



BRIGHAM AND
WOMEN'S HOSPITAL



HARVARD
MEDICAL SCHOOL

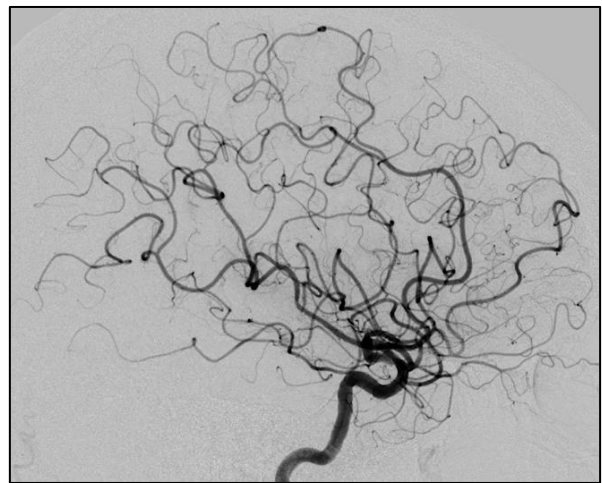
Simulating flow through blood vessels using particle systems

The Image and Model Guided Neurosurgery Laboratory

We are computer scientists and engineers with backgrounds in computer vision, computer graphics and physics-based modeling. We work closely with neurosurgeons and neuroradiologists at Brigham and Women's Hospital to develop new tools to help plan surgery and provide guidance during surgery.

Background

Digital subtraction angiography (DSA) is an x-ray-based imaging technology that allows surgeons and radiologists to observe the flow of a contrast agent through vessel networks. In the brain, it is used to diagnose conditions such as stroke, aneurysms, and arterial venous malformations, all of which can cause life-threatening ischemia (lack of blood) or hemorrhaging (bleeding) in the brain. We are working to extract additional information from DSA to improve diagnosis, planning and treatment of these diseases.



Project description

In this project you will write a 2D particle system to visualize the flow of contrast agent through blood vessels. You will use a 2D distance field to control movement of the particles and keep them inside the vessels. You will also develop a graphical user interface to interact with the particle system.

Components

The project has the following components

1. Generate a 2D distance field from a 2D vessel with bifurcations (branches). A 2D distance field is an image where each pixel stores the distance to the closest vessel wall. Distances for pixels inside the vessel are positive and distances for pixels outside the vessel are negative.
2. Develop a 2D particle system, with particles that interact with the distance field (i.e., they stay inside the vessel, bounce off vessel walls and die when they exit the vessel)
3. Render the vessels and the particles in a window
4. Develop a user interface that allows the user to drop a burst of particles at any point in the vessel

Implementation details

You can use any of the following combinations of systems

- WebGL and JavaScript, or

- Python/C++ and OpenGL, or
- An open-source game engine of your choice (approval required)

Contact

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Background reading

1. J. van der Burg. [Building an Advanced Particle System \(gamedeveloper.com\)](https://gamedeveloper.com/) (March 2020)
2. The Nature of Code, Particle Systems: <https://natureofcode.com/book/chapter-4-particle-systems/>
3. Simple 2D particle system implementations: [Simple Particle System / Examples / Processing.org](https://processing.org/examples/simpleparticle.html)
4. T. limon et al. Collision Avoidance and Surface Flow for Particle Systems Using Distance/Normal Grid, http://wscg.zcu.cz/WSCG2006/Papers_2006/Full/A71-full.pdf