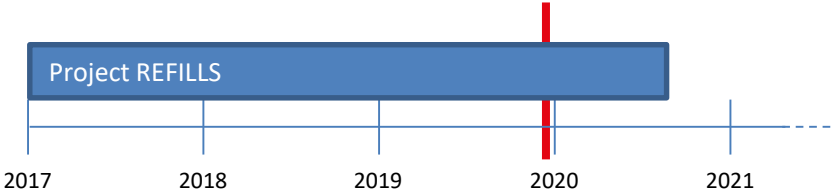
REFILLs: robotic depalletization in retail markets

Jonathan Cacace
PRISMA Lab
D.I.E.T.I
University of Naples Federico II & CREATE Consortium
www.prisma.unina.it
jonathan.cacace@unina.it

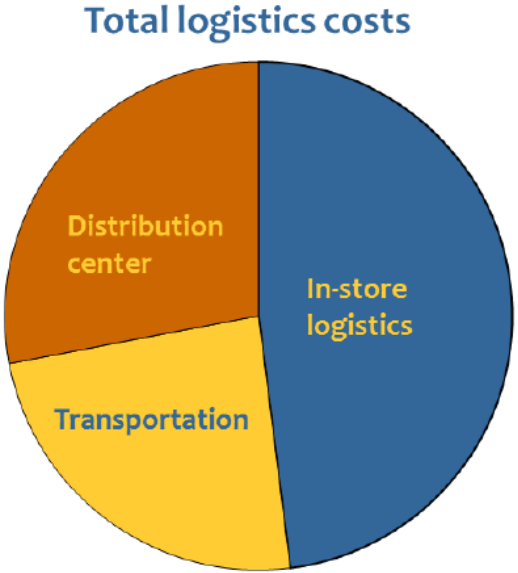
Robotics Enabling Fully-Integrated Logistics Lines for Supermarkets (REFILLs)

- In REFILLs, novel robotic systems in close and smart collaboration with humans will allow addressing the main in-store logistics processes for retail stores, leading to a smarter shelf refilling in supermarkets.

Robotics Enabling Fully-Integrated Logistics Lines for Supermarkets (REFILLS)



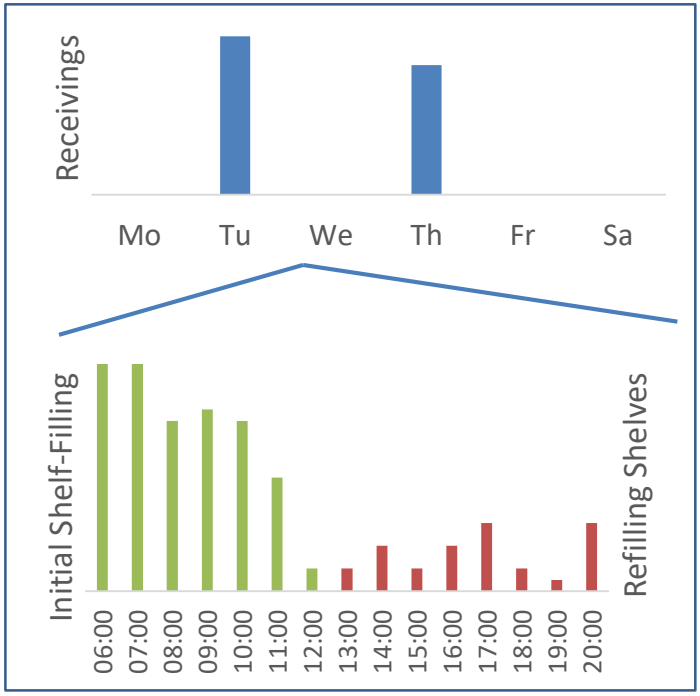
– **CREATE (UniNa)**	Italy	Research/Coordinator
– **dm-drogerie markt**	Germany	End-User
– **Intel**	Israel	Industry Partner
– **KUKA**	Germany	Industry Partner
– **SUN**	Italy	Research
– **Swisslog**	Switzerland	Industry Partner
– **University of Bremen**	Germany	Research


Total logistics costs
Distribution center
In-store logistics
Transportation


Total operational store costs
Further operational store costs
In-store logistics

Robotics Enabling Fully-Integrated Logistics Lines for Supermarkets (REFILLs)

- Environment
  - Safety aspects with customers around.
  - Error Handling - no technical personal on site.
- Variety of objects
  - >10,000 different objects.
  - Rapidly changing portfolio.
- Large number of decentralised locations.
- Tight working space.
- High peaks in utilisation.



Supply chain

Entry point:
Pallet disassembly

Pallet

Trolley

Shelf

Case study: heterogenous pallets

REFILLS

Case study: heterogenous pallets

- Depalletizing is the process where products are removed from the original shipping pallet and organized for the storage.
- Boxes can be of different sizes and weights.
- Are organized in order to fit the higher number of objects in the pallet space: cluttered and heterogeneous objects.
- Depalletizing can be an hard and tiresome activity for human clerks and since they have to manually remove a huge number of weighty boxes, usually one by one and organize them in the different trolleys.

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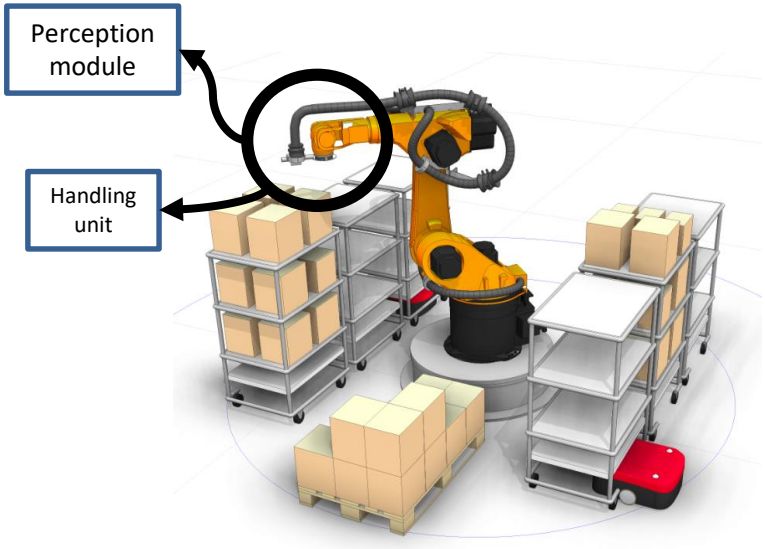
- Requirements:
  - The robotic system should be able to exploit 2D and 3D data to reconstruct the pallet structure.
  - Each box of the pallet must be detected and localized and classified considering the contained items.
  - Each box must be properly grasped and placed on the correct trolley.

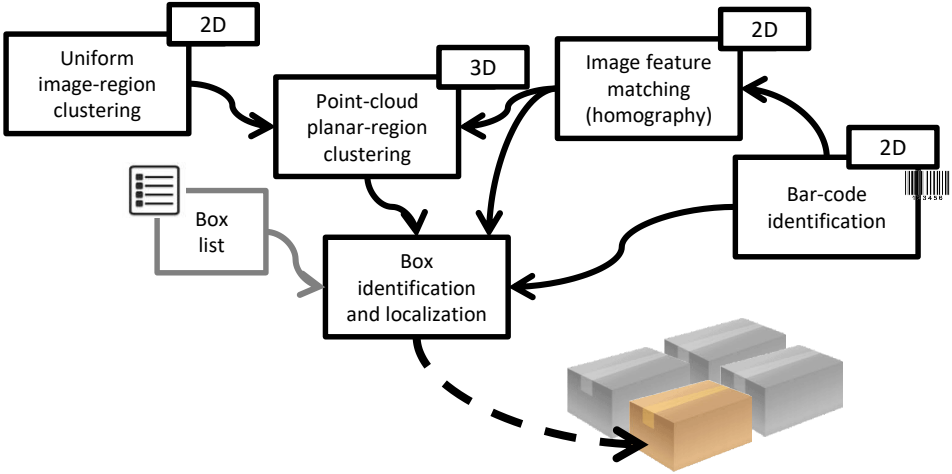
Depalletizing cell

- Perception Module:
  - Detect and localize the boxes.
  - Depth camera to get 2D/3D data: Intel Realsense D435.
- Robotic Arm:
  - Kuka kr 60 Industrial manipulator.
  - Remotely controller using ROS-Industrial experimental stack for kuka robots.
- Handling unit:
  - Custom gripper: sliding fingers with suctions.
  - Allow multiple grasping solutions for each type of boxes.



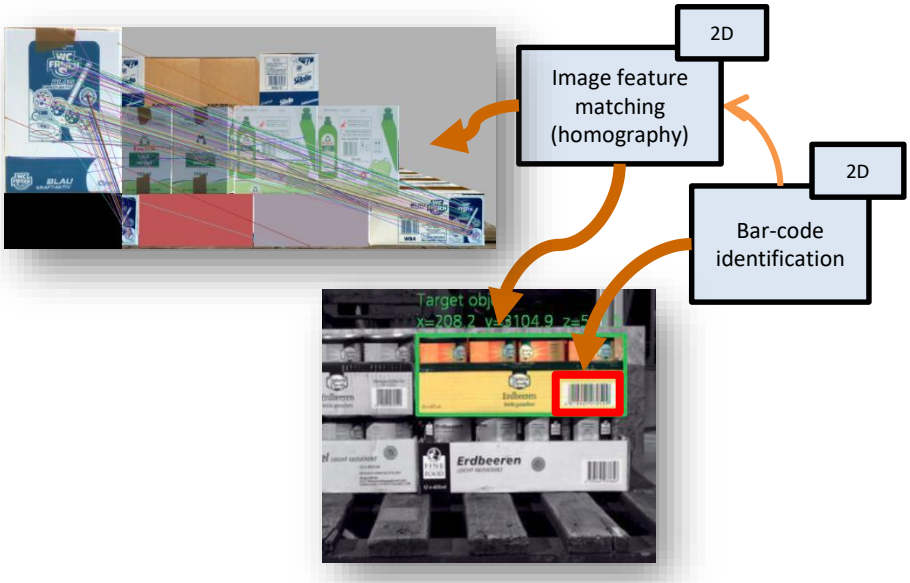
Perception-strategy flow chart

- Goal:
  - Localization and identification of the boxes on the pallet.
- Input:
  - Image (2D) and spatial (3D) data.
  - Description of the objects included on the pallet: Box list.
- Output:
  - Position, orientation and box type for each boxes of the pallet.

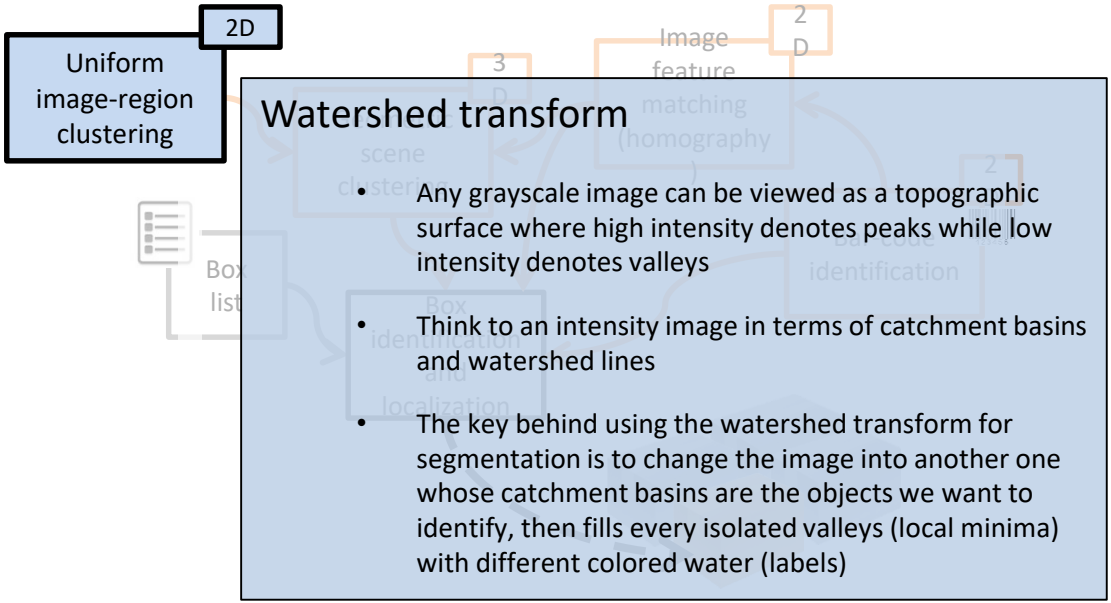


2D Elaboration: texturized image-region clustering and bar-code identification

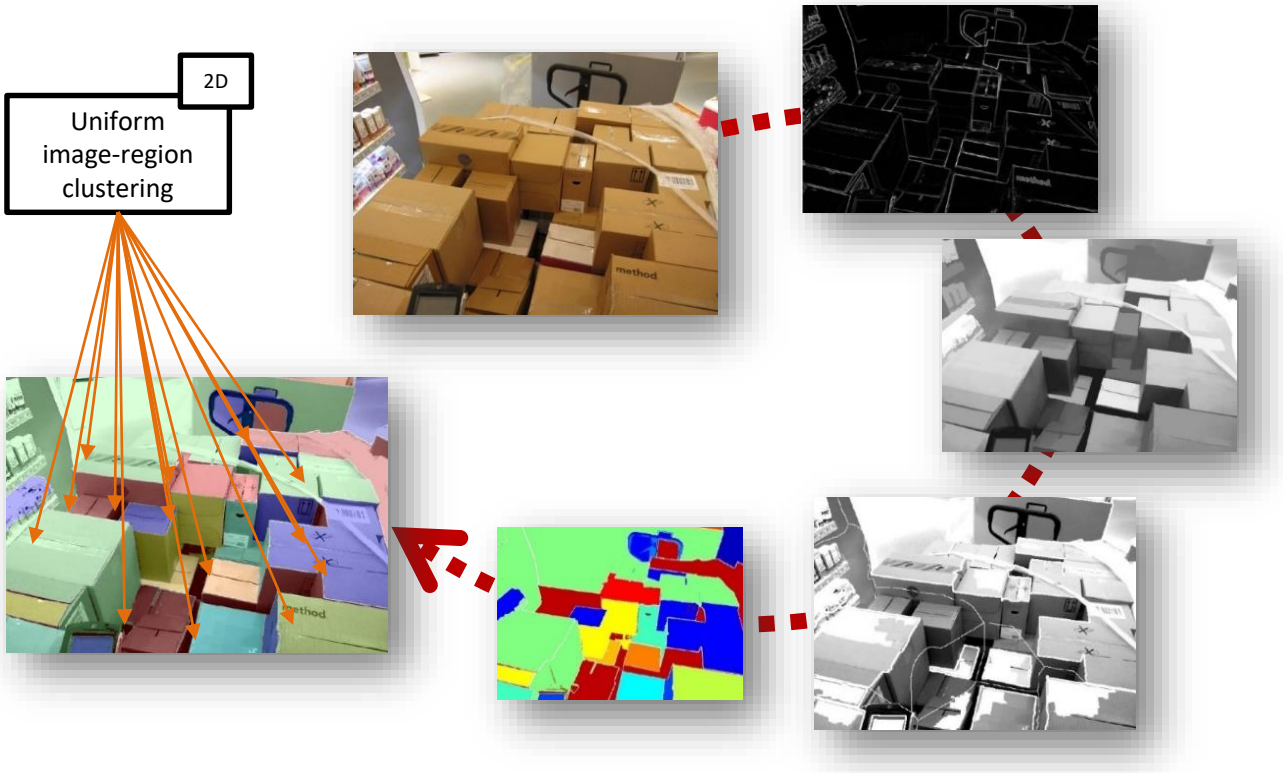
- Texture matching:
  - Box side textures provide useful information to recognize the geometry of the box and its items.
  - SIFT features are used to perform the template matching between description of the pallet and the current image.
- Bar-code identification:
  - If present and visible, the bar code uniquely identify the box.



2D Elaboration: watershed

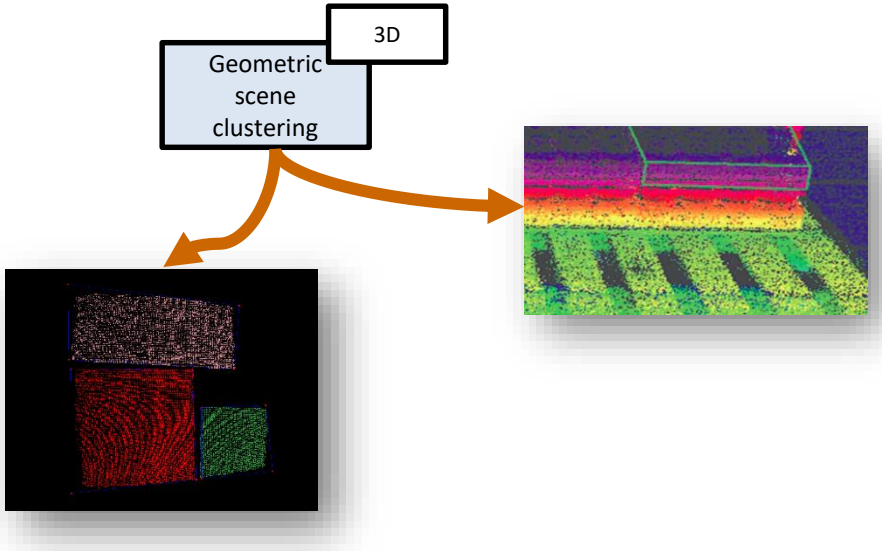


2D Elaboration: watershed



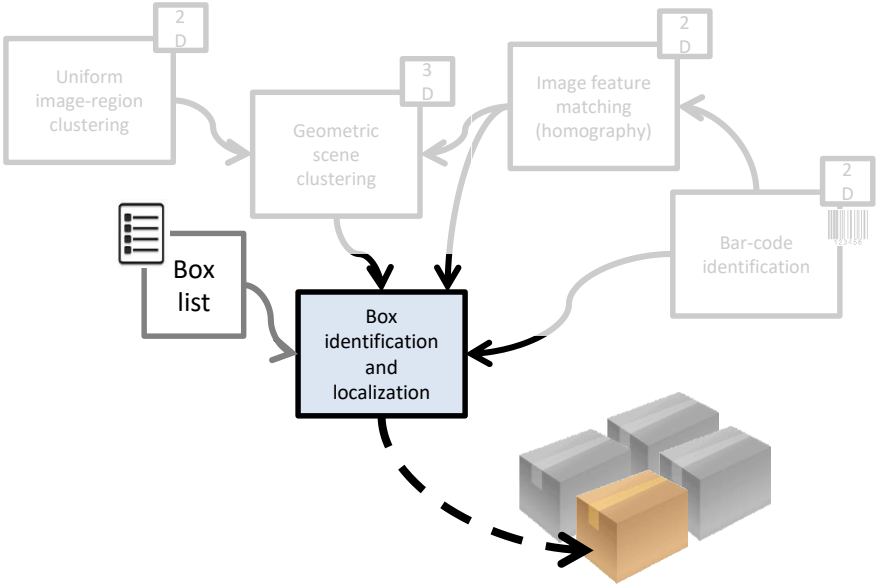
3D box-surface clustering

- Box reconstruction:
  - 2D elaboration only compares camera data with the information of the box lists.
  - Point cloud data are used to precisely reconstruct the 3D shape of the boxes.
- Goal:
  - Detect occlusions and geometric connections between the boxes!

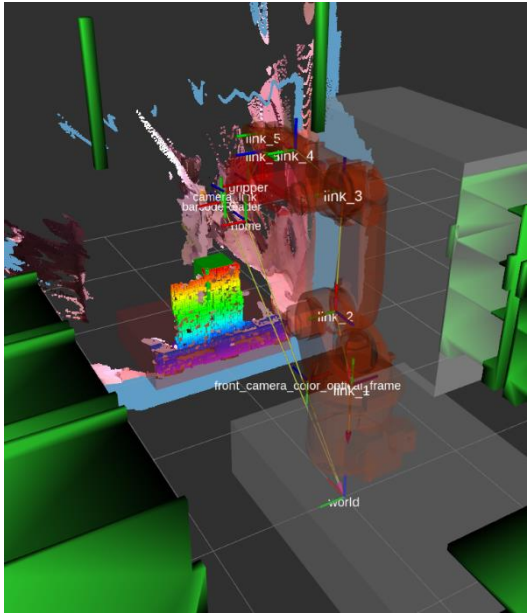


Optimal data fusion and box identification

- At each iteration, the information gathered by the 2D and 3D elaboration are fused in order to define:
  - Boxes size and width
  - Boxes item
  - Free space boxes
- These information are used by the executive system of the robot to define the best box candidate to grasp, and a grasping strategy for the handling unit.

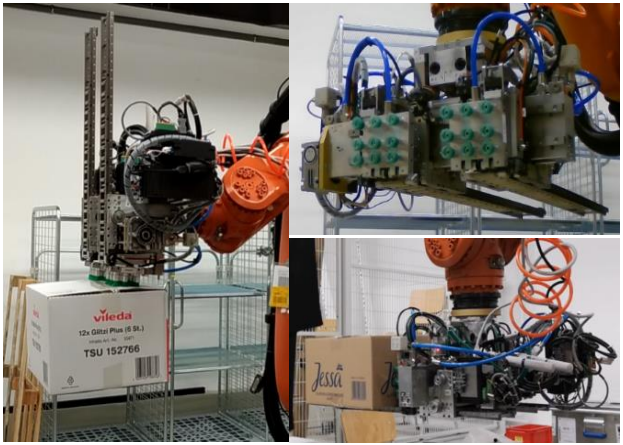


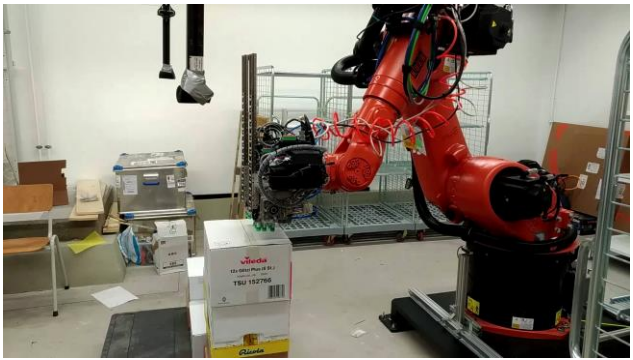
Perception module at work



Handling unit

- Sliding fingers with suction
  - Handle boxes from underneath
  - Handle different box size
  - Deploy on a multilayer trolley





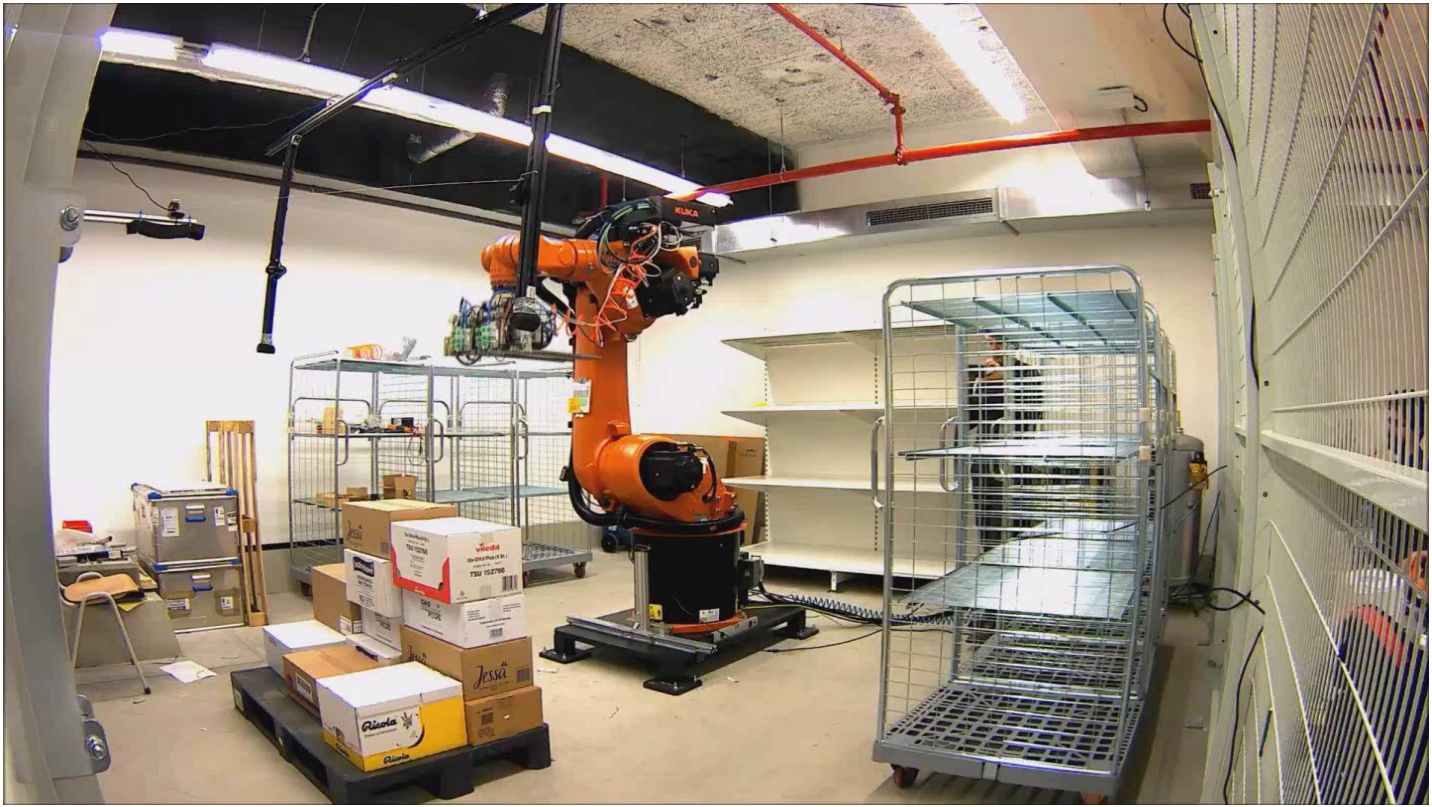
Executive system

- Motion planning based on ROS-Industrial: MoveIt!
- Planning scene:
  - Static objects: trolleys
  - Dynamic objects: pallet object
- Planner: RRT*
- The system database: environment specifications
  - Pose and type of storing spaces (shelves, trolleys, etc.).
  - Pose of the bar-code reading room, positions and dimensions of potential obstacles.

Robot control is based on ROS-Industrial:

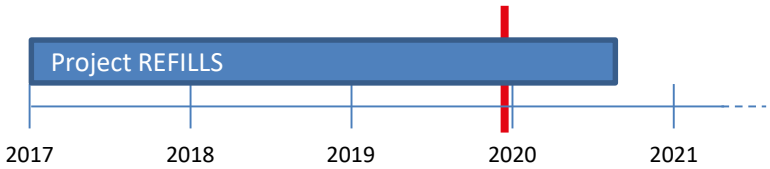
- Kuka kr 60 support package added to kuka experimental stack .
- Six degree of freedom.
- Payload: 30 kg.
- Trajectory position controller.
- KR-C4 controller supported.
  - Planning time: 10 *s*
  - Attempts: 5

Demo



Next stop: automatica 2020

- Final demonstrator of RefillS Project @ Automatica 2020
  - Munich, Messe Munchen – June 16-19 2020
  - Heterogeneous pallet disassembly
  - Shelves monitoring
  - Autonomous refilling of shelves
- **Hall: C6, Booth: 317**



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automatica

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Questions?

Thank you very much

for your kind attention!

Jonathan CACACE
Jonathan.cacace@unina.it
www.prisma.unina.it

PRISMA Lab
Department of Electrical Engineering
and Information Technology
University of Naples Federico II