1. Abstract
We present a non-parametric and threshold-independent part-base segmented method for CAD mesh models. The algorithm uses hyperbolic points in the input mesh model to find the concavities in the model. As opposed to patch-based segmentation, the algorithm finds the boundaries of the model where the part-based segmentation is likely to happen. The boundaries are identified using the strongly-connected components of the hyperbolic edges and the various segments are found using a flooding based region growing method.

2. Motivation
• Need for a fully-automatic method.
• Part-based approach opposed to patch-based segmentation.
• CAD mesh models consist of sparse and dense region, may contain multiple genus and has sharp changes in curvature and hence require suitable segmentation algorithm.

3. Methodology
• Finding the hyperbolic vertices in the mesh model (Green dots in Figure 4(a)).
• Finding the hyperbolic edges connecting hyperbolic vertices which lie on concave region (Red edges in Figure 4(b)).
• Avoid the hyperbolic edges lying on non-concave region (Yellow edges in Figure 4(a)).
• Avoid the edges where the incident triangle T2 lies below the supporting plane P constructed using triangle T1 (Blue edges in Figure 4(f)).
• Suppress the hyperbolic edges on a filleted region. For every edge if two edges out of the six edges are non-hyperbolic, then it is considered, else it is suppressed. (In figure 4(c) red edges are hyperbolic edges but non-candidate edge. Blue edges are hyperbolic edges which is a candidate edge).
• The strongly connected components of the candidate edges are found.
• The solitary edges are the hyperbolic edges which did not form any strongly connected component. (Red edges in Figure 4(d)).
• Find all edges which lie on a supporting plane of an unused hyperbolic edge (Red edges in Figure 4(h)) and find strongly connected component.
• Remove all connected components where atleast one edge is non-hyperbolic (Red edges in Figure 4(c)). All the remaining ones constitute the region boundaries.
• Segmentation is done by a region growing process. A seed triangle is picked which is adjacent to a boundary edge (Green triangle in Figure 4(i)). The adjacent edges (Red edges in Figure 4(i)) and incident triangles are added to the current region until it hits a boundary edge. This process is repeated for all boundaries thereby segmenting entire model.
• Figure 1 shows the illustration of the Algorithm in various steps.

4. Results
• Discussion: The algorithm was able to segment models with multiple genus, non-planar boundary, fillets, tiny segments etc. It can also segment at a boundary with atleast one hyperbolic edge.
• Run time: The complexity of our approach is $O(|V|+|E|)$ and the running time is quite fast (0.01s - 1.7s).
• Limitation: If there is a single through hole passing through two parts, the model will not be segmented.

5. Comparison

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• Comparison was done with approaches [1],[2] and [3]. Our algorithm was able to segment all the models into meaningful components without any user intervention or using threshold values. The SDF method has undersegmented the models and the WC method does not give a meaningful segmentation. The HFP method requires the user to select the shape primitives and the number of segments require and hence is a trial and error method for segmentation.

References