



## Review on Surface Reconstruction Algorithms

Neha Rathore\*, Richa Gupta  
CSE & Kurukshetra University  
India

**Abstract**—Surface reconstruction is to find a surface from a given finite set of geometric sample value. Surface reconstructing 3D surfaces from point samples is a well studied problem in computer graphics. All algorithms, aim to solve this problem must overcome several difficulties. One of which is related to the size and quality of the input, under sampling, and noise. The main aim of this research paper is to study different algorithm for image reconstruction from scattered cloud points. Most of the surface reconstruction algorithms discussed in this paper is coming from the computer graphics community

**Keywords**— Reverse Engineering, Crust Algorithm, Delaunay Triangulation, Power Crust, BPA

### I. INTRODUCTION

Surface reconstruction is study about finding surface from given finite set of geometric sample values. It allows fitting of scanned data, filling of surface holes, & re-meshing of existing models. Most surface reconstruction methods grouped mainly into two, explicit methods and implicit methods Reverse engineering of geometric shapes is the process of converting a large number of measured data points into a concise and consistent computer representation. In the way that it is the inverse of the traditional CAD/CAM procedures, which create physical objects from CAD models [7].

Triangulating scattered point-sets is a very general flaw in reverse engineering. Given a set of unorganized points which lie approximately on the boundary surface of a three-dimensional object, and without a prior information about topology, our aim is to reconstruct the surface by constructing a triangular mesh using the given points as vertices [1]

The Delaunay triangulation is a cell complex that subdivides the convex hull of the sampling. If the sampling fulfils certain non-degeneracy conditions then all cells in the Delaunay triangulation are surplices and the Delaunay triangulation is unique [10] Explicit methods are mainly local geometric approaches based on Delaunay triangulation and dual Voronoi diagram such as Alpha shape and CRUST algorithm. Modern 3D scanners make it possible to acquire several (ten) millions of sample points on the object's surface. Algorithms which reconstruct surfaces from large data have been proposed in the past. The explicit methods are subject to many reconstruction difficulties such as no uniformity, under sampling, and noise [5].

### II. ANALYSIS AND COMPARISON OF ALGORITHMS EFFICIENCY

Some basic algorithms work by projecting the points to a carrier surface and creating triangles in the parametric domain of the carrier surface. These methods have limited scope for disconnected surface portions & objects with positive Genus [9]. Other methods start from various subsets of the 3D Delaunay tessellation of the sampling points and try to choose a proper subset of the faces. Another leading idea is to define implicit surfaces containing the given sampling points and extract these surfaces

Following fig show the time used by each algorithm to compute the surface is directly proportional to the number of input points. More time is needed to estimate the surface when the number of point clouds is increasing Delaunay/Voronoi based algorithm (Alpha shape ,cocone and Power crust ) using more time to calculate surface compare with other algorithm. This is because the estimations of voronoi diagram or Delaunay triangulation is time consuming .The interpolated method, for example, the computation of moving least square surface, involve the use of matrix in the algorithm. The BPA algorithm not involved any computation in voronoi diagram or Delaunay triangulation .Hence, this algorithm is faster than other algorithm. When the number of point clouds increase, the dimension of matrix will also increase, the high memory storage is required. Obliquely the complexity time for an algorithm will also increase.

TABLE 1: Speed Comparisons of Algorithms

NUMBER OF POINT CLOUDS	ALGORITHM	TIME
6000	BPA	1
	Alpha Shape	1.2
	Power Crust	6.4
	COCONE	5.6

	Interpolate Method	7.1
7000	BPA	1.2
	Alpha Shape	1.5
	Power Crust	6.6
	COCONE	5.9
	Interpolate Method	7.5
8000	BPA	1.6
	Alpha Shape	1.8
	Power Crust	6.6
	COCONE	6
	Interpolate Method	7.9
9000	BPA	1.6
	Alpha Shape	1.8
	Power Crust	8
	COCONE	7.4
	Interpolate Method	8
10000	BPA	1.8
	Alpha Shape	1.8
	Power Crust	8.2
	COCONE	8
	Interpolate Method	8
11000	BPA	2.3
	Alpha Shape	2.1
	Power Crust	11.5
	COCONE	10
	Interpolate Method	11

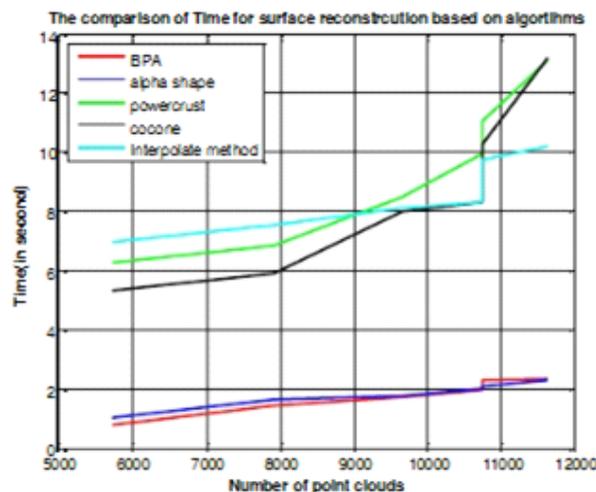


Fig 1 The Comparison of Time for Surface Reconstruction based on algorithms

### III. RELATED STUDY

Sithu Bala[1] develop a system for image reconstruction from scattered cloud points. Various algorithms like crust algorithm and Delaunay algorithm will be implemented and compared for time taken by the algorithm for surface reconstruction .Keyword surface reconstruction, feature point . Delaunay-based surface reconstruction approaches were mainly developed in the field of computational geometry. This technique functions best when it is possible to control the sampling density over the surface In this paper, presented the feature point technique as in for large cloud points of a image surface reconstruction according to the local feature size, we propose a new fast and effective method that not only give good reconstruction to the smooth areas of the given surface, but also restores the sharp features.

Agostinho de Medeiros [2] describes the multi-resolution approach for surface reconstruction from clouds of unorganized points representing an object surface in 3D space. The given method uses a set of mesh operators and simple rules for scrupulous mesh refinement, with a scheme based on Kohonen's self-organizing map (SOM). Basically, a self-adaptive scheme is used for continual moving vertices of an initial simple mesh in the direction of the set of points near the object boundary. Subsequent refinement and motion of vertices are applied chiefly to a more precise surface, in a multi- resolution, iterative scheme. Reconstruction was experimented with certain point sets, including various shapes and sizes. Results show resulted meshes very close to object actual shapes. We include measures of performance and also discuss robustness.

Andrei C. Jalba [3] present that after accumulating the sample points on a volumetric grid, a novel, iterative algorithm is applied to analyse grid points as exterior or interior to the surface. This algorithm is based on intrinsic properties of the smooth scalar field on the grid which emerges after the aggregation action. Second, a mesh-smoothing paradigm established on a mass-spring system is introduced. By augmenting this system with a bending-energy minimizing term we ensure that the final triangulated surface is smoother than piecewise linear in speed and flexibility, the method compares with respect to previous approaches. Most parts of the method are implemented on modern graphics processing units (GPUs). Results in a wide variety of settings are presented, ranging from reconstruction on noise-free point clouds to gray scale image segmentation.

Shengjun Liu [4] present to develop framework for processing point clouds that improves their quality and thus the reconstructed surfaces' quality. The input to our framework is an unorganized point cloud that might contain outliers, noise & non uniformities. On basis the of point positions, our framework uniformly distributes points by inserting samples into sparse regions, using interlaced down sampling and up sampling and many operators. Particularly we use particle repulsion to ensure that the inserted sample points extrapolate the point set's missing points.

Vikas Chauhan [5] present work is to study the Crust algorithm and Delaunay algorithm. We analyse these algorithm for the time taken for the surface reconstruction. The objective of surface reconstruction is to find a surface from a given finite set of geometric sample value the optimization of surface reconstruction system from scattered cloud points. This simulation result are in the form of graphs of time taken to complete surface reconstruction v/s the number of cloud points.

Cheng Tai [6] study novel graph-cuts-based method is suggested for reconstructing open surfaces out of unordered point sets. Using a Boolean operation on the crust around the data set, the open surface problem is changed to a watertight surface problem within a confined region. Integrating the variational model, Delaunay-based tetrahedral mesh & multiphase technique, the suggested method can reconstruct open surfaces robustly and adequately. Furthermore, a surface reconstruction method with domain decomposition is discussed, which is based on the recent open surface reconstruction method.

Shivali Goel [7] develops a system for image reconstruction from scattered cloud points. Crust algorithm along with umbrella Filtering will be implemented and compared for time taken by the algorithm for surface reconstruction. The main aim of the algorithm is to filter out left insignificant data while preserving an acceptable level of output quality. Three-dimensional data collected by measuring device is usually dense and is called Point Cloud data

R. Poranne [8] develop a generalized distance function on an unoriented 3D point set and shows how it may be used to Reconstruct a surface approximating these points. The distance function is shown to be a Mahalano bis distance in a higher-dimensional embedding space of the points, the resulting reconstruction algorithm a natural extension of the attic Radial Basis Function (RBF) approach. Experiment's results reveals the superiority of our reconstruction algorithm to RBF and other methods in a variety of practical scenarios describe a novel construction of an unsigned distance function from sample data (without normal information). This function gets very small values on the data, which increase smoothly and monotonically with distance from the data. Thus, almost no spurious components will be present in the reconstruction.

Tong-guang [9] applied the BPA to datasets of large no of points showing a real scans of complex objects in 3D. The small amount of memory required by the BPA, time efficiency, and the result's quality are compared favourably with existing techniques

#### IV. CONCLUSION

This paper analyzes and compares the surface generated by well known algorithms of surface reconstruction. No of point clouds are directly proportional to time and the density of point cloud is not good enough, alpha shape ,BPA and cocone algorithm will reconstruct the incomplete surface .Power crust algorithm can reconstruct the surface from low density point clouds ,but the surface created is not smooth. This problem can be resolved by representing the surface as AMLS or adaptive moving least square surface. The number of surface generated by BPA algorithm is less than the number of surfaces generated by Delaunay/voronoi based algorithms. All above said algorithms lack in reconstructing the smooth surface when the points cloud has noise.

#### REFERENCES

- [1] S. Bala , Gianetan S.Sekhon ,Punjabi University ,Guru Kashi Campus ,YCOE, Telwandi Sabo, Punjab ,India, IJCST VOL.2,Issue 4,Oct.-Dec. 2011
- [2] Agostinho de Medeiros Brito Junior, A. D. Doria Neto, Jorge Dantas de Melo, and Luiz Marcos Garcia Gonçalves, *the Department of Computer and Automation Engineering, DCA-CT-UFRN, , Natal, RN, Brasil, Digital Object Identifier 10.1109/TNN.2008.2000390*
- [3] Andrei C. Jalba and Jos B. T. M. Roerdink, Senior Member, IEEE, *the Institute for Mathematics and Computer Science,University of Groningen, 9700 AK Groningen, The Netherlands, Current version published in April 10, 2009*
- [4] Shengjun Liu, Kwan-Chung Chan, and Charlie C.L. Wang ,Chinese University of Hong Kong, Published by the IEEE Computer Societyin may/june 2012
- [5] Vikas Chauhan, Manoj Arora\* and R. S. Chauhan, Pelagia Research LibraryAdvances in Applied Science Research, 2011, 2 (6):483-487, ISSN: 0976-8610 ,CODEN (USA): AASRFC.
- [6] Cheng Tai, and Desheng Wang, *IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL. 19, NO. 2, FEBRUARY 2*

- [7] Shivali Goel , Rajiv Bansal , International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 5, May 2013
- [8] R. Poranne1, C. Gotsman1 and D. Keren2,1 *Department of Computer Science, Technion – Israel Institute of Technology, Haifa, Israel* 2*Department of Computer Science, University of Haifa, Haifa, Israel*, Vol 29 (2010), NO 8 pp. 2479–24
- [9] Tong-guang Ni, zheng-hua Ma, "A Fast Surface Reconstruction Algorithm for 3D Unorganized Points", 2010 IEEE.
- [10] Frederic Cazals; Giesen, "*Delaunay Triangulation Based Surface Reconstruction: Ideas and Algorithms*".
- [11] Z. Zongqian; Z. Xiaoqian, "3D surface reconstruction & panorama stitching on LCD-based calibration & multi-baselines stereo matching," *Image Analysis and Signal Processing*, 2009. IASP . International Conference on , vol., no., pp.278-281, 11-12 April 2009
- [12] .Andriy, P.; Bohdan, R., "*Application of methods of 3-D surface reconstruction for characterization of pitting defects*," *CAD Systems in Microelectronics*, 2009. CADSM 2009. 10TH International Conference - The Exp of Designing and Application of , volume., no., pp.468-468, 24-28 Feb. 20
- [13] L. T.; Soubret, A.; rl, J.; Ntziachristos, V., "Surface Reconstruction for Free-Space 360  $^{\circ}$  *Fluorescence Molecular Tomography and the Effects of Animal Motion*," *Medical Imaging*, IEEE Transactions on , volume.27, no.2, pp.188-194, Feb
- [14] de M Brito, A.; Doria Neto, A.D.; Dantas de Melo, J.; Garcia Goncalves, L.M., "*An Adaptive Learning Approach for 3-D Surface Reconstruction From Point Clouds*," *Neural Networks*, IEEE Transactions on , volume.19, no.6, pp.1130-1140, June 2008
- [15] L. Zhang; T. Hu; X. Liu; Yan Li; Tao Wu; Hangen He, "*Surface reconstruction from cloud points based on Support Vector Machine*," *Automation and Logistics*, 2008. ICAL 2008. IEEE International Conference on , vol., no., pp.377-381, 1-3 September. 2008
- [16] Bin Forkan, F.; Shamsuddin, S.M.H., "*Kohonen-Swarm, Algorithm for Unstructured Data in Surface Reconstruction*," *Computer Graphics, Imaging and Visualisation*, 2008. CGIV '08. Fifth International Conference on , vol., no., pp.5-11, 26-28 Aug. 2008
- [17] Bernardini, F. ; IBM Thomas J. Watson Res. Center, Yorktown Heights, NY, USA ; Mittleman, J ; Rushmeier, H. ; Silva, C. "*The ball-pivoting algorithm for surface reconstruction*". *Visualization and Computer Graphics*, IEEE Transactions on (Volume:5 , Issue: 4 ) Oct-Dec 1999