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[Paper tile] AtlasNet: A Papier-Mache Approach to Learning 3D Surface Generation
[Summary] Describe the key ideas, experiments, and their significance.
The paper introduces a learning based method for generating surface based 3D shapes, The key idea of the paper is to use a multi layer perceptron along with small patch based parametric surfaces to generate intuitive surface meshes. The paper highlights some of the advantages of surface-based 3D representations such as infinite resolution (which is the main drawback of voxels) and the ability of surfaces to provide neighborhood information (this is where point cloud fails). The UV parameterization of surfaces also helps in the effectively storing the surface textures, BRDF and other visual properties which the Point cloud and voxel representations cannot do it easily. The paper solves two key challenges a surface parameterization on a global scale of the object and meshing. Method: A surface can be represented as a topological space that is identical to a euclidean plane, the paper takes advantage of this property by mapping 3D space into small set of squares. These multiple squares act as pieces of maps which are analogous to an atlas. This property is termed as a non-disk topology in the paper. In the paper the author's provide proof of how a 2-manifold surface and its loss can be represented as a MLP with relu activation function. The network architecture then uses this property to combine multiple MLPs along with the latent map from a pointnet encoder or other encoders (in case of images) with the 2-manifold representation to predict 3D points. The architecture uses chamfer distance to model the loss between ground truth and predictions. The mesh generation is experimented with three methods, the first one is to directly map the unit square surfaces and stitching it together but have drawbacks like holes in the mesh. Another method is to use Poisson surface reconstruction which gives points and normals. The last method is to use a canonical 3D shape to sample points instead of 2D unit squares. Results and Experiments: The authors explore both qualitative and quantitative results. The architecture is tested on shapenet dataset. The evaluation criteria for comparison is the Chamfer Distance and the METRO software which calculates the Euclidean distance directly between two meshes. The results are also compared with a baseline method which generates points using similar learning based architectures. The authors also test their proposed applications like auto-encoding 3d shapes and find that their method outperforms the points baseline along with testing of other methods which includes testing their methods with varying number unit squares and 3d sphere as a canonical surface. The authors also test their algorithm for single view reconstruction and find that the method is able to reconstruct 3d surfaces well as compared to other derived counterparts.
[Strengths] Consider the aspects of key ideas, experimental or theoretical validation.
The strengths are listed as below: 1) The authors test on various datasets including testing on a real world object 2) There are many applications to the authors methods highlighted like single view reconstruction and shape interpolation

3) The method also proves the advantages of using a surface based representation which has advantages of higher resolution and ability to store texture data. 4) Although there are weaknesses to this point, but this method also has good precision and generalization capabilities as seen in testing and experiments where the authors test their method on previously unseen 2d images and the method achieves reasonable 3d surface reconstruction. 5) The writing of the paper is also better as it highlights areas of improvement, limitations in their work
[Weaknesses] Consider the aspects of key ideas, experimental or theoretical validation, writing quality, and data contribution (if relevant). Explain clearly why these are weak aspects of the paper
The weaknesses are listed as below: 1) Since the method uses chamfer loss which has a complexity of quadratic form the inference time will increase with a larger size of atlas. 2) The method is also shows a limitation where if the number of parameterizations are less the network has a tendency to distort objects 3) On the other hand if the same number of parameterizations are increased this leads to generation of artifacts in the reconstruction 4) Another highlighted weakness is that the patches are not necessarily ensured to be connected with each other 5) Also most of the testing and results were demonstrated only on synthetic datasets while the method's objective also was to extend to real scenes too.
[Reflection] Share your thoughts about the paper. What did you learn? How can you further improve the work?
The method described in this paper requires a lot of knowledge in computational graphics of surfaces and math and geometry areas like topologies and 2-manifold and manifold based 3d shapes. The authors try their best to give a background on that in the paper but it is difficult for the reader to grasp that. For this reason I had to explore a lot of content related to geometry of surfaces and the parameterization of surfaces. Another thing I learned which was later taught in class was the use of chamfer distance as a loss function. Although the evaluation of such a loss as highlighted by the author is done based on energy minimization of two point clouds. There needs to be better ways to optimize that loss. Other areas of improvement include the work on modeling real world 3d scenes instead of just testing on the shape net datset. Another area of improvement highlighted by the authors was to learn parameterization of meshes instead of generating after the fact. The most exciting direction would be to use this to do shape segmentation and recognition as the atlas based method provides correspondences. (this is also tested in the additional applications section of the paper in the form of comparing chairs).