Prong Features Detection of a 3D Model Based on the Watershed Algorithm

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1 Introduction

In this paper, a simple and robust prong features detection algorithm is proposed. A prong feature is an assisting feature that can be used in many applications. For instance, it can be used to identify a model that consists of several prong parts for model decomposition. It represents a useful feature for skeleton extraction as well as a comparable feature for object matching. In addition, it could also be a fast alignment feature for model alignment and morphing. Furthermore, it is an invariant feature for mesh simplification.

In traditional application, a watershed algorithm is often applied to solve segmentation problems, such as [Mangan and Whitaker 1999]. In this paper, we outline an approach based on mesh connectivity relationships which apply to watershed algorithms on a 3D data to detect some meaningful features. If we could find other suitable continuing scale functions on a 3D data, they would also be suitable to detect or to segment other features.

2 Algorithm

First, we construct a normalized scale function on the input mesh to describe the position of a potential prong. The scale function is calculated by the sum of the geodesic distance from each node among the mesh to the evaluated node [Lazarus and Verroust 1999]. The scale function is defined in the following: $f(v) = \sum_{\forall v_i \in S} Geodesic(v, v_i)$, where v is the vertex on the shape S. To ensure the calculation of the geodesic distance approximates the real value, a remesh pre-process is required. The result is shown in the following:

Figure 1: From the scale function, a higher value indicates a prong feature that is denoted by the green color.

In order to find these prong features we apply a watershed algorithm. First, all of the vertexes are sorted by the scale function value. Then, the maximum value of the vertex is picked up as the first prong feature and marks it as traversed. As we have to focus on the feature detection, the water level decreases iteratively from the maximum value. The decreasing level effects the sensitivity of a prong feature. The prong shape's valley value divided by its peak value is defined as the smoothness ratio. If the smoothness ratio is larger than the threshold, the result is a small prong and will be ignored. Each non-traversed vertex in the sorting sequence will reset the water level, i.e., its function value is multiplied by the smoothness ratio. Consequently, we can mark all vertexes as traversed if their function value is above water level and if they are a neighbor of the traversed set. If the vertex is not in the traversed set, it is a new prong feature. The pseudo code is as follows:

```
Function watershed algorithm
V=sort (S); //if v_i ∈ V, f(v_0) > f(v_1) ... > f(v_n)
T ← v_0;     //insert v_0 into the traversed set
P ← v_0;     //v_0 is the first prong feature.
for each (v_i ∈ V .and. v_i ∉ T) {
  water_level=f(v_i)× smoothness_ratio;
  do{
    for each ( v_j ∈ Neighbor(T) .and. v_j ∉ T)
      if (f(v_j) > water_level)
        T ← v_j;
  }while (there exists a new traversed vertex)
  if ( v_i ∉ T)
    T ← v_i; P ← v_i;
}
```

For a model with about 8,000 triangles, the execution time is 22 seconds using a notebook PC with an Intel Pentium 4 2.4GHz CPU and 512 Mb memory. About 75% of execution time is needed in order to calculate the scale function. The following graph shows the demonstration of an application which is based on the detected prong features to construct a skeleton.

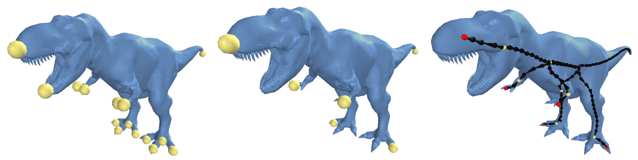

Figure 2: The results are shown in different decreasing levels. (a) Fifteen features are detected when the smoothness ratio is set to 1.0. (b) Six features are detected when the smoothness ratio is set to 0.85. (c) A skeleton is constructed based on these prong features

3 Conclusion

We have presented an algorithm in order to detect the prong features on a 3D mesh. The procedure includes a smoothness ratio that can be adjusted for different applications. According to our experience, setting the smoothness ratio to 0.85 is suitable to detect significant prong features for most models. We also have demonstrated that prong features are a useful information in skeleton construction.

References

LAZARUS, F., AND VERROUST, A. 1999. Level set diagrams of polyhedral objects. In *ACM Solid Modeling and Applications 1999 Conference Proceedings*, 130–140.

MANGAN, A. P., AND WHITAKER, R. T. 1999. Partitioning 3d surface meshes using watershed segmentation. *IEEE Transactions on Visualization and Computer Graphics 5*, 4, 308–321.

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