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A Smart Workcell for Automatic Pick and Sorting for Logistics

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***Abstract*—Vision-guided robots are enjoying growing success in industry, thanks to their adaptability to unstructured contexts and applications. In typical bin-picking applications, a robot is guided to pick known rigid objects randomly placed inside a container. Given the objects' CAD models, it is possible to accurately estimate the object pose and to perform the grasp synthesis in a closed form. Unfortunately, in logistics, as in many other sectors, robots are required to manipulate polymorphic and deformable objects.**

In this work, we present a complete robotized pick and place solution for logistics able to address these challenges related to the variability of shapes of the objects. It exploits a model-less data-driven approach to bin-picking to detect boxes and parcels both randomly placed in containers or palletized. The proposed system will be easily adaptable to a wide range of applications, thus greatly improving its potential impact.

***Index Terms*—instance segmentation, artificial intelligence, industrial robotics, vision system, workcell, logistics**

I. Introduction

The growth of e-commerce is leading to the explosion of box shipments. Picking and sorting boxes is still a manual and time-consuming process that requires picking each box from a container or pallet.

The ability to locate and manipulate palletized or randomly placed objects inside containers and accurately insert them into production processes is an enabling technology that is becoming increasingly popular in many industries. In general, this problem relies on robust 3D pose estimation algorithms that exploit either 2D or 3D vision technologies [1], [2], with an increasing trend toward data-driven approaches based on deep models [3], [4]. Most of these systems assume to deal with one or more objects of known and non-variable shape. Since boxes may have different shapes, sizes, and colours, developing a fully automated system is more challenging.

In this work, we present a complete robotized pick and sorting solution for logistics (Fig. 1) developed to address these challenges. It relies on a robust AI-based localization module [5] able to localise and handle deformable and non-fixed size objects. The recognition algorithm, therefore, moves from a parameter-based approach to a data-driven approach, allowing even untrained personnel to set up a pick and place application with a very small effort and without the need to fix/change dozens of parameters.

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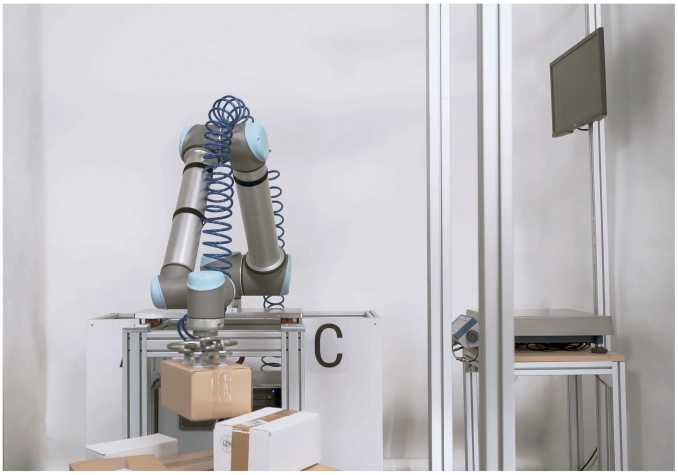

Fig. 1. Example of workcell. A UR10 pick up randomly placed boxes and places them on a delivery tracking system.

II. The Workcell

The presented workcell is a complete pick and place solution for logistics. It exploits a model-less approach to bin-picking that enables an application to detect boxes and parcels both in containers or palletized.

The workcell is composed of several modules:

1) an AI-based vision system based to identify and localize boxes from a container or pallet;
2) a grasping synthesis module that identifies the best parcel to be picked up and computes the optimal grasping point;
3) a motion planner module generates collision-free trajectories to perform a pick and place routine or to sort packages.

The developed solution is designed to be easily integrated into existing production lines.

The main innovation introduced in the workcell is the AI-based vision system to recognize and localize boxes for picking and sorting applications.

The developed algorithm exploits a model-less, data-driven approach using RGB-D data to identify object instances. A Zivid One+ 3D camera has been used to acquire RGB-D (colour and depth) data. As depicted in Fig. 2, the first step consists in finding each instance of boxes in the image. To perform this task, we identified Mask-RCNN [6] as a suitable model-less algorithm. Mask-RCNN is a modular algorithm for instance segmentation that predicts segmentation masks

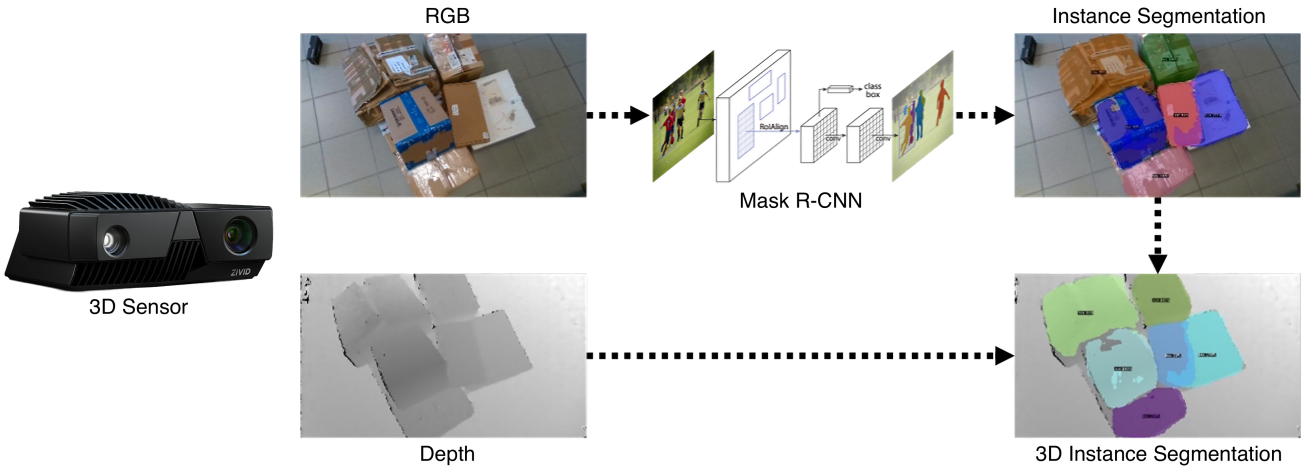

Fig. 2. The presented 3D instance segmentation pipeline. RGB-D data are acquired by a 3D camera. The first step consists in find each instance of box in the RGB data exploiting Mask R-CNN. Then instance masks were merged with the relative depth data to obtain a segmented point cloud with a 3D cluster for each box.

on regions of interest in parallel with the classification and bounding box recognition. To improve the segmentation performance, the algorithm merges the instances masks and the relative depth data to find a 3D cluster for each box.

The 3D instance segmentation of the boxes lets to identify the boxes free from occlusions and most suitable for grasping. The grasp synthesis module then evaluates the reachability and computes the optimal grasping pose.

III. Results

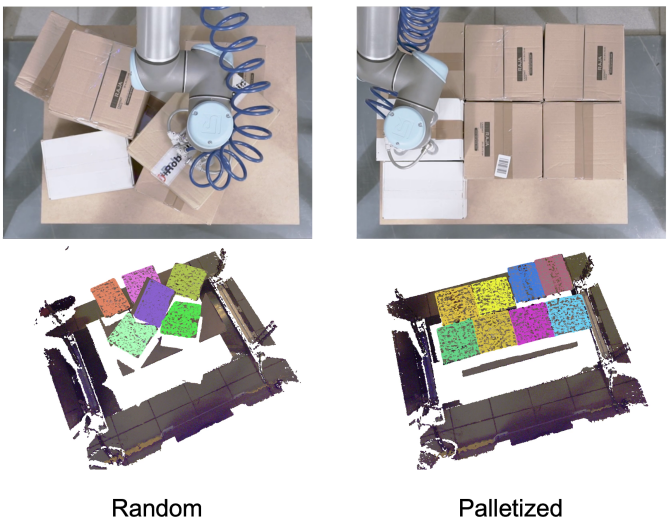

Fig. 3. Test executed with both random placed and palletized boxes. The first row shows the scene from the top, and the bottom row shows the segmented point cloud. The system has been able to localize and manipulate boxes in both cases.

The developed workcell was tested with both random placed and palletized boxes as depicted in Fig. 3. Ten trials with 100 boxes each have been performed. During them, the robot cycles until 100 boxes were moved to the correct destination. The perception module was able to localize boxes in 99.7% of cases. Focusing on the cycle time, the robot takes an average of 14.6 seconds to perform the entire pick and place cycle, with a min of 13.1 seconds and a max of 15.3 seconds. So that the system in the test was able to process around 250 boxes/hour.

IV. Conclusions

In this paper, an AI-based workcell for boxes and parcels picking and sorting was presented. The workcell use a model-less approach to localize and pick boxes and parcels both palletized or randomly placed. The core of the workcell is an AI-based vision system that make use of RGB-D data to identify object instance. The proposed system will be easily adaptable to a wide range of applications, thus greatly improving its potential impact.

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