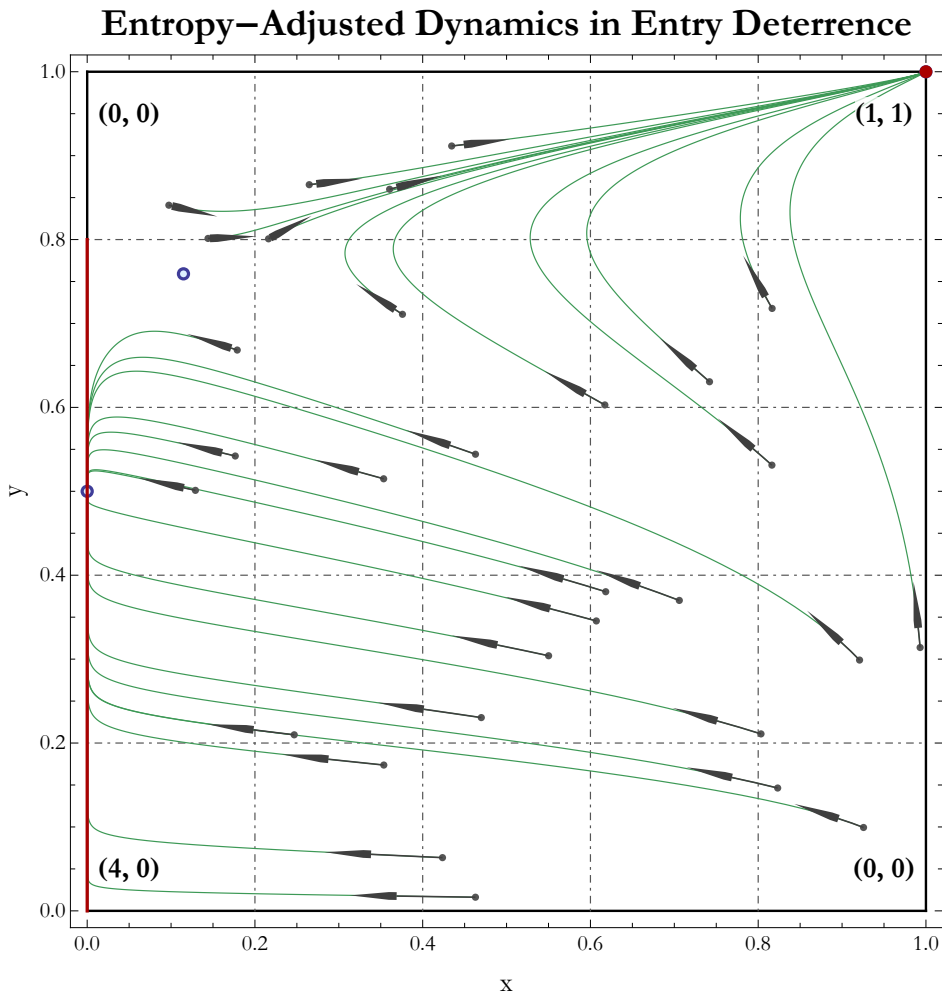
GameSeer

Visualizing Game Dynamics

A Short User's Guide



GameSeer

Table of Contents

What is GameSeer?

GameSeer is a tool for students and researchers in game theory that uses Mathematica to generate phase portraits for normal form games under a variety of (user-customizable) evolutionary dynamics.

The whole point behind GameSeer is to provide a dynamic graphical interface that allows the user to employ Mathematica's vast numerical capabilities from a simple and intuitive front-end. So, even if you've never used Mathematica before in your life, you should be able to generate fully editable and customizable portraits quickly and painlessly.

Why require Mathematica? Why is GameSeer not stand-alone?

I feel your pain: why create a program that requires Mathematica (a very expensive piece of software), instead of writing a Java applet (that could then be deployed on the web)?

There are many reasons behind this development decision, first and foremost being that Mathematica's numerical solvers simply cannot be matched in the public domain. The C/C++/Java libraries out there that would allow GameSeer to be deployed as a stand-alone application need constant pampering and goading by the programmer in order to produce correct results, and this is not really in line with the whole "ease-of-use-no-expert-skills-required" approach that is the guiding philosophy behind GameSeer(for instance, implicit Runge-Kutta methods work in certain cases where explicit methods fail, and vice versa). Mathematica on the other hand uses some fairly sophisticated adaptive solvers that choose the correct solver in all but the most pathological cases – and when they fail, they fail spectacularly, so it is easy for the human eye to detect that something has gone awry. In fact, this last point is one of Mathematica's strongest suits: it may be sluggish, it may be slow and it may be expensive, but the amount of failsafes built within it is staggering.

Another reason is that GameSeer is intended for academic use, and most universities and research institutions offer Mathematica licenses that can be used on-campus (or via VPN). So, even though Mathematica is as closed-source as things get, if you want to use GameSeer, you should be able to do it without having to pay the price for Mathematica.

That said, a stand-alone version of GameSeer *is* in the works; it might not have the full functionality of its Mathematica counterpart, but it should work well enough in most cases.

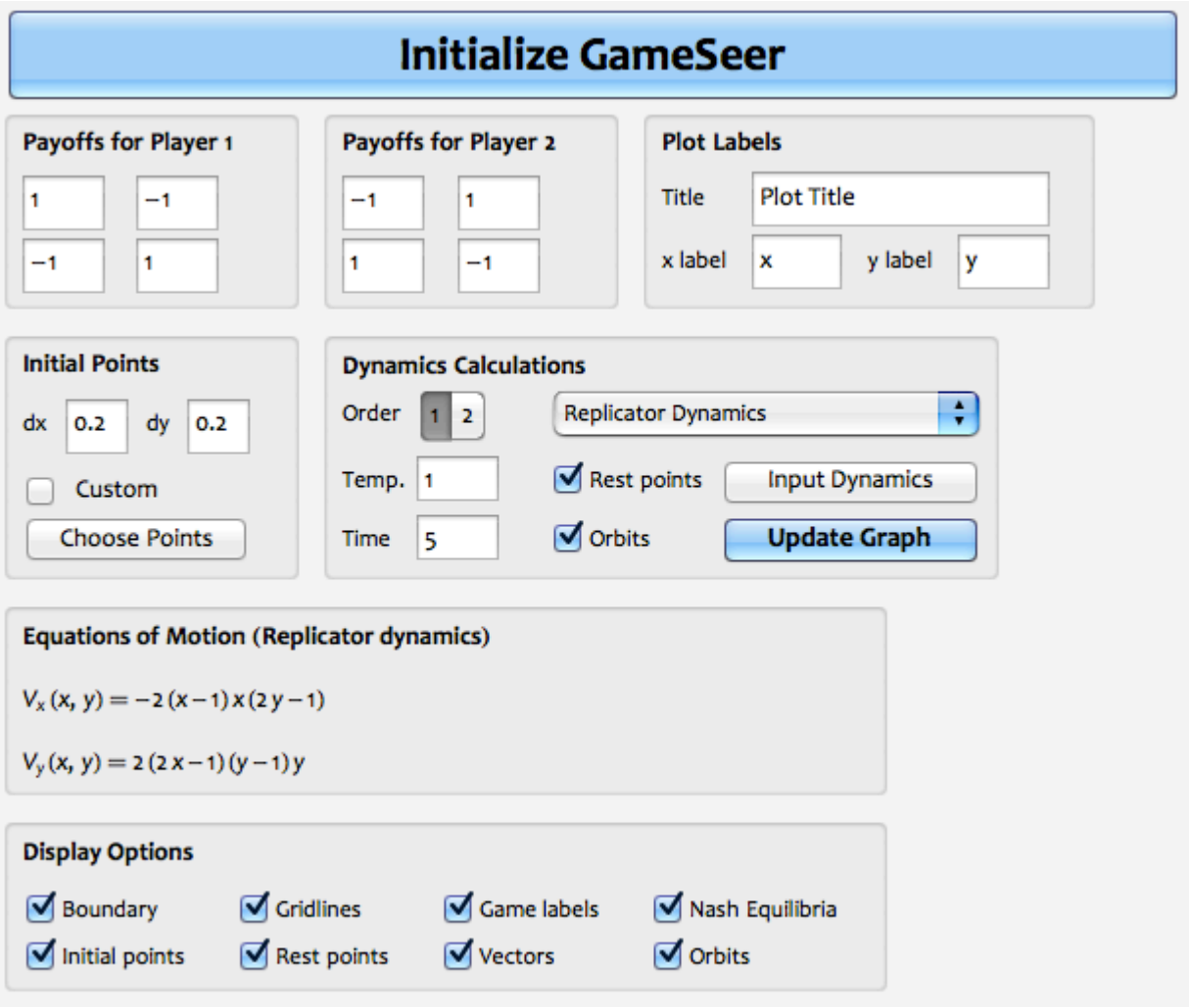
What are GameSeer's terms of use?

GameSeer is released under the GNU General Public License: you can use it and you can modify its source at will, as long as you acknowledge the original author and agree to keep all future/modified copies of GameSeer free as well. My only request is that you include an acknowledgment if you use GameSeer for published work.

Ok, so how do I use GameSeer?

First off, you need to load the notebook - double-clicking on its icon should work in most cases, but in some platforms you might need to launch Mathematica and then open the GameSeer notebook from File>Open.

Depending on your Mathematica preferences you might be asked to "Enable dynamic content" and/or to "Evaluate initialization cells. Accept both options, and you should get to the main GameSeer window:

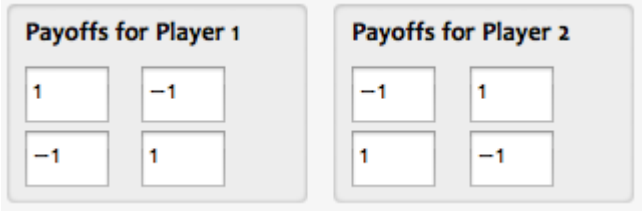


This is the GameSeer interface: what follows is a rundown of the menus, option boxes and panels.

Initialize GameSeer

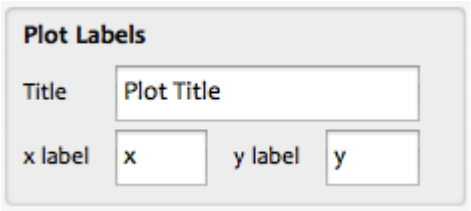
This button is your run-of-the-mill reset button. If you find GameSeer behaving erratically, or if you would like to restore the default program parameters, click it and the program should re-initialize.

Payoff Panels



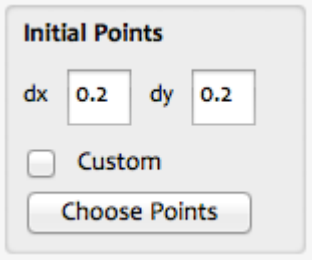
Should be self-explanatory. An important feature is that you can enter your game's payoffs either as numbers (e.g. "`1`", "`.2`", "`1/5`") or as Mathematica expressions that evaluate to a real number (e.g. "`Pi`", "`Sqrt[2]`", "`Random[]`"). If possible, Mathematica will retain the number in exact symbolic form (e.g. "`1/5`" for "`.2`"), allowing GameSeer to give exact outputs where possible (e.g. in Nash equilibrium calculations).

Plot Labels



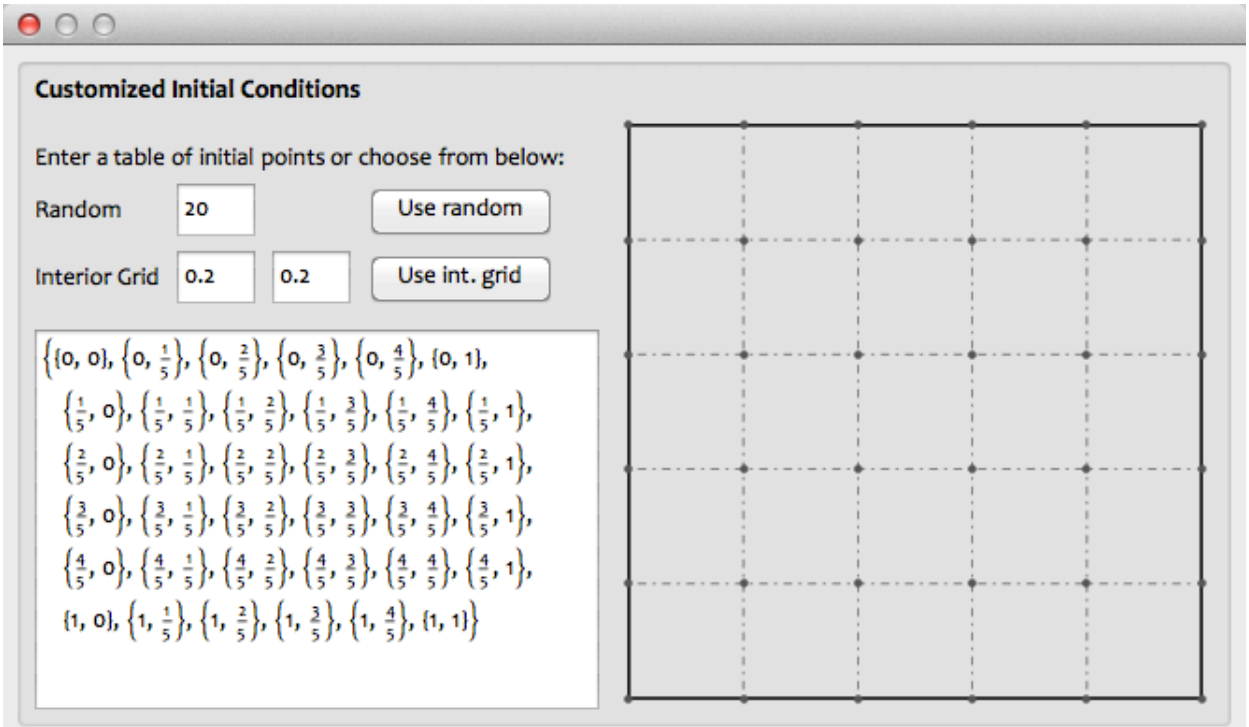
Again, this panel should be self explanatory. Enter the desired labels, and you should see them in the GameSeer graph.

Initial Points



From this panel, you can control the lattice of initial points, by default a grid with x-spacing "dx" and y-spacing "dy". If you would like to input your own initial conditions, check the "Custom" checkbox, and then click on "Choose Points" to enter the initial conditions of your choice.

By clicking on the "Choose Points" button, you will then see the following window:



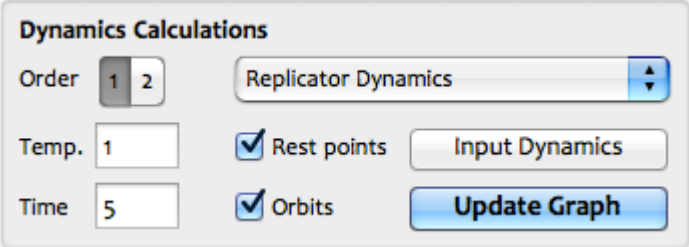
You then have the following options:

1. Use (uniformly) random initial conditions. Choose the number of points you want, and then click on "Use random".
2. Use an interior grid of initial conditions, i.e. a grid with spacing "2dx" and "2dy", and with distance dx and dy from the boundary of the state space. Input the desired "dx" and "dy" parameters and then click on "Use int. grid".
3. Input your own initial conditions in the form of a nested list (see above for the format), or any other Mathematica expression that evaluates to a list of pairs of real numbers. For instance, the input `Table[{Random[],y},{x,0,1,.1},{y,0,1,.1}]` creates a grid of 100 uniformly spaced y-coordinates with random x-coordinates.

In all cases, you will see the results of your choice in the preview pane to the right, so you can keep playing until you get the initial conditions you want.

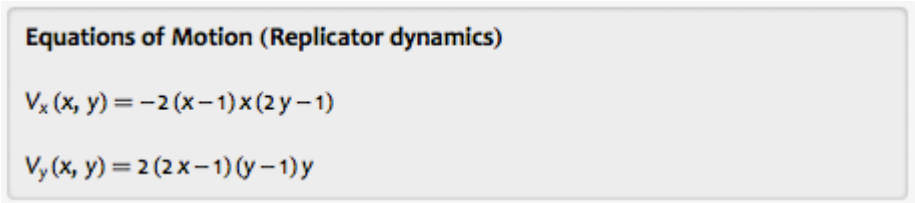
IMPORTANT: In order to use custom initial conditions for calculations etc., the "Custom" checkbox must be checked. If you only click on "Choose points", then you will generate a custom set of initial conditions, **but they will not be used for calculations.**

Dynamics & Calculations



Not surprisingly, this panel is the beating heart of GameSeer. You have the following controls:

1. Dynamics selection menu: from this menu, you can select the dynamics that you want to integrate. The choices are Replicator, Maynard Smith, Entropy-Adjusted, Smith, Brown–von Neumann–Nash, Logit and Custom. If you choose "Custom", you can then click on the "Input Dynamics" button to type in the dynamics you want. Once you choose (or input) the desired dynamics, you should see a (simplified) expression in the "Equations of Motion" panel, as in the following figure:



2. Order: this toggle allows you to set the order of the dynamics to be solved. This is an experimental feature based on ongoing work, so if you are not sure what this means, leave the toggle at 1 and don't worry about it. It only affects imitative dynamics such as the replicator dynamics, the Maynard Smith dynamics and the entropy-adjusted dynamics.
3. The "Temp." field refers to the dynamics' temperature, a parameter that affects the "Entropy-Adjusted" and "Logit" dynamics.
4. The "Time" field indicates the solution horizon of the dynamics.
5. The "Rest points" and "Orbits" checkboxes tell GameSeer whether to calculate the dynamics' rest points, solution orbits, or both. In some cases (notably the "Maynard Smith" and "Entropy-Adjusted" dynamics), the calculation of rest points might be problematic; if you encounter problems, uncheck this box.

6. Once you have made the choices you want, simply click on the "Update Graph" button and GameSeer will produce the required graph (see next item for options).

IMPORTANT: The "Update Graph" button is what tells GameSeer to perform the necessary calculations. If you change any parameters that affect the evolution of the dynamics or its rest points, then you will obviously need to recalculate GameSeer's output by clicking on "Update Graph".

IMPORTANT: The "Update Graph" stage is the hard calculational part of GameSeer, so be patient. In most cases, this step should take a fraction of a second in a 2012 high-end laptop, but it might take considerably more in older machines. At any rate, if the drawing step takes more than 15-20 seconds, you might want to consider increasing the memory allocated to Mathematica for faster performance.

Display and Export

Once you have entered the desired calculation parameters and clicked on the "Update Graph" button, you should see your graph in the plot window. You can then check any of the above boxes to include or exclude a particular element. The graph updates dynamically if you change any of these parameters, but it does not auto-update if you change any of the game or dynamics parameters; if you wish to change these parameters, you will need to re-update the graph by clicking on "Update Graph" again.

The "Export data" button creates a time-stamped .dat file which contains the definitions and output data of a GameSeer session, so that they can be imported in future Mathematica sessions with a "Get" command (see the Mathematica documentation for more details), or in other data-processing software (such as Matlab).

Finally, the "Export plot" button creates a time-stamped pdf file of the current graph.

All files will be created and saved in the same directory that GameSeer is run from.