Fireflies: New software to interactively visualise the behaviour of dynamical systems by harnessing the power of GPU computing.

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Visualising the behaviour of dynamical systems, such as those studied in mathematical neuroscience, is a powerful way to gain an intuitive understanding of their behaviour. In this poster we present *Fireflies*, a new piece of software designed to provide an interesting and exciting new way to visualise arbitrary systems of ordinary differential equations (ODEs) for both research and teaching purposes.

Fireflies simulates many trajectories in state space in parallel, and displays the current position of each trajectory on the screen as a small particle of coloured light. As the simulation runs the user can see the system's dynamics through the motion of the particles and, over time, stable fixed points and limit cycles become apparent as particles accumulate near to them. Additional particles that are integrated backwards in time can also be included, and these reveal unstable spirals, nodes and limit cycles. *Fireflies* projects the position of each particle in N-dimensional state space onto the 2-dimensional screen by using either a straight 2D projection of two of the state variables or a 3D perspective projection of three state variables. In the case of a 3D projection, the user can interactively move around state space using the keyboard and mouse, in order to examine areas of interest. The parameters of the system can also be varied in real time, and the effect that this has on the system's dynamics is immediately visible. Finally, by varying a parameter value across particles and setting the parameter as a dimension of the screen projection, *Fireflies* can generate a 2D or 3D visualisation that resembles a bifurcation diagram; the other parameters of the system can then be varied in order to see their effect on this.

In order for this techinque to be effective, a very large number of particles must be simulated at the same time. To achieve this, *Fireflies* makes use of the graphical processing unit (GPU) hardware found in all modern computers. GPUs are becoming increasingly popular for certain scientific computing applications, and their "massively parallel" architecture is ideal for computations that contain many independent components, such as those performed by *Fireflies*. Using the GPU allows *Fireflies* to run simulations containing millions of particles quickly enough that the user can watch their behaviour and interact with them in real time - something that would not be possible using traditional central processing unit based programming techniques. *Fireflies* supports multiple operating systems and is written in the Python programming language, using the OpenCL library for interaction with the GPU.

This poster demonstrates several colourful examples of using *Fireflies* to visualise the behaviour of various neuroscience-related systems of ODEs.