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TECHNOLOGY FOR RAPID GENERATION OF INFRARED-VISIBLE HIGH-CONTRAST CALIBRATION BOARD BASED ON STRUCTURAL PARAMETRIZATION

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Introduction. Infrared–visible (IR–VIS) imaging has become a standard configuration in machine vision, inspection, surveillance, and robotic perception, because the two modalities provide complementary information: thermal radiation highlights heat targets while visible imaging preserves texture and edges [1]. A persistent bottleneck in IR–VIS fusion pipelines is the geometric registration between sensors with different optics, resolutions, and imaging mechanisms. In unconstrained scenes, feature-based matching can be unstable because the same object may exhibit weak cross-spectral feature consistency [2]; in controlled scenes, calibration targets provide stronger geometric constraints but are often slow to redesign and fabricate, especially when different cameras, fields of view, and working distances demand different target sizes and feature scales.

This work focuses on a single enabling technique: structural parametrization of a bimodal, high-contrast IR–VIS calibration board, and a workflow for rapid generation (and optionally rapid manufacturing) of target geometry from a small set of user parameters. The baseline target design is a 3D-printed checkerboard that remains high-contrast in both modalities under controlled laboratory illumination. In the reference implementation, a 6 × 6 checkerboard with 50 × 50 mm square size is fabricated in SUNLU PETG, with thickness modulation between “black” and “white” squares (1.2 mm vs 0.8 mm) to induce different heating/thermal responses. When illuminated by a 60 W wide-spectrum incandescent lamp with an internal mirrored reflector, the board exhibits pronounced IR thermal contrast while maintaining strong VIS contrast, enabling robust corner extraction and sub-pixel registration.

The contribution of this summary is to formalize the calibration board as a parametric, manufacturable model and to propose a rapid workflow that outputs printable CAD/STL and a reproducible parameter report. This directly supports fast adaptation to different IR/VIS camera modules and experimental setups, complementing algorithmic registration approaches by providing a reliable geometric “ground truth” under controlled conditions.

Main part. The proposed technology models an IR–VIS calibration board as a manufacturable parametric structure driven by a compact set of geometric and process-related parameters. The pattern prototype of the calibration plate references the Zhang chessboard calibration plate. [3] The core geometry is a checkerboard defined by rows, cols, square_size, and a two-level thickness modulation t_black, t_white to enhance cross-spectral contrast. In the validated baseline, the board uses a 6 × 6 pattern with 30 mm squares, printed in SUNLU PETG, where the “black” and “white” cells are realized as 1.2 mm and 0.8 mm thickness levels, respectively. Under controlled excitation (wide-spectrum incandescent lamp and reflective enclosure), thickness-induced thermal response differences yield stable IR contrast while maintaining strong VIS edges, supporting robust corner detection in both modalities.

A rapid generation pipeline converts a single parameter file into printable geometry without manual CAD editing. The pipeline constructs the checkerboard array, applies structural features required for deployment, and exports CAD/STL/STEP together with a parameter report for traceability. This design-to-model workflow enables fast adaptation to different camera resolutions, fields of view, and working distances by simply adjusting the parameter set (e.g., scaling square_size, changing rows/cols, or extending the frame), while preserving manufacturability constraints.

For calibration and registration, the generated target provides deterministic point correspondences through its known grid topology. In practice, IR and VIS sensors often differ in resolution and image quality; therefore, IR frames can be optionally super-resolved prior to corner extraction to improve sampling consistency. The resulting corner sets are then used to estimate a geometric mapping (e.g., homography or camera-model-based transformation), yielding accurate IR–VIS alignment. This target-driven approach complements scene-based registration methods by providing a stable, reproducible calibration mechanism when cross-spectral features are weak or when controlled laboratory calibration is required.

Conclusion. This summary presents a single core technique—structural parametrization for rapid generation of a bimodal IR–VIS calibration board—and a practical workflow that converts a small set of parameters into a manufacturable target geometry. Using a 3D-printed 6 × 6 checkerboard with 30 mm squares in PETG, and two-level thickness modulation (1.2 mm vs 0.8 mm) under controlled lamp heating, the target achieves high contrast in both modalities and supports accurate corner-based registration. The proposed approach reduces the iteration time of calibration target design, facilitates quick adaptation across camera modules and experimental constraints, and provides a reproducible bridge between geometry-based calibration and learning-assisted IR–VIS registration/fusion pipelines. Future work can extend the parameterized model to include additional fiducials, add process-aware thermal contrast constraints, and integrate interactive web customization for field deployment.

References:

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