

Master thesis:

Robot bin-picking

The Volvo Group is one of the world's leading manufacturers of trucks, buses, construction equipment and marine and industrial engines under the leading brands Volvo, Renault Trucks, Mack, UD Trucks, Eicher, SDLG, Terex Trucks, Prevost, Nova Bus, UD Bus, Sunwin Bus and Volvo Penta.

Volvo Group Trucks Operations encompasses the production of state-of-the-art products for the truck brands of the Volvo Group, as well as Volvo Group engines and transmissions, through an international world class industrial environment.

With Volvo Group Trucks Operations you will be part of a global and diverse team of highly skilled professionals working with energy, passion and respect for the individual to become the world leader in sustainable transport solutions.

Background of thesis project

At the final assembly line in our manufacturing plants mounting details are provided as a "kit" to each mounting station. The reason for this is that there is no space for storage of materials at each assembly station. Therefore materials are placed in a storage rack a bit away from the assembly station but still in the vicinity. The required components for the specific product variant shall be picked by hand or by robot from smaller bins and placed on a ATR (Autonomous Transport Robot) that takes the kit to an assembly station where components are mounted on the engine variant.

In order to make the installation more flexible, we're using cameras as generic input sensors and are developing algorithms that will, out from camera pictures, identify the best "pickable component" in a bin of randomly placed components and define its pose in 6D. This information (a 3D CAD-model and camera images) will be the input to the system that this thesis is intended to develop. The goal is to find generic algorithms based on machine learning that can find a suitable gripping/grasping point for a (collaborative) robot to pick and place the component(s).

Suitable background

Automation & Mechatronics (M/Z/F). Knowledge of Machine learning algorithms and experience with robot simulations (e.g. Pybullet, Gazebo, VREP), Python, C++ would be plus.

Thesis project tasks

This project will focus on autonomous pick and place of industrial parts. The aim is to reduce human involvement in these types of tasks and free up the human for more added value tasks. A robot with a UR arm, a two finger gripper and different vacuum cups will be used and evaluated. The objects will be randomly placed in a bin where there will be instances of only one type of object in the same bin. After the bin is recognized, a grasp planner will be used to determine grasp locations and parameters for the robot to pick objects and empty the bin by placing them in the designated area. All the tasks to realize this project are listed below.

- The experiment objects will be selected, categorized and documented considering the following: Which objects can be grasped with the two-finger gripper or the suction cup; how the expert users are grasping/handling these objects in terms of grasp locations and

placements; which of these objects will be entangled in the cluttered bin, CAD models for each selected objects will be stored in a database using assigned object names in a format suitable for simulation and real experiments. These objects and bins will be provided by Volvo for the real experiments.

- Automatic offline grasp generation/annotation to be used with an off-the-shelf object pose detection component. For this a heuristic based approach can be used based on sampling and force closure criteria. This baseline method will be used to grasp objects on top of the pile with reachable top grasps that are achievable with robot configuration close to its current configuration fast. There will be heuristic filters to prune out grasp hypothesis to achieve this.
- A generic grasp planner based on a Machine Learning approach will be developed that directly uses the visual input (rgb/point cloud) to construct grasp pose for the gripper (6D pose for the hand along with hand preshape).
- A force/torque based execution will help to identify unexpected contacts or events, e.g. more than one object grasped, failures due to unexpected torques, or to verify success cases.
- Other components to complete the full system such as using markers (e.g. Aruco) to detect bins and corresponding object identities, a state machine or behaviour tree-based implementation of high-level planner.
- Simulation of the setup including cameras, gripper, arm and potentially f/t sensor. The simulation behaviour will reliably demonstrate the real robot behaviour and speed up the development time.
- Real robot demonstration: At the end of the project, using selected objects, sensors (camera, force/torque sensor), and the designated pick and place areas, the robot will pick objects from a bin and place them successfully. The aimed success rate is above 80%.
 - For this task, from the beginning of the project, we will build a similar robot setup at Chalmers to the one at Volvo site. Therefore, in the beginning of the project, a suitable low-cost camera that can sense the experiment objects needs to be purchased.

Methodology

- Literature studies of bin picking.
- Machine learning based grasp planner and system integration of all the components described above.
- Run demonstration to validate the result

Thesis Level

Master

Language

Thesis is to be written in English.

Starting date

January 2021

Number of students

Two (2)

This document describes a Master Thesis to be performed at Group Trucks Operations, GTO, Göteborg, during 2021.

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