OPTICAL 2D MEASUREMENT: CONNECTORS AND PINS

LARS FERMUM, CHIEF INSTRUCTOR, STEMMER IMAGING
CONNECTORS & PINS

- Connectors for electrical power transmission and electronic (and optical) signal transmission

- Typical interconnect solutions:
  - Wire-to-wire-connection (connecting two cable wires)
    - Wire(cable)-to-board (connecting a cable to a PCB)
    - Board-to-board (connecting two pcb boards)
  - Contacting by a rigid (pin) element and a Spring-loaded contact element (spring or female-socket)

- PCBs: solder pins (pin-in-paste technology / THT reflow) or press-in pins
CONNECTORS & PINS

- Trend: Increasing bandwidths for signal transmissions with simultaneous miniaturization

- Correct, permanent connection: A guarantee for function

- Increasing demands on accuracy
  - Housings
  - Pins
  - Holes, springs & female-sockets

- 100% control of pins
  - X- and Y-position (tumbling circle)
  - insertion depth (z) (=> not possible with 2D solution)

  • Required accuracies +/- 1/10 mm, +/- 5/100 mm and better (measuring-capable)

- Problems: Thin pins, pin tip even smaller, glossy, dark housing, different measuring planes, interfering contours
Illumination
THE PERFECT ILLUMINATION

- Measurement of pin tips: only incident light, no transmitted light
- Creating a reflection on the pin that is as even as possible
- But: pin tip often inhomogeneous (stamped) pins, electroplated layers
- Pins: different contour angles
- Rather not: normal ring light, too many direct illumination reflexes
- Rather not: diffuse dome lighting in combination with telecentric lens (difficult due to dome opening)
COAXIAL ILLUMINATION

- Illumination from top side
- Creates diffuse reflection at pin tip
- Can optionally be integrated into telecentric lenses
- Illuminates even surfaces homogeneously
- Stamped pins difficult, not always ideal surface
DIFFUSED LIGHT, FROM THE SIDE

- Lateral illumination at an angle from the side
- Larger illuminated surface depending on pin geometry
- Working distance and angle of illumination must match pin
- Ideal: multidirectional illumination using different angles
DARK FIELD

- Incident light from the side with low angle

- Depending on pin geometry different reflections, illumination of contours, no entire illuminated surface

- Longer exposure times required

- Small working distances: difficult with deeper located pins, possibly no proper illumination of housing
SHAPE FROM SHADING

- Photometric Stereo: Illuminating from four different directions, acquisition and computation of four images
- The use of telecentric optics is important
- Computing a curvature image
- Pros:
  - Independent of brightness and pin and housing materials
- Cons:
  - Four shots: Cycle time
  - Mostly no motion, without vibrations
Optics
ENTOCENTRIC LENSES

- Depending on the working distance, different sizes of optical depiction. Pin tip or upper edge of housing appears larger than features positioned further away.

- Pin measurement with usual entocentric optics not useful.

- Opening angle of lens: Is the pin bent (x/y) or shorter (z)?
TELECENTRIC LENSES

- Objects will have “same size” within the telecentric range, regardless of whether they are closer or further away.

- No change of scale: measuring from pin to connector edge or to board is no problem.

- No perspective effects due to aperture angle of lens 0.0x degrees.
**TELECENTRIC BASICS**

Camera
For determining the optics, the size of the sensor is important (image size)

Telecentric range
No visible change of reproduction scale

Reproduction scale (magnification):
\[ \beta = \frac{\text{image size}}{\text{object size}} \]

Measuring planes
Measuring points in different planes (but should be checked for x/y offsets)

Field of view
Visible detection area of camera system

Also available with built-in coaxial lighting
OBJECT SEARCH ALGORITHMS

- Positioning using gradient based object searches ("contour searches")
- Rotation invariant, brightness independent

- Subpixel-accurate measurements possible
- Not suitable for pin tip detection, especially for small areas too little significant information
MEASUREMENT TOOLS

- Positioning and measurement using Edge tools. Pin tips rather difficult to "measure" because of very small "point".

- Subpixel-accurate measurements: high contrast as possible, but no overexposure!

- Rather for finding longer edges, not small pin tips

- Attention: Sensor blooming on overexposed metal structures leads to falsified results
**BLOB TOOLS**

- Pin position often done with blob tools (pin tips often too small for measuring tools)
- Problems: Metal pins reflect very differently (due to shape and material) and appear brighter / darker

- Determination of the center of gravity using as many pixels as possible, thus also increased accuracy as with sub-pixeling
- Attention: Incorrect thresholds or pin-brightnesses lead to falsified results
WORKPIECE EFFECTS

Problems with plastic injection moulding

- Housing colours: dark or light in combination with shiny pin tips
  - Single exposure time? Image fusion with 2 images? HDR?

- Fibre glass particles in plastic can cause reflections

![Bright pins](image1)
![Bright background](image2)
![HDR](image3)
![Fusion of 2 images](image4)
WORKPIECE EFFECTS

Problems with plastic injection moulding

- Depth of field
- What are suitable reference edges?
- Material deformation of housing

Distance 1

0.157 mm Offset

Different measuring planes
Focus?
WORKPIECE EFFECTS

Problems with pins

- Stamping strips with different gloss depending on the electroplating process. Raw material for pins meets metric tolerances, but appears brighter or darker depending on the coating.

- Different stamped/shaped pins: tool abrasion, changes in stamping strips...

- Combined lighting setups, multiple software tools for a single pin
ILLUMINATION EFFECTS

Measuring troubles

- Evaluation is not based on the physical center of the pin tip, but on the visible reflection that is illuminated.

- In case of pin bending the reflection is reflected in a different place (rounded pin tip).

- or the reflection does not appear uniformly illuminated (stamped pins).

- Result: falsification of the measuring accuracy.
POSITIONING EFFECTS

Measuring troubles

- Systematic measurement errors may also occur within the telecentric range when using telecentric lenses.
- Tilting or rotating the component leads to changed lengths. Parallax error!
- Accurate positioning / fixing of the component

Example:

- Real length = 50mm
- Part height = 10mm
- Component tilt = 0.25 degrees

Visible length $L_{\text{new}} = L - L*(1-\cos \alpha) + H*\sin \alpha$
THANK YOU FOR YOUR TIME!

QUESTIONS?

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