Machine vision integration for simultaneous metal sheet pick-and-place with a collaborative robot

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***Abstract*— […]**

Keywords—machine vision, robot, end-effector, image processing, conveyor tracking

I. Introduction

LEAN production has always been the goal for any manufacturing lines. Although many advancements have been applied, especially with the implementation of automatic control and industrial robots, transportation and motion are still possible wastes which could be optimized [1]. This has posed challenges for material handling systems in their daily operations, particularly in buffer areas or intermediate sections between workstations, like in this research topic, where a part of an industrial metal blank fabrication that needs enhancing. Currently, a workpiece is transported by a Cartesian robot between the buffer table to the next machining station. The operation is fine, but downtime is still accumulated because the conveyor must stop for the robot to pick the workpiece. Moreover, the orientation of the sheet after being cut in the previous station may be slightly tilted. Since this issue cannot be fixed yet, small deviations could still be conveyed to the next stage. No considerable problems have occurred, but there is clearly room for improvement.

A machine vision system and a Universal Robots collaboration robot (cobot) (UR10) are planned to resolve the issue. Regarding the vision system, an algorithm would be developed to process images from a camera. Object images will go through multiple filters as well as thresholding methods to remove noises and extract critical features for detection, here are edges, positions, and orientation [2] [3] [4]. A so-called "approved" posture based on standard requirements is used for calibration. Therefore, the deviation in orientation between the incoming sheet metal and the standard one can be detected, informed by the program and adjusted by the robot while moving it to the next station. Illumination is also a crucial factor that must be considered in this process to avoid reflection and shadow, particularly from the sheet metal, which could potentially disrupt the accuracy of the machine vision [3]. In case shadow cannot be omitted, some other approaches must be studied to minimize or even better, utilizing them to strengthen the algorithm [5].

The cobot will be equipped with a magnetic gripper suitable for perforated metal workpiece. This gripper is controlled by pneumatics. Hence, it is vital to implement and regulate this subsystem to ensure the magnet would be in place timely. For that, an in-house proximity sensor is refined to conduct the regulation. Overall, the integration between the machine vision and cobot will determine the effectiveness of this project, whether harmony can be reached to reduce downtime and improve efficiency. Fulfilling that goal means the workpiece must be detected precisely and its movement on the conveyor belt must be tracked to guide the robot [3] [6] [7]. Based on image processing, the centroid of a sheet as well as its motion along the belt can be identified for sufficient path planning and inverse kinematics calculation by the robot controller for gripping [3]. Moreover, an encoder is planned to be installed on the conveyor belt to exploit the "Conveyor tracking" feature of the UR programming software, providing an alignment for the cobot to follow the conveyor better.

Eventually, the goal is to illustrate an intuitive workflow with effective error handling protocols to guarantee safety and productivity. An assessment of the efficiency after this update must also be made to determine the feasibility of applying this onto the current system.

II. Methods

A. *Collaboration robot system implementation*

1) *End-effector installation*

[…]

2) *End-effector control*

[…]

3) *Robot controller program*

B. *Machine Vision program development*

1) *Edge detection*

[…]

2) *Centroid identification*

[…]

3) *Workpiece orientation calibration*

[…]

C. *System integration*

1) *Operation workflow*

[…]

2) *Conveyor tracking*

[…]

3) *Error handling*

[…]

III. Results

IV. Discussions

A. Efficiency evaluation

[…]

B. Potential optimization

[…]

***** Potential titles for the research paper:**

- Machine vision integration for simultaneous metal sheet pick-and-place with a collaborative robot in an automatic production line
- Collaborative robot control and image processing of workpieces for simultaneous transportation between stations in metal sheet fabrication
- Edge detection of metal sheet and conveyor tracking with machine vision for robot concurrent identification and transportation in an automatic production line

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