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THESIS OUTLINE

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A faster way to generate better planar mapping from 2-manifold surfaces by bounded-parameterization

Mesh parameterization is defined as a problem to compute a mapping between a 3D manifold surface and a suitable target domain. In general, mesh parameterizations are formulated to generate a mapping from a 3D triangulated surface and a certain 2D planar domain. However, they require a specific topology of input mesh first. Since image-like information is a favorite one to work with it, therefore, there are many cases where a topological disk surface is specified to be the input of parameterization processing. To resolve such requirements, we need to convert the input surface into disk topology, by a homotopy basis. Some parameterizations also have restrictions on the input surface such as disallowing any holes inside it. Moreover, parameterization between these two domains causes unavoidable distortion errors such as stretch. The homotopy basis without any strategy may generate a large distortion result. This thesis presents an enhanced process to create continuous mapping information from any kind of 2 manifold surfaces by bounded-parameterization without pre-analysis.

First, to convert an input surface into a disk topology patch that be required for a surface parameterization, this thesis presents an enhancement method to generate a cut path in high-genus surface which also can apply to any kinds of genus 0 surfaces by defining a cut path at the areas where geodesic distance's paths are crossing together. The areas can be categorized into two types, crossing at the edge and crossing nearby the edge. Those areas can be found by analyzing edge's accessible windows and path direction routes in a geodesic distance algorithm. Also, a proper approach to handling holes inside the surface with the cut path is introduced by connecting with the shortest paths to the main cut path. The experiment results shown an improved cut path in high-genus surfaces in tunnel areas with a minor extra calculation time from the original method.

After the surface was converted into a disk topology patch, an enhancement method for extending cutting path in iterated cut augmentation is presented. By only analyzing circular parameterization in each iteration, it uses the highest stretch face' s location and overall stretch error information to determine iteration's termination without performing heavily computing stretch-minimizing parameterizations that be used in the original method. The proposed method give more stable results and a better mapping information at last.

Second, to get an optimal result from parameterization, this thesis presents various approaches for constraints optimization in bounded-parameterization, to deliver the lowest stretch error as possible. In circular parameterization, it is not necessary to perform optimization because circle mapping can be rotated to any degree. However, square parameterization may need optimization process. The easiest way for delivering the lowest stretch square parameterization is to do 25% brute-force approach with a stretch-minimizing parameterization method. However, it will consume a lot of calculation time and resources. Heuristics optimization was used to optimization this problem but failed to deliver expected result. To overcome brute-force drawbacks, sampling and circular mapping analysis approaches were presented. Sampling method is a method that samples constraints setting as interval to define the optimal area then perform deep-checking that area to get the actual optimal constraints setting. It can reduce the computational time more than half and still can maintain stable result same as brute-force. Also, a simple formula to calculate step interval value is also presented. For circular mapping analysis method, by observing stretch error of faces around boundary area in circular mapping, it can predict an optimal constraints setting in square domain. It can represent which two ideas how to constrain and then select a better one as an optimum. They are focusing highest stretch vertex and focusing high stretch vertices in circular mapping, to be around corners of the square. It can reduce calculation cost to only 3 parameterizations but still cannot guarantee the same result as brute-force one.

At last, a hybrid approach is presented by combining the two proposed approaches to minimize calculation and preserve the best result that suits for a restricted calculation environment. It is done by using circular analysis approach first to determine an initial searching scope and, then apply sampling approach to determine the actual optimal mapping. The result shows that it can reduce a lot of calculation while maintaining the stable result as brute-force approach.

On application topic, this thesis presents an example how to utilize square mapping with other fields besides computer graphics. Reaction-diffusion mesh was presented how to use spiral 2D reaction-diffusion to control deformation on a tube mesh. And, cooperate with a machine learning or optimization system such as a genetic algorithm to resolve a problem challenge. The system demonstrated how to move a solid ball to come out from a deformable tube using reaction-diffusion plane with square mapping information to control how to deform the tube. The position of balls will be a feedback to genetic algorithm system to control pattern of reaction-diffusion to be variant over the time. As the result, the balls could move out from the tubes by various patterns in reaction-diffusion fields over the time.