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Automated Dimensional and Geometric Inspection of Metal Plates Using a Collaborative SCARA Robot: A Preliminary Proof-of-Concept Study

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INTRODUCTION & AIM

Problem and Motivation

Manual inspection of small metallic components in automotive production lines is often operator-dependent, difficult to standardize, and poorly scalable. This is particularly critical when parts must be verified not only by their main dimensions, but also by geometric characteristics such as height, thickness variation, and flatness.

Objective

Present a proof-of-concept for an automated dimensional and geometric inspection cell built around a collaborative SCARA robot, where the robot ensures repeatable part handling, positioning and cycle control.

Small metallic plate

METHOD

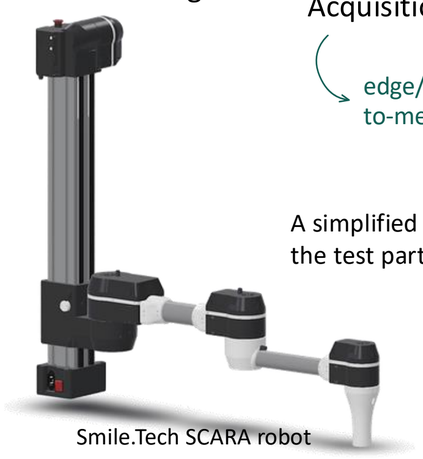
Proposed Concept

The proposed architecture is modular: the SCARA robot performs part handling and positioning, while the sensing subsystem can be adapted according to the inspection task. The inspection workflow follows:

Referencing → Image Acquisition → Image Processing → Conformity evaluation

edge/contour extraction, pixel-to-metric conversion

pass/fail against tolerance limits



Smile.Tech SCARA robot

A simplified rectangular plate was adopted as the test part to validate the inspection concept.

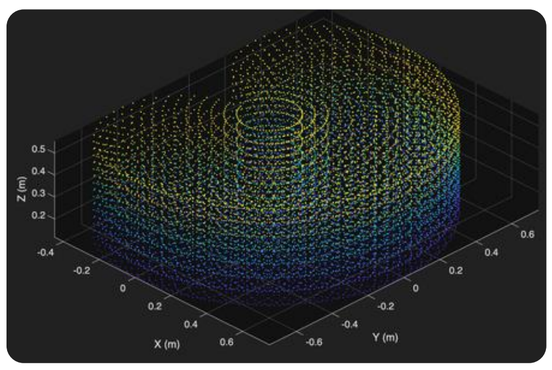
Simplified rectangular plate

RESULTS & DISCUSSION

Development Stages

Workspace Simulation

- SCARA workspace evaluated in MATLAB/Simscape Multibody
- Required inspection region is reachable



End-effector

- Gripper concept developed
- Suitable for stable handling of the simplified plate

Camera Integration

- Camera mounted at the end effector
- Image acquisition tests performed

Dimensional Processing

- Checkerboard calibration performed
- Pixel-to-metric conversion prepared for length/width estimation

Current Status and Limitations

Validated so far:

- SCARA workspace feasibility
- Gripper concept
- Camera integration
- Preliminary image calibration/processing

Still to validate:

- Experimental repeatability
- Height and flatness measurement
- Comparison with CMM
- Uncertainty under realistic conditions

Flatness sensing next steps:

- Evaluate laser triangulation for height-profile acquisition
- Evaluate structured light for dense 3D surface reconstruction
- Generate a surface height map and calculate flatness deviation
- Compare results with CMM reference measurements
- Assess strong calibration, metallic reflectance effects, and repeatability

CONCLUSIONS

- ☑ A modular SCARA-based inspection concept was defined for dimensional and geometric verification of small metallic plates
- ☑ Simulation, gripper development and preliminary camera calibration confirmed the technical feasibility of the proposed architecture
- ☑ The architecture allows future integration of different sensing technologies for height and flatness measurement

FUTURE WORK

The next stage will move the concept from feasibility assessment to experimental validation:

- ☐ Build and test the complete inspection setup
- ☐ Calibrate dimensional measurements using Mitutoyo gauge blocks
- ☐ Assess repeatability under controlled conditions
- ☐ Integrate height/flatness sensing and validate results against CMM measurements

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