Use Case: data-driven camera calibration for light field camera systems

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Use Case: Cross-Shaped Camera Array [Center + North/East/South/West]

Phase 1 — Initial Lab Calibration (once)

- **Target-based, OpenCV:** Checkerboard-based initialization to estimate intrinsic/extrinsic parameters.
- **Global refinement:** Joint bundle adjustment over the collected frames/image points to minimize reprojection error and obtain a consistent calibration.
- **Baseline:** Store the resulting calibration as the known-good reference for later comparison.

Phase 2 — In-Field Self-Check (periodic or event-based)

- **Triggers:** fixed interval (e.g., hourly), temperature jumps, restart, or detected shock.
- **Short capture window:** record a brief sequence during normal operation (no targets).
- **Option A — Model-based check (baseline comparison):**
  - *Windowed reprojection error:* median over the latest frames/micro-images.
  - *Parameter estimation error:* deviation of key parameters (principal point, effective focal length, low-order distortion) from the baseline/reference calibration.
  - *Parameter drift:* normalized change of these parameters across consecutive windows.
- **Option B — Feature-based check (persistent tracks):**
  - Detect one or a few stable features (e.g., corners/patches) visible across the short window; track with a robust matcher.
  - *Track-consistency error:* difference between observed feature motion and the motion predicted by the baseline calibration.
- **Decision:** Trigger online recalibration if the Option A metrics exceed thresholds for ≥ 3 consecutive windows *or* if the Option B track-consistency error persists above threshold over the same period.

Phase 3 — Target-Free Online Recalibration

- **Trigger:** Start only when the health score has stayed below a threshold across multiple windows. When the health score stays ≤ 70 across ≥ 3 consecutive windows (e.g., 20s each).
- **Short data window:** Use a brief, recent multi-camera sequence from normal operation (no targets).

- **What to update:** Only adjust drift-sensitive internal parameters (principal point; small low-order distortion if needed). Keep the rig geometry fixed (no baseline changes).
- **Method (multi-camera BA):** Run bundle adjustment on the latest frames so that corresponding scene points align consistently in all views (i.e., lower reprojection error). No checkerboard required.
- **Commit rule:** Apply the update only if health metrics clearly improve; otherwise defer and retry later.

Extras (optional but recommended)

- **Rollback & versioning:** keep the last known-good calibration and auto-rollback if a new update worsens the health metrics.