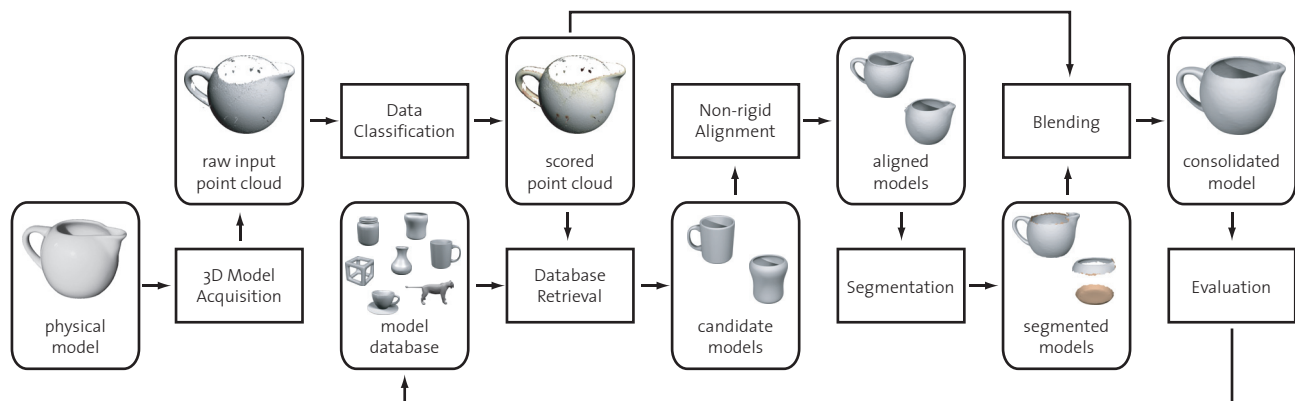


Example-Based 3D Scan Completion

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Goal: Simplify the creation of 3D models from acquired data using context information retrieved from a 3D model database

3D Model Acquisition

- 3D acquisition devices produce discrete samples of the surface of a given physical object (e.g. laser range or structured light scanning)
- Acquired sample set is often noisy and incomplete due to occlusion and physical limitations of the scanner
- Current systems require significant manual intervention to extract a clean, complete, and consistent model

Data Classification

- Classify data according to geometric fidelity to improve robustness in the presence of noise and outliers
- Confidence estimate based on eigenvalues of covariance matrix of local neighborhood

$$C_i = \sum_j (p_j - p_i)(p_j - p_i)^T \phi_i(\|p_j - p_i\|)$$

$$\phi_i = 1 - \frac{3\lambda_i^3}{\lambda_1^3 + \lambda_2^3 + \lambda_3^3}$$

$$\phi_i = \lambda_1^2 / \lambda_3^2$$

Database Retrieval

- Combination of textual search and shape-based signatures to retrieve suitable context models from the database
- Keywords to confine search space
- PCA to factor out global scaling and initial pose
- Rigid alignment using minimization of squared distances

$$E(M, P) = \sum_{i \in P} c_i \|R p_i - q_i\|^2$$

Non-rigid Alignment

- Compute 3D warping function using optimization to align context models with input point cloud
- Define consistent shape matching penalty function:

$$\Psi(P, M, T) = \alpha \cdot \Phi(M, T) + (1 - \alpha) \cdot \Omega(P, M, T)$$

- Distortion of warp: $\Phi(M, T) = \sum_{j \in M} \sum_{k \in N_1(j)} A_{jk} \left(\frac{t_j - t_k}{|e_{jk}|} \right)^2$
- Geometric error: $\Omega(P, M, T) = \sum_{j \in M} \omega_j A_j \|v_j + t_j - q_j\|^2$

Segmentation

- Segment context model according to best local fit with input data
- Incremental region growing process that respects local shape matching penalty and input data correspondence weights

Blending

- Extrapolate geometric information to fill in regions of missing data
- Incrementally add triangles at current patch boundary
- Continuously update warping function to create smooth transition
- Combine context models using geometric stitching

Results