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The VDI/VDE metrological evaluation of range-based sensors with CENAGiS standard

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As part of the EU's ScanClouDT project, a team at Warsaw University of Technology (WUT) and Central Office of Measures (GUM) developed and modified VDI/VDE standard to assess the quality of surveying range-based sensors, and determined the measurement uncertainty and class of utilise device.

INTRODUCTION

Modern coordinate metrology faces growing demands for precision, speed, and automation, driven by advancements in measurement technologies and rising industrial quality standards. Optical measurement systems—such as structured light, photogrammetry, TOF sensors, CT, and MRI—require rigorous calibration and supervision, guided by international standards like ISO 9001 and ISO 10012-1. The German PTB's VDI/VDE 2634 [2] guidelines offer detailed procedures for verifying these systems, emphasizing the importance of calibration under real operating conditions. Key error types analyzed include probing error, sphere-spacing error, and flatness error, all critical for ensuring measurement reliability. However, for small measurement volumes (used in commonly defined surveying), such solutions do not exist. An attempt was made to apply and modify the VDI/VDE standard in the evaluation of the quality of surveying studies

METHODS AND PROCEDURES

The CENAGIS VDI/VDE allows for the verification of measuring systems based on a maximum measuring volume of 1.5 x 1.5 x 1 metres. The probing error reference: diameter – 47.638 mm, measurement uncertainty: 1.5 µm. The sphere space error reference: distance – 710.168 mm, measurement uncertainty: 6.0 µm. The flatness error reference: flatness error – 0.0528 mm, measurement uncertainty: 4.4 µm

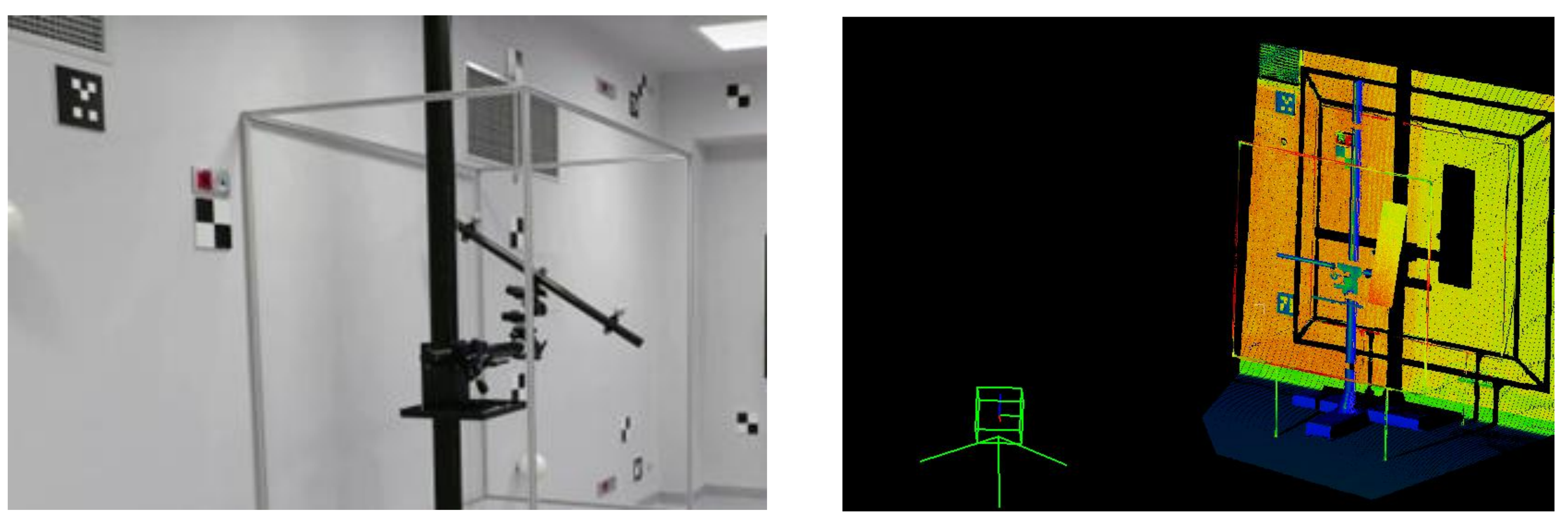

Figure 1. The CENAGIS VDI/VDE benchmarks.

PROBING ERROR

Measurement assumptions:

- 10 spheres positions
- All possible scanning resolutions
- All possible measurement modes

Proposed analysis:

- Probing error (VDI/VDE)
- Sphere deviations distributions

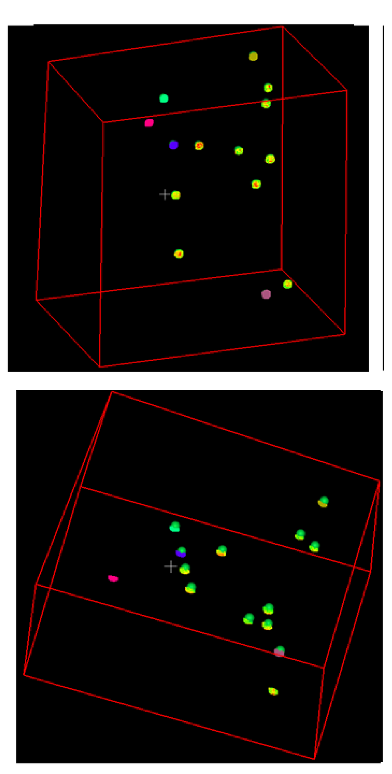

Figure 2. Spheres positions in probing error.

SPHERE-SPACING ERROR

Measurement assumptions:

- 6 standard positions
- All possible scanning resolutions
- All possible measurement modes

Proposed analysis:

- Space-spacing error (VDI/VDE)
- Sphere deviations distributions

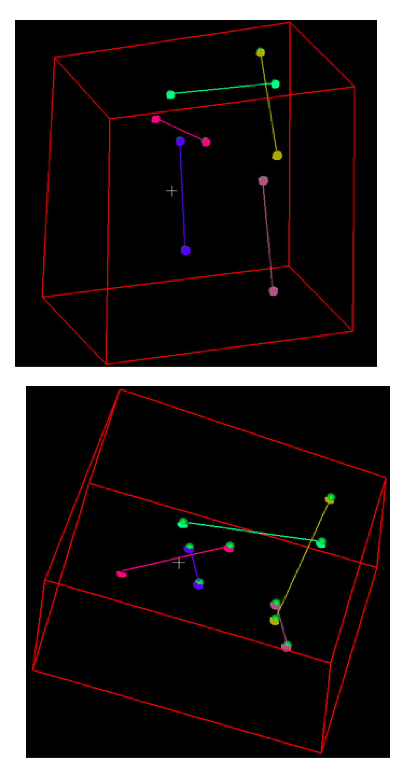

Figure 3. Scalebar position in sphere-spacing error.

FLATNESS ERROR

Measurement assumptions:

- 6 standard positions
- All possible scanning resolutions
- All possible measurement modes

Proposed analysis:

- Flatnness error (VDI/VDE)
- Flatness deviations distributions
- The worst results as a reference

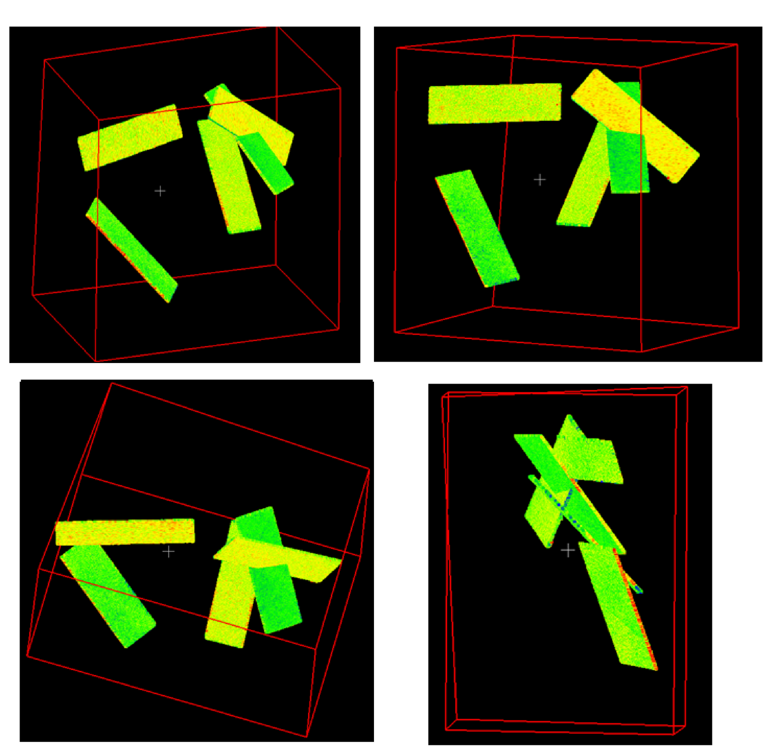

Figure 4. Flatness benchmark.

Figure 5. Utilised sensors.

RESULTS

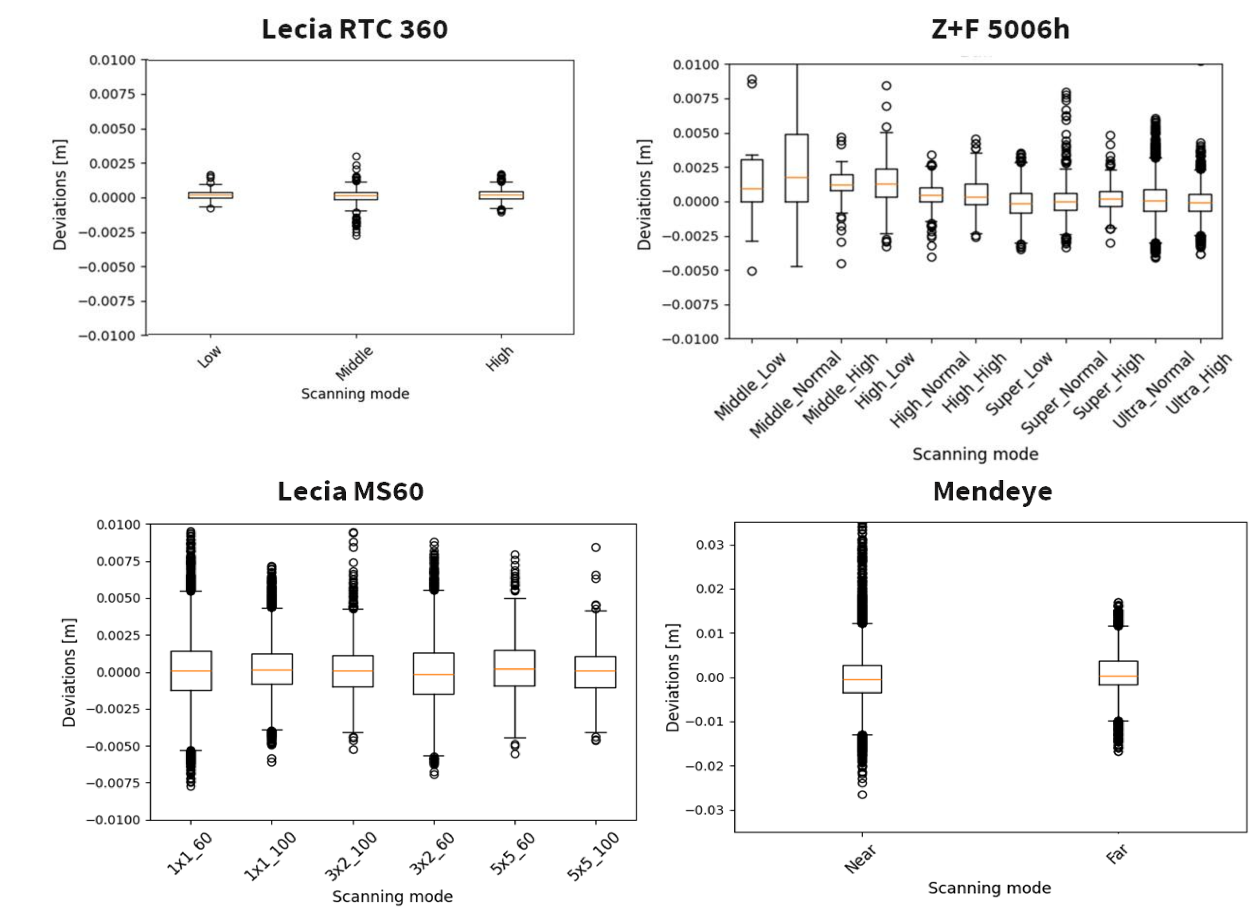

Figure 6. Probing error results.

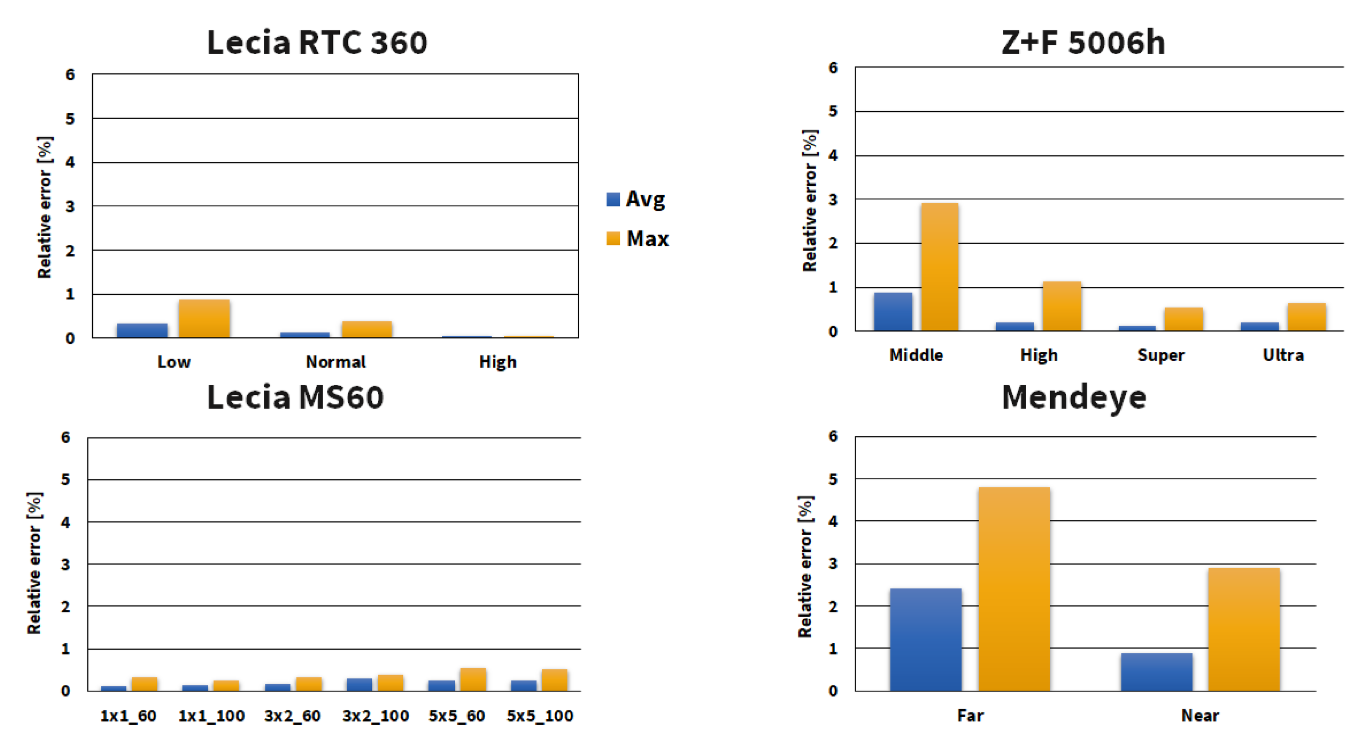

Figure 7. Sphere-spacing error results.

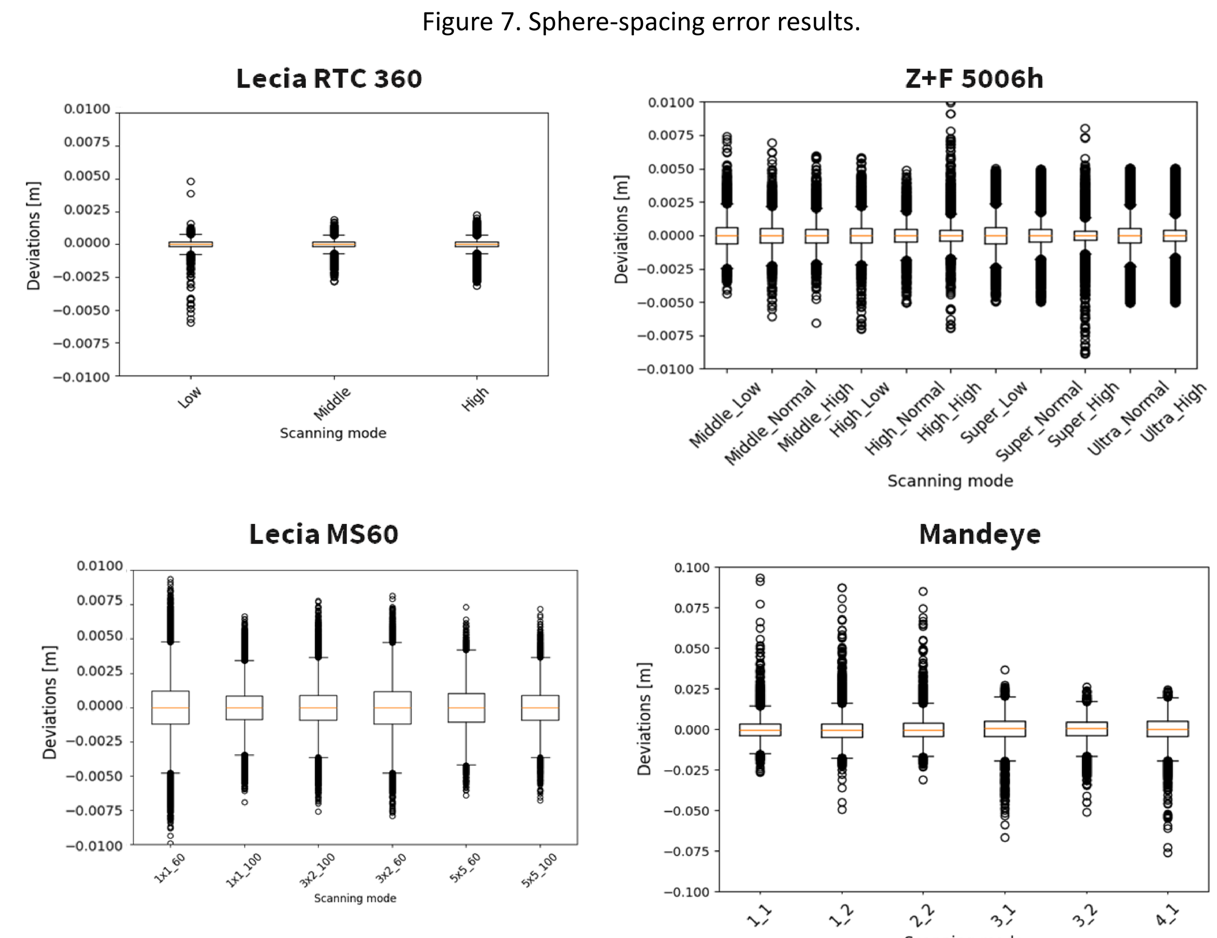

Figure 8. Flatness results.

CONCLUSIONS

	Leica RTC 360	Z+F 5006h	Leica MS60	Mendeye
Probing error	green	yellow	yellow	red
Sphere space error	green	green	green	green
Flatnes error	green	yellow	red	red

green	Full compliance with the 1/5 relative error criterion
yellow	Partly compliance with the 1/5 relative error criterion
red	Exceeds 1/5 of the relative error value

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