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Generalized constraints on reference data generation for software verification

Vision-based systems in industrial applications involve a wide range of software, including fitting, association, and cloud-to-cloud registration. Software verification is required to guarantee the accuracy of estimated parameters. Verification typically relies on realistic datasets generated using ray casting to sample points on the predefined surface, followed by the addition of random deviations from the surface to simulate measurement noise. However, random and unconstrained deviations introduce a statistical bias, as the predefined fitting, association or registration parameters do not necessarily correspond to the optimal parameters of the underlying problem.

This paper proposes a generalized method for reference data generation that ensures unbiased verification. The approach is applicable to any differentiable parametric surface representation and to many least-squares problems. This is achieved through inequality constraints based on curvature and outlier bounds, combined with a positive semi-definite Hessian condition and a null gradient equality constraint.

To implement these constraints, a symbolic programming paradigm is adopted for automatically computing gradients, Hessians, and curvature-related quantities from the problem definition. The generation of deviations satisfying both equality and inequality constraints is formulated as a quadratic programming problem and is solved using an efficient operator splitting solver.

The proposed method produces unbiased reference datasets, ensuring metrological traceability to the reference parameters. Furthermore, the method can be generalised straightforwardly by modifying the surface parametrization and distance definition, making it accessible to non-expert users. In addition, the efficient solver leads to practical data generation for a wide range of vision and metrology software.

Special/ Invited session

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