Published Research on 3D Scan Matching and Registration

Shape Descriptors and Local Feature Matching

- [Tangelder and Veltkamp 2004] Survey of contemporary methods in shape matching
- [Ankerst et al. 1999] A shape descriptor characterizing the distribution of a model's surface area across space
- [Vranic 2003] A shape descriptor characterizing what a viewer would first see when looking down at the center of a model
- [Johnson and Hebert 1997, Johnson and Hebert 1998] Spin images are a local descriptor suitable for initial range scan alignment
- [Belongie and Malik 2000, Mori et al. 2001] Describes 2D shape contexts for local feature matching
- [Frome et al. 2004] Describes 3D shape contexts for local feature matching

Signal Processing Methods in Shape Matching

- [Zahn and Roskies 1972] Early work in the use of the Fourier transform for obtain 2D rotation invariants
- [Burel and Henocq 1995, Kazhdan et al. 2003] Methods for obtaining 3D rotation invariants for shape matching
- [Kovacs and Wriggers 2002, Funkhouser et al. 2004] Applications of the Wigner-D transform for solving the 3D registration problem
- [Driscoll and Healy 1994, Mohlenkamp 1997, Healy et al. 2003, Kostelec and Rockmore 2003] Algorithms for computing the fast spherical harmonic transform and fast Wigner-D transform
- [FFTW 1998, SOFT 1.0 2003, SpharmonicKit 2.5 1998] Source for efficient signal processing on the group of 2D and 3D rotations

Geometric Hashing and Other Partial Matching/Alignment Methods

- [Fischler and Bolles 1981] RANSAC algorithm for outlier elimination
- [Chen et al. 1999] Initial alignment by exhaustive search for correspondences

Rigid-Body Pairwise Iterative Alignment

- [McLachlan 1979, Horn 1987, Horn et al. 1988, Arun et al. 1987] Describe a closed-form algorithm based on quaternions for obtaining the rigid-body transform given point-to-point correspondences

* [Besl and McKay 1992] The original ICP paper

* [Chen and Medioni 1992] Introduces the point-to-plane metric for ICP; this technique also performs global alignment by incrementally aligning new scans to the full model

- [Godin et al. 1994] Describes an algorithm for aligning meshes using both geometric and color information
- [Blais and Levine 1995] Describes an ICP-like algorithm that incorporates projection-based matching

* [Rusinkiewicz and Levoy 2001] Surveys and analyzes variants of the different stages of ICP, focusing on those that improve convergence or speed
* [Gelfand et al. 2003] Describes the stable sampling algorithm for selecting ICP samples which will fully constrain the transformation
* [Mitra et al. 2004] Describes an algorithm for pairwise registration that precomputes a piecewise-quadratic approximation to the distance function and performs minimization using Newton's method

- [Gelfand et al. 2005] Describes an algorithm for pairwise registration with early termination

Rigid-Body Global Registration

- [Turk and Levoy 1994] Includes a global rigid-body alignment algorithm that aligns all scans to a single "anchor"
- [Bergevin et al. 1996] Global rigid-body alignment algorithm that iteratively aligns each scan to the union of all others
- [Masuda et al. 1996] Global rigid-body alignment algorithm that aligns each scan (once) to the union of all others
- [Benjemaa and Schmitt 1997] Global rigid-body alignment algorithm that iteratively aligns each scan to the union of all others, with hardware acceleration

- [Neugebauer 1997] Global rigid-body alignment algorithm which uses Levenberg-Marquardt optimizatoin
- [Lu and Milios 1997] Global rigid-body alignment algorithm that formulates the problem as a linear optimization
- [Pulli 1999] Global rigid-body alignment algorithm that precomputes pairwise correspondences
- [Williams and Bennamoun 2000] Global rigid-body alignment algorithm
- [Sharp et al. 2004] Global rigid-body alignment algorithm that spreads out error across loops of mutual pairwise alignments
- [Krishnan et al. 2005] Global rigid-body alignment algorithm using SVD and Newton's method

Thin-Plate Splines

- [Duchon 1977] The definitive proof of the thin-plate spline's properties; in French
- * [Wahba 1990] An excellent English reference to the thin-plate spline
- [Bookstein 1989] Uses the thin-plate spline for medical image alignment; this appears to be the first use of the thin-plate spline for (2-D) scan alignment
- [Rohr et al. 1996, Rohr et al. 2003] Extended versions of the thin-plate spline to incorporate more extensive constraints and confidence values; used for medical image alignment

Non-Rigid Alignment

- * [Ikemoto et al. 2003] Hierarchical ICP is the first non-rigid global range scan alignment algorithm; it models the warp as a piecewise-rigid function
- [Hähnel et al. 2003] ICP for jointed objects
- [Allen et al. 2003] Non-rigid alignment algorithm designed to align body scans to a template
- * [Chui and Rangarajan 2003] Align using thin-plate splines in the softassign/deterministic annealing framework
- * [Brown and Rusinkiewicz 2004] Pairwise range scan alignment using thin-plate splines
- [Zhang and Rangarajan 2004] Uses a mutual information-style metric to perform global registration of images. It aligns to a chosen reference frame using affine transformations.

- [Guo et al. 2004] An extension of [Chui03] in which a diffeomorphism is used that approximates the thin-plate spline. Diffeomorphisms are guaranteed to be well-behaved and cannot fold back on themselves, for example.

* [Brown and Rusinkiewicz 2005] Global range scan alignment using thin-plate splines

3D Scanners and Applications

- [Woodham 1980] Introduces the photometric stereo technique
- [Lucas and Kanade 1981] Describes an iterative technique for image alignment
- [Levoy et al. 2000] Describes the Digital Michelangelo Project, which acquired several large ($10^8 - 10^9$ samples) 3D models using a triangulation scanner
- [Bernardini et al. 2002] Describes the Florentine Pietà Project, a large-scale, photometric stereo project
- [Rusinkiewicz et al. 2002] Describes a system that performs real-time 3D model acquisition by capturing, aligning, and rendering range data at 60 frames per second
- [Huber and Hebert 2003] Describes a complete system for 3D model acquisition that obtains initial guesses using spin images, and includes a number of techniques for verifying the consistency of alignments.

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