

Ultrasound Imaging of Brain Shunts

Paper Seminar Presentation
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Project Summary

Photoacoustic excitation on the occlusion material induced by laser systems will generate acoustic waves to propagate to all the directions, which can be further collected by an external ultrasound probe, making the occlusion and the shunts visible.

- ▶ Able to distinguish different level of occlusions
- ▶ Able to identify the distance between the end of the fiber and the occlusion by the output image intensity.

Paper Selection

“An Anthropomorphic Polyvinyl Alcohol Triple Modality Brain Phantom based on Colin27 ”.

- ▶ Sean Jy-Shyang Chen, Pierre Hellier, Jean-Yvs Gauvrit, Maud Marchal, Xavier Morandi, and D. Louis Collins, Mechanical Image Computer-Assisted Intervention – MICCAI 2010 6362 (2010) 92-100.

“Three-Dimensional Printing (3DP) of neonatal head phantom for ultrasound: Thermocouple embedding and simulation of bone”.

- ▶ Matteo Gatto, Gianluca Memoli, Adam Shaw, Neelaksh Sadhoo, Pierre Gelat, Russell A. Harris, Medical Engineering & Physics 34 (2012) 929-937.

Paper Selection

▶ Reasons for selecting the paper

- ▶ A good phantom that can mimic the real head for testing and measuring is needed

Paper I

- ▶ Propose a method to build a brain phantom that has good acoustic properties

Paper II

- ▶ Propose a novel material combination for skull construction that can be used on the 3D printer

Paper I

“ An Anthropomorphic Polyvinyl Alcohol Triple Modality Brain Phantom based on Colin27 ”

- ▶ Sean Jy-Shyang Chen, Pierre Hellier, Jean-Yvs Gauvrit, Maud Marchal, Xavier Morandi, and D. Louis Collins, Mechanical Image Computer-Assisted Intervention – MICCAI 2010 6362 (2010) 92-100.

Key Results and Significance – Paper I

- ▶ A brain phantom with anatomically realistic structures and physically realistic texture by using PVA-C is built.
- ▶ Different levels initial combination of the solution are investigated to determine how to control the phantom contrast.
- ▶ Images acquired from three ways of MR, CT and US showed good qualities

Background – Paper I

Polyvinyl alcohol cryogel

- ▶ PVA-C is a typical tissue-mimicking material for ultrasound imaging in the medical field.
- ▶ It is formed from PVA solution undergoing some freeze-thaw cycles.
- ▶ Optical and mechanical properties change with the number of F/T cycles.
- ▶ This kind of material can be used in a permanent way under humidity-controlled conditions.

Construction Process – Paper I

1. 5% or 8% by weight PVA are dissolved in distilled water. And this solution is heated for about 7 hours at the temperature of 93 to 95 degree Celsius.
2. The PVA solution is cooled to -25 to -20 degree Celsius for 12 hours.
3. The solution will warm back to room temperature in a continuous way for another 12 hours. If needed, this F/T cycle can be repeated for several times. Without the addition of dimethyl sulfoxide (DMSO), the scattering coefficient will increase with each cycle and the phantom will be stiffer, too.
4. Approximating the live Brain Texture. (Useful data from paper: 6% PVA solution at 1 FTC is similar to palpating the surface of a live brain and 4% PVA at 3FTC as being similar to palpating a low-grade gliomas.)
5. Implants for registration and image guidance are included.

Construction Process – Paper I



Images from: <http://pvabrain.inria.fr>

Assessment-Paper I

- ✓ Material formulation experiment
- ✓ PVA solution preparation and PVA-C preparation
- ✓ Mold preparation and usage
- ✓ Typical data for brain phantom based on the results
- ✓ Hardness control – important for approximating the pathological tissue
- ✓ Triple Modality Imaging Contrast – US, MR, CT
- ✓ A novel idea to conquer the weakness of registration reference
- x Mold construction – no guide provided
- x Less instructed for 3D file generation

Future Work – Paper I

1. Develop better multimodal imaging spherical markers for higher contrast imaging.
2. Find better contrast agents to reduce diffuse.

Paper II

“ Three-Dimensional Printing (3DP) of neonatal head phantom for ultrasound: Thermocouple embedding and simulation of bone ”.

- ▶ Matteo Gatto, Gianluca Memoli, Adam Shaw, Neelaksh Sadhoo, Pierre Gelat, Russell A. Harris, Medical Engineering & Physics 34 (2012) 929-937.

Key Results and Significance – Paper II

- ▶ A neonatal skull phantom for ultrasound testing is designed and created
- ▶ A novel 3DP material is found to be able to mimic the acoustic properties of the neonatal skull

Background – Paper II

Two main problems meet in Skull Phantom:

Complex Structures
&
Materials



Background – Paper II

3D Printing Technology

▶ Working Process:

1. A thin layer of plaster powder is spread on the powder bed.
2. An inkjet head moves in the plane, jetting a liquid binder over the powder bed, allowing the binding of powder particles.
3. Once the first cross-sectional layer of the part is completed, the piston is lowered by approximately 0.1 mm and a new layer of powder is spread.
4. The next layer is selectively jetted by the print heads.
5. This cyclic process proceeds till completion of the part.

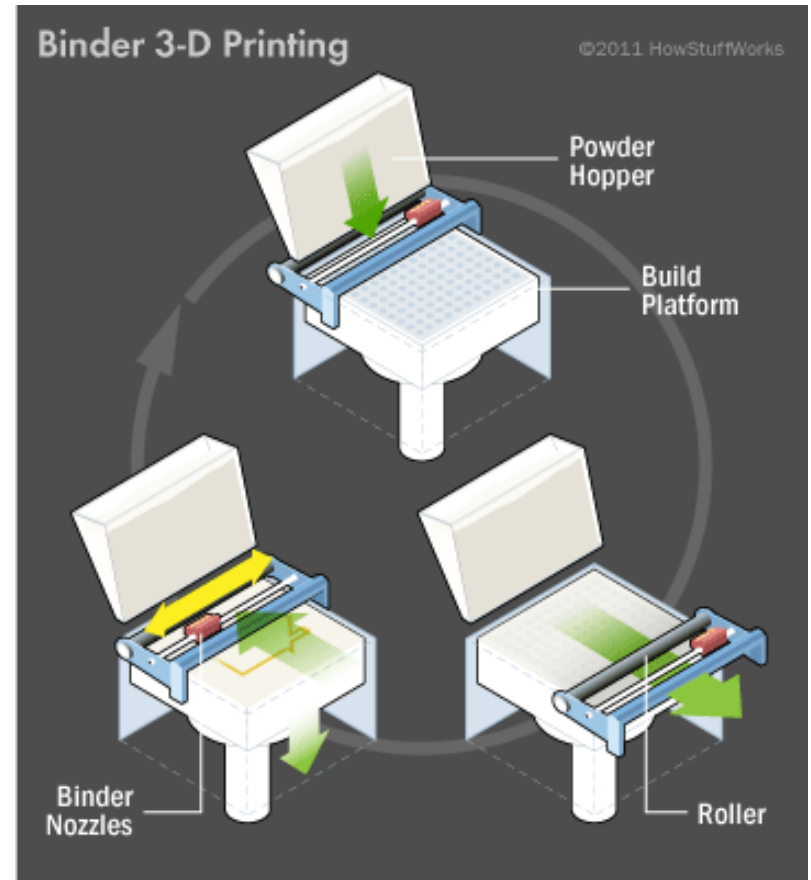


Image from:
<http://computer.howstuffworks.com/3-d-printing2.htm>

Construction Process – Paper II

1. Use CT/MRI to get the medical image
2. 3D model reconstruction in the medical software
3. Computer Aided Design (CAD)
4. STL file generation
5. Prototyping (3DP)
6. Post-processing: cleaning, support removal, **INFILTRATION..**

A typical modeling process for medical application expect ..

Construction Process – Paper II

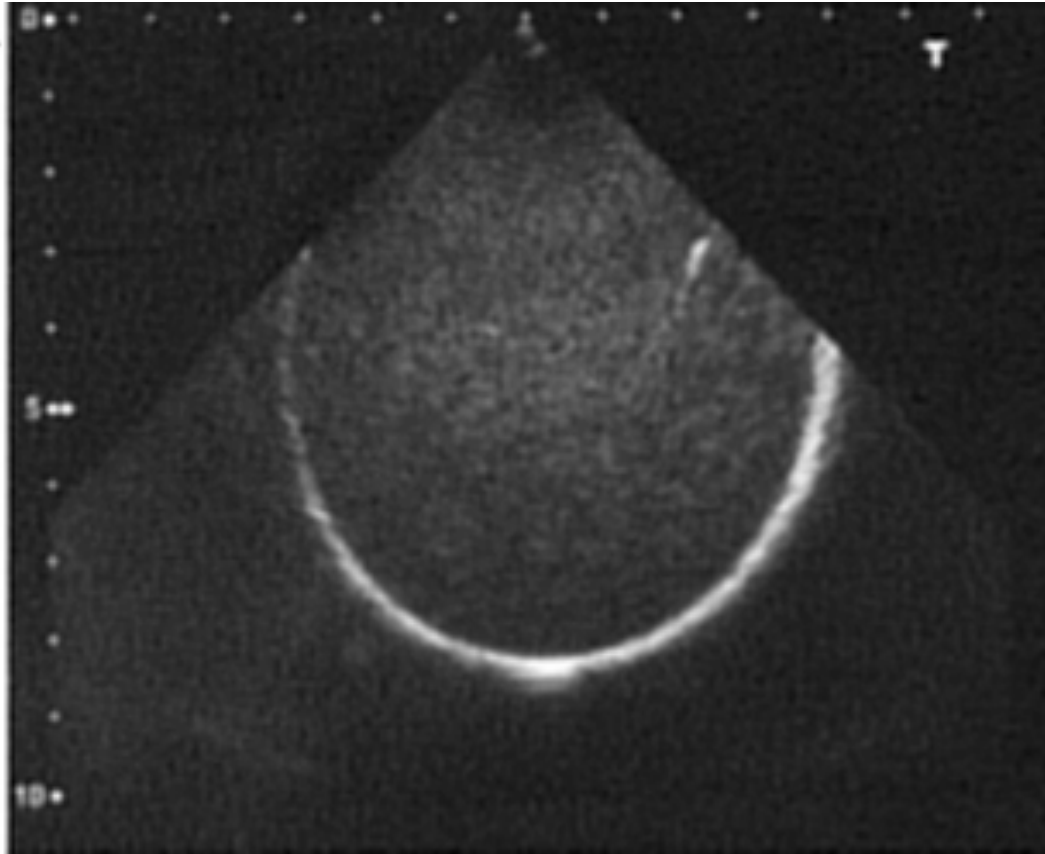


Image from: Three-Dimensional Printing (3DP) of neonatal head phantom for ultrasound: Thermocouple embedding and simulation of bone

Assessment-Paper II

- ✓ A novel 3DP material combination
- ✓ Brain and skin for the whole head construction
- x Results based on a simple shaped phantom
- x Realistic phantom should not be so smooth

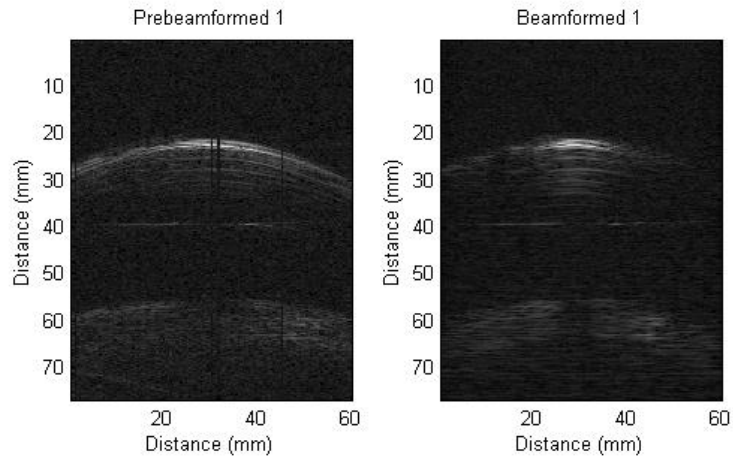
Future Work – Paper II

1. Create more realistic shape model
2. Replace the brain part with more realistic material (Paper I)

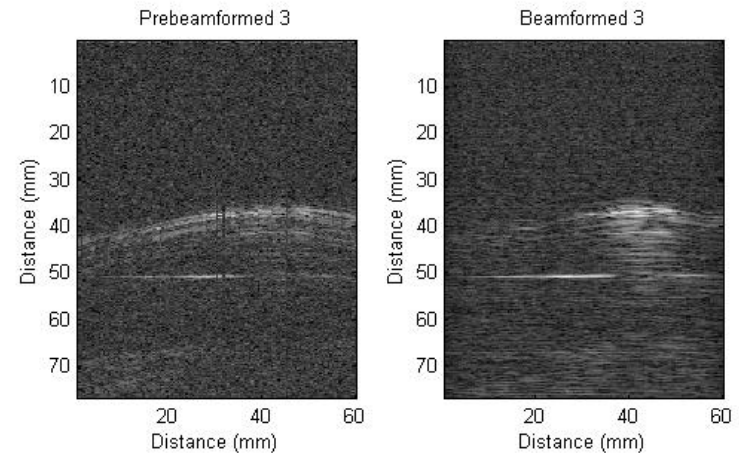


Utilization in our project

- ▶ Brain Phantom – PAV-C based and Jell-O based



PAV-C based



Jell-O based

- ▶ Skull – a series of plates with 100 mm diameter ...

Thank you !

Questions ?

