Contribution à la manipulation de colis sous contraintes par un torse humanoïde; application à la dépaléttisation autonome dans les entrepôts logistiques

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Abstract

This PhD thesis explores the development and implementation of URNik-AI, an AI-powered automated depalletizing system designed to handle cardboard boxes of varying sizes and weights using a dual-arm humanoid torso. The primary objective is to enhance the efficiency, accuracy, and reliability of industrial depalletizing tasks through the integration of advanced robotics, computer vision, and deep learning techniques. The URNik-AI system consists of two UR10 robotic arms equipped with six-axis force/torque sensors and gripper tool sets. An ASUS Xtion RGB-D camera is mounted on Dynamixel Pro H42 pan-tilt servos to capture high-resolution images and depth data. The software framework includes ROS Noetic, ROS 2, and the MoveIt framework, enabling seamless communication and coordination of complex movements. This system ensures high precision in detecting, grasping, and handling objects in diverse industrial environments. A significant contribution of this research is the implementation of deep learning models, such as YOLOv3 and YOLOv8, to enhance object detection and pose estimation capabilities. YOLOv3, trained on a dataset of 807 images, achieved F1-scores of 0.81 and 0.90 for single and multi-face boxes, respectively. The YOLOv8 model further advanced the system's performance by providing keypoint and skeleton detection capabilities, which are essential for accurate grasping and manipulation. The integration of point cloud data for pose estimation ensured precise localization and orientation of boxes. Comprehensive testing demonstrated the system's robustness, with high precision, recall, and mean average precision (mAP) metrics confirming its effectiveness. This thesis makes several significant contributions to the field of robotics and automation, including the successful integration of advanced robotics and AI technologies, the development of innovative object detection and pose estimation techniques, and the design of a versatile and adaptable system architecture.