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Biography

I'm a Ph.D. student at UC Irvine. Before that, I was a research assistant in NYU Multimedia and Visual Computing Lab, advised by Professor Yi Fang. I am broadly interested in 3D Computer Vision, Pattern Recognition and Deep Learning.

Capstone Project: Towards The Design Of Intelligent 3D Computer Vision

1 Description

With recent developments in advanced 3D acquisition and printing techniques, we have observed an exponential increase in 3D data across domains as diverse as engineering, entertainment, biology, and medicine. Therefore, as 3D acquisition increases the number of 3D object models, the need to identify and process various geometrically diverse object models efficiently and effectively requires computers being able to perceive the similar and different features on a model in a robust and efficient manner as according to human perception and computational analysis. Current 3D analysis focuses on the preparation of shapes for field-specific analysis, effectively capturing 3D objects, digitizing them and converting them for relevant applications in shape referencing and matching. Existing challenges for 3D shape analysis techniques are posed by geometric structural deformation, incompleteness of 3D data, and noise present in 3D objects from rendering and scanning issues of 3D objects. This capstone project aims to design an intelligent framework for addressing such challenging issues from ever-growing 3D datasets. We intend to develop a system that takes 3D objects and presents them in various robust analytical models. Specifically, the proposed framework seeks to develop a cohesive and consistent shape analysis pipeline system that can correctly identify and preserve the important features of shapes. These important shape features will be processed and modelled into shape correspondences for 3D shapes registration, shape descriptors to evaluate the geometric similarities between shapes for 3D shape retrieval, and a clustering paradigm for discerning parts for 3D shape segmentation. The overall shape analysis pipeline is intended to deliver a standard process for capturing 3D object information from different analytical perspectives for further field-specific interests, such as categorization, detection, and representation. These perspectives are based in one-to-one, one-to-all, and introspective object comparisons that provide deep yet generally important understanding of shape features, opening them to further studies in matching, relating, and labelling.

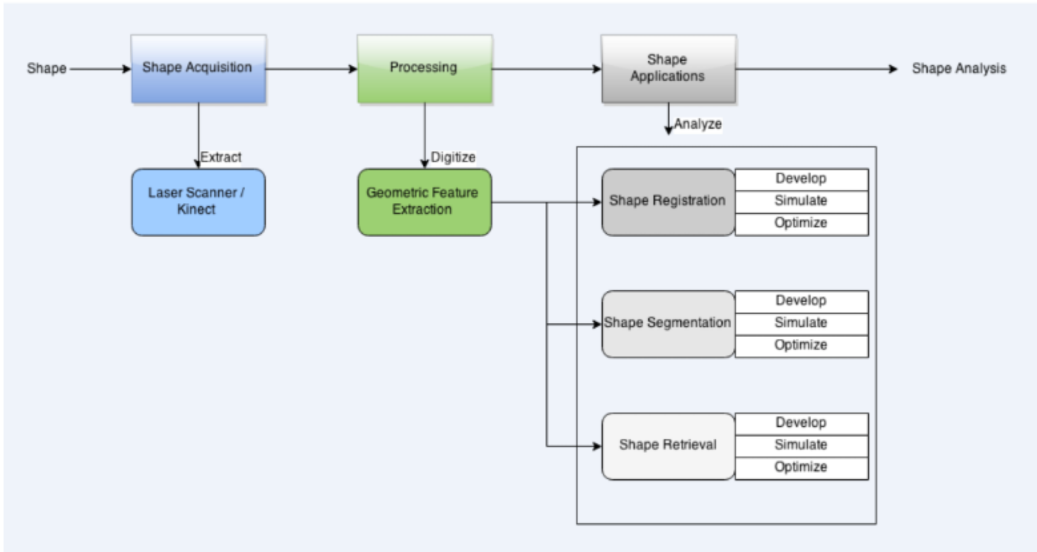

Figure 1: Design Flowchart.

2 Method

In this project we intend to develop a system that takes 3D objects and presents them in various robust analytical models. Specifically, the proposed framework seeks to develop a cohesive and consistent shape analysis pipeline system that can correctly identify and preserve the important features of shapes. These important shape features will be processed and modelled into shape correspondences for 3D shapes registration, shape descriptors to evaluate the geometric similarities between shapes for 3D shape retrieval, and a clustering paradigm for discerning parts for 3D shape segmentation. The preliminary design of the project consists of a system pipeline of a shape analysis algorithm for identifying shape correspondences utilizing various technologies: triangle meshes for shape acquisition format, geodesic diffusion distance for shape retrieval, heat kernel analysis for shape segmentation, and symmetry-aware nonrigid matching. Each component of shape analysis will undergo phases of development, simulation and optimization. Figure.1 demonstrates the overall structure of the design. In the final design, a program was created to apply to shape registration and shape retrieval analysis data for the purpose of demonstration. The demonstration program was made to represent the entire process working. Another significant change in design was that instead of building geodesic diffusion distance data from SIFT features, since SIFT features are sets of vector properties based on the 3D object, the shape retrieval process performed its correspondence activities

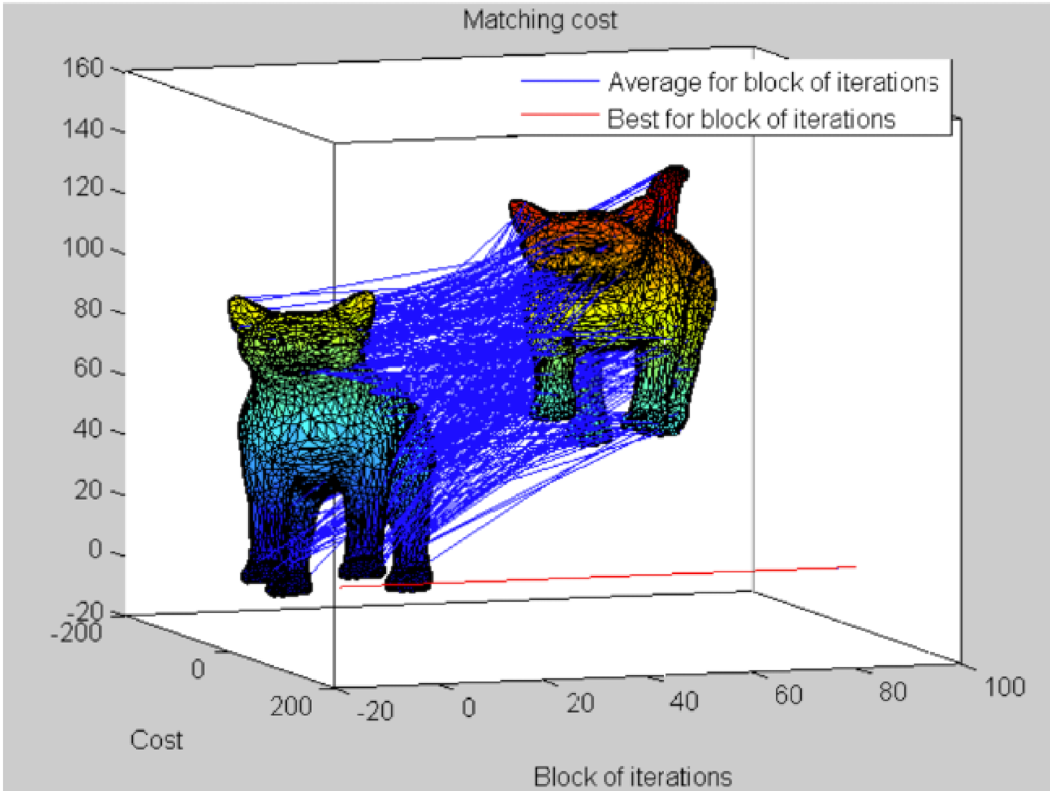

Figure 2: Shape Registration Viewer.

on SIFT feature data directly instead of additionally analyzing SIFT features for geodesic diffusion distance data. In terms of optimization, the ant colony optimization method replaced the Hungarian method in shape registration. It works equivalently with the Hungarian method, but the usage of ant colony optimization builds the linear programming paths with path frequency. On top of search engine optimization, K-means clustering was also used to create categorical data for shape retrieval, simplifying the process.

3 Results

In this section, we conduct experiments to demonstrate the effectiveness of the proposed method. After the completion of shape registration and retrieval, a demonstration program was created to represent a user interface of how the analysis data is interpreted. This demonstration program was created using MATLAB GUI, and covered the shape analysis pipeline. Upon launching, the program started with the extraction of SIFT features from models in a directory. Then, shape retrieval was performed on the model, displaying a list of the shape retrieval values. Finally, the user would choose two models to com-

Shape Analysis Process	Noise Error	Incompleteness Error
Shape Registration	15.8%	17.2%
Shape Retrieval	19.9%	30%

Table 1: Noise and Incompleteness Test Results.

pare, and correspond them. Figure.2 shows the interface of the demonstration program. Table 1 shows the noise and incompleteness test results. Shape registration showed consistent ability in being able to discriminate shapes even with noise. However, shape retrieval performed worse in incompleteness, finding issues with many values. Retrieval values in testing incompleteness were usually lower than the original values, indicating a loss of features due to partial modelling is identified by shape retrieval.