Computational Vacuum Forming with Conformal Mapping

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ABSTRACT

To be determined.

KEYWORDS

Conformal mapping, manufacturing, MRI

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1 INTRODUCTION

Magnetic Resonance Imaging is a powerful, noninvasive imaging technique that can produce high resolution images of human anatomy. While a conventional imaging system captures emitted or reflected light with an image sensor, MRI takes advantage of hydrogen atoms (protons) with intrinsic magnetic moments. The magnetic moments of the protons are aligned with a main field called B_0. They are then excited with a secondary field called B_1. The excitation causes a change in magnetic field which can be detected with a coil due to Faraday's Law of Induction.

$$\epsilon = -\frac{\partial \phi}{\partial t}$$

In a typical system, arrays of coils are used to decrease scan time and increase SNR. One issue with MRI coils is that they are designed to be one size fits all. Pediatric patients will have to use the same coils as a large adult. Just like a conventional imaging system, the MR signal drops off quadratically based on the distance from the subject. Therefore, it is essential to have coils that closely conform to the body in order to get high quality images.

Vacuum forming is a commonly used manufacturing technique which involves heating a sheet of plastic beyond its glass transistion temperature, draping over a mold, and drawing a vacuum to force the plastic to conform to the mold. Silver ink can be patterned onto the flat sheet to create 3D electronics on complex surfaces. These printed structures can be turned into antennas that can receive the MR signal. By using a mold based on a 3D scan of a person, a custom, highly conformal coil array can be rapidly manufactured.

Since the plastic is stretched over the mold, the vacuum forming process introduces a lot of distortion. Therefore, the printed pattern on the flat sheet must be pre-distorted in order to preserve scale after forming. Schuller et. al. showed that colored 3D objects could be manufactured by simulating the forming process and pre-distorting the colors of a textured 3D model [2]. One issue with their method is that it requires a colored 3D model. These typically require a skilled artist to create. Our simulation will only require a non distorted 2D image and a blank 3D model.

2 CURRENT PROGRESS

So far, we have adapted project 4 to simulate the vacuum forming process. We have integrated the Embree ray tracing engine and implemented a basic collision detection algorithm for arbitrary meshes. Vacuum forces were implemented with a linearly increasing force proportional to the area of each triangle, directed along their normal vectors [3]. The first attempt at pre-distortion involved traversing the mesh and assigning new texture coordinates based on deformed areas of the triangles. Each triangle was assigned a proportional area in the texture domain. We suspect that this resulted in numerical errors since it required a breath first search of the mesh.

3 FUTURE WORK

We plan to integrate and modify the Computational Geometry Algorithms Library (CGAL) to generate a scale preserving conformal map between the 3D sheet and a 2D plane [1]. This will allow us to apply a texture and limit the distortion to the unimportant areas away from the mold. In addition, we will make the simulation more realistic by adding a plastic strain model and predicting the stretch due to heating. The accuracy of the simulation will be improved with a more stable, physically based integration method such as implicit Euler or the classical Runge-Kutta method. Finally, we will validate our pre-distortion by vacuum forming various patterns onto 3D molds.

4 CONCLUSIONS

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