Calibration Strategies for Optical Underwater 3D-Scanners

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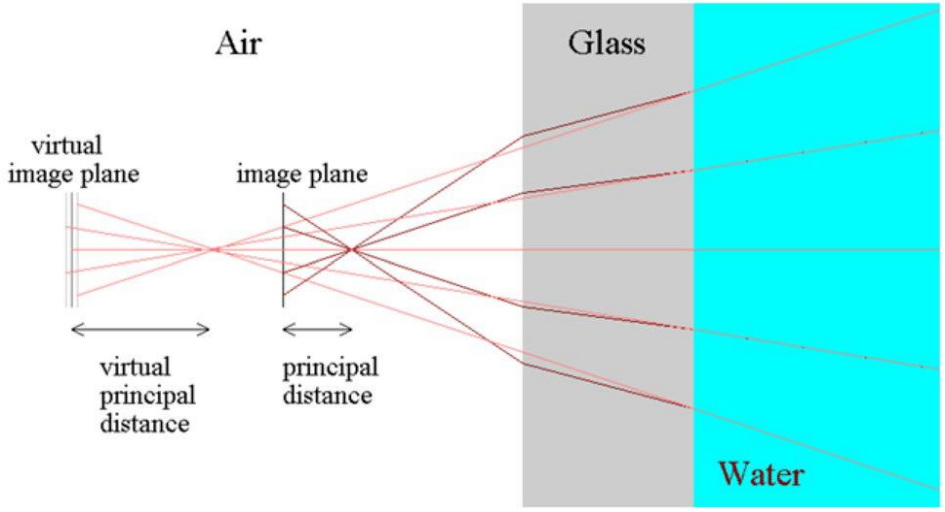
Calibration strategies for optical underwater 3D scanners

Outline

- Motivation
- Camera modeling for underwater 3D reconstruction
- Calibration strategies based on
  - Advanced pinhole model
  - Ray-based model
  - Additional error compensation functions
- Experimental evaluation
- Summary, Discussion and Outlook



Calibration strategies for optical underwater 3D scanners

Motivation

- Optical underwater 3D measurements are challenging because of
  - Geometry of the image generation due to media transition,
  - Possible bad visibility conditions,
  - Difficult handling of equipment
  - Typical only one trial (higher effort than for air measurements)
- Calibration of the optical system is one of the deciding components
- Other influences cannot be changed

→ A simple, robust, accurate, and easy handling solution for the calibration procedure is necessary

Calibration strategies for optical underwater 3D scanners

Motivation

- Many suggestions for high accuracy underwater calibrations available (see comprehensive literature)
- Typical high calibration effort for accurate calibrations or
- Lower 3D measurement accuracy using more “simple” calibrations
- Special calibration solutions for certain applications according to the particular conditions

→ Looking for a general, simple, accurate, and easy handling solution!

→ Give three suggestions

Calibration strategies for optical underwater 3D scanners

Initial situation and goal

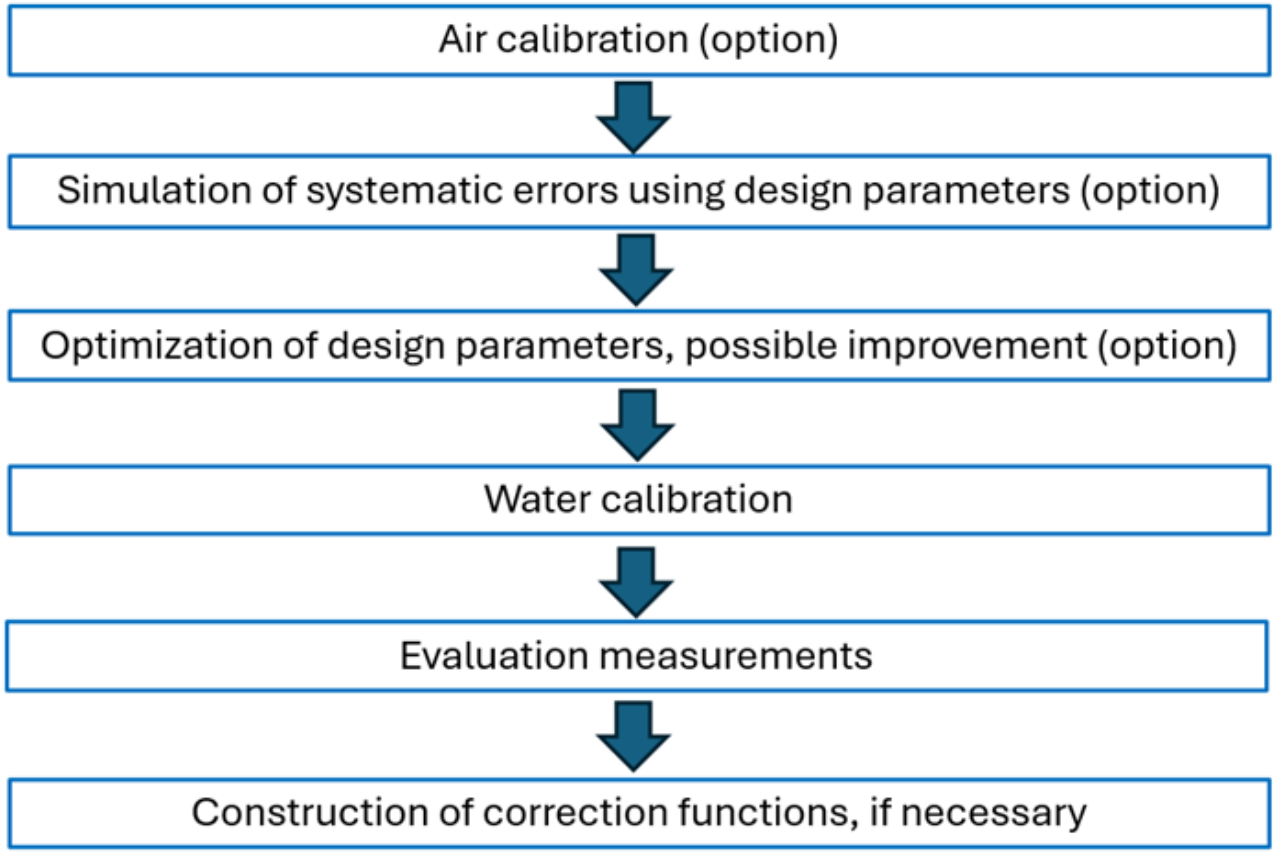
- UW-Sensor: new optical system for accurate 3D measurements under water
- New planned project: miniaturization and extensive evaluation
- Realization and comparison of different calibration strategies
- Unfortunately, not yet realized practically

→ Report former results and outcome of incomplete new experiments

→ Only estimated comparison possible

Calibration strategies for optical underwater 3D scanners

Approach 1: Based on extended pinhole model



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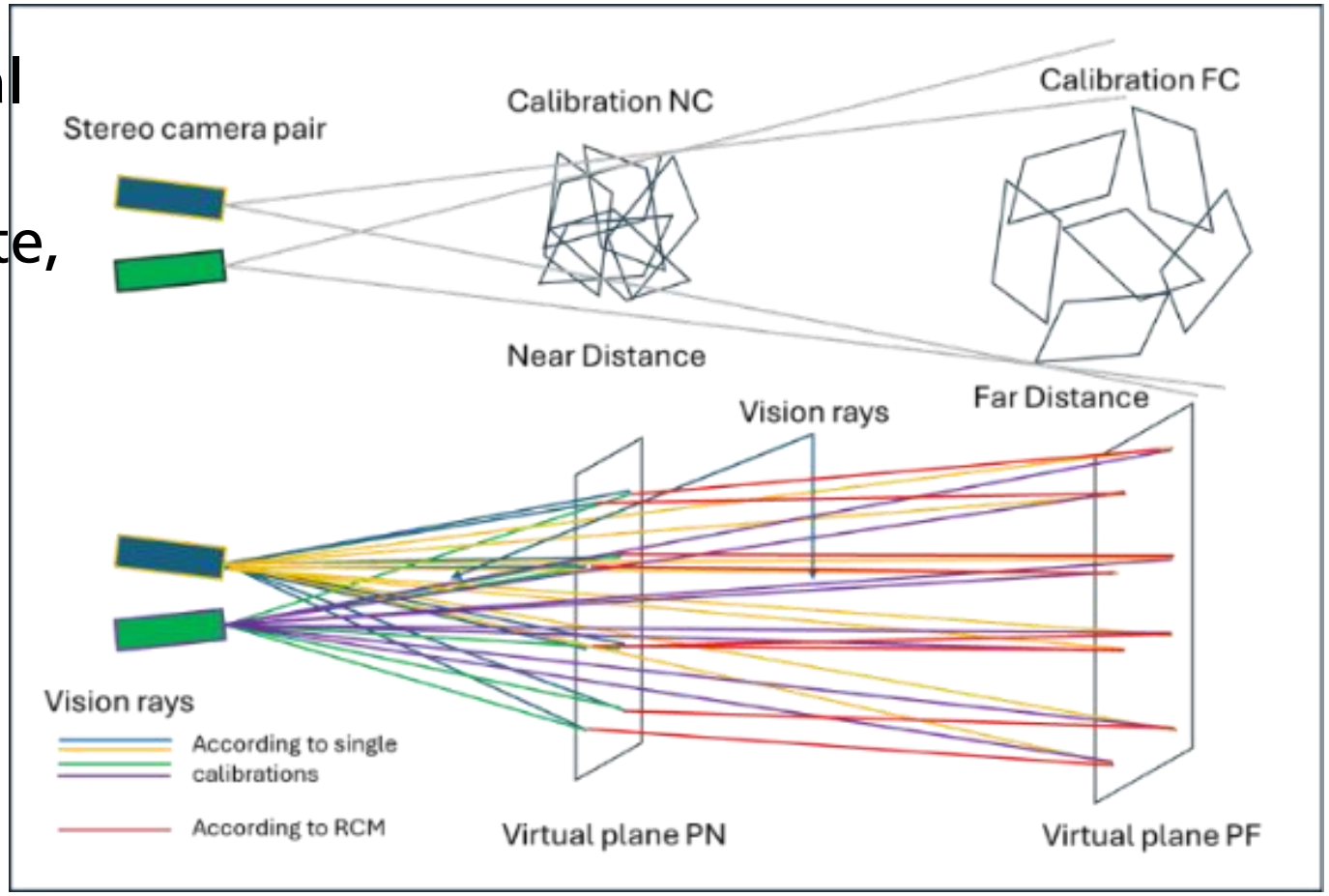
Approach 2: Based on ray-based camera model

- Ray-based model: most general (most accurate) camera model
- Calibration is usually complicate, even in air!
- No commercial solution available
- Own (air) solution developed, applicable under certain conditions only
- New own approach developed for air and underwater use



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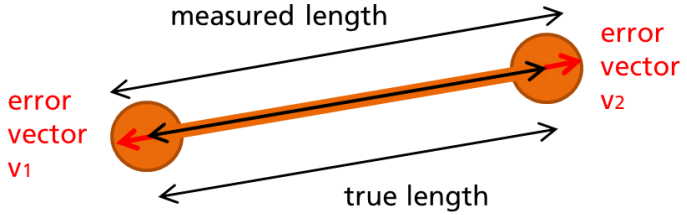
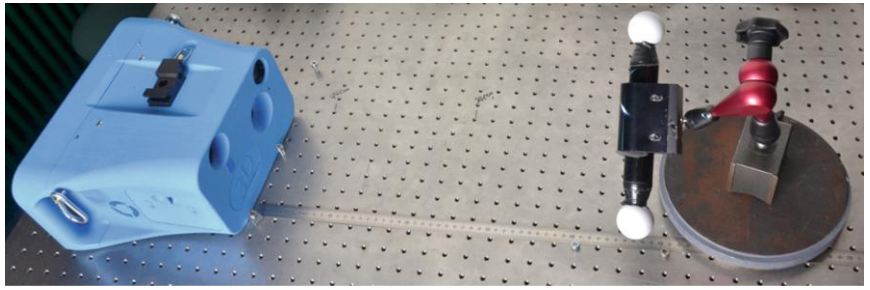
Approach 3: Use of pinhole model with additional 3D correction functions

- Pinhole based common calibration under water
- Systematic estimation of remaining 3D errors in the (well defined) measurement volume (MV)
  - Special experimental setup, e.g. using ball-bars
  - Regular distribution over MV
  - Estimation of a systematic error vector in the MV
- Analysis of the error vectors and construction of a 3D correction function over MV





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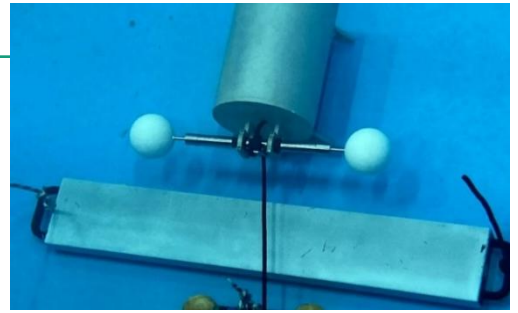
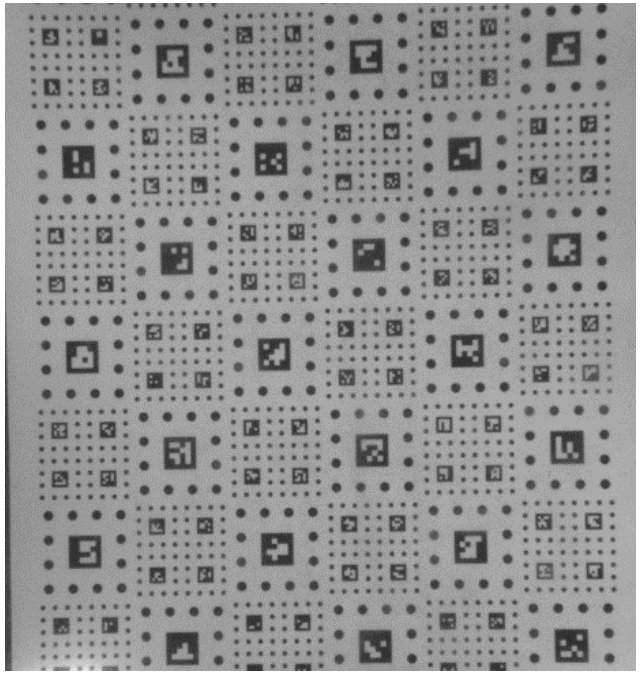
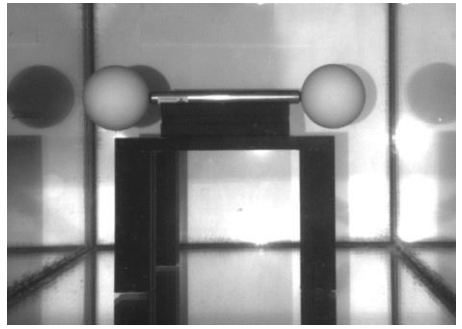
Experimental evaluation



- Successful application of approach A1 in a former project
- Laboratory setup using an aquarium 1.5 x 0.5 x 0.6 m³





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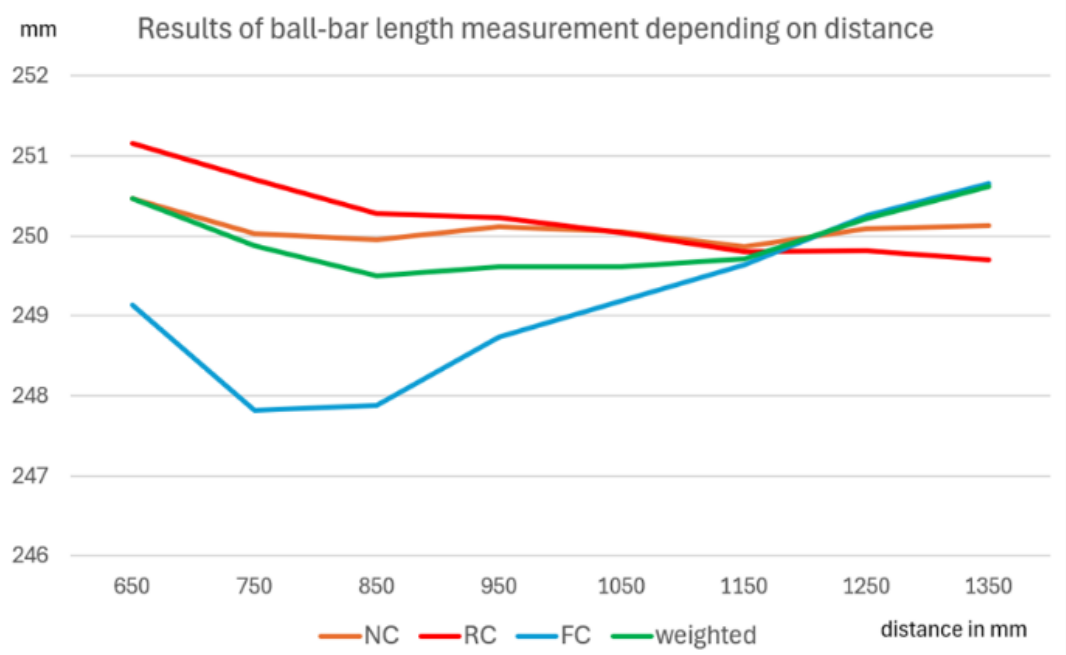
First results

- Approach 1: no new experiments, see former publications
- Approach 2: aquarium experiments did not provide evaluable results, but first error analysis showed expected results
- Approach 3: former experiments in air: reduction of systematic error by factor two



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Discussion and outlook

- All proposed strategies seem to be suitable methods
- Extended pinhole model sufficient for most applications
- Approach 2 could not yet completely performed → task for future work
- Approach 3 has not been tested yet under water → task for future work

Summary, Discussion, and Outlook

Underwater camera calibration strategies

- Three new approaches for suitable underwater camera calibrations for 3D reconstruction introduced
  - Extended pinhole model including vision ray refraction
  - Approach using general ray-based camera model
  - Experimental estimation of systematic 3D errors
- Sufficient experimental results still missing
- Direct comparison of all three approaches using identical input data planned
- Further research planned in current and future projects

Thank you for your kind attention!

Questions?