Matching and Visualization for Refitting Materials of Stone Tool Based on 3D Measured Point Cloud

Abstract

In Japan, lithic materials are most important evidences of archaeological research in the Palaeolithic and Jomon periods. Most organics, such as bones or wood, decay easily, due to the hot and humid weather, and in the acidic ground soil. To make a stone tool, the edge of a rock is struck repeatedly with a pebble, and flake pieces in various sizes are obtained. These pieces are called lithic refitting materials. The flakes are pieces peeled for adjusting the core shape, while the core is the rock left as a raw material for a stone tool when flakes are peeled. Refitting lithic materials is the most important research work for analyzing human activities of that period. By this work, the manufacturing process of stone tools can be restored and human activities in the ancient times can be conjectured. The original form of relics can be known, while, additionally these reassembled stone tools can also have educational values as exhibition materials at history museums. However, reassembly of stone tools is a complex and hard task, it consumes a lot of manpower and time. In order to efficiently process massive stone tools, this thesis studied computer graphics techniques to assist this archaeological research. This work is mainly composed of the following two aspects: lithic materials matching and assembly instruction visualization.

In recent decades, a large number of methods have been presented to solve various registration or matching problems, however, few methods have been successfully applied to the matching of flakes. In the previous work, it is possible to process refitting materials from a single stone core, while it is impossible to finish them from multiple stone cores. By improving this method, this thesis proposed a new method for refitting mixture lithic materials from multiple stone cores by matching flake surfaces. First, each of the input point clouds of lithic materials is segmented and simplified to obtain flake surfaces. Then, according to

several refitting principles in archaeology, the lithic materials are matched starting from a stone core by searching the best matching flake surface. Additionally, the flake surfaces of matched lithic materials are detected and reconstructed. The matching process is repeated until all data are matched.

In the next research, independently from the polygon mesh, a new algorithm is proposed to process pairwise matching of stone tools based on contour points and mean normals of regions on all flake surfaces, according to the characteristics of the flake models. The input of our method is a pair of flake models from the point cloud. First, the normal vectors are calculated for each point. Second, each flake surface is segmented and uniformly downsampled. After that, the contour points are extracted. Finally, the flake surface pair with the best matching is rapidly identified based on the contour points, and further matching is conducted using the nearest point sets.

For studying stone tools, repeating assembly and separation of stone tools is an inevitable process. However, ambiguous traditional 2D illustrations are commonly used to instruct this process. The 3D exploded view is an effective way for instructing the assembly, and it has been widely used in many fields, while seldom being used in archaeology. We applied a powerful presentation technique, 3D exploded view, to stone tool models. Based on the refitting results of lithic materials, a method is studied to calculate relationships and directions of stone tool models for generating exploded graphs with point clouds. In addition, the assembly and separation sequences is computed. According to archaeological conventions, the animation of the rotating separation of a flake is also generated. Moreover, lithic knapping methods and relic excavation reports are analyzed to evaluate the difference of flake knapping sequences between the contents of report and automatic generation.

We have implemented the proposed methods, and tested with lithic material 3D models. Two groups are efficiently finished through our matching method by refitting materials from mixture of several groups. The limitation of this method has been solved by the next research. These

experimental examples indicated that the matching methods can achieve superior matching results. After that, the explosion graphs of two groups are generated , and the assembly and separation sequences are computed and analyzed. The experimental results of stone tool assemblies indicate that 3D visualization technology can assist in the efficient research of assembly and separation instruction of stone tools for chipped stone tools.