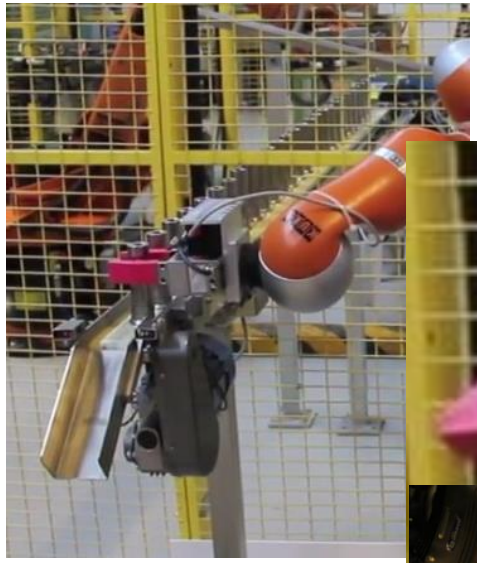


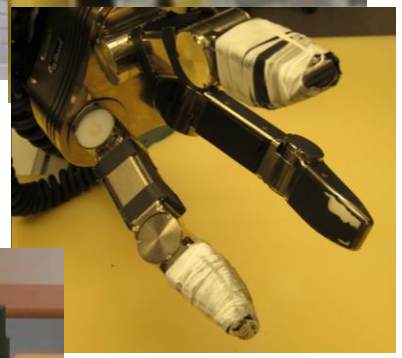


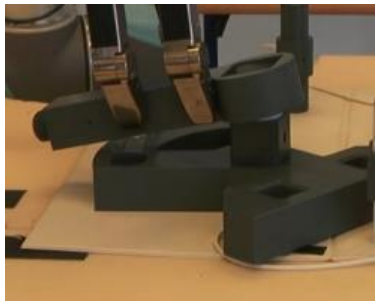
Pose Estimation

Dexterous Gripping

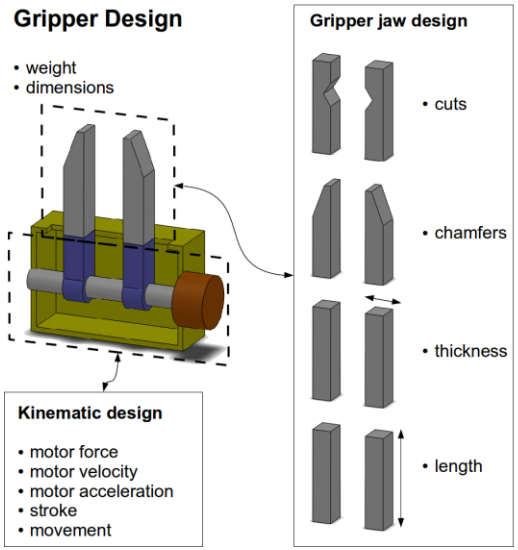
- The design of appropriate hands and fingers is a cost factor for few-of-a-kind production
- Dexterous Gripper allow for a higher degree of flexibility

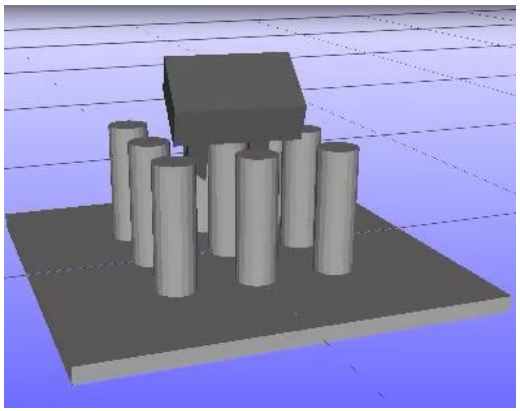






Alternative Solution: Designing fingers in Simulation





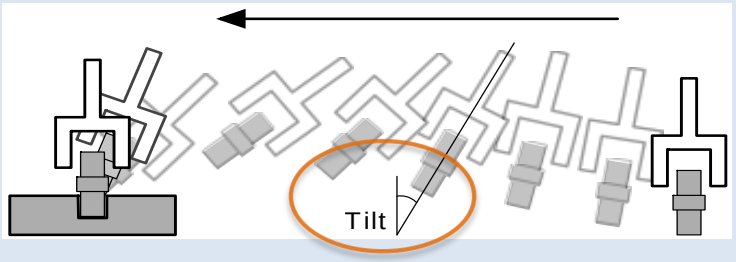
	a) standard	b) chamfered	c) flat	d) square	e) std. w/ cut.	f) chf. w/ cut.	g) clumsy	h) magic	
Success ratio Coverage Wrench avg./top									
S	0.475	0.611	0.752	0.709	0.462	0.574	0.007	0.797	A Rotor cap
C	0.4750	0.4749	0.4755	0.4792	0.4503	0.4551	0.4638	0.4772	
W	3.787	3.871	4.433	2.509	5.308	5.282	1.626	0.433	
W_{20}	5.581	5.566	6.072	3.989	8.552	8.609	4.874	1.635	
Success ratio Coverage Wrench avg./top									
S	0.431	0.803602	0.900	0.885	0.475	0.793	0.234	0.793	B Dolt object
C	0.0415	0.0441	0.0378	0.0609	0.0493	0.0530	0.0312	0.0730	
W	0.909	0.647	0.573	1.063	2.309	2.175	0.438	0.961	
W_{20}	3.954	3.169	2.890	3.490	4.995	4.991	2.203	3.260	
Success ratio Coverage Wrench avg./top									
S	0.861	0.648	0.969	0.969	0.853	0.655	0.747	0.959	C Cylinder
C	0.3241	0.3238	0.3296	0.3306	0.3227	0.3218	0.3150	0.3271	
W	5.116	5.166	5.3091	4.683	3.913	3.721	3.885	3.271	
W_{20}	8.937	9.121	9.093	8.237	9.060	9.212	7.090	6.733	

Adam Wolniakowski, Konstantsin Miatliuk, Norbert Kruger, Jimmy Alison Rytz. Automatic evaluation of task-focused parallel jaw gripper design SIMPAR 2014

Status on Robot Control

- Mostly position control in industry
  - Force-Torque is usually not touched
- However, humans can make efficient use of force torque information

- Strategy
  - Distance minimizing
  - Insertion-focused

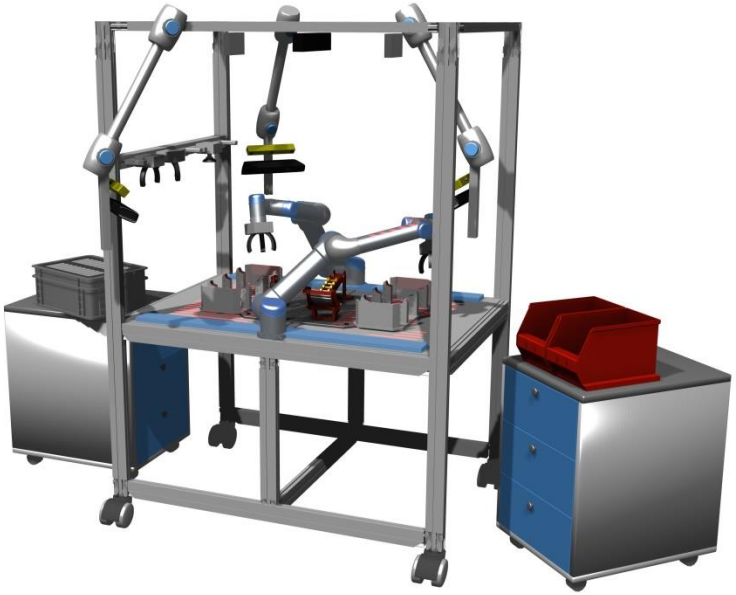


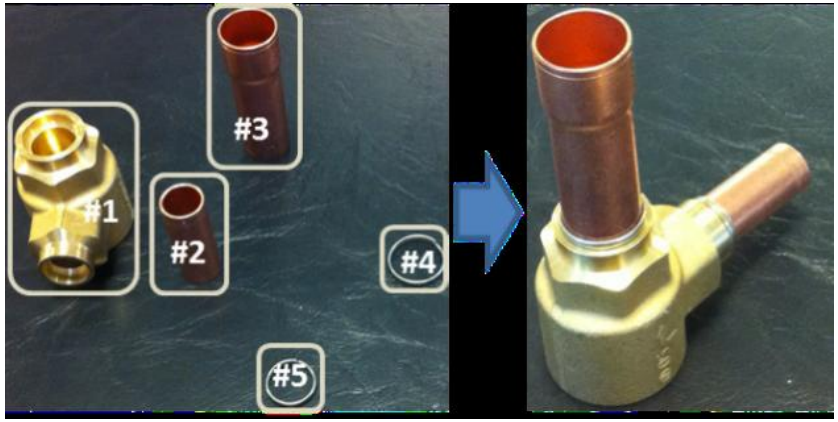
Fares Abudakka, Bojan Nemec, Aljaz Kramberger, Anders G. Buch, Norbert Krüger, and Ales Ude. Solving Peg-In-Hole Tasks by Human Demonstration and Exception Strategies. Industrial Robot: An International Journal, Vol. 41 Iss 6 pp. 575 - 584

Conclusion

- Set-up times need to be reduced
- IntellAct
  - Made **Vision Working** in controlled scenarios using 3D approaches
  - Provides a Mid-level vision framework
  - Exploits potential dexterous manipulation
    - However, design by simulation might be more promising due to hardware issues
  - Developed robot control techniques which allow for adaptation of trajectories based on FT information
- IntellAct provides methods and technology for achieving faster set-up times

Next step: Reconfigurable Cell





Our system	
Initial installation time	1-3 days
Operator training	3-5 days
Training of new assembly tasks	4 hours
Assembly task	
Production mode	Batch production
Part dimensions	min: 10x10x10 [mm]/ max: 300x300x300 [mm]
Part materials	Rigid, non transparent metals, plastics or wood
Part weights	< 3 [kg]

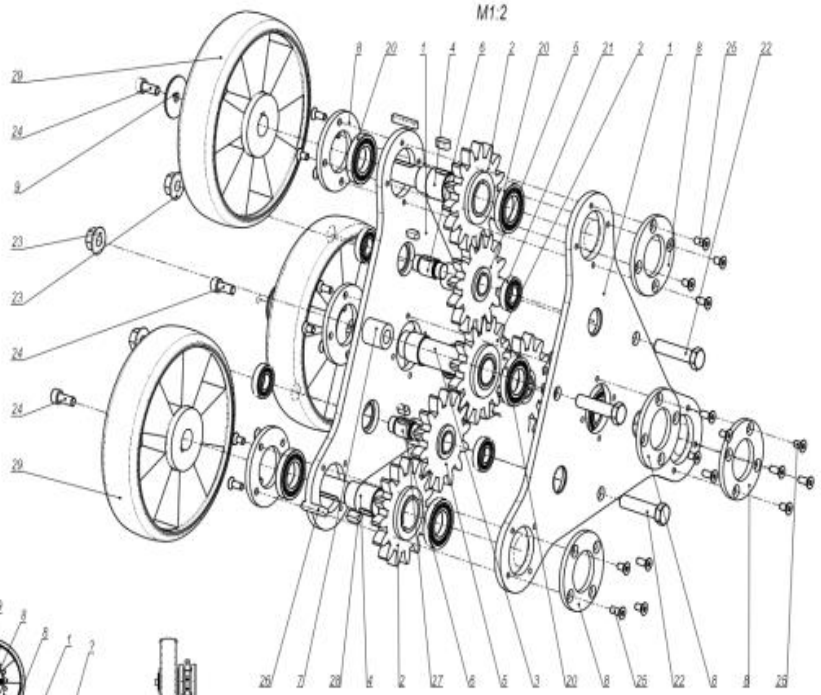
Thank you

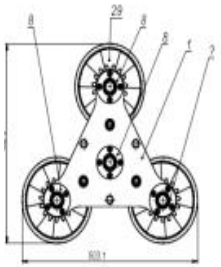
Other Use Cases

Housing LH/RH

Heat shield LH/RH

LWR Actuator Adjusting screw Bulb holder





Other Use Cases