Research on 3D CAD Model Retrieval Based on Ant Colony Algorithm

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Abstract. In order to better implement the reuse of CAD model, a 3D CAD model retrieval algorithm using ant colony algorithm is proposed. By extracting B-rep information of CAD model, the model is represented by attribute adjacency graph. If there are similar features or local structures in two CAD models, then there should be common subgraph in attribute adjacency graph corresponding to CAD model. The ant colony algorithm is used to detect common subgraphs in attribute adjacency graphs, the local detail features with similarlocal CAD models are obtained. Then CAD models are evaluated by comparing similar local detail features. The experimental results show that the algorithm can achieve 3D CAD model retrieval better, the retrieval performance is higher than the general domain retrieval algorithm, and CAD model design and manufacturing knowledge can be reused.

Introduction

With the development of 3D modeling technology and the expansion of computer networks, the number of 3D CAD models that can be shared and reused rapidly increases. Under existing conditions, how to effectively manage and retrieve existing 3D CAD models and how to improve the sharing and reuse of 3D CAD model resources have become urgent problems. Therefore,3D CAD model retrieval technology has gradually become a hot topic in computer graphics. 3D CAD model has complex geometry and topology structure, how to enable designersquickly and accurately find the reusable models from massive CAD models and use these resources efficiently designnew products to meet the requirements has become a challenging problem to solve the urgent.

This paper focuses on the study of 3D CAD model and retrieval technology based on ant colony algorithm. The results show that the retrieval is simple and accurate.

Retrieval Model and Algorithm

The retrieval model provides a way to measure the similarity between a query and a document. These models are based on a common idea that the more terms shared by a document and a query are, the more relevant between the document and the query will be.There are many uncertainties in language itself. In reality, a similar concept may be expressed in many different terms. For example, New York and the Big Apple may mean the same thing. In addition, the same term can also have many kinds of semantics. For example, the meanings of the noun form and the verb form of bark and duckare quite different.

A retrieval model is an algorithm that deals with query Q and collection of document{D1, D2,„, Dn}. The process is to calculate each document Di ($1 \leqslant i \leqslant n$) and the query similarity SC(Q, Di).

The commonly used retrieval models are as follows.

Vector space model

We represent both the query and the document as the vectors in term space, and then we can calculate the similarity between the two vectors.

Probability model

The probability is calculated from the possibility of each term appearing in the relevant document based on a document set. The joint probability of all the terms matching the document and the query is calculated to obtain the similarity between the document and the query.

Language model

For each document, a language model is established and the probability of “generating” queries for each document is calculated.

Boolean retrieval

In the original Boolean query results, we assign a score to each document so that the query results can be sorted. The specific approach is to assign each query term to a weight, and then use the weight to calculate the similarity between the document and the query.

CAD Model Attribute Graph Representation

CAD model has very strict requirements on the accuracy, which is represented by B-rep model. The model B-reprepresentation is to define the model as a limited space which is surrounded by boundary surface, so that a body can be represented by its boundary (i.e. the subset). Each surface can be defined by each boundary and each boundary can be defined by each vertex. Through the precise description of each vertex, each boundaryand each surface, the 3D CAD model can be accurately described.

By extracting B-rep information in 3D CAD model, the model can be represented by attribute adjacency graph. Every vertex of attribute adjacency graph corresponds to one surface of CAD model. The attributes of a surface (such as the type and the direction of the surface) are taken as the attributes of a vertex.The connection between the twosurfaces is a boundary of the graphand the type and the concavity of the boundary are the attributes of the boundary.

The problem of the similarity comparison of CAD model can be converted to the problem of the detection of the common subgraph of theattribute adjacency graph. The definitions of a common subgraph and a maximum common subgraph are given as below.

As shown in Figure 1,there aretwo CAD models and attribute adjacency graphs.Although the two models have different overall shapes, they have the same local structure as shown in Figure 1. The graph formed by nodes in elliptic graph as shown in Figure 2 is the common subgraph which is also the maximum common subgraph of the two attribute adjacency graphs.

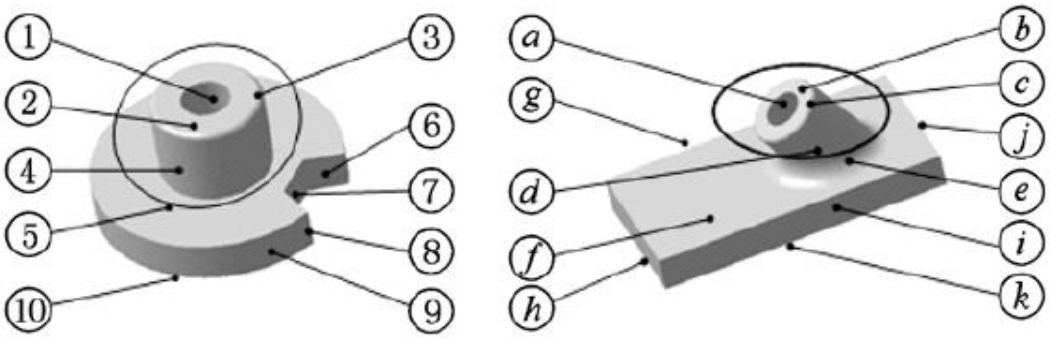

Figure 1. CAD models

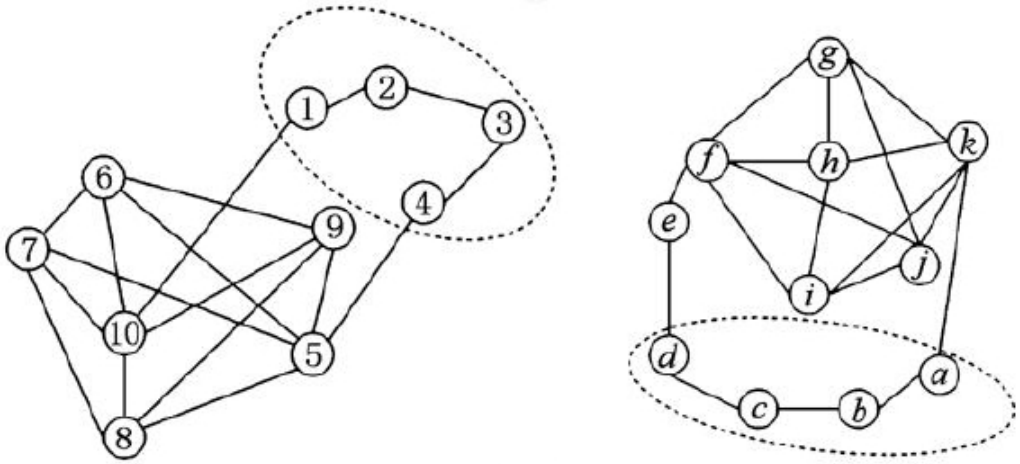

Figure 2. Attribute adjacency graph

CAD Retrieval Based on Ant Colony Algorithm

Ant colony algorithm is a probabilistic algorithm for searching the optimal path. It was proposed by Marco Dorigo in his doctoral thesis in 1992, inspired by ants' behavior of finding paths during the search for food.

The principle of ant algorithm is as follows. It is due to the pheromone and the environment that ants can find the shortest path during the search for food. Assuming there are two pathsthat lead to the food from ant nest, at the beginning, the number of ants on the two paths is similar. When ants reach the end of the paths, they will return immediately. The time needed by the ants on the shorter path is shorter, the repetition rate is higher and the number of ants returning in unit time is more which leavemore pheromones, that will attract more antsleaving much more pheromones. The longerpath is the opposite. So more and more ants gather on the shorter path.

The problem of detecting the maximum common subgraph of the two graphs is a NP complete problem and it is very complex. In this paper, a polynomial time algorithm ant colony algorithm (ACA) is used to detect the common subgraph. Ant colony algorithm is inspired by ants' behaviors of searching food. It is a simulated evolutionary algorithm based on population. It is originally used to solve traveling salesman problem. The algorithm of this paper first establishes an association graph by the given adjacency graph of the two CAD model attributes, and then uses ant colony algorithm to detect the common subgraph of the CAD model. The algorithm can detect the similar local detail features of the two CAD models.

The schematic figures of the association graphs are shown as shown in Figure 3.

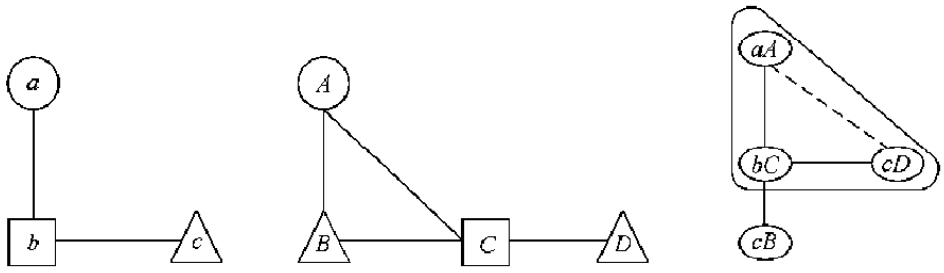

Figure 3 Schematic figures of association graphs

The nodes of circular, square and triangular respectivelyrepresent the vertices of different attributes.According to Step1,the correlation graph HV consists of nodes aA, bC, cB and cD; according to Step2, nodes aA and bC are connected by a boundary. The other boundaries of the association graphs are connected by the same way. Because the vertices a and c in G1 and the vertices A and D in G2 are not adjacent, there is also one boundary connection between nodes aA and cD, the correlation graph HV is shown in Graph 2C.The vertex set in the triangle is called the maximum clique of the correlation graph HV. Then we detect the problem of common subgraph of the two CAD models adjacency graph and transform it into the maximum clique problem of

detecting association graph. Here, the definition of the maximum group is given first.

Taking Microsoft Visual Studio 2008 as an integrated development environment, a 3D CAD model test library is built. There are 200 common CAD models in the library. In the experiment, the parameters of the ant colony algorithm are set as follows:α= 1， ρ= 0. 99, the maximum number of iterations maxiter= 3000, τmin= 0. 01,τmax=6. 0, the ant number in ant colony m= 10. Comparing the similarity of 6 CAD models, we can see that the more the similaritiesor the local structures are among the models, the higher the similarity values are.

Conclusion

In this paper, a retrieval algorithm for reusable 3D CAD model is proposed. First, CAD model is represented by attribute adjacency graph. Then ant colony optimization algorithm is used to detect the similar features or local structures contained in CAD model. Finally, the similarity evaluation of CAD model is achieved based on similarity or local structure. The biggest feature of the algorithm is to fully consider the similarity of the local details and features in the design and manufacturing process. Only when local detail features are retrieved, can CAD model be reused better. The experimental results show that the comprehensive performance of the proposed algorithm is obviously higher than the shape distribution algorithm and the spherical harmonic algorithm.

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