User Guide

GPGPU Disease

DEVELOPMENT

Introduction

What Is This?

This code sample demonstrates chemical reaction-diffusion simulation on the GPU, and uses it to create a creepy "disease" effect on a 3D model.

Reaction-diffusion is a model of how the concentrations of chemical reactants change over time during a reaction. The particular reaction-diffusion model simulated in this sample is called the Gray-Scott model, and it is governed by the following two equations.

$$\frac{\partial U}{\partial V} = D_u \nabla^2 U - UV^2 + F \cdot (1 - U)$$

$$\frac{\partial U}{\partial V} = D_v \nabla^2 V + UV^2 - (F + k) \cdot V.$$

In these equations, U and V are the concentrations of two chemical reactants, D_u, and D_v are diffusion coefficients (the first term is a diffusion term), and F and k are constants. In the *GPGPU disease* sample application we fix the diffusion coefficients and allow the user to adjust the values of F and k. U and V are represented as two channels of a floating-point texture. The concentration fields are initialized to constant values, with a square of a different value (a "seed") in one corner.

Each frame, we run a fragment program that computes the Gray-Scott equations and updates the values in the concentration texture. We then use one of the channels as a height field to generate a normal map texture. The concentration and normal map textures are then used as input to shaders that shade the head model with different "disease" effects.

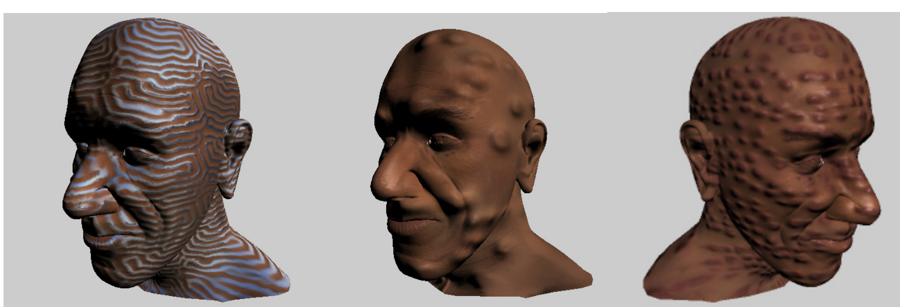

Figure 1: Three effects generated by the GPGPU disease sample. From left to right, a chrome "cyber disease" effect, scarab beetles crawling under the skin, and the deadly "super measles".

Using this Sample

When you first run GPGPU Disease, you will see a healthy head. Press 'd' to show and hide the reaction diffusion texture. The 't' key allows you to cycle between the healthy head and three disease modes (creepy crawly, discolored bumps, and fungal chrome). To show the parameter sliders, you can press '~'. You can use the sliders to adjust parameters such as *K* and *d* (see above), and the bump map scales. By varying *K* and *d*, you can generate a wide variety of interesting, dynamic patterns. If the patterns fade out, try pressing 'r' to reset the simulation, and possibly adjust the parameters. Try cycling through the built-in presets with the 'p' key. The rest of the controls are below.

Table 1. Mouse Controls

Button	Description
Left Button	Rotate view.
Right Button	Show Menu.
CTRL + Left Button	Zoom view.
SHIFT + Left Button	Translate view.

Table 2. Keyboard Commands

Key	Description
`,~	Toggle HUD (parameter sliders).
w	Toggle wireframe display.
d	Display reaction-diffusion texture.
h	Show / hide diseased head.
SPACE	Pause, resume simulation.

Key	Description
.	Take a single simulation time step (when paused).
t	Cycle disease display mode ("healthy", "creepy crawly", "discolored bumps", "fungal chrome")
p	Cycle reaction-diffusion parameter presets.
?	Print help text to console.
Esc, q	Exit

Known Bugs

There are no known bugs. Please report bugs to Mark Harris (mharris@nvidia.com).

References

Reaction-diffusion models were originally proposed by Alan Turing (1952), and were used to generate textures by Turk and Witkin & Cass (1991). The Gray-Scott model was described by Pearson (1993), and the results were shown to be similar to real chemical reactions by Lee et al. (1993). Reaction-diffusion was first shown running on a GPU by Harris et al. (2002).

Harris, M.J., Coombe, G., Scheuermann, T., and Lastra, A. (2003). Physically-based visual simulation on graphics hardware. In Proceedings of the ACM SIGGRAPH / EUROGRAPHICS conference on Graphics Hardware, pages 109-118.

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Pearson, J.E. (1993). Complex patterns in a simple system. Science, 261:189-192.

Turing, A.M. (1952). The chemical basis of morphogenesis. Transactions of the Royal Society of London, (B237):37-72.

Turk, G. (1991). Generating textures on arbitrary surfaces using reaction-diffusion. In Proceedings of SIGGRAPH 1991, pages 289-298.

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