Chapter 7
A 3D Geometry Model Search Engine to Support Learning

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ABSTRACT
Due to the popularity of 3D graphics in animation and games, usage of 3D geometry deformable models increases dramatically. Despite their growing importance, these models are difficult and time consuming to build. A distance learning system for the construction of these models could greatly facilitate students to learn and practice at different time and geographical locations. In such a system, an important component is the search engine, which serves as both the source of teaching materials and a platform for sharing resources. Although there have been a lot of works on text and multimedia retrieval, search engines for 3D models are still in its infant stage. In this article, we investigate two important issues: feature analysis, which affects the general usage of a system, and speed, which affects the number of concurrent users. Our method offers a mechanism to extract, index, match and efficiently retrieve features from these models.

INTRODUCTION
The Internet has become an important place for educational resources in recent years. Ranging from instructor-led learning to self-study, students are encouraged to actively learn from this free library. To find relevant information and learning materials from this huge knowledge collection, an effective search engine is typically needed, which means that the search engine may be considered as the entry point to the Internet. One notable search engine for text documents is Google. Taking a simple example of searching for a mathematic equation, a student may type in some descriptive keywords of the equation and the search engine will return its definition and usage. Hence, the search
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engine may also be considered as an important educational tool to help locate useful information from this huge information/knowledge/resource database of the Internet.

In the past, education was generally conducted through textbooks. With the advance in multimedia technology, we are beginning to see a lot of multimedia educational materials that include images, animation and videos. The use of multimedia in presentations not only promotes students’ interests and interactivity but also helps prolong their memory on the subject materials (Smith, 2000). Similar to text and documents, there is a growing demand for more effective search engines that support multimedia information too. 3D geometry models, being a type of multimedia information, are getting popularity in recent years due to their widespread use in animation and games. However, geometry models can also be used in many 3D applications for education too. For example, Li (2004) discusses how to progressively transmit geometry models in a 3D training system or a 3D engine for educational games. Despite the advance in 3D modeling tools, geometry models are still difficult and time consuming to build. Students often need to spend a long time to learn and to construct geometry models because of the deep learning curve and the effort in producing fine geometry details. Here, a learning system that guides the students in constructing the desired models from existing models of similar type may help reduce the learning time, model construction time and encourage model sharing. To support this type of applications, an efficient geometry search engine that facilitates sharing and reuse of geometry models is essential. A typical scenario is that one may want to construct a model by combining parts coming from multiple existing models created by others. This may require the retrieval of some desired models based on some user defined specifications (Funkhouser, 2004). With the retrieved models, the user may then cut and paste parts to form the new model.

As geometry models are becoming more popular, we are beginning to see geometry search engines that are developed for retrieving various 3D geometry data from the Internet or a 3D database, e.g., medical data (Keim, 1999), protein molecules (Kastenmüller, 1998), cultural artifacts (Rowe, 2001), and mechanical parts (Berchtold, 1997). For example, a search engine may help trainee medical doctors search for similar organs, archaeology students search for antiques, and mechanical students search for mechanical parts from a geometry database. Hence, a geometry search engine is useful in many applications including education.

Currently, there is a substantial amount of work devoted to matching and retrieving rigid geometry models efficiently and accurately. For example, Princeton University has developed a search engine (Funkhouser, 2003) where benchmarking is also available (Shilane, 2004). The method presented here, however, targets a more general type of models: the deformable models, i.e., models with similar skeletons but different postures. These models are very useful in designing and creating 3D applications for education and computer games. There are not many search engines designed for 3D deformable models, and they are generally slow because they need to apply graph matching techniques. In our recent work (Tam, 2007), we have presented an effective method for extracting and matching deformation-stable features. However, in order to build a search engine for web-based or distance learning systems, there are two challenges to overcome. First, it should be accurate in retrieval. Second, it should be fast enough to support many concurrent users (Herremans, 1995). In this article, we focus our discussion on the necessary information for building a search engine that supports distance learning.

The rest of this article is organized as follows. Section 2 briefly surveys related work. Section 3 presents an overview of the whole matching framework. Section 4 discusses the representation and storage of features. Sections 5 and 6 discuss
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