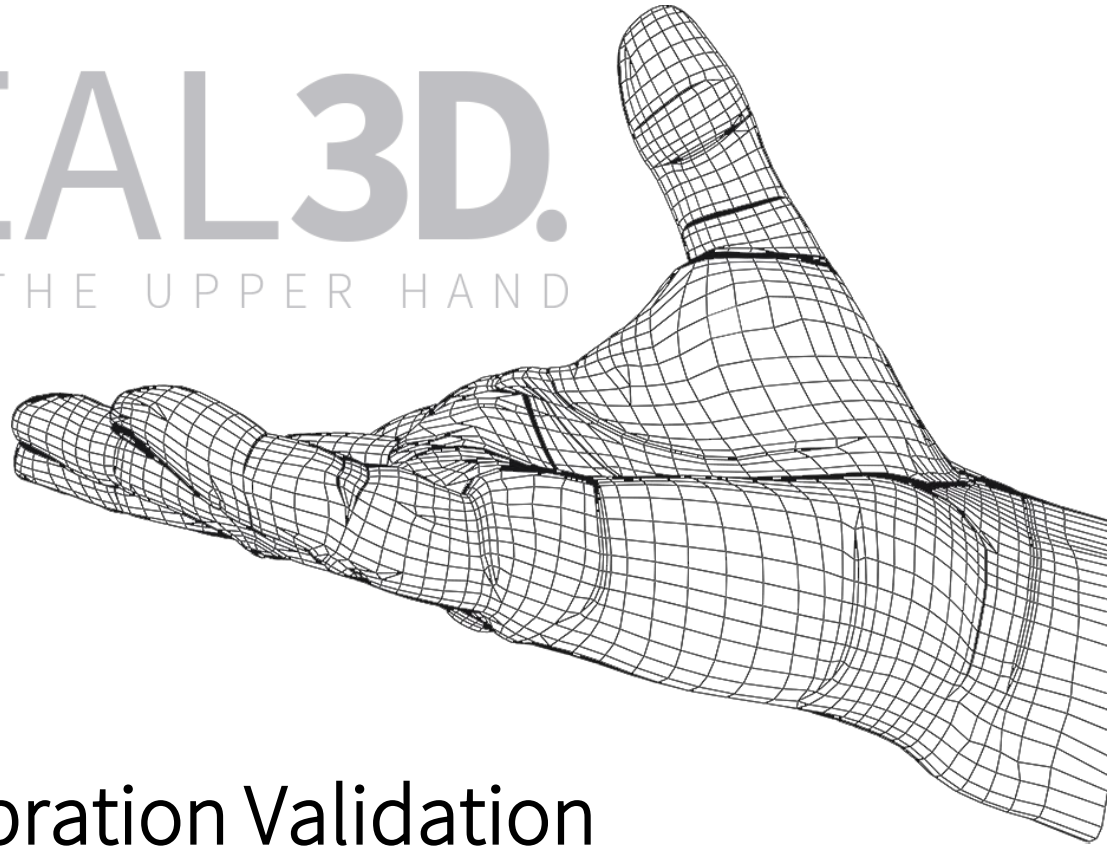
REAL3D.

GAIN THE UPPER HAND



ToF Calibration Validation

Performance check after calibration

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Introduction to ToF data validation

ToF calibration:

- LED box – Lens and offset calibration with LED markers and a planar target
- Fiber box – Wiggling calibration via multiple optical fibers for increased accuracy (optional)

Calibration principle:

- The calibration operates by evaluating the deviations between “measured values” and “true values”

Aspects that may have an impact calibration data accuracy:

1) “true values” rely on mechanical accuracy of the calibration box, device mounting precision
2) “measured values” may be impaired by conditions that are not sufficiently respected/detected during calibration (e.g. mixed signals due to stray light in the calibration setup)

Validation method:

- The ToF device must be put at a **different position** in respect to a known target and the deviation between “measured values” and “true values” must be re-evaluated.
- Full characterization: multiple different positions, e.g. using a linear translation stage (LTS)

Is a validation required?

- Aspect 1) must be ensured. Aspect 2) is likely identical for all devices.

Recommendation:

- Initially validate the performance of all devices at one position, of some devices at multiple positions (LTS).
- Mass production: Validate sample devices in regular intervals to ensure quality.

ToF validation measurement setups

- **Linear translation stage (LTS)**
  - multiple distances to a planar target
    - enables full characterization
  - large space requirements (several meters in all dimensions)
  - long test time (typically several minutes)
  - for details, see separate LTS documentation

- **Validation Box**
  - single position
    - sufficient for validation of calibration
  - highly reproducible test conditions
  - low space requirements (depends on actual position and field-of-view)
  - short test time (few seconds)

Validation Box #1

Boundary conditions:

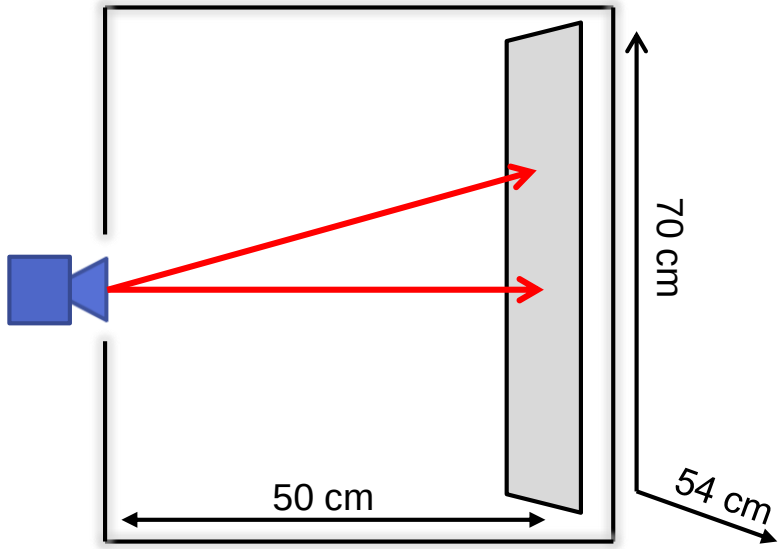
- IRS1645C
- K6 lens

} field-of-view: 60°×45°

- Modulation frequencies: 80 MHz / 60 MHz
- calibration/focusing distance: 40 cm
- Main working range: 50 cm to 400 cm (in-focus range: 20 cm to infinity)

Validation Box Proposal:

- distance to target: **50 cm**
- some safety margin between enclosure and target surface / field-of-view should be ensured to avoid reflections at target edge



black, matte, IR non-reflective enclosure

Target dimensions:
70 cm x 54 cm x 1 cm
(flat aluminum target plate)
Box outer dimension:
86 cm x 66 cm x 54 cm

Validation Box

Test execution / data processing

Overview

Boundary conditions:

- ToF data accuracy and data quality should be tested with final calibration data.
- The test execution must be fast, so that it can be done with every single device.
- Test box data with planar target surface can be acquired.

Proposal:

- Acquire 20 frames, perform statistical analysis

Possible test points with planar target surface:

- general ToF imager functionality (e.g. power-up, frame rate)
- temperature sensor: reasonable temperature range (~20 to 40 °C)
- XYZ accuracy: plane fit, absolute distance, deviation of individual points from plane
- noise of XYZ data
- data stability (frame drops, data integrity)
- additional calibration verifications
  (e.g. amplitude wiggling, noise parameters)
- beam profile

Point cloud test point proposal (XYZ data)

Steps:

1) retrieve single XYZ point cloud from framework (1 frame)
2) evaluate valid pixel count
3) plane fit of valid pixels
4) evaluate fit accuracy, plane distance from camera
5) evaluate maximum pixel deviations from plane fit

Validates:

- FPPN
- temperature compensation
- phase wiggling
- lens parameters
- sensor performance

Does not validate:

- amplitude wiggling (MPI flag can be used, if available)
- noise parameters (access to calibration data required)
- beam profile

Amplitude test point proposal

Steps:

1) retrieve amplitude image from framework (~20 frames)
2) evaluate: mean, min and max standard deviation of valid pixels

Validates:

- sensor performance
- beam profile homogeneity
- data stability

Depth data test point proposal (Depth data)

Steps:

1) retrieve depth image from framework (~20 frames)
2) evaluate: mean, min and max standard deviation of valid pixels

Validates:

- FPPN
- temperature compensation
- phase wiggling
- lens parameters
- sensor performance
- calibration accuracy
- data stability