論 文 の 内 容 の 要 旨

Abstract

論文題目　　Fabrication-aware 3D Geometry Optimization
（実際のファブリケーション過程を考慮した三次元形状最適化）

氏　　名　　中島　一崇

Digital fabrication is widely spread and used for actual manufacturing in recent years. There are many researches about fabrication not only in the field of engineering, but also computer graphics. However, the applications of the digital fabrication are still limited and it cannot be said that digital fabrication is commonly used.

One of the critical reasons that prevents digital fabrication from becoming common is its inevitable manual effort. Digital fabrication procedure consists of following four steps; 1) 3D shape is designed by using CAD software or sculpting software. 2) Pre-processing for actual fabrication is applied to the shape. 3) The shape is fabricated with some fabrication techniques. 4) Post-processing for finishing is applied to the fabricated objects. The 2) pre- and 4) post-processing are done by artists or 3D printing engineers manually, and which takes many efforts. These pre- and post-processing significantly depend on fabrication techniques users employ, and thus the manual efforts are largely varied. To our best knowledge, minimizing such manual efforts are not well studied yet.

In this thesis, we focus on two commonly used fabrication techniques, molding and powder-type 3D printing, and propose practical methods to minimize their pre- and post-processing manual efforts. Specifically, we propose two methods; i) an interactive method for decomposing the input shape into moldable parts and semi-automatically creating mold piece geometries. ii) Automatic drain hole position optimization for powder-type 3D printing.

Molding process consists of three following steps; 1) Assemble mold pieces. 2) Pour liquid material such as resin into the void between mold pieces, and

solidify the material. 3) Disassemble mold pieces and remove fabricated object from the mold pieces. When we fabricate objects with molding, shapes to be fabricated must be moldable (i.e. can be removed from mold pieces after fabrication). This moldability constraints can be formulated that there is no 3D geometrical feature called undercut. However, it is not practical to naively judge whether there is any undercut due to its computational costs. Furthermore, the cutting seams are significant disturbances in the visual quality of the assembled models, and thus it is necessary for users to freely add some constraints of the cutting seam positions. To solve the problem, we propose a semi-automatic method to decompose a 3D mesh and design mold pieces with user-defined constraints in interactive speed by approximating the input mesh.

For 3D printing, it is common to hollow the target shape for reducing the amount of material and the cost for materials. Different from fused deposition modeling, which requires infill structure to support the printed object itself, almost all target shape is hollowed when powder-type 3D printing technique is employed. However, with powder-type 3D printing, unsolidified powder material is enclosed by solidified shell, and thus drain holes are needed to recover and reuse such trapped powder. In current practice, the drain holes are manually placed by designers or 3D printing engineers. For specifying drain hole positions, we propose an automatic optimization method that computes drainability on the surface of the input mesh, and finds the best position for drain holes. Computing the drainability with physics-based simulation for powder material movement is not practical due to its expensive computational costs. The proposed method extends the concept of the radiosity method, which is used to compute global illumination efficiently, and approximates the powder movement with matrix operations.

In this thesis, we propose two methods for minimizing the manual efforts for typical fabrication techniques. We are confident that our insights accelerate the researches about the manual efforts for fabrication.