

GAMI: Generation of Arbitrary Foldable Mesh from Images

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Abstract

As the algorithms and technique of folding any polyhedron develop practically and effectively, it is significant to research into the description and reconstruction of the general polyhedrons.

The automatic or semi-automatic origami design algorithm includes disk-packing, pleat folding and freeform origami, etc. Tree method, put forward by Robert J. Lang, fits the flat foldability which abstracts the crease pattern problem as trunk and branch based on circular packing, but only basic model with particular requirements can be designed with interaction. As for the universal hinge patterns, compared with boundary-based mesh, voxel-based mesh is easier to describe a polyhedron and thus recover the crease pattern, but the surface of the origami model is still cubic like. Among the descriptor of generic polyhedron, the triangle mesh straightforwardly defines an origami model instead of trunk abstraction used in tree method. What you see is what you get from the real object although it cannot best represent the artistic origami design as the tree method.

Triangle mesh can be unfolding and the crease pattern can be practically generated, which has been proved by the recent works of Erik Demaine and Tomohiro Tachi, namely the Origamizer. They display their work with the classic Stanford bunny. But given an arbitrary mesh, it is necessary to modify the mesh to suit the Origamizer and takes fairly long to interaction to make the design or reconstruct the mesh. Thus an algorithm to automatically generate the mesh and regularize the mesh for folding is necessary.

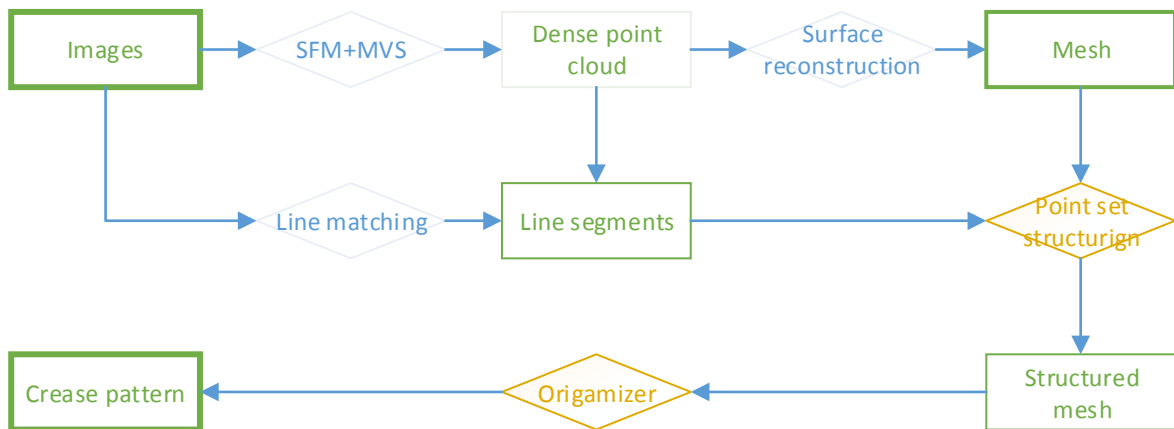


Figure 1: Flow chart of the mesh reconstruction strategy.

To this end, we develop a pipeline designed specifically to reconstruct the mesh for practical folding from images captured towards the model based on the theory of photogrammetry. For any object from the real world (should be satisfied with the Riemann's reflection), point cloud can be reconstructed from the images taken toward the object. And then the mesh of the object will be generated through surface reconstruction and structured according to both the texture information from images and the geometry information from the point cloud. The main flow is illustrated in Figure 1.

Firstly, images are taken around the model. We use images captured by mobile phones or cameras of any kind which are rather easy to access. Then the three-dimensional structure, namely the point cloud of the object will be reconstructed based on the algorithm of structure from motion (SFM). With the unorganized point cloud, the mesh can be generated by surface reconstruction, such as Screened Poisson Surface Reconstruction and Floating Scale Surface Reconstruction, etc. The reconstruction procedure is shown in Figure 2.

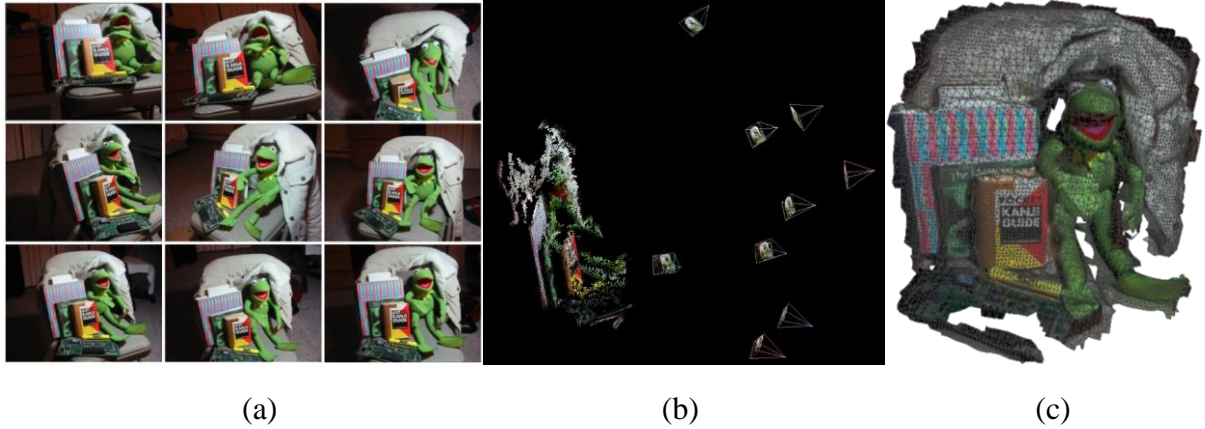


Figure 2: (a) Unordered images; (b) Point cloud reconstructed from the unordered images. (c) Textured mesh.

However, a realistic origami model requires not only the accurate geometry, but also the texture feature represented by the crease (mountain or valley fold). Thus it is better to make the crease fit to the obvious boundary of the object as much as possible and make sure the edge feature in the image also be the edge of the mesh.

Secondly, the mesh will be modified for the foldability. According to the edge feature in the images, the line segment matching and adjustment will be conducted to obtain the line segments in the object coordinate. Then the line element can be described as circular splines and then put into the existing mesh to sharpen the mesh through remeshing. Obviously, the edge in the boundary, such as the boundary of a book, should be extruded as the edge element in the mesh while the sharpening of edge features in the plane can also make the origami model more realistic after the mesh folding.

Finally, crease pattern design method like Origamizer can be conducted to the structured and regularized mesh to obtain the final crease pattern. After the folding process, an origami model is reconstructed totally based on the images.