Approximate Symmetry Detection and Symmetrization

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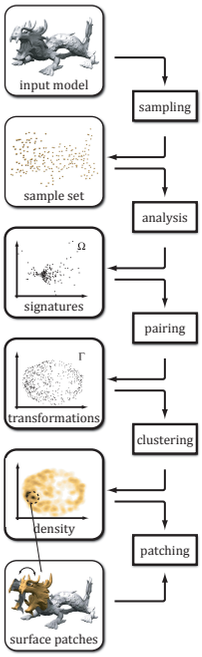
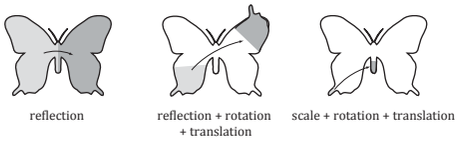
SYMMETRY DETECTION: Natural and man-made objects often exhibit symmetry and contain repeated structures. We present an output sensitive algorithm to detect *partial* and *approximate* symmetries in 3D objects. We gather evidence for possible symmetries by matching local symmetries in pairs, followed by accumulation in the transform domain by mean shift clustering. Potential symmetries are then verified in the object domain to generate a set of symmetric patches.



Symmetry Extraction Pipeline.



Types of symmetry. Planar reflection, rigid transforms, uniform scaling, or their combinations.

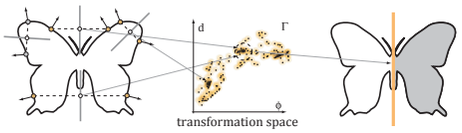
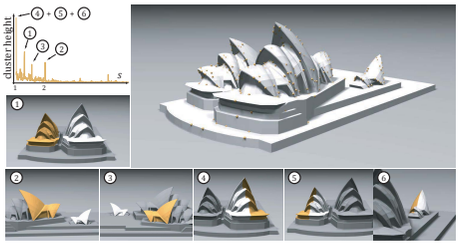
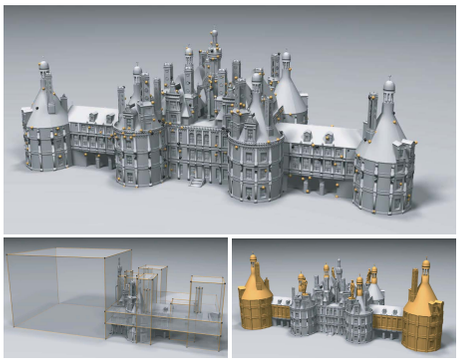


Illustration of symmetry detection for reflections. Every pair of points defines a symmetry line that can be described by a distance d and an angle ϕ. Multiple points clustered in a small region in transformation space provide evidence of a symmetry. The pair on the top left is discarded due to normal inconsistency.



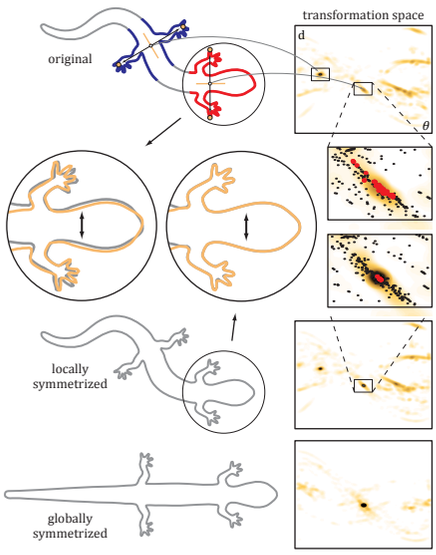
Combined Symmetries. The six most significant modes of the Sydney Opera with the full 7-dimensional symmetries (1, 2, 3) and pure reflections (4, 5, 6). The graph shows the distribution of scaling factors.



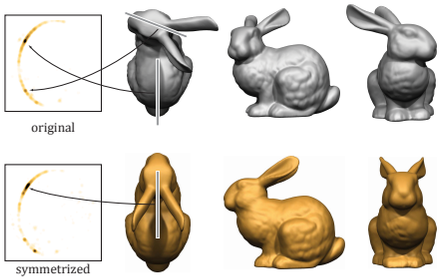
Model compression and advanced editing. (Top) Chambord castle, (bottom left) reduced model with detected (partial) symmetry structure, (bottom right) advanced editing respecting the original symmetry relations.

Approximate symmetry detection. (Top) Original sculpted dragon model, (left) detected partial and approximate symmetries, (right) color-coded deviations from perfect symmetry as a fraction of the bounding box diagonal.

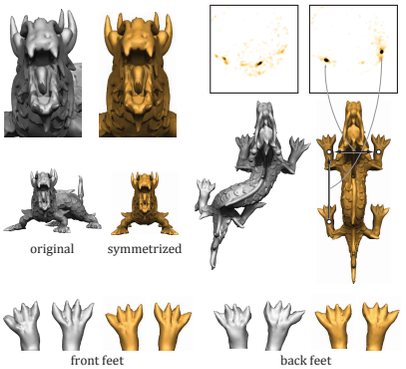
SYMMETRIZATION: We present a novel algorithm for enhancing approximate symmetries of geometric models by minimally deforming their shapes. Symmetrizing deformations are formulated as an optimization process that couples the spatial domain with a transformation configuration space, where symmetries can be expressed more naturally as parametrized pointpair mappings. Displacement vectors computed from the optimal symmetry transformation are used to drive a constrained deformation model that pulls the shape towards symmetry.



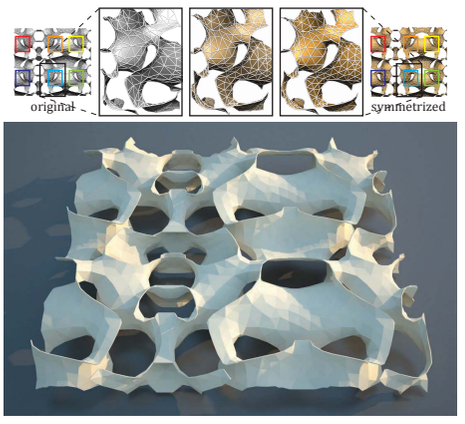
Symmetrization in 2D. Local and global symmetrization of a gecko model.



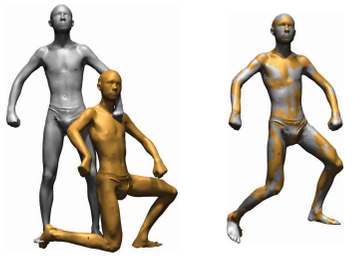
Symmetrizing the Stanford bunny. Two clusters corresponding to reflective symmetries of the head and body of the model are merged to obtain a globally symmetric shape.



Symmetrization of a sculpted model. Large-scale deformations achieve a global reflective symmetry by straightening the spine, while many small-scale deformations symmetrize the model locally, e.g., the horns, tongue, or toes.



An architectural design study. The zooms in the top row show how the meshing of the extracted symmetric element evolves during the optimization. This element appears six times in different location and orientation.



Automatic correspondence computation. The two poses are deformed towards each other by successively contracting and merging the most prominent clusters

References:
1. Symmetrization, N. J. Mitra, L. Guibas, M. Pauly, ACM SIGGRAPH, 2007.
2. Partial and Approximate Symmetry Detection in 3D Geometry, N. J. Mitra, L. Guibas, M. Pauly, ACM SIGGRAPH, 2006.

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