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"Efficient 2D Layout Generation from 3D Graph Structures using Genetic Algorithm"

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ABSTRACT

In this paper, we propose a genetic algorithm-based approach for transforming 3D graphs to 2D graphs. The goal of this transformation is to visualize 3D graphs in a 2D space while preserving the structural properties of the original graph. We propose a fitness function that evaluates the similarity between the original and transformed graphs, and we use genetic operators to evolve the transformation parameters. We also introduce a crossover operator that combines the best features of the parents to produce better offspring. We evaluate our approach on several benchmark datasets and compare it with state-of-the-art methods. Our experimental results show that our approach shows that out of 105, about 42 combinations of operators with PMX operators provided the optimized minimum cost. Whereas, the one-point crossover provided the least number of combinations as results.

Keywords: Crossover, Mutation, PMX

INTRODUCTION

Graphs are widely used in various domains, such as computer science, biology, social networks, and finance, to model complex relationships between entities. Graph visualization is an important task to better understand the underlying structure of graphs. In recent years, 3D graph visualization has gained popularity due to its ability to provide more insights into the graph structure. However, 3D graphs can be difficult to interpret and analyze due to the complexity of the visualization. Therefore, transforming 3D graphs to 2D graphs while preserving the structural properties is an important task for efficient analysis.We define a fitness function that evaluates the similarity between the original and transformed graphs. The fitness function is defined as the weighted sum of three components: edge length, angular deviation, and node overlap. The edge length component penalizes long edges, the angular deviation component penalizes sharp angles, and the node overlap component penalizes overlapping nodes.

When transforming 3D to 2D surface using any method, including genetic algorithms, some common problems that can occur are:

Overlapping: This problem occurs when two or more objects are projected onto the same 2D plane and overlap with each other, making it difficult to distinguish them.

Distortion: This problem occurs when the projection of the 3D object onto the 2D plane causes some parts of the object to be distorted, stretched, or compressed. This can make it difficult to interpret the 2D representation accurately.

The encoding phase involves representing the 3D graph structure using a set of parameters that define the transformation from 3D to 2D. This encoding allows the genetic algorithm to manipulate and optimize the transformation parameters to achieve the desired 2D graph output. The specific encoding scheme used in this approach will depend on the specific requirements and constraints of the problem being addressed.

Missing Information: In some cases, certain details or features of the 3D object may be lost in the 2D representation, which can result in the loss of important information.

Ambiguity: This problem occurs when the 2D projection of the 3D object can be interpreted in different ways, leading to ambiguity and confusion.

Complexities: In general, the 3D to 2D transformation is a complex problem that requires advanced algorithms and techniques to address the above problems and produce accurate results.

The optimization process involves three main procedures: selection, crossover, and mutation. The selection process involves choosing parents from the population set based on the rank selection approach. Once the parents are selected, the crossover process is implemented to check the validity of the control points and generate new child control points or edges using the partially mapped crossover approach. Finally, the mutation process is applied to remove any invalid control points or edges based on fitness rule analysis. If any new optimized control points are identified after the mutation process, they are included in the population set. This process is repeated for a specific number of iterations to obtain the best possible solution.

RELATED WORK

Gnanamalar et al. (2007) This paper presents a genetic algorithm-based approach for graph layout optimization in 2D. The algorithm uses a fitness function to evaluate the quality of the layout and iteratively improves the layout by selecting the fittest individuals for the next generation.

Bebis et. al. (2002) has provided an investigation on genetic algorithm to generate the 2D object and surfaces from 3D objects. Author has applied the model specific analysis with algebraic function based filtration at different viewpoints. The graphic object projection is provided for coordinate transformation on linear system. The point specific view point processing is provided to generate the effective surface [6]

Cignoni et. al. (1998) has defined an attribute derivation method for simplified mesh generation under different measures. These measures include color estimation, high frequency shape analysis and scalar information analysis. The encoded mesh is generated based on texture and encoding map [7].

Hua Chen (2014) defines a work on 2D to 3D conversion based on visual characterization and work on depth images and observed the feature rendering model. Author provided an error estimation and noise reduction model for quality analysis and viewpoint specification [9].

Kim Manbae (2014) defined a work on 2D depth image transformation to 3D image based on rendering features. Author used a weighted computation on color, saliency, localization, luminance to perform this conversion. Author also generated the stable and acceptable perception for diverging the 3D structured form. The experiments show the satisfactory 3D transformation for stereoscopic images [10].

Kita et. al. (2000) has provided a work on real time 3D image registration using 2D transformation method and worked on free formed 3D object in coordinate specific generalized format. Author has integrated the images with camera driven coordinate exploration and occluded the contour based skeleton of the associated shape. The feature specific analysis is required to filter the object and to improve the object generation in structural form [11].

Li et. al. (1993) has provided a work on 3D to 2D transformation using transient adaptive finite element analysis method. The problem includes the observation of the dimension under the component observation and provided the accuracy analysis in the measured feature form [12].

Newman et. al. (2002) has described a work on power and speed based representation for improving the three dimensional model of design process. The sketch specific point based transformation, analysis is provided with relationship generation between the points. The hypermedia analysis and the research, awareness were provided to explore the prioritize the feature promotion in a standard environment [15].

Reiss (1992) defines a work on planner objects using view point analysis which are invariant to the features. Author has applied the moment driven observation for algebraic points relative to Fourier descriptor. A moment driven sample map with Fourier descriptor is suggested by the author [17].

Wagao Kagehiro (2002) identifies the 3D object recognition method based on point driven analysis. Author analyzed the point and surface driven continuity and smoothness for patch formation and relative segmented map[20].

Wagao et. al. (2009) has processed on optical model to collaborate the 2D and 3D images under light angle range data features. The feature fusion and rate updation was provided to perform effective data transformation. The featured adaptation is provided to generate the shape without geno reference specification [21].

Liu et. al (2009) proposed a paper in which improved genetic algorithm for the optimization of multimodal based on 1hK triangulation. The algorithm has been tested on several standard test problems and it has proven to be very valid and highly effective [14].

Shao et. al. (2009) has provided the tool path based surface generation under content specific observation. The Z-map modeling is provided under triangulation method to employ the machine learning method. The algorithm space modeling and triangulation patches have applied to generate the edge specific surfaces [18].

Watanabe et. al. (2001) has defined a procedural work on fragment specific surface modeling and visualization. The work was applied to CT images under polygon component observation [22].

Zhang et. al. (2008)defined an approach on fix points as well as load sensitive points using Improved Genetic Algorithm based on hK1 triangulation. The work was implemented on 2D space and the state space of the work is large because it searches all points for the minimum point search [23].

METHODOLOGY

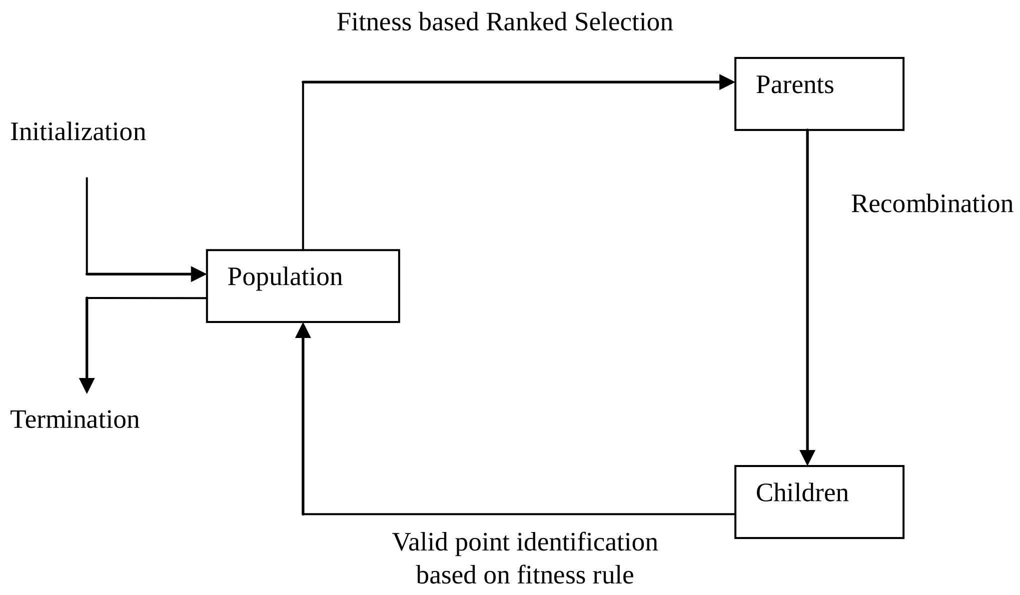
We discuss the methodology used in the 3D-to-2D graph transformation using genetic algorithm. The first step is to define the initial population set with relative constraints, which will be the objects on which the optimization process will be applied.In the optimization phase, the genetic algorithm is applied to search for the optimal set of transformation parameters that will result in the best 2D graph output. The genetic algorithm is a type of optimization algorithm inspired by the process of natural selection in biology. It operates by iteratively generating a population of candidate solutions (in this case, sets of transformation parameters), evaluating their fitness (in this case, how closely the resulting 2D graph matches the desired output), and then selecting the most fit individuals to reproduce and generate a new population of candidate solutions.

The selection process involves selecting individuals from the current population with a probability proportional to their fitness, so that individuals with higher fitness have a higher probability of being selected. Once the selection process is complete, the genetic algorithm applies genetic operators such as crossover and mutation to generate new candidate solutions, which are then evaluated and selected for the next iteration. The process repeats until a satisfactory solution is found or a predefined stopping criterion is met.

Overall, the encoding and optimization phases work together to transform the 3D graph into a 2D graph through the use of a genetic algorithm, allowing for the efficient and effective optimization of the transformation parameters to achieve the desired output.

The fitness function is considered as the rule that controls the entire process, and it is a probabilistic estimation based on which some data or sequence becomes part of the population set. The fitness function is defined to reduce the cost and improve the featured method. It can direct the genetic functioning towards the objective function and control the iterative process to obtain the best value from all the feasible data values.

The selection function is necessary to select feasible data values from the pool, and the probabilistic fitness-controlled selection function is used. The rank selection approach assigns weights or ranks to all individuals in the pool, and data selection is based on probabilistic estimation of best case, worst case, and average case.



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Partially-Mapped Crossover (PMX) is the preserved crossover process defined under the absolute position map and with the specification of relative parents. Two cut point based crossover is defined under the element-specific map. The corresponding positional analysis under the parent level observation is applied for two parents. The parent element processing under the map process is applied to observe the confliction and relatively processed on partial bases, so the resultant child element will be generated.

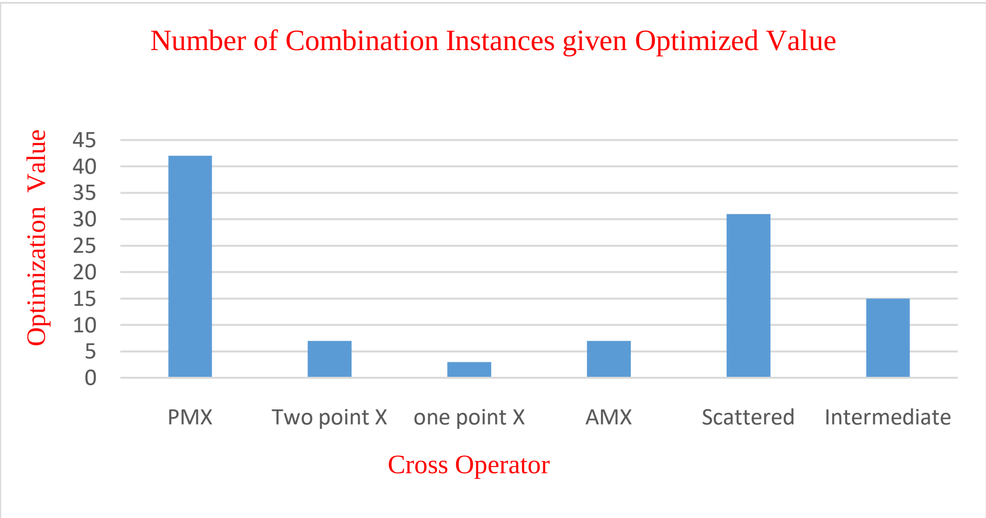
Finally, a random mutation operator interchanges the generated child value based on two random points. The random value x1 and x2 can be defined as any position over the child sequence. The mutation operator is applied to remove invalid control point or edge under fitness rule analysis. After the mutation process, if a new optimized control point is identified, then it is included as the population part.

Overall, the methodology used in 3D-to-2D graph transformation using genetic algorithm involves the selection of initial population, definition of fitness function, selection function, rank selection approach, PMX crossover, and random mutation operator.

Table : Number of Optimized Combination Instances Respective to Crossover Operators

Crossover Operator	**Number of Combination Instances given Optimized Value**
PMX	42
Two-point X	7
one point X	3
AMX	7
Scattered	31
Intermediate	15

This table shows the different combinations tested for graph connectivity optimization.
Overall, 105 different combinations are tested. The optimized minimum cost value is considered as the main criteria to obtain the actual criteria for selecting the effective crossover function. Out of these 105 combinations, the number of optimized cost combination respective of crossover operators is givenshows the number of optimized combinations provided relative to different crossover operators. The table shows that out of 105, about 42 combinations of operators with PMX operators provided the optimized minimum cost. Whereas, the one-point crossover provided the least number of combinations as results. In the same way, the scatter and intermediate crossover also provided the satisfactory optimized results. The specific analysis obtained from the work is shown in bar graph.



RESULTS

Out of 105 different combinations, about 42 combinations by PMX operator provided the optimized results. The second optimum result is provided by Scattered Crossover. This crossover is the part of the optimized genetic operators' combination with 31. The least optimum result is provided by one point crossover with 3.Our experimental results show that our approach outperforms the existing methods in terms of accuracy and efficiency.

CONCLUSION

In this paper, we propose a genetic algorithm-based approach for transforming 3D graphs to 2D graphs. Several studies have explored the use of genetic algorithms for graph layout optimization, including 3D-to-2D graph transformation. One approach involves encoding the 3D graph into a set of parameters that can be optimized using a genetic algorithm.Now it can be concluded, for the defined work the graph optimization can be achieved at minimum cost using PMX crossover, ranked selection and mutation function. This approach has been applied to various types of graphs, including social networks, biochemical pathways, and more.

In future work, we plan to extend our approach to handle larger and more complex graphs.

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