TECHNISCHE UNIVERSITÄT WIEN

AUTOMATION & CONTROL INSTITUTE
INSTITUT FÜR AUTOMATISIERUNGS- & REGELUNGSTECHNIK

Innovation in Applied AI – Learning Objects and Grasps

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ERF 2020, Workshop on Applied AI for Agile Production

Study with Industrial Experts

“What Do Industrial Developers and End-Users Expect from a Cognitive Robot?”

- Questionnaire of AICoR Topic Group
- ERF Workshops on AI & Robotics 2016-2020
- Interviews with selected key persons in industry

[Vernon, Vincze: Industrial Priorities for Cognitive Robotics; EU Cognitive robotics workshop, 2016]

Teach a Robot like an Intern

Cognitive Abilities

- Safe, reliable, transparent
- Task learning → knowledge
- Reasoning about own capabilities

Goals specified at high level

- Robot knows about purpose

Partial Autonomy: user sets goal

- Formal limits, adapt intermediate steps

Instructions

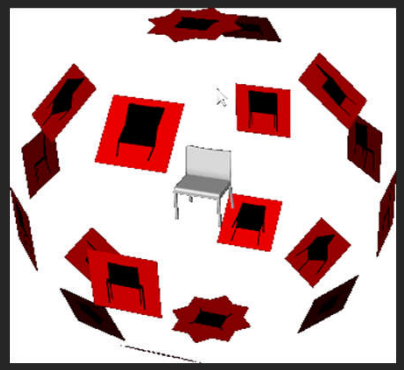
- Teaching by demonstration, learn application context

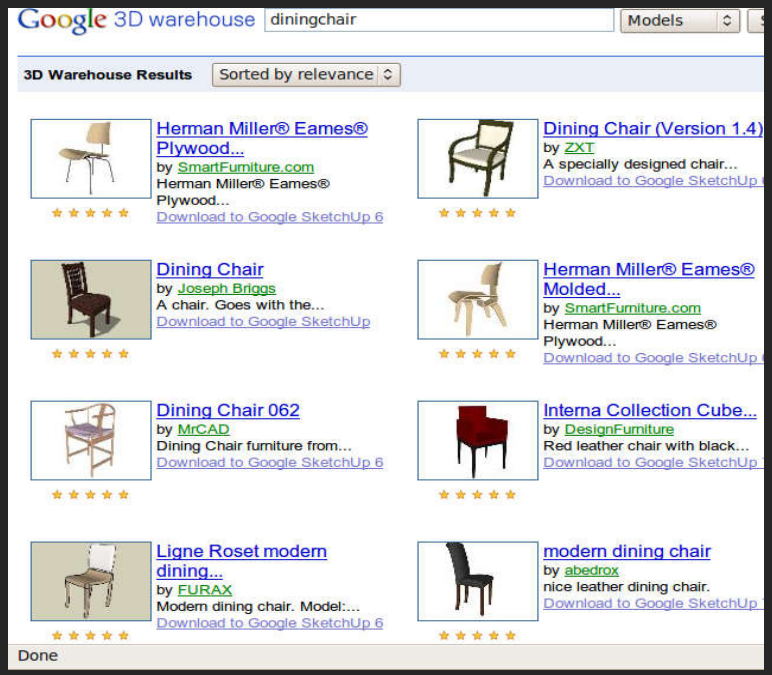
Learn Objects and Grasps

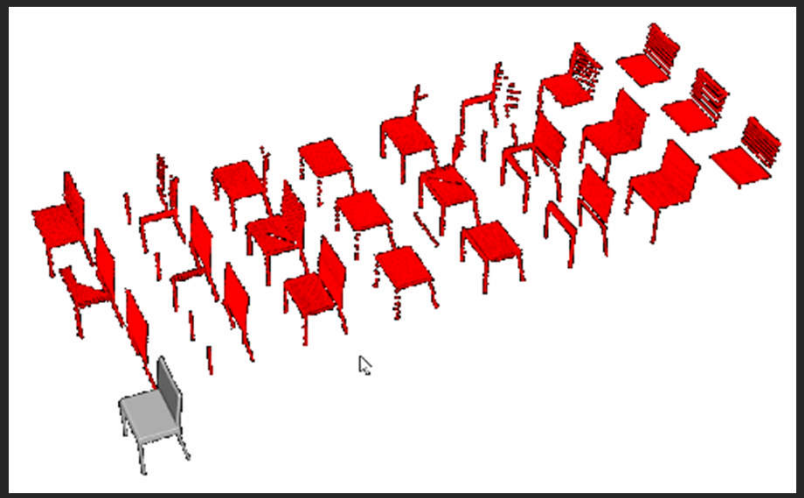
- Tasks defined by objects and actions
  - Grasp and manipulate objects
- Needs visual perception and understanding
  - Learn objects & pose estimation
  - Understand scenes
  - Grasp points & task relation

Efficient Virtual Learning

- 3D Shape from CAD models
- Simulate sensor properties







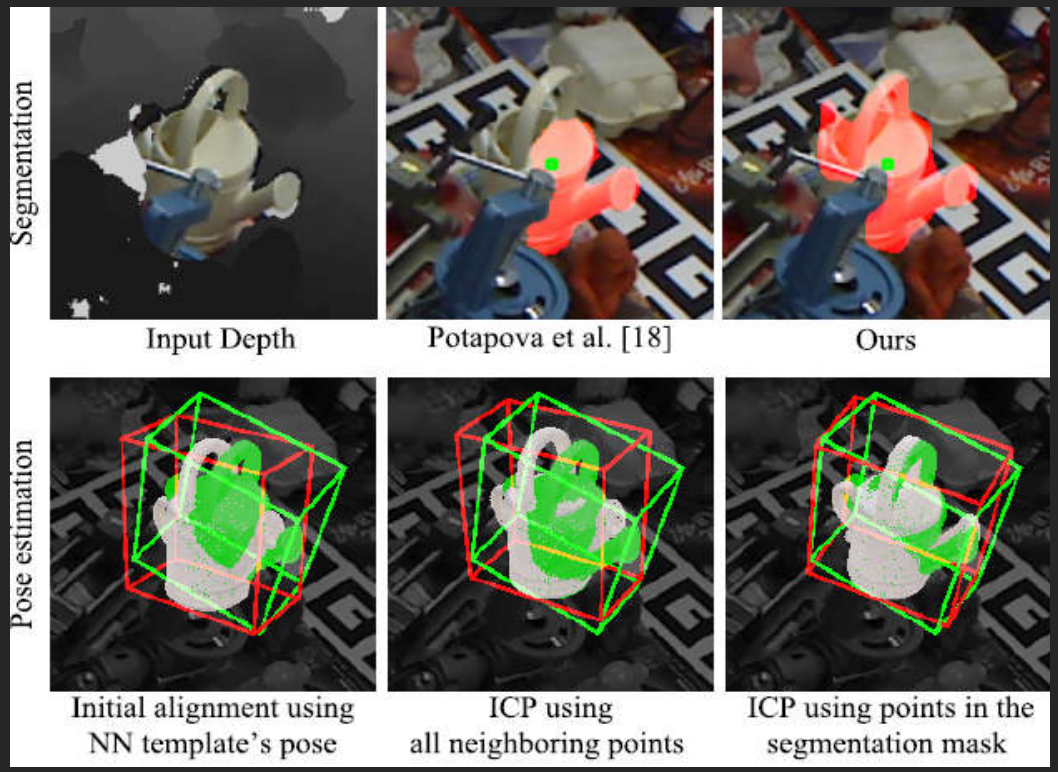
[Wohlkinger, IROS 2012]

Templates for New Objects

- Synthetic data for 2D templates to learn object masks
- Object segmentation improves model fit to 3D data
- Learn masks from simulated data

Objects dropped

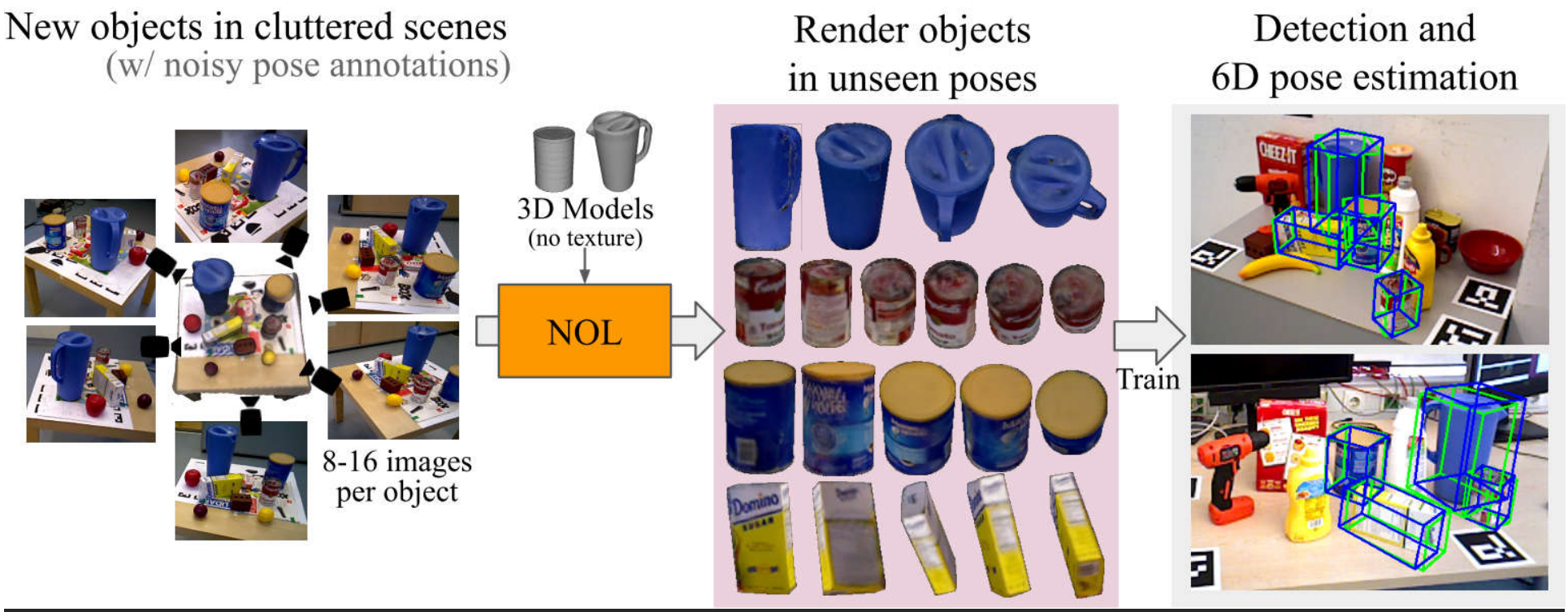
Ground truth



[Park, ICRA'19]

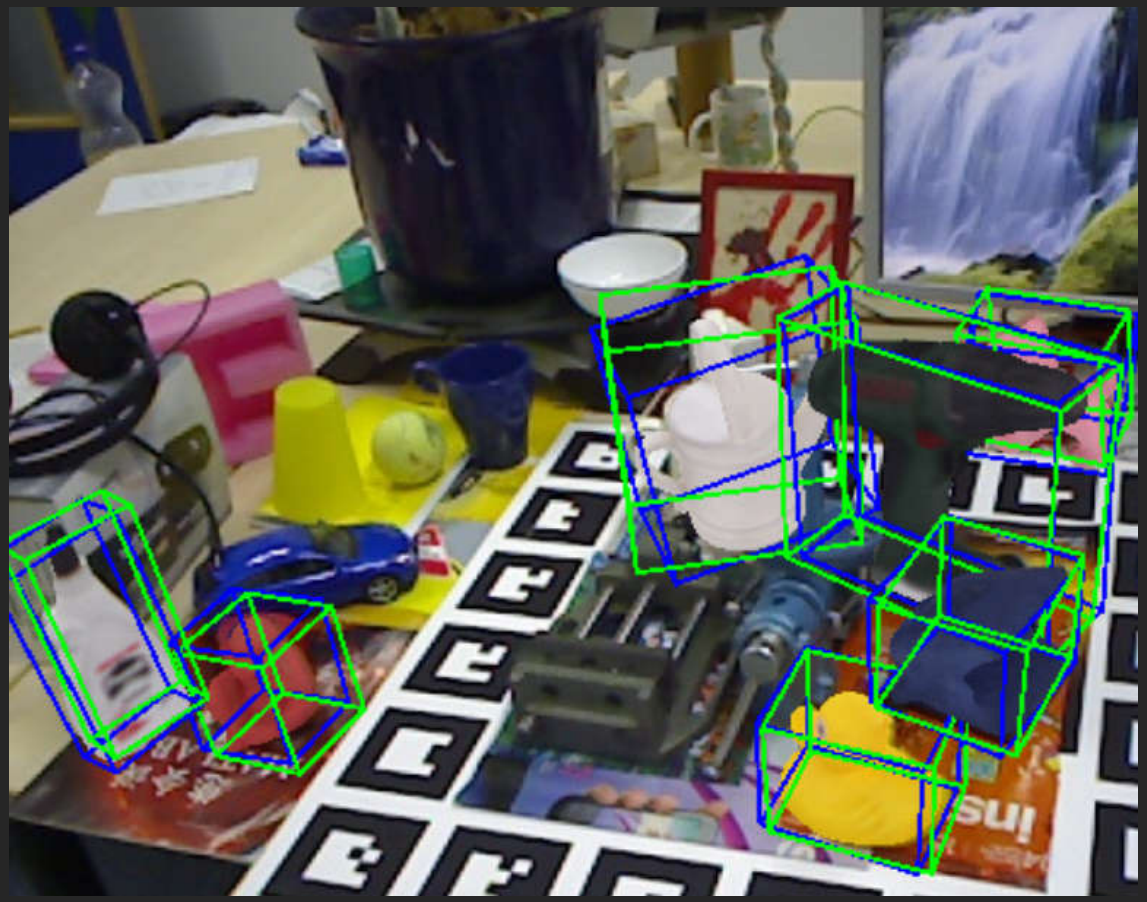
Learning Real Objects

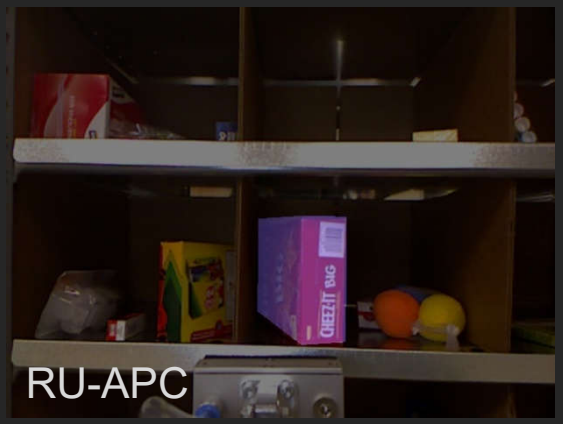
- Neural Object Learning (NOL)
  - Shape plus rendering texture



[Park, ECCV'20]

Pix2Pose: Learning Pose Estimation





[Park, ICCV 2019, 6DPose Estimation: winner on YCB and Amazon Dataset]

Scene Understanding?

- Local/global classifier → object and pose hypotheses
  - Acceptance thresholds tricky, occlusion, FPs
- → Consider *all hypotheses simultaneously in a global model* of the scene in terms of objects

[Aldoma, ECCV 2012, PAMI 2016]

Iterative Physics Simulation and Pose Refinement

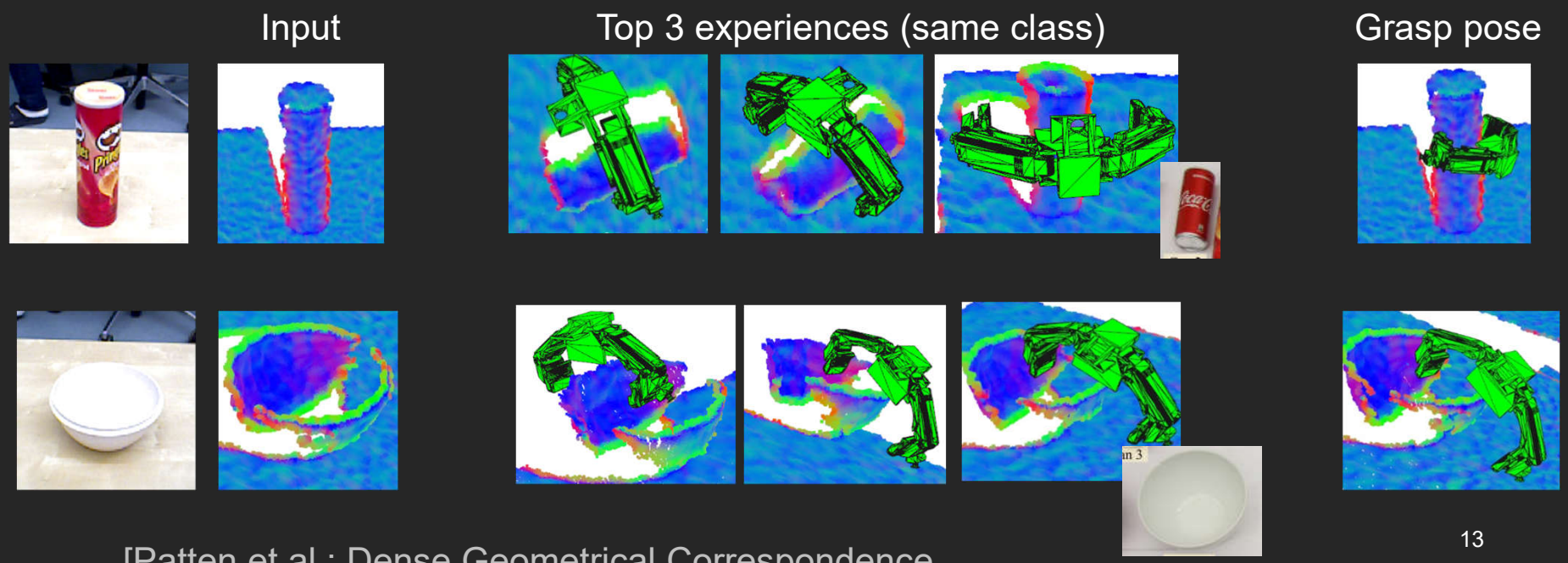
- Physics simulation and refinement in one iterative loop
- Monitoring of loop through rendering-based verification
- Using this monitoring to allocate computing time given multiple hypotheses

[Bauer et al.: VeREFINE .., RA-L 2020]

“Understanding Cluttered Scene”

Learning to Transfer Grasps

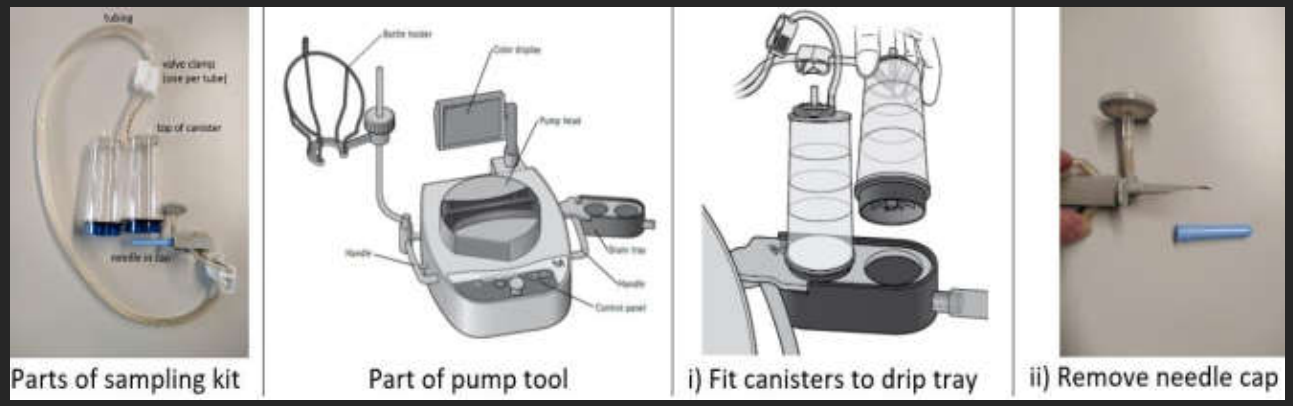
- Depth/shape correspondences to transfer learned grasps
- Learn good grasps from trials and succesful lift of object



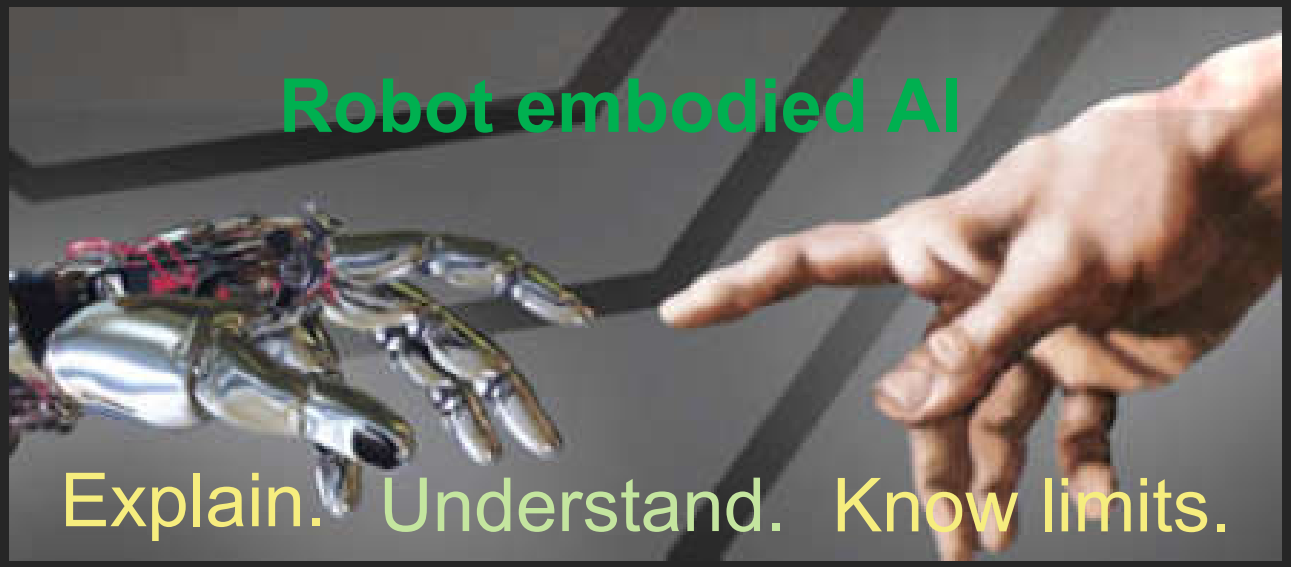
[Patten et al.: Dense Geometrical Correspondence Matching Network for Incremental Experience-based Robotic Grasping, Frontiers in Robotics and AI, 2020]

Open Challenges

- **Perception**: transparent/small/flexible objects, varying illumination conditions, clutter
- **Manipulation:** assemble from a single/few demonstrations by human
- **Understand & verify:** execute the necessary checking actions according to medical regulations



TraceBot: Traceability of assembling a sterility kit.

Teach a Robot Like an Intern

- Industry needs to respond to faster product cycles
- Easily and rapidly learn new task in a domain
- Perception: novel objects, understand scene & context
- Link perception to semantic explanation & domain knowledge