

# The Autonomous Picking & Palletizing (APPLE) Robot: A Research Platform for Intralogistics Applications

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**Abstract—** **Todo ...**

## I. INTRODUCTION

The increasing need for fast and flexible commissioning (i. e., order picking and collection of unstructured goods from storage compartments in warehouses) in logistic scenarios has created substantial interest for autonomous robotic solutions. This was also evidenced by a recent BBC investigation into a UK-based Amazon warehouse, which highlighted that the dull and strenuous nature of commissioning could cause mental and physical illness in human workers. Amazon themselves took action by organizing their first Picking Challenge at ICRA 2015.

The key obstacle for many application scenarios is the autonomous grasping in uncertain real-world environments. Currently, despite of a large research effort, no commercially viable solution is available for this problem. State of the art autonomous grasping systems [1], [2], [3] commonly employ sampling based planners [14] to generate online reach-to-grasp motion plans for offline planned grasps which are stored in a database. During the execution phase, such approaches necessitate many futile motion planning attempts which often incurs significant time delays mainly due to the frequent collision checks which are necessary to avoid the robot coming in contact with itself or the environment. For APPLE, we adopted a real-time reactive control approach for manipulator motion generation which allows to exploit redundancy, opposed to the commonly used sense-plan-act architectures which constrain all manipulator DoF. The main idea is to formulate a hierarchical set of tasks [4] such as move end-effector on this plane or avoid joint limits and to compute controls such that tasks of lower priorities are executed in the null-space of higher ranked tasks [5], [6], [7].

## II. SYSTEM ARCHITECTURE

- A. AGV Navigation
- B. People Detection
- C. Object Perception and Grasp Planning
- D. Manipulator Motion Generation
- E. Robust Grasp Execution

## III. EVALUATION

## IV. DISCUSSION AND OUTLOOK

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