Wave Simulator User Manual

1. Controls

Keyboard is optional but mouse is necessary. The application could support touch screen but there is no practical way for me to test such functionality so it is not implemented.

1.1 Mouse

Behaviour of mouse input varies depending on the current editing mode. There are three editing modes: Oscillator, mass map, and static map.

All actions must performed when the mouse cursor is on drawing area.

1.1.1 Oscillator Mode

The mouse cursor turns into crosshair inside the pool.

All actions are performed on the currently selected oscillator. Position of an oscillator is changed by mouse button press only when the mouse cursor is inside the pool.

- Left click activates the oscillator and sets its primary position to the mouse location.
- Double left click deactivates the oscillator.
- Right click sets the secondary location of the oscillator to the mouse location.
- Scroll up increases the period of the oscillator.
- Scroll down decreases the period of the oscillator.

1.1.2 Mass Map Mode

The mouse cursor becomes invisible and a dashed circle is rendered in place of the mouse cursor inside the pool. Outside the pool and inside the drawing box, crosshair cursor is rendered.

Rendering depends on the *Maximum Frames Per Second* parameter in the *2.4 Rendering* section. If this is set to a very low value, the circle and crosshair will lag. This may mislead the user to thinking that the rendering uses very high CPU.

All actions are performed on particles contained by the dashed circle.

- Left click sets the mass values to the primary mass.
- Right click sets the mass values to the secondary mass.
- Scroll up enlarges the pen.
- Scroll down shrinks the pen.

1.1.3 Static Map Mode

Concepts for this mode are the same with those mentioned in *1.1.2 Mass Map Mode*.

Selected *Operation* for drawing is assumed to be *Add* for the following rules. *Subtract* just swaps the actions.

- Left click makes the particles static.
- Right click makes the particles dynamic.

1.2 Keyboard

There are shortcuts specific to the application. In order for these shortcuts to work, no numeric inputs should have focus. Unfocusing can be achieved by simply clicking on an empty area. The reason for the necessity of unfocusing is that the ‘Ctrl’ key is not used for most of the shortcuts.

- Keys from 1 to 9 set the currently selected oscillator index to the key number. For example, pressing ‘4’ sets the selected oscillator to *Osc-4*.
- ‘P’ to resume or pause the simulation.
- ‘Spacebar’ to refresh the scene.
- ‘M’ to enable or disable mass map editing mode.
- ‘S’ to enable or disable static map editing mode.
- ‘O’ to disable both static map and mass map modes.
- ‘L’ to enable or disable line drawing mode depending on the active editing mode.
- ‘Ctrl+S’ to save the current scene.
- ‘Ctrl+O’ to open a scene.

2. Inputs and Actions

2.1 Tool Buttons

New

Loads the default scene.

The default scene is a special scene that is loaded every time the application starts. If the application can’t find the default scene while starting, it creates one.

For details about scenes, see *Open*.

Open

Opens a scene.

A scene is basically a project file. Properties of the pool and oscillators, mass map and particle map are all contained in a scene file. Other settings are saved to ini file every time the program is closed.

Save

Saves the current scene.

Saving to the default scene will result in the current scene to be opened every time the application starts. For further details about the default scene, see *New*.

Play

Resumes the simulation.

Pause

Pauses the simulation. Only the calculations are stopped, not rendering.

Refresh

Refreshed the scene. Only the velocity and height of the particles are reset.

2.2. Pool

2.2.1 General

Size

Sets both width and height of the pool in pixel unit. For example, if this value is 300, the pool will be 300x300 pixels in size so there will be 90000 particles in the pool.

Higher size will obviously result in more memory and CPU usages but gives higher resolution. The benefits of a higher resolution are a bigger working area, more detailed geometry for static structures, wider frequency range for waves.

It is not recommended to change the size too frequently if there is a static structure. Doing so will eventually ruin the structure due to rounding errors during resizing so change the size only when necessary.

Loss Ratio

Sets the loss ratio for each particle in the pool. There is an exception for particles near edges if the absorber is enabled. See *Enable Absorber*.

Loss ratio is used to absorb particles' energy. This can be thought as if some of the mechanical energy of particles are converted to heat. The higher the loss ratio, the shorter the distance the particles will propogate before fading away.

Absorber Peak Loss Ratio

Sets the loss ratio of particles close to the edges as percent in such a way that the loss ratio value will linearly increase towards the edges. The highest loss ratio is set by this parameter. This value can also be lower than *Loss Ratio* so the loss ratio will decrease towards the edges.

The purpose of increasing the loss ratio of the edge particles is to reduce reflectivity of the edges. This makes it possible to simulate a pool with no boundaries so that the waves will never come back by means of reflection and interfere with the inner pool.

Absorber Thickness

Sets the offset value for the absorber from which the loss ratio linearly starts to increase or decrease towards the edges in pixel unit. See *Absorber Peak Loss Ratio* for further details about the absorber.

Increasing this value will most likely reduce the reflectivity further but the side effect is that the useful size of the pool is decreased by increased thickness.

Shift Center of Geometry to Origin

When we give energy to particles, say, by means of oscillators, the average height of the particles may no longer be zero as soon as the system becomes stable. This may be a problem for visuals because the color of any particle in the pool is determined by its height and if the height value is already too high or too low then the oscillation around that high or low value may not be fully distinguishable. For example, in default settings, a particle whose height value is 1 will look completely white. If that particle oscillates between 0.5 and 1.5 then the particle will go beyond the dynamic range as soon as it is becomes bigger than 1 and hence the height of the particle will no longer be distinguishable. In order to reduce the probability of such a case, particles could be shifted to a point as a whole such that the geometric center shifts to absolute zero.

Enable Absorber

Sets whether the absorber which is used to reduce reflection from boundaries is enabled or disabled. See *Absorber Peak Loss Ratio* for further details about the absorber.

2.2.2 Oscillators

Show Oscillators

Sets whether the active oscillators should be shown on the pool with their index numbers. There is a scale to the right of the switch that sets the font size.

Selected Oscillator

Sets the selected oscillator to edit. When a selection is made, the rest of the widgets are updated for that selection.

Enabled

Sets whether the selected oscillator is enabled or disabled.

Source

There are three radio buttons: *Point*, *Line*, and *Moving Point*. When *Point* is selected, the energy is radiated from a single particle. When *Line* is selected, energy is radiated from a line of particles, *Moving Point* is a *Point* source but it also moves between primary and secondary locations.

Period

Sets the period of the selected oscillator in iterations per cycle unit. The period as we know is the inverse of frequency so increasing the period will decrease the frequency.

An iteration is a single calculation step in the wave engine. The duration of an iteration is a function of the performance so the time itself is not used. In order to yield a time based unit for period, we must be able to make the number of iterations per second constant. See *Maximum Iterations Per Second*.

Phase

Sets the phase of the selected oscillator in degrees. The range is from 0 degree to 180 degrees.

To give an example about the phase we know, waves with a phase difference of 180 degrees will destructively interfere while waves with the same phase will constructively interfere.

Amplitude

Sets the amplitude of the selected oscillator. This value should be between -1 and 1 for the corresponding oscillator's effect to be fully distinguishable on the pool. Setting it to a negative value is same as adding 180 degrees to the phase.

Location X1-Y1

Sets the primary location of the selected oscillator.

Location X2-Y2

Sets the secondary location of the selected oscillator.

Move Period

Sets the movement period of the selected oscillator in iterations per cycle unit. In each cycle, the oscillator will move from location-1 to location-2 if its source is a *Moving Point* (see *Source* for details). For example, if this value is 200 and *Maximum Iterations Per Second* is also 100 then the oscillator will return to its starting position in every two seconds.

2.2.3 Mass

Edit Mass Map

Sets whether the mass map editing mode is active or deactive. Setting this to active will deactive any other modes and vice versa.

Pen Thickness

Sets the thickness of the pen in pixel unit.

Line Mode

Sets whether to use line drawing mode or free drawing mode. In line mode, press and hold the mouse button and then drag it to another point to draw a line.

Primary Mass

Sets the primary mass value. The mass map is painted with this value when left mouse button is used.

Secondary Mass

Sets the secondary mass value. The mass map is painted with this value when right mouse button is used.

Fill

Sets all particles' mass value to that of primary mass.

Clear

Sets all particles' mass value to that of secondary mass.

Swap

Swaps the primary and secondary colors.

Mass Range Minimum

Sets the darkest mass value.

The depiction method of mass map used is similiar to that of a thermal camera. Lower mass values are black/blue/violet and higher mass values are orange/yellow/white. The lowest mass value which is black is determined by this parameter. Any mass value going below this value will still be seen black and going above the maximum counterpart will result in white color.

Mass Range Maximum

Sets the brightest mass value.

See *Mass Range Minimum* for details.

2.2.4 Static

Edit Static Map

Sets whether the static map editing mode is active or deactive. Setting this to active will deactive any other modes and vice versa.

Pen Thickness

Sets the thickness of the pen in pixel unit.

Line Mode

Sets whether to use line drawing mode or free drawing mode. In line mode, press and hold the mouse button and then drag it to another point to draw a line.

Operation

Sets the behaviour of the left and right mouse buttons while drawing. If the operation is *Add*, left mouse button sets the particles as static, and right mouse button sets the particles as dynamic. *Subtract* inverts the behaviour.

Fill

Sets all particles as static.

Clear

Sets all particles as dynamic.

2.3 Threading

Maximum Iterations Per Second

Sets the maximum number of calculations per second. This is used to stabilize the speed of the simulation and/or avoiding CPU overuse.

Setting this to zero will disable the parameter but it should be only done for benchmarking or baking a complex scene.

Number of iterations per second may sometimes slightly go beyond the maximum. It may not also reach the maximum due to insufficient performance.

On a high performance system, the waves would propogate very fast and we wouldn't be able to see many things that are important or fun. By this parameter, we can limit the speed as such that the waves will propogate in equal speed regardless of the performance of the system.

This value can also be used to provide a real time based unit for oscillator period so that the unit for period of an oscillator can be, for example, milliseconds per cycle instead.

Number of Co-Threads

Sets the number of calculator & painter threads. This value should be set to the number of CPU cores for the best performance but there may be exceptions.

The wave engine supports multi-threading. If there is more than one thread, equal parts of the pool are shared among each thread to make calculations on. These threads are called 'co-threads' because there is a 'main' thread that manages and gives orders to the co-threads.

Set to Number of CPU Cores

Sets the *Number of Co-Threads* to the number of CPU cores available on the system.

Thread Sleep Duration

Sets the amount of sleeping time of the wave engine in paused state in millisecond unit. The higher this value, the lower the CPU usage in paused state.

While the wave engine is paused, the co-threads go to low level sleep where they are to be woken up by notification signal but the main thread doesn't go to such a sleep (it could go but that means additional work). The main thread calls 'usleep' repeatedly. If there would be no such call, some kind of short circuiting would take place and the application would consume very high CPU even in paused state. That wouldn't make sense and could also make the user interface unresponsive. By sleeping for some time, other threads can get a chance to do whatever they want to do and CPU would not be overused.

2.4 Rendering

Render

Sets whether the rendering is enabled or disabled. If disabled, the rendering will not take place, including the painting calculations.

We need to enable this to see the changes during editing.

Maximum Frames Per Second

Sets the maximum number of frames rendered per second. This can be thought of as a classic FPS limiter.

Setting this to zero will disable the parameter but it is highly recommended not to do so since the painting calculations are done on CPU rather than on GPU and this could lead to serious performance issues.

Note that keeping this value low will result in mouse cursor lag in static map and map editing modes.

Amplitude Multiplier

Sets the amplitude multiplier value used in the painting stage. This value is multiplied by the height value of each particle in painting stage so that particles with weaker vibrations could be easily seen without adjusting contrast and brightness.

Extreme Contrast

Extreme contrast results in particles with an height above zero to have a color ‘A’, below zero to have a color ‘B’, and at zero to have a color between ‘A’ and ‘B’. In default settings, ‘A’ would be white, ‘B’ would be black, and the color between them would be gray.

Crest Color

Sets the color for particles whose height is greater than zero.

A particle’s color changes linearly from trough color to crest color while its height goes from -1 to 1 linearly.

Trough Color

Sets the color for particles whose height is less than zero.

For further details, see *Crest Color*.

Static Color

Sets the color for particles which are static.

2.5 UI

Ignore Scrolling On Numeric Box

Sets whether to ignore mouse scroll on numeric input box.

In GTK, which is a tool for creating user interface, mouse scroll on numeric input box (spin button) causes its value to change depending on the scroll direction. This can be undesirable when the box is contained in a scrollable window. We may accidentally change the value while scrolling. By enabling this, we may safely scroll.

Ignore Scrolling On List Box

Sets whether to ignore mouse scroll on list box.

For further details, see *Ignore Scrolling On Numeric Box*.

Ignore Scrolling On Scale

Sets whether to ignore mouse scroll on scale.

For further details, see *Ignore Scrolling On Numeric Box*.

Decimal Place Count

Sets the number of decimal places for each numeric input box. This may allow us to input more precise values.