Caging Loops in Shape Embedding Space: Theory and Computation

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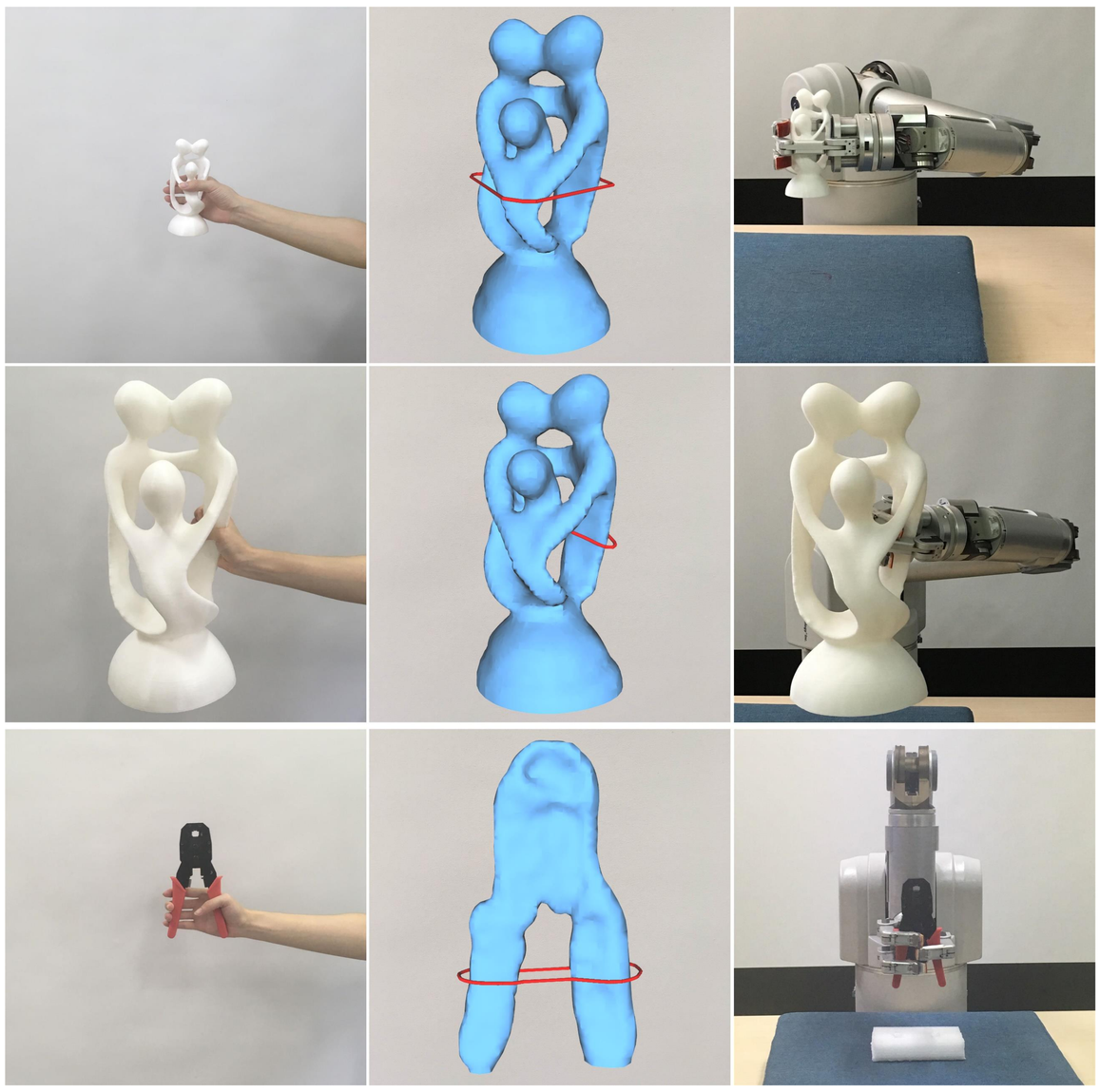
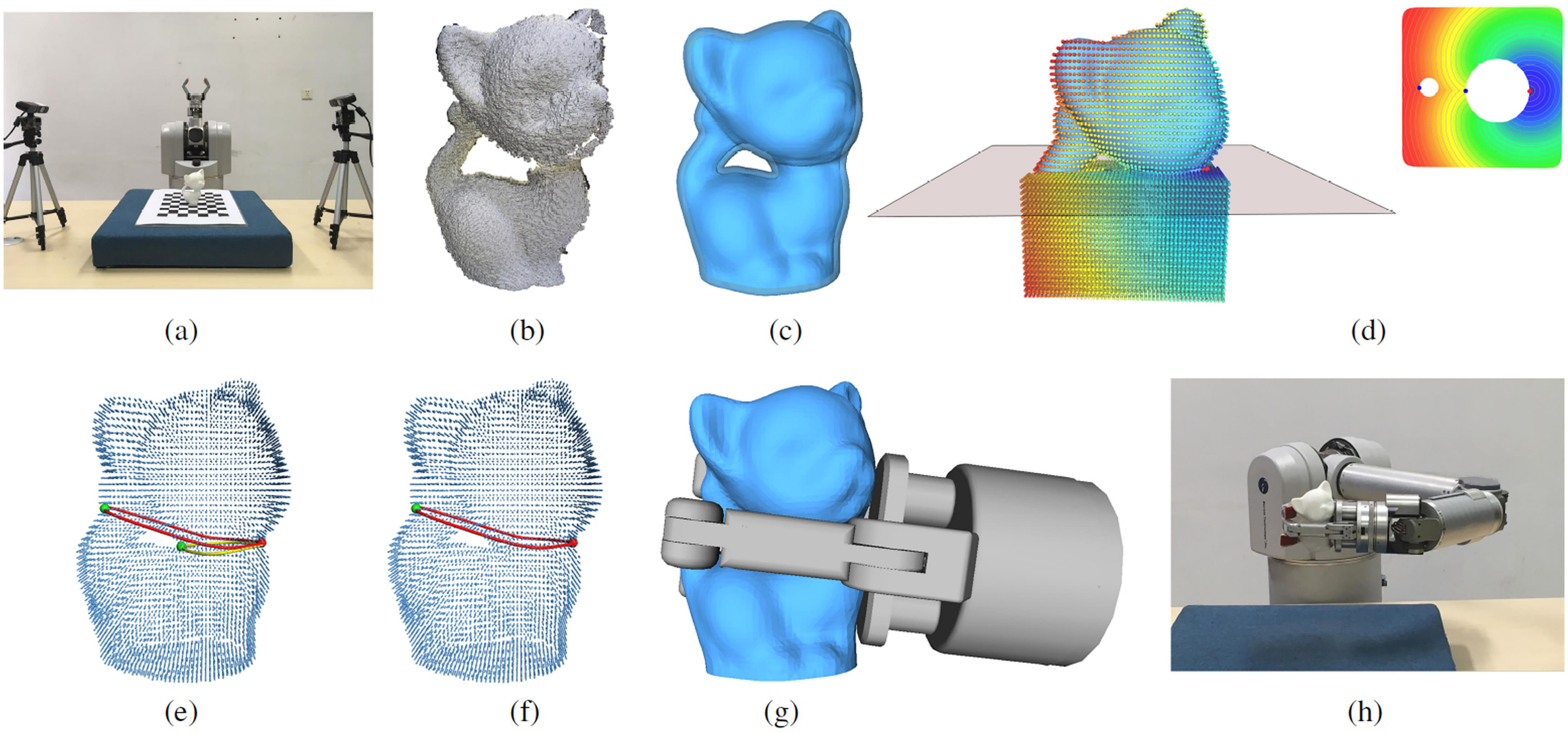
We propose to synthesize feasible caging grasps for a target object through computing Caging Loops, a closed curve defined in the shape embedding space of the object. Different from the traditional methods, our approach decouples caging loops from the surface geometry of target objects through working in the embedding space. This enables us to synthesize caging loops encompassing multiple topological holes, instead of always tied with one specific handle which could be too small to be graspable by the robot gripper. Our method extracts caging loops through a topological analysis of the distance field defined for the target surface in the embedding space, based on a rigorous theoretical study on the relation between caging loops and the field topology. Due to the decoupling, our method can tolerate incomplete and noisy surface geometry of an unknown target object captured on-the-fly.





An overview of our caging loop based grasping system. (a) Our system setup, composed of one robotic arm and two depth cameras. (b) The incomplete point cloud scanned by the two depth cameras. (c) The r-offset surface of the reconstructed target object that defines the grasping space. (d) A p-based distance field and two Morse saddle points (blue). (e) Two caging loop candidates induced by the two Morse saddle points. (f) The yellow loop is filtered since it is far from being locally shortest at the base point (red). (g) A simulation of grasping. (h) Real grasping conducted by our system.