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A Mathematical Model to Generate 3D Surface

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Abstract— When we have n control points on a 2D or 3D space, then using these control points different forms of surface can be constructed. In such case, the construction of a most meaningful surface over these points is the challenging task. The presented work, has defined a fitness function based on the distance and region specification so that only the valid control points and edges will be selected and will avoid the illegal and hidden edges and faces while forming the triangulation. In this work, control points are taken as the initial population for the mathematical process. The process is repeated for specific number of iterations. With each iteration, effective control points, edges and faces get selection.

Keywords— Mathematical, 3D Surface Construction, Hidden Surface

I. INTRODUCTION

Implicit surfaces are two-dimensional, geometric shapes that exist in three dimensional space. They are defined according to a particular mathematical form. This article examines their definition, representation, and geometric properties. Related fields are discussed and practical methods are reviewed.

As a two-dimensional analogy, imagine a drop of die spreading on a flat surface, changing color as it spreads. Tracing an infinitesimally thin range of color produces a contour. Extending to three dimensions, imagine a drop of dye, released under water, changing shape and color as it radiates outwards. In this case, an infinitesimally thin range of color produces a surface.

An implicit surface may be imagined as an infinitesimally thin band of some measurable quantity such as color, density, temperature, pressure, etc. The quantity varies within the volume but is constant along the surface. Thus, an implicit surface consists of those points in three-space that satisfy some particular requirement. Mathematically, the requirement is represented by a function f, whose argument is a three-dimensional point p (i.e., (x, y, z)).

By definition, if $f(p) = 0$ then p is on the surface. If inherently characterizes a volume: those points for which $f < 0$ are on one side (nominally the 'inside') of the surface, those points for which $f > 0$ are on the other side of the same surface. If does not explicitly describe the surface, but implies its existence. For many functions, f is proportional to the distance between p and the surface. This and other attributes encourage particular forms of geometric design.

Implicit surfaces may differ in appearance, and always differ in expression, from the parametric surfaces more typical of computer aided design and computer graphics. For example, the parametric and implicit expressions for the unit circle, although describing identical shapes greatly differ in their form and properties. In the equiangular parametric case, it is simple to compute a point on the circle at a given angle; this is not possible for the implicit representation, but it, unlike the parametric, inherently determines whether a point is inside, outside, or on the circle.

Analytic geometry is the branch of mathematics devoted to the relationship between geometry and the mathematical expression of the coordinates of points in space. When applied in three dimensions, it is called solid analytic geometry. If geometric relationships between points in three-space are compared to corresponding mathematical (i.e., algebraic) relationships between the coordinates (x, y, and z) of the points, it is possible by algebraic proof to establish a geometric property. For example, the distance between the centers of two spheres can be compared algebraically with the sum of their radii, thereby predicting whether the spheres intersect geometrically.

Analytic geometry has been applied to a wide variety of mathematical functions to establish their properties (especially tangency) and to enable their graphical display. The relationship between the coordinates of points on a geometric object is fundamental to geometric design.

An explicit equation might express the z coordinate in terms of the x and y coordinates: that is, $z = f(x, y)$. Such a surface is called a height field. The different treatment of z from that of x and y inherently limits shape. For example, a height field cannot contain an overhang or a vertical slope (similarly, a planar curve produced by an explicit equation $y = f(x)$ cannot double-back or be closed, nor can it parallel the y axis).

There are at least two approaches that treat coordinates symmetrically, thereby resolving the difficulty with vertical slopes. One approach is parametric: each of the coordinates is expressed according to the geometric dimension of the object. That is, for a one-dimensional curve embedded in two-space, $x = f_x(t)$ and $y = f_y(t)$. For a two-dimensional surface embedded in three-space, $x = f_x(s, t)$, $y = f_y(s, t)$, and $z = f_z(s, t)$. Parametric curves and surfaces provide a convenient mapping from the object to the space within which it is embedded. For example, any three-dimensional point on the surface may be specified by an (s, t) ordered pair. This forward mapping (or parameterization) is useful for display, surface texture, and other applications.

II. LITERATURE SURVEY

A Genetic Algorithm for the Minimum Weight Triangulation (1997)
Kaihuai Qin
Approach : Author defined a minimum weighted Traingulation approach using genetics , The presented approach was based on the rational search along with iterative algorithmic process for complex structure optimization. Author incorporated the basic genetic steps in series to meet the objective. Author derive a matrix structure from the graph and implement the optimization over it.
Findings : Author defined an optimization approach to achieve the triangulation formation and avoid the exponential search space. Author derive the solution in acceptable time frame.
Problems : Author implemented the work on 2D space structure it does not work for 3D Plane. Author defined the work on finite element method.

An improved Genetic Algorithm based on hK1 Triangulation (2008)
Jingjun Zhang
Approach : Author defined the genetic approach on fix points as well as load sensitive points. The work performed on extreme points with the inclusion of extreme points analysis and with definition of artificial initial point. Author define and solve the problem in dual multimodal function. Author defined the limit in the evolution of search of simplex points. Author used the Hessian matrix for the convergence.
Findings : Author design a hessian matrix based genetic algorithm to build the triangulation effectively. The work efficient and provide the optimized results
Problems : The work was implemented on 2D space and the state space of the work is large because it search all points for the minimum point search.

An Improved Genetic Algorithm Based on Fixed Point Theory for Function Optimization
Jingjun Zhang
Approach : Author handle the fix point problem with the introduction of triangulation along with genetic approach. Author defined a square shape analysis over the control points and then perform cut point to convert it to the triangulation. These square points are taken as the initial population set. Author performed the sign square analysis and obtained the control points so that effective formulation of the surface is done. The work is performed on fixed point.
Findings : Author design a new algorithm based on genetics to avoid the wide solution space. Genetic operator is here used to find full scale triangle to perform the convergence.
Problems : The work is implemented on 2 D space and no implementation results are provided by the author. So that the validity of work is not verified.

An Improved Genetic Algorithm Based on J1 Triangulation and Fixed Point Theory
Jingjun Zhang
In this paper, several typical functions are used to demonstrate the effectiveness of this algorithm, and the testing results show that the improved genetic algorithm is valid and highly effective. The algorithm is based on 1 J triangulation. By searching completely labeled simplex nearly all the minimum points can be found.
Findings : The algorithm has been tested on several standard test problems and it has proven to be very valid and highly effective. Obtained results shows that the presented work has provided the optimized results
Problems : The work is implemented on 2D space.

An Improved Parallel Genetic Algorithm Based on Injection Island Approach and K1 Triangulation for the Optimal Design of the Flexible Multi-body Model Vehicle Suspensions
Guangyuan Liu
Approach : This model was inspired by the natural phenomenon in which a number of spatially isolated populations are linked together by dispersal and migration. In an island model, the population is divided into several small sub-populations, called islands or demes, which evolve
independently of each other. In this paper, the multi-body model is optimized five times using improved Parallel Genetic Algorithms mentioned above, Niche Genetic Algorithms (NGA) and Standard Genetic Algorithms (SGA), which are compared with the traditional optimization method.
Findings : The presented work is able to provide the effective solution to the problem. As the comparative analysis shows the work is more optimized then existing approaches
Problem : No specification of actual algorithm or the model is given.

An Improved Genetic Algorithm Based on Triangulation
Guangyuan Liu
Approach : In this paper a global search algorithm with strong optimization performance and
robustness, an improved genetic algorithm is proposed to solve optimal problem of the dual multimodal function. The work includes the evolution from a group of stochastic initial points, and then carries on selection operator, crossover operator and mutation operator to the population using the label information of load simplex. As the simplex number of bounded function is limited, this algorithm can achieve the condition of global optimal solution though limited generation of evolution by marking the searching simplex.

Findings : The work presented by the author includes the generation of improved genetic algorithm for multimodel functionality. The work is based on hK traingulation. It includes the search based on minimum point analysis and the Hessian Matrix

Problems : The paper is having only the analytical results. No specification about the process results or graphical representation of output.

A Diversity-guided Heuristic-based Genetic Algorithm for Triangulation of Bayesian Networks
Xuchu Dong

Approach : The work includes the definition of a stochastic optimization algorithm so that convergence to the system can be done. The work includes the specification of population diversity along with the clear specification of stagnation and convergence. Here a diversity guidance mechanism is suggested by the author. Author used the hybrid algorithm using the genetics and the baysian network. The main work is defined in terms of heuristic mutation function so that the diversity over the population is managed.

Finding : Author perform the comparision of proposed algorithm with genetic and Bayesian network algorithms on different kind of networks. The analysis is performed in terms of statistical measure and obtained results shows the author work is more worthful then other approaches.

Problems : The work is performed on 2D state space.

III. RESEARCH METHODOLOGY

In this present, the identification of the participating control points and the edges is identified that can participate in the construction of triangulation. In this work, to perform this selection, the distance analysis based fitness function is defined. The control points within the range will be elected as the valid control point. Moreover to this the work include to perform a ratio selection respective to the control point selection and the edge selection. If the control point is selected to the multiple edges, then it can be the reason for the selection of cross edge. The presented work is about to perform the effective selection of the control points and the edges. At the initial stage, the control points are represented as a matrix and it is taken as the initial population to the system. From these control points, the possible edges are identified itself during the initialization phase. The fitness function for the work is defined based on the distance analysis. Later on the genetic process is defined under the fitness function for specific number of iterations. From this population set, the selection of the control points and edges is done to form the triangulation. The selection of these points and edges is done under the fitness rule. Once the selection is done the cross over is been defined in this work. The selection procedure adapted in this work is the rank based selection whereas the distance preserving cross over is implemented to identify the next valid control point and the edge. Based on these control points and the edges, the triangles of the delnauy triangulation is formed. Later on the mutation process is performing so that the removal of the invalid control points and edges will be done. The hidden points and edges removal is done in this section. Finally, the triangulation reconstruction is done with the updating of control set or the population. This updated population set includes the valid points and remove the invalid control points from the system. This whole process is repeated for the specific number of iterations so that effective triangulation will be generated using the genetic approach.

The SH has been developed for Delanuay Triangulation for which procedure is described as below:

Step 1. Generate the initial sequence.

Step 2. Set $k = 2$. Pick the first two vertex points from the rearranged points list and arrange them in order to minimize the tour length. Set the better one as the current solution.

Step 3. Increment k by 1. Generate k candidate sequences by inserting the first point in the remaining points list into each slot of the current solution. Amongst these Candidates, select the best one with the least partial minimization of objective function. Update the selected partial solution as the new current solution.

Step 4. If $k = n$, a schedule (the current solution) has been found and stop. Otherwise, go to step 3.

One of the major problem of surface generation is to provide the effective representation to the control available control points. There are number of surface formation and triangulation approaches to cover these control points to give the meaningful representation to these control points. The triangulation methods having the problems such as to avoid the inclusion of illegal points, edges or the faces. It also deals with the exclusion of hidden points and edges. As the control points increases over the space, the efficiency of the triangulation generation also decreases the efficiency of work. There are number of existing triangulation generation approaches to resolve these problems and generate the effective triangulation in optimized way. In this present work, a delenauy triangulation optimization approach is been defined using genetics. In this approach, a Euclidean distance analysis approach is combined with genetic approach to identify the valid control points and the edges. The work also includes the dynamic removal of the hidden points and the edges over the process of triangulation generation. The obtained work includes the dynamism in terms of points selection and removal so that the effective triangulation is generated as the final results from the work. for the mating pool. Higher performers will be copied more often than lower performers. Example: the probability of selecting a string with a fitness value of f is f/ft, where ft is the sum of all of the fitness values in the population.

In this present work the main focus is on selection algorithm. Here the work is about the function optimization using genetics with the variation on selection function. The analysis is being performed on different selection approaches and based on these the results are being obtained. On the basis of selection procedure three main models are discussed analyzed here

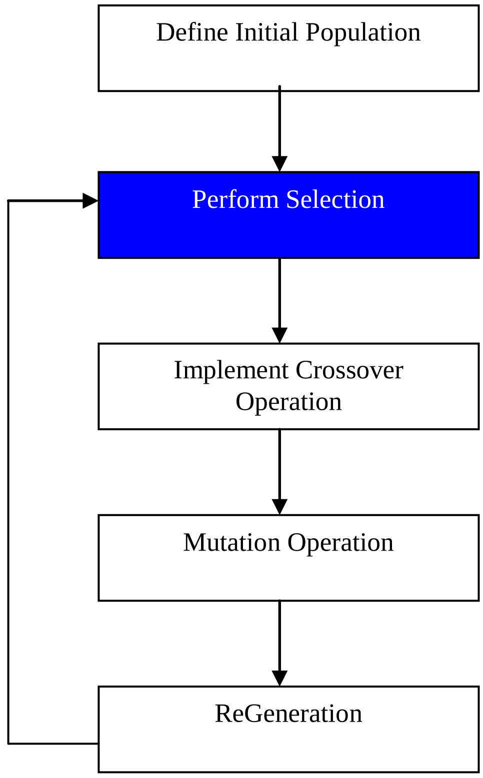

Figure 3 : Flow of Genetic Processconclusion

The Triangulation generation over the random set of point problem is one of the major algorithmic problems that always require some kind of optimization to get the results in efficient time. In this present work we have used Genetics to identify the focused points and to eliminate the hidden points from the points set. As the optimization approach to find the solution of the problem in effective time. We have generated an effective triangulation surface as well as optimized the work.

IV. CONCLUSION

The Triangulation generation over the random set of point problem is one of the major algorithmic problems that always require some kind of optimization to get the results in efficient time. In this present work we have used Genetics to identify the focused points and to eliminate the hidden points from the points set. As the optimization approach to find the solution of the problem in effective time. We have generated an effective triangulation surface as well as optimized the work.

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