Research Experience at the Geometric and Intelligent Computing Laboratory

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During my first semester at Drexel University I joined the Geometric and Intelligent Computing Laboratory directed by Dr. William Regli. There I obtained valuable experience in performing individual research in solid modeling. Currently, I am involved with the National Design Repository project. A long-term goal of our work is to develop uniform methodologies to interact with CAD data in an engineering information management system. Much of my time is spent working on new retrieval techniques for CAD models in polyhedral representation that can be used in the CAD database. We choose to use models in polyhedral representation, since it is a common denominator (and can be easily obtained) for different CAD representations available today.

My very first task was to implement a technique for comparing shape models (any geometric shape; e.g. tree, dolphin, etc.) in mesh representation. Then I adopted this technique so that it could be used to compare CAD models. The technique uses Multiresolutional Reeb Graphs, which are 2D characterizations of 3D shapes based on a predefined function μ that reflects an object's topology. This work was published in the 2003 ASME Design Engineering Technical Conference.

Next, I shifted my focus towards the development of a completely new framework for topological shape matching through scale-space decomposition of 3D models. I was largely under the direction of Dr. Shokoufandeh, a computer science professor focused on object recognition. The reason we decided to develop a completely new technique was because most of the matching approaches for models in polyhedral representation used some kind of function (i.e. μ for Reeb Graph based approach) to capture model's geometry or topology information. We wanted to have a framework that would enable us to extract more meaningful surface features from meshed models. The use of features would allow us to perform better matching for CAD models (all of the CAD models are composed of certain features).

Our new approach was based on the eigenvalue decomposition of a model into meaningful features. Based on that decomposition, a binary tree was constructed. This enabled us to reduce the problem of topological matching to that of computing a mapping and distance measure between vertex-labeled rooted trees. This work was accepted as a full publication to the 8^{th} ACM Symposium on Solid Modeling and Applications in 2003. Later, the extended version of the paper appeared in the Journal of Computing and Information Science in Engineering in December 2003. In comparison to my first task, my work on the scale-space based technique required significantly less advisor supervision.

By the time of the acceptance of my publications, I had my own ideas for the extension of the scale-space based technique. The experimental results for scale-space based approach showed that the use of features in matching meshed CAD models could significantly improve the accuracy of the retrieval process. However, this new approach relied on global information of the model and would fail if only part of the model was available.

I have successfully applied my ideas in order to address the shortcomings of the approach. As a result, I came up with a new technique that was able to extract surface features from the CAD models in polyhedral representation. The highlight of this technique is that it can deal with CAD models even if only part of the model is available. In addition, the feature-extraction technique is stable to noise which enables it to work with models acquired from 3D laser scanner. Most of the feature extraction approaches for models in polyhedral representation can not work with partial models nor noisy data. There is a number of applications for the feature extraction technique that can work with partial and noisy data. For instance, it could be used in reverse engineering: if only a physical engineering part is available, one could take a 3D scan (even only one side of the part to create a partial model) and then query a database of CAD models using the obtained scan in order to get the CAD model (similar or exactly the same) or to establish what machine (or any other engineering assembly) the physical part came from.

This work was presented in the 2004 ASME Design Engineering Technical Conference. Later, it was invited to the Journal of Computing and Information Science in Engineering and is currently under peer review. At this time, I'm working with a graduate student on developing benchmark datasets for evaluating techniques for automated classification and retrieval of CAD objects.

Throughout my experience at the Geometric and Intelligent Computing Laboratory I have been able to obtain new knowledge and apply it to the research work in solid modeling. At first, I required constant supervision from my advisors, but as my work progressed, I was able to perform more and more research work on my own. For instance, the feature extraction technique is the result of my individual research work, since I did not require any supervision from my advisors. My successful work at the Geometric and Intelligent Computing Laboratory makes me confident that I am capable of doing research work on my own. At this time I have a strong intention of pursuing a doctorate degree after graduating from Drexel University.