1 GeNN Documentation

GeNN is a software package to enable neuronal network simulations on NVIDIA GPUs by code generation. Models are defined in a simple C-style API and the code for running them on either GPU or CPU hardware is generated by GeNN. GeNN can also be used through external interfaces. Currently there are prototype interfaces for Spine↩ Creator and SpineML and for Brian2.

GeNN is currently developed and maintained by

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Project homepage is http://genn-team.github.io/genn/.

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Note

This documentation is under construction. If you cannot find what you are looking for, please contact the project developers.

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2 Installation

You can download GeNN either as a zip file of a stable release or a snapshot of the most recent stable version or the unstable development version using the Git version control system.

2.1 Downloading a release

Point your browser to https://github.com/genn-team/genn/releases and download a release from the list by clicking the relevant source code button. Note that GeNN is only distributed in the form of source code due to its code generation design. Binary distributions would not make sense in this framework and are not provided. After downloading continue to install GeNN as described in the Installing GeNN section below.

2.2 Obtaining a Git snapshot

If it is not yet installed on your system, download and install Git (http://git-scm.com/). Then clone the GeNN repository from Github

```
git clone https://github.com/genn-team/genn.git
```

The github url of GeNN in the command above can be copied from the HTTPS clone URL displayed on the GeNN Github page (https://github.com/genn-team/genn).

This will clone the entire repository, including all open branches. By default git will check out the master branch which contains the source version upon which the latest release is based. If you want the most recent (but unstable) development version (which may or may not be fully functional at any given time), checkout the development branch

```
git checkout development
```

There are other branches in the repository that are used for specific development purposes and are opened and closed without warning.

As an alternative to using git you can also download the full content of GeNN sources clicking on the "Download ZIP" button on the bottom right of the GeNN Github page (https://github.com/genn-team/genn).

2.3 Installing GeNN

Installing GeNN comprises a few simple steps to create the GeNN development environment.

(i) If you have downloaded a zip file, unpack GeNN.zip in a convenient location. Otherwise enter the directory where you downloaded the Git repository.

(ii) Define the environment variable "GENN_PATH" to point to the main GeNN directory, e.g. if you extracted/downloaded GeNN to /usr/local/GeNN, then you can add "export GENN_PATH=/usr/local/GeNN" to your login script (e.g. `.profile` or `.bashrc`. If you are using WINDOWS, the path should be a windows path as it will be interpreted by the Visual C++ compiler `cl`, and environment variables are best set using `SETX` in a Windows cmd window. To do so, open a Windows cmd window by typing `cmd` in the search field of the start menu, followed by the `enter` key. In the `cmd` window type

```
setx GENN_PATH "C:\Users\me\GeNN"
```

where `C:\Users\me\GeNN` is the path to your GeNN directory.

(iii) Add $GENN_PATH/lib/bin to your PATH variable, e.g.

```
export PATH=$PATH:$GENN_PATH/lib/bin
```

in your login script, or in windows,

```
setx PATH=%GENN_PATH%\lib\bin;%PATH%
```

(iv) Install the C++ compiler on the machine, if not already present. For Windows, download Microsoft Visual Studio Community Edition from https://www.visualstudio.com/en-us/downloads/download-visual-studio-vs.↩ aspx When installing Visual Studio, one should select "custom install", and ensure that all C++ optional extras are also installed. Mac users should download and set up Xcode from https://developer.apple.↩ com/xcode/index.html Linux users should install the GNU compiler collection gcc and g++ from their Linux distribution repository, or alternatively from https://gcc.gnu.org/index.html Be sure to pick CUDA and C++ compiler versions which are compatible with each other. The latest C++ compiler is not necessarily compatible with the latest CUDA toolkit.

(v) If you haven't installed CUDA on your machine, obtain a fresh installation of the NVIDIA CUDA toolkit from https://developer.nvidia.com/cuda-downloads Again, be sure to pick CUDA and C++ compiler versions which are compatible with each other. The latest C++ compiler is not necessarily compatible with the latest CUDA toolkit.

(vi) Set the `CUDA_PATH` variable if it is not already set by the system, by putting

```
export CUDA_PATH=/usr/local/cuda
```

in your login script (or, if CUDA is installed in a non-standard location, the appropriate path to the main CUDA directory). For most people, this will be done by the CUDA install script and the default value of /usr/local/cuda is fine. In Windows, CUDA_PATH is normally already set after installing the CUDA toolkit. If not, set this variable with:

```
setx CUDA_PATH C:\path\to\cuda
```

This normally completes the installation. Windows useres must close and reopen their command window to ensure variables set using `SETX` are initialised.

Depending on the needs of your own projects, e.g., depencies on other libraries or non-standard installation paths of libraries used by GeNN, you may want to modify Makefile examples under `$GENN_PATH/userproject/xxx↩ _project` and `$GENN_PATH/userproject/xxx_project/model` to add extra linker-, include- and

compiler-flags on a per-project basis, or modify global default flags in $GENN_PATH/userproject/include/makefile↩
common[win|gnu].mk.

For all makefiles there are separate makefiles for Unix-style operating systems (GNUmakefile) such as Linux or MacOS and for Windows (WINmakefile).

If you are using GeNN in Windows, the Visual Studio development environment must be set up within every instance of the CMD.EXE command window used. One can open an instance of CMD.EXE with the development environment already set up by navigating to Start - All Programs - visual studio - tools - visual studio native command prompt. You may wish to create a shortcut for this tool on the desktop, for convenience. Note that all C++ tools should have been installed during the Visual Studio install process for this to work. Alternatively one can use the make.↩
bat scripts to build the example projects, which will attempt to setup your development environment by executing `vcvarsall.bat` which is part of every Visual Studio distribution, inside the visual studio/VC directory. For this to work properly, GeNN must be able to locate the Visual Studio install directory, which should be contained in the `VS_PATH` environment variable. You can set this variable by hand if it is not already set by the Visual C++ installer by typing:

```
setx VS_PATH "C:\Program Files (x86)\Microsoft Visual Studio 10.0"
```

Note

- The exact path and name of Visual C++ installations will vary between systems.
- Double quotation marks like in the above example are necessary whenever a path contains spaces.

GeNN also has experimental CYGWIN support. However, with the introduction of native Windows support in GeNN 1.1.3, this is not being developed further and should be considered as deprecated.

2.4 Testing Your Installation

To test your installation, follow the example in the Quickstart section. Linux and Mac users can perform a more comprehensive test by running:

```
cd $GENN_PATH/userproject && ./testprojects.sh
```

This test script may take a long while to complete, and will terminate if any errors are detected.

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3 Quickstart

GeNN is based on the idea of code generation for the involved GPU or CPU simulation code for neuronal network models but leaves a lot of freedom how to use the generated code in the final application. To facilitate the use of Ge↩
NN on the background of this philosophy, it comes with a number of complete examples containing both the model description code that is used by GeNN for code generation and the "user side code" to run the generated model and safe the results. Running these complete examples should be achievable in a few minutes. The necessary steps are described below.

3.1 Running an Example Model in Unix

In order to get a quick start and run a provided model, open a shell, navigate to `GeNN/tools` and type

```
make
```

This will compile additional tools for creating and running example projects. For a first complete test, the system is best used with a full driver program such as in the Insect olfaction model example:

```
./generate_run <0 (CPU) / 1 (GPU) / n (GPU n+2)> <nAL> <nMB> <nLHI> <nLb> <gscale> <outdir> <model
       name> <OPTIONS>
```

Possible options:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger,
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use,
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run,
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

To compile `generate_run.cc`, navigate to the `userproject/MBody1_project` directory and type

```
make
```

This will generate an executable that you can invoke with, e.g.,

```
./generate_run 1 100 1000 20 100 0.0025 test1 MBody1
```

which would generate and simulate a model of the locust olfactory system with 100 projection neurons, 1000 Kenyon cells, 20 lateral horn interneurons and 100 output neurons in the mushroom body lobes.

The tool generate_run will generate connectivity matrices for the model `MBody1` and store them into files, compile and run the model on an automatically chosen GPU, using these files as inputs and output the resulting spiking activity. To fix the GPU used, replace the first argument `1` with the device number of the desired GPU plus 2, e.g., `2` for GPU 0. All input and output files will be prefixed with `test1` and will be created in a sub-directory with the name `test1_output`. More about the DEBUG flag in the debugging section . The parameter `FLOAT` will run the model in float (single precision floating point), using `DOUBLE` would use double precision. The REUS←E parameter regulates whether previously generated files for connectivity and input should be reused (1) or files should be generated anew (0).

The MBody1 example is already a highly integrated example that showcases many of the features of GeNN and how to program the user-side code for a GeNN application. More details in the User Manual .

3.2 Running an Example Model in Windows

All interaction with GeNN programs are command-line based and hence are executed within a `cmd` window. Open a Visual Studio `cmd` window via Start: All Programs: Visual Studio: Tools: Native Tools Command Prompt, and navigate to the `userprojects\tools` directory.

```
cd %GENN_PATH%\userprojects\tools
```

Then type

```
nmake /f WINmakefile
```

to compile a number of tools that are used by the example projects to generate connectivity and inputs to model networks. Then navigate to the `userproject/MBody1_project` directory.

```
cd ..\MBody1_project
```

By typing

```
nmake /f WINmakefile
```

you can compile the `generate_run` engine that allows to run a Insect olfaction model of the insect mushroom body:

```
generate_run <0 (CPU) / 1 (GPU) / n (GPU n+2)> <nAL> <nMB> <nLHI> <nLb> <gscale> <outdir> <model
      name> <OPTIONS>
```

To invoke `generate_run.exe` type, e.g.,

```
generate_run 1 100 1000 20 100 0.0025 test1 MBody1
```

which would generate and simulate a model of the locust olfactory system with 100 projection neurons, 1000 Kenyon cells, 20 lateral horn interneurons and 100 output neurons in the mushroom body lobes.

The tool `generate_run.exe` will generate connectivity matrices for the model `MBody1` and store them into files, compile and run the model on an automatically chosen GPU, using these files as inputs and output the resulting spiking activity. To fix the GPU used, replace the first argument `1` with the device number of the desired GPU plus 2, e.g., `2` for GPU 0. All input and output files will be prefixed with `test1` and will be created in a sub-directory with the name `test1_output`. More about the DEBUG flag in the debugging section . The parameter `FLOAT` will run the model in float (single precision floating point), using `DOUBLE` would use double precision. The REU↩
SE parameter regulates whether previously generated files for connectivity and input should be reused (1) or files should be generated anew (0).

The MBody1 example is already a highly integrated example that showcases many of the features of GeNN and how to program the user-side code for a GeNN application. More details in the User Manual .

3.3 How to use GeNN for New Projects

Creating and running projects in GeNN involves a few steps ranging from defining the fundamentals of the model, inputs to the model, details of the model like specific connectivity matrices or initial values, running the model, and analyzing or saving the data.

GeNN code is generally created by passing the C / C++ model file (see below) directly to the genn-buildmodel script. Another way to use GeNN is to create or modify a script or executable such as `userproject/MBody1↩
_project/generate_run.cc` that wraps around the other programs that are used for each of the steps listed above. In more detail, the GeNN workflow consists of:

1. Either using tools (programs) to generate connectivity and input matrix files, which are then loaded into the user's simulation code at runtime, or generating these matrices directly inside the user's simulation code.

2. Building the source code of a model simulation using `genn-buildmodel.sh` (On Linux or Mac) or `genn-buildmodel.bat` (on Windows). In the example of the MBody1_project this entails writing neuron numbers into `userproject/include/sizes.h`, and executing

   ```
   genn-buildmodel.sh MBody1.cc
   ```

   The `genn-buildmodel` script compiles the installed GeNN code generator in conjunction with the user-provided model description `model/MBody1.cc`. It then executes the GeNN code generator to generate the complete model simulation code for the MBody1 model.

3. Compiling the generated code, found in `model/MBody1_CODE/`, by calling:

   ```
   make clean all
   ```

   It is at this stage that GeNN generated model simulation code is combined with user-side code. In this example, `classol_sim.cu` (classify-olfaction-simulation) which uses the `map_classol` (map-neuron-based-classifier-olfaction) class.

4. Finally, running the resulting stand-alone simulator executable. In the MBody1 example `classol_sim` in the `model` directory.

The `generate_run` tool is only a suggested usage scenario of GeNN. Users have more control by manually executing the four steps above, or integrating GeNN into the development environment of their choice.

Note

> The usage scenario described was made explicit for Unix environments. In Windows the setup is essentially the same except for the usual operating system dependent syntax differences, e.g. the build script is named genn-buildmodel.bat, compilation of the generated model simulator would be `nmake /f WINmakefile clean all`, and the resulting executable would be named `classol_sim.exe`.

GeNN comes with several example projects which showcase its features. The MBody1 example discussed above is one of the many provided examples that are described in more detail in Example projects.

3.4 Defining a New Model in GeNN

According to the work flow outlined above, there are several steps to be completed to define a neuronal network model.

1. The neuronal network of interest is defined in a model definition file, e.g. `Example1.cc`.
2. Within the the model definition file `Example1.cc`, the following tasks need to be completed:

   a) The GeNN file `modelSpec.h` needs to be included,

   ```
   #include "modelSpec.h"
   ```

   b) The values for initial variables and parameters for neuron and synapse populations need to be defined, e.g.

   ```
   float myPOI_p[4] = {
       0.1,        // 0 - firing rate
       2.5,        // 1 - refractory period
       20.0,       // 2 - Vspike
       -60.0       // 3 - Vrest
   };
   ```

   would define the (homogeneous) parameters for a population of Poisson neurons.

   Note

   > The number of required parameters and their meaning is defined by the neuron or synapse type. Refer to the User Manual for details. We recommend, however, to use comments like in the above example to achieve maximal clarity of each parameter's meaning.

   If heterogeneous parameter values are needed for any particular population of neurons (synapses), a new neuron (synapse) type needs to be defined in which these parameters are defined as "variables" rather than parameters. See the User Manual for how to define new neuron (synapse) types.

   c) The actual network needs to be defined in the form of a function `modelDefinition`, i.e.

   ```
   void modelDefinition(NNmodel &model);
   ```

   Note

   > The name `modelDefinition` and its parameter of type `NNmodel&` are fixed and cannot be changed if GeNN is to recognize it as a model definition.

   d) Inside modelDefinition(), The time step `DT` needs to be defined, e.g.

   ```
   model.setDT(0.1);
   ```

Note

All provided examples and pre-defined model elements in GeNN work with units of mV, ms, nF and muS. However, the choice of units is entirely left to the user if custom model elements are used.

`MBody1.cc` shows a typical example of a model definition function. In its core it contains calls to `model.addNeuronPopulation` and `model.addSynapsePopulation` to build up the network. For a full range of options for defining a network, refer to the User Manual.

3. The programmer defines their own "user-side" modeling code similar to the code in `userproject/MBody1_project/model/map_classol.*` and `userproject/MBody1_project/model/classol_sim.*`. In this code,

a) They define the connectivity matrices between neuron groups. (In the MBody1 example those are read from files). Refer to the User Manual for the required format of connectivity matrices for dense or sparse connectivities.

b) They define input patterns (e.g. for Poisson neurons like in the MBody1 example) or individual initial values for neuron and / or synapse variables.

Note

The initial values given in the `modelDefinition` are automatically applied homogeneously to every individual neuron or synapse in each of the neuron or synapse groups.

c) They use `stepTimeGPU(...);` to run one time step on the GPU or `stepTimeCPU(...);` to run one on the CPU. (both GPU and CPU versions are always compiled, unless `-c` is used with genn-buildmodel).

Note

However, mixing CPU and GPU execution does not make too much sense. Among other things, The CPU version uses the same host side memory where to results from the GPU version are copied, which would lead to collisions between what is calculated on the CPU and on the GPU (see next point). However, in certain circumstances, expert users may want to split the calculation and calculate parts (e.g. neurons) on the GPU and parts (e.g. synapses) on the CPU. In such cases the fundamental kernel and function calls contained in `stepTimeXXX` need to be used and appropriate copies of the data from the CPU to the GPU and vice versa need to be performed.

d) They use functions like `copyStateFromDevice()` etc to transfer the results from GPU calculations to the main memory of the host computer for further processing.

e) They analyze the results. In the most simple case this could just be writing the relevant data to output files.

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4 Examples

GeNN comes with a number of complete examples. At the moment, there are seven such example projects provided with GeNN.

4.1 Single compartment Izhikevich neuron(s)

```
Izhikevich neuron(s) without any connections
=====================================

This is a minimal example, with only one neuron population (with more or less
neurons depending on the command line, but without any synapses). The neurons
are Izhikevich neurons with homogeneous parameters across the neuron population.
This example project contains a helper executable called "generate_run", which also
```

```
prepares additional synapse connectivity and input pattern data, before compiling and
executing the model.

To compile it, navigate to genn/userproject/OneComp_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)> <n> <DIR> <MODEL>

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

For a first minimal test, the system may be used with:

generate_run.exe 1 1 outdir OneComp

for Windows users, or:

./generate_run 1 1 outdir OneComp

for Linux, Mac and other UNIX users.

This would create a set of tonic spiking Izhikevich neurons with no connectivity,
receiving a constant identical 4 nA input. It is lso possible to use the model
with a sinusoidal input instead, by setting the input to INPRULE.

Another example of an invocation would be:

generate_run.exe 0 1 outdir OneComp FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 1 outdir OneComp FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.
```

Izhikevich neuron model: [1]

4.2 Izhikevich neurons driven by Poisson input spike trains:

```
Izhikevich network receiving Poisson input spike trains
=======================================================

In this example project there is again a pool of non-connected Izhikevich model neurons
that are connected to a pool of Poisson input neurons with a fixed probability.
This example project contains a helper executable called "generate_run", which also
prepares additional synapse connectivity and input pattern data, before compiling and
executing the model.

To compile it, navigate to genn/userproject/PoissonIzh_project and type:

nmake /f WINmakefile

for Windows users, or:

make
```

```
for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)> <nPoisson> <nIzhikevich> <pConn> <gscale> <DIR> <MODEL>

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE or FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 100 10 0.5 2 outdir PoissonIzh

for Windows users, or:

./generate_run 1 100 10 0.5 2 outdir PoissonIzh

for Linux, Mac and other UNIX users.

This will generate a network of 100 Poisson neurons with 20 Hz firing rate
connected to 10 Izhikevich neurons with a 0.5 probability.
The same network with sparse connectivity can be used by adding
the synapse population with sparse connectivity in PoissonIzh.cc and by uncommenting
the lines following the "//SPARSE CONNECTIVITY" tag in PoissonIzh.cu and commenting the
lines following `//DENSE CONNECTIVITY`.

Another example of an invocation would be:

generate_run.exe 0 100 10 0.5 2 outdir PoissonIzh FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 100 10 0.5 2 outdir PoissonIzh FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.
```

Izhikevich neuron model: [1]

4.3 Pulse-coupled Izhikevich network

```
Pulse-coupled Izhikevich network
================================

This example model is inspired by simple thalamo-cortical network of Izhikevich
with an excitatory and an inhibitory population of spiking neurons that are
randomly connected. It creates a pulse-coupled network with 80% excitatory 20%
inhibitory connections, each connecting to nConn neurons with sparse connectivity.

To compile it, navigate to genn/userproject/Izh_sparse_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)/n(GPU n-2)> <nNeurons> <nConn> <gScale> <outdir> <model name> <input factor>

Mandatory arguments:
```

```
CPU/GPU: Choose whether to run the simulation on CPU (`0`), auto GPU (`1`), or GPU (n-2) (`n`).
nNeurons: Number of neurons
nConn: Number of connections per neuron
gScale: General scaling of synaptic conductances
outname: The base name of the output location and output files
model name: The name of the model to execute, as provided this would be `Izh_sparse`

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 10000 1000 1 outdir Izh_sparse 1.0

for Windows users, or:

./generate_run 1 10000 1000 1 outdir Izh_sparse 1.0

for Linux, Mac and other UNIX users.

This would create a pulse coupled network of 8000 excitatory 2000 inhibitory
Izhikevich neurons, each making 1000 connections with other neurons, generating
a mixed alpha and gamma regime. For larger input factor, there is more
input current and more irregular activity, for smaller factors less
and less and more sparse activity. The synapses are of a simple pulse-coupling
type. The results of the simulation are saved in the directory `outdir_output`,
debugging is switched off, and the connectivity is generated afresh (rather than
being read from existing files).

If connectivity were to be read from files, the connectivity files would have to
be in the `inputfiles` sub-directory and be named according to the names of the
synapse populations involved, e.g., `gIzh_sparse_ee` (\<variable name>=`g`
\<model name>=`Izh_sparse` \<synapse population>=`_ee`). These name conventions
are not part of the core GeNN definitions and it is the privilege (or burden)
of the user to find their own in their own versions of `generate_run`.

Another example of an invocation would be:

generate_run.exe 0 10000 1000 1 outdir Izh_sparse 1.0 FTYPE=DOUBLE DEBUG=0 CPU_ONLY=1

for Windows users, or:

./generate_run 0 10000 1000 1 outdir Izh_sparse 1.0 FTYPE=DOUBLE DEBUG=0 CPU_ONLY=1

for Linux, Mac and other UNIX users.
```

Izhikevich neuron model: [1]

4.4 Izhikevich network with delayed synapses

```
Izhikevich network with delayed synapses
========================================

This example project demonstrates the synaptic delay feature of GeNN. It creates
a network of three Izhikevich neuron groups, connected all-to-all with fast, medium
and slow synapse groups. Neurons in the output group only spike if they are
simultaneously innervated by the input neurons, via slow synapses, and the
interneurons, via faster synapses.


COMPILE (WINDOWS)
-----------------

To run this example project, first build the model into CUDA code by typing:

genn-buildmodel.bat SynDelay.cc
```

```
then compile the project by typing:

nmake /f WINmakefile


COMPILE (MAC AND LINUX)
-----------------------

To run this example project, first build the model into CUDA code by typing:

genn-buildmodel.sh SynDelay.cc

then compile the project by typing:

make


USAGE
-----

syn_delay [CPU = 0 / GPU = 1] [directory to save output]
```

Izhikevich neuron model: [1]

4.5 Insect olfaction model

```
Locust olfactory system (Nowotny et al. 2005)
=============================================

This project implements the insect olfaction model by Nowotny et
al. that demonstrates self-organized clustering of odours in a
simulation of the insect antennal lobe and mushroom body. As provided
the model works with conductance based Hodgkin-Huxley neurons and
several different synapse types, conductance based (but pulse-coupled)
excitatory synapses, graded inhibitory synapses and synapses with a
simplified STDP rule. This example project contains a helper executable called "generate_run", which also
prepares additional synapse connectivity and input pattern data, before compiling and
executing the model.

To compile it, navigate to genn/userproject/MBody1_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)/n(GPU n-2)> <nAL> <nKC> <nLH> <nDN> <gScale> <DIR> <MODEL>

Mandatory parameters:
CPU/GPU: Choose whether to run the simulation on CPU (`0`), auto GPU (`1`), or GPU (n-2) (`n`).
nAL: Number of neurons in the antennal lobe (AL), the input neurons to this model
nKC: Number of Kenyon cells (KC) in the "hidden layer"
nLH: Number of lateral horn interneurons, implementing gain control
nDN: Number of decision neurons (DN) in the output layer
gScale: A general rescaling factor for snaptic strength
outname: The base name of the output location and output files
model: The name of the model to execute, as provided this would be `MBody1`

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.
```

```
An example invocation of generate_run is:

generate_run.exe 1 100 1000 20 100 0.0025 outname MBody1

for Windows users, or:

./generate_run 1 100 1000 20 100 0.0025 outname MBody1

for Linux, Mac and other UNIX users.

Such a command would generate a locust olfaction model with 100 antennal lobe neurons,
1000 mushroom body Kenyon cells, 20 lateral horn interneurons and 100 mushroom body
output neurons, and launch a simulation of it on a CUDA-enabled GPU using single
precision floating point numbers. All output files will be prefixed with "outname"
and will be created under the "outname" directory. The model that is run is defined
in `model/MBody1.cc`, debugging is switched off, the model would be simulated using
float (single precision floating point) variables and parameters and the connectivity
and input would be generated afresh for this run.

In more details, what generate_run program does is:
a) use some other tools to generate the appropriate connectivity
   matrices and store them in files.

b) build the source code for the model by writing neuron numbers into
   ./model/sizes.h, and executing "genn-buildmodel.sh ./model/MBody1.cc.

c) compile the generated code by invoking "make clean && make"
   running the code, e.g. "./classol_sim r1 1".

Another example of an invocation would be:

generate_run.exe 0 100 1000 20 100 0.0025 outname MBody1 FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 100 1000 20 100 0.0025 outname MBody1 FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users, for using double precision floating point
and compiling and running the "CPU only" version.

Note: Optional arguments cannot contain spaces, i.e. "CPU_ONLY= 0"
will fail.

As provided, the model outputs a file `test1.out.st` that contains
the spiking activity observed in the simulation, There are two
columns in this ASCII file, the first one containing the time of
a spike and the second one the ID of the neuron that spiked. Users
of matlab can use the scripts in the `matlab` directory to plot
the results of a simulation. For more about the model itself and
the scientific insights gained from it see Nowotny et al. referenced below.


MODEL INFORMATION
-----------------

For information regarding the locust olfaction model implemented in this example project, see:

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the
olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005),
doi:10.1007/s00422-005-0019-7
```

Nowotny insect olfaction model: [3]; Traub-Miles Hodgkin-Huxley neuron model: [5]

4.6 Insect olfaction model with user-defined neuron and synapse models

```
Locust olfactory system (Nowotny et al. 2005) with user-defined synapses
========================================================================

This examples recapitulates the exact same model as MBody1_project,
but with user-defined model types for neurons and synapses. Also
sparse connectivity is used instead of dense. The way user-defined
types are used should be very instructive to advanced users wishing
to do the same with their models. This example project contains a
helper executable called "generate_run", which also prepares
additional synapse connectivity and input pattern data, before
compiling and executing the model.

To compile it, navigate to genn/userproject/MBody_userdef_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


  USAGE
  -----

generate_run <0(CPU)/1(GPU)/n(GPU n-2)> <nAL> <nKC> <nLH> <nDN> <gScale> <DIR> <MODEL>

Mandatory parameters:
CPU/GPU: Choose whether to run the simulation on CPU (`0`), auto GPU (`1`), or GPU (n-2) (`n`).
nAL: Number of neurons in the antennal lobe (AL), the input neurons to this model
nKC: Number of Kenyon cells (KC) in the "hidden layer"
nLH: Number of lateral horn interneurons, implementing gain control
nDN: Number of decision neurons (DN) in the output layer
gScale: A general rescaling factor for snaptic strength
outname: The base name of the output location and output files
model: The name of the model to execute, as provided this would be `MBody1`

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 100 1000 20 100 0.0025 outname MBody_userdef

for Windows users, or:

./generate_run 1 100 1000 20 100 0.0025 outname MBody_userdef

for Linux, Mac and other UNIX users.

Such a command would generate a locust olfaction model with 100
antennal lobe neurons, 1000 mushroom body Kenyon cells, 20 lateral
horn interneurons and 100 mushroom body output neurons, and launch
a simulation of it on a CUDA-enabled GPU using single precision
floating point numbers. All output files will be prefixed with
"outname" and will be created under the "outname" directory.

In more details, what generate_run program does is:
a) use some other tools to generate the appropriate connectivity
   matrices and store them in files.

b) build the source code for the model by writing neuron numbers into
   ./model/sizes.h, and executing "genn-buildmodel.sh ./model/MBody_userdef.cc".

c) compile the generated code by invoking "make clean && make"
   running the code, e.g. "./classol_sim r1 1".

Another example of an invocation would be:

generate_run.exe 0 100 1000 20 100 0.0025 outname MBody_userdef FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:
```

```
./generate_run 0 100 1000 20 100 0.0025 outname MBody_userdef FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.


MODEL INFORMATION
-----------------

For information regarding the locust olfaction model implemented in this example project, see:

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the
olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005),
doi:10.1007/s00422-005-0019-7
```

Nowotny insect olfaction model: [3]; Traub-Miles Hodgkin-Huxley neuron model: [5]

4.7 Insect Olfaction Model using INDIVIDUALID connectivity scheme

```
Locust olfactory system (Nowotny et al. 2005)
=============================================

This example is very similar to the MBody1_project example. The
only difference is that PN to KC connections are defined with
the INDIVIDUALID mechanism.

To compile it, navigate to genn/userproject/MBody_individualID_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)/n(GPU n-2)> <nAL> <nKC> <nLH> <nDN> <gScale> <DIR> <MODEL>

Mandatory parameters:
CPU/GPU: Choose whether to run the simulation on CPU (`0`), auto GPU (`1`), or GPU (n-2) (`n`).
nAL: Number of neurons in the antennal lobe (AL), the input neurons to this model
nKC: Number of Kenyon cells (KC) in the "hidden layer"
nLH: Number of lateral horn interneurons, implementing gain control
nDN: Number of decision neurons (DN) in the output layer
gScale: A general rescaling factor for snaptic strength
outname: The base name of the output location and output files
model: The name of the model to execute, as provided this would be `MBody1`

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 100 1000 20 100 0.0025 outname MBody_individualID

for Windows users, or:

./generate_run 1 100 1000 20 100 0.0025 outname MBody_individualID

for Linux, Mac and other UNIX users.

Such a command would generate a locust olfaction model with 100
antennal lobe neurons, 1000 mushroom body Kenyon cells, 20 lateral
horn interneurons and 100 mushroom body output neurons, and launch
```

```
a simulation of it on a CUDA-enabled GPU using single precision
floating point numbers. All output files will be prefixed with
"outname" and will be created under the "outname" directory.

In more details, what generate_run program does is:
a) use some other tools to generate the appropriate connectivity
   matrices and store them in files.

b) build the source code for the model by writing neuron numbers into
   ./model/sizes.h, and executing "genn-buildmodel.sh ./model/MBody_individualID.cc".

c) compile the generated code by invoking "make clean && make"
   running the code, e.g. "./classol_sim r1 1".

Another example of an invocation would be:

generate_run.exe 0 100 1000 20 100 0.0025 outname MBody_individualID FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 100 1000 20 100 0.0025 outname MBody_individualID FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.


MODEL INFORMATION
-----------------

For information regarding the locust olfaction model implemented in this example project, see:

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the
olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005),
doi:10.1007/s00422-005-0019-7
```

Nowotny insect olfaction model: [3]; Traub-Miles Hodgkin-Huxley neuron model: [5]

4.8 Insect Olfaction Model using delayed synapses

```
Locust olfactory system (Nowotny et al. 2005)
=============================================

A variation of the \ref ex_mbody example using synaptic delays.
In this example, the Kenyon Cell-Decision Neuron synapses are
delayed by (5 * DT) ms, and the Decision Neuron-Decision Neuron
synapses are delayed by (3 * DT) ms. The example is intended
to test the operation of synapses which have a combination of
delayed spike propagation and STDP (plasticity). This example
project contains a helper executable called "generate_run",
which also prepares additional synapse connectivity and input
pattern data, before compiling and executing the model.

To compile it, navigate to genn/userproject/MBody_delayedSyn_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <0(CPU)/1(GPU)/n(GPU n-2)> <nAL> <nKC> <nLH> <nDN> <gScale> <DIR> <MODEL>

Mandatory parameters:
CPU/GPU: Choose whether to run the simulation on CPU (`0`), auto GPU (`1`), or GPU (n-2) (`n`).
nAL: Number of neurons in the antennal lobe (AL), the input neurons to this model
```

```
nKC: Number of Kenyon cells (KC) in the "hidden layer"
nLH: Number of lateral horn interneurons, implementing gain control
nDN: Number of decision neurons (DN) in the output layer
gScale: A general rescaling factor for snaptic strength
outname: The base name of the output location and output files
model: The name of the model to execute, as provided this would be `MBody1`

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 100 1000 20 100 0.0025 outname MBody_delayedSyn

for Windows users, or:

./generate_run 1 100 1000 20 100 0.0025 outname MBody_delayedSyn

for Linux, Mac and other UNIX users.

Such a command would generate a locust olfaction model with 100
antennal lobe neurons, 1000 mushroom body Kenyon cells, 20 lateral
horn interneurons and 100 mushroom body output neurons, and launch
a simulation of it on a CUDA-enabled GPU using single precision
floating point numbers. All output files will be prefixed with
"outname" and will be created under the "outname" directory.

In more details, what generate_run program does is:
a) use some other tools to generate the appropriate connectivity
   matrices and store them in files.

b) build the source code for the model by writing neuron numbers into
   ./model/sizes.h, and executing "genn-buildmodel.sh ./model/MBody_delayedSyn.cc".

c) compile the generated code by invoking "make clean && make"
   running the code, e.g. "./classol_sim r1 1".

Another example of an invocation would be:

generate_run.exe 0 100 1000 20 100 0.0025 outname MBody_delayedSyn FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 100 1000 20 100 0.0025 outname MBody_delayedSyn FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.


MODEL INFORMATION
-----------------

For information regarding the locust olfaction model implemented in this example project, see:

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the
olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005),
doi:10.1007/s00422-005-0019-7
```

Nowotny insect olfaction model: [3]; Traub-Miles Hodgkin-Huxley neuron model: [5]

4.9 Voltage clamp simulation to estimate Hodgkin-Huxley parameters

```
Genetic algorithm for tracking parameters in a HH model cell
============================================================

This example simulates a population of Hodgkin-Huxley neuron models on the GPU and evolves them with a simple
guided random search (simple GA) to mimic the dynamics of a separate Hodgkin-Huxley
neuron that is simulated on the CPU. The parameters of the CPU simulated "true cell" are drifting
```

```
according to a user-chosen protocol: Either one of the parameters gNa, ENa, gKd, EKd, gleak,
Eleak, Cmem are modified by a sinusoidal addition (voltage parameters) or factor (conductance or capacitance)
protocol 0-6. For protocol 7 all 7 parameters undergo a random walk concurrently.

To compile it, navigate to genn/userproject/HHVclampGA_project and type:

nmake /f WINmakefile

for Windows users, or:

make

for Linux, Mac and other UNIX users.


USAGE
-----

generate_run <CPU=0, GPU=1> <protocol> <nPop> <totalT> <outdir>

Mandatory parameters:
GPU/CPU: Whether to use the GPU (1) or CPU (0) for the model neuron population
protocol: Which changes to apply during the run to the parameters of the "true cell"
nPop: Number of neurons in the tracking population
totalT: Time in ms how long to run the simulation
outdir: The directory in which to save results

Optional arguments:
DEBUG=0 or DEBUG=1 (default 0): Whether to run in a debugger
FTYPE=DOUBLE of FTYPE=FLOAT (default FLOAT): What floating point type to use
REUSE=0 or REUSE=1 (default 0): Whether to reuse generated connectivity from an earlier run
CPU_ONLY=0 or CPU_ONLY=1 (default 0): Whether to compile in (CUDA independent) "CPU only" mode.

An example invocation of generate_run is:

generate_run.exe 1 -1 12 200000 test1

for Windows users, or:

./generate_run 1 -1 12 200000 test1

for Linux, Mac and other UNIX users.

This will simulate nPop= 5000 Hodgkin-Huxley neurons on the GPU which will for 1000 ms be matched to a
Hodgkin-Huxley neuron where the parameter gKd is sinusoidally modulated. The output files will be
written into a directory of the name test1_output, which will be created if it does not yet exist.

Another example of an invocation would be:

generate_run.exe 0 -1 12 200000 test1 FTYPE=DOUBLE CPU_ONLY=1

for Windows users, or:

./generate_run 0 -1 12 200000 test1 FTYPE=DOUBLE CPU_ONLY=1

for Linux, Mac and other UNIX users.
```

Traub-Miles Hodgkin-Huxley neuron model: [5]

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5 Release Notes

Release Notes for GeNN v2.2

This release includes minor new features, some core code improvements and several bug fixes on GeNN v2.1.

User Side Changes

1. GeNN now analyses automatically which parameters each kernel needs access to and these and only these are passed in the kernel argument list in addition to the global time t. These parameters can be a combination of extraGlobalNeuronKernelParameters and extraGlobalSynapseKernelParameters in either neuron or synapse kernel. In the unlikely case that users wish to call kernels directly, the correct call can be found in the `stepTimeGPU()` function.
   Reflecting these changes, the predefined Poisson neurons now simply have two extraGlobalNeuron↩ Parameter `rates` and `offset` which replace the previous custom pointer to the array of input rates and integer offset to indicate the current input pattern. These extraGlobalNeuronKernelParameters are passed to the neuron kernel automatically, but the rates themselves within the array are of course not updated automatically (this is exactly as before with the specifically generated kernel arguments for Poisson neurons).
   The concept of "directInput" has been removed. Users can easily achieve the same functionality by adding an additional variable (if there are individual inputs to neurons), an extraGlobalNeuronParameter (if the input is homogeneous but time dependent) or, obviously, a simple parameter if it's homogeneous and constant.

   Note

   The global time variable "t" is now provided by GeNN; please make sure that you are not duplicating its definition or shadowing it. This could have severe consequences for simulation correctness (e.g. time not advancing in cases of over-shadowing).

2. We introduced the namespace GENN_PREFERENCES which contains variables that determine the behaviour of GeNN.

3. We introduced a new code snippet called "supportCode" for neuron models, weightupdate models and post-synaptic models. This code snippet is intended to contain user-defined functions that are used from the other code snippets. We advise where possible to define the support code functions with the CUDA keywords "__host__ __device__" so that they are available for both GPU and CPU version. Alternatively one can define separate versions for **host** and **device** in the snippet. The snippets are automatically made available to the relevant code parts. This is regulated through namespaces so that name clashes between different models do not matter. An exception are hash defines. They can in principle be used in the supportCode snippet but need to be protected specifically using ifndef. For example

```
#ifndef clip(x)
#define clip(x) x > 10.0? 10.0 : x
#endif
```

   Note

   If there are conflicting definitions for hash defines, the one that appears first in the GeNN generated code will then prevail.

4. The new convenience macros spikeCount_XX and spike_XX where "XX" is the name of the neuron group are now also available for events: spikeEventCount_XX and spikeEvent_XX. They access the values for the current time step even if there are synaptic delays and spikes events are stored in circular queues.

5. The old buildmodel.[sh|bat] scripts have been superseded by new genn-buildmodel.[sh|bat] scripts. These scripts accept UNIX style option switches, allow both relative and absolute model file paths, and allow the user to specify the directory in which all output files are placed (-o <path>). Debug (-d), CPU-only (-c) and show help (-h) are also defined.

6. We have introduced a CPU-only "-c" genn-buildmodel switch, which, if it's defined, will generate a GeNN version that is completely independent from CUDA and hence can be used on computers without CUD↩ A installation or CUDA enabled hardware. Obviously, this then can also only run on CPU. CPU only mode can either be switched on by defining CPU_ONLY in the model description file or by passing appropriate parameters during the build, in particular

```
genn-buildmodel.[sh|bat] \<modelfile\> -c
make release CPU_ONLY=1
```

7. The new genn-buildmodel "-o" switch allows the user to specify the output directory for all generated files - the default is the current directory. For example, a user project could be in '/home/genn_project', whilst the GeNN directory could be '/usr/local/genn'. The GeNN directory is kept clean, unless the user decides to build the sample projects inside of it without copying them elsewhere. This allows the deployment of GeNN to a read-only directory, like '/usr/local' or 'C:\Program Files'. It also allows multiple users - i.e. on a compute cluster - to use GeNN simultaneously, without overwriting each other's code-generation files, etcetera.

8. The ARM architecture is now supported - e.g. the NVIDIA Jetson development platform.

9. The NVIDIA CUDA SM_5∗ (Maxwell) architecture is now supported.

10. An error is now thrown when the user tries to use double precision floating-point numbers on devices with architecture older than SM_13, since these devices do not support double precision.

11. All GeNN helper functions and classes, such as `toString()` and `NNmodel`, are defined in the header files at `genn/lib/include/`, for example `stringUtils.h` and `modelSpec.h`, which should be individually included before the functions and classes may be used. The functions and classes are actually implementated in the static library `genn\lib\lib\genn.lib` (Windows) or `genn/lib/lib/libgenn.a` (Mac, Linux), which must be linked into the final executable if any GeNN functions or classes are used.

12. In the `modelDefinition()` file, only the header file `modelSpec.h` should be included - i.e. not the source file `modelSpec.cc`. This is because the declaration and definition of `NNmodel`, and associated functions, has been separated into `modelSpec.h` and `modelSpec.cc`, respectively. This is to enable NNmodel code to be precompiled separately. *Henceforth, only the header file `modelSpec.h` should be included in model definition files!*

13. In the `modelDefinition()` file, DT is now preferrably defined using `model.setDT(<val>);`, rather than `#define DT <val>`, in order to prevent problems with DT macro redefinition. For backward-compatibility reasons, the old `#define DT <val>` method may still be used, however users are advised to adopt the new method.

14. In preparation for multi-GPU support in GeNN, we have separated out the compilation of generated code from user-side code. This will eventually allow us to optimise and compile different parts of the model with different CUDA flags, depending on the CUDA device chosen to execute that particular part of the model. As such, we have had to use a header file `definitions.h` as the generated code interface, rather than the `runner.cc` file. In practice, this means that *user-side code should include `myModel_CODE/definitions.h`, rather than `myModel_CODE/runner.cc`. Including `runner.cc` will likely result in pages of linking errors at best!*

Developer Side Changes

1. Blocksize optimization and device choice now obtain the ptxas information on memory usage from a CUDA driver API call rather than from parsing ptxas output of the nvcc compiler. This adds robustness to any change in the syntax of the compiler output.

2. The information about device choice is now stored in variables in the namespace `GENN_PREFERENCES`. This includes `chooseDevice`, `optimiseBlockSize`, `optimizeCode`, `debugCode`, `showPtxInfo`, `defaultDevice`. `asGoodAsZero` has also been moved into this namespace.

3. We have also introduced the namespace GENN_FLAGS that contains unsigned int variables that attach names to numeric flags that can be used within GeNN.

4. The definitions of all generated variables and functions such as pullXXXStateFromDevice etc, are now generated into definitions.h. This is useful where one wants to compile separate object files that cannot all include the full definitions in e.g. "runnerGPU.cc". One example where this is useful is the brian2genn interface.

5. A number of feature tests have been added that can be found in the `featureTests` directory. They can be run with the respective `runTests.sh` scripts. The `cleanTests.sh` scripts can be used to remove all generated code after testing.

Improvements

1. Improved method of obtaining ptxas compiler information on register and shared memory usage and an improved algorithm for estimating shared memory usage requirements for different block sizes.

2. Replaced pageable CPU-side memory with `page-locked memory`. This can significantly speed up simulations in which a lot of data is regularly copied to and from a CUDA device.

3. GeNN library objects and the main generateALL binary objects are now compiled separately, and only when a change has been made to an object's source, rather than recompiling all software for a minor change in a single source file. This should speed up compilation in some instances.

Bug fixes:

1. Fixed a minor bug with delayed synapses, where delaySlot is declared but not referenced.

2. We fixed a bug where on rare occasions a synchronisation problem occurred in sparse synapse populations.

3. We fixed a bug where the combined spike event condition from several synapse populations was not assembled correctly in the code generation phase (the parameter values of the first synapse population over-rode the values of all other populations in the combined condition).

Please refer to the `full documentation` for further details, tutorials and complete code documentation.

Release Notes for GeNN v2.1

This release includes some new features and several bug fixes on GeNN v2.0.

User Side Changes

1. Block size debugging flag and the asGoodAsZero variables are moved into include/global.h.

2. NGRADSYNAPSES dynamics have changed (See Bug fix #4) and this change is applied to the example projects. If you are using this synapse model, you may want to consider changing model parameters.

3. The delay slots are now such that NO_DELAY is 0 delay slots (previously 1) and 1 means an actual delay of 1 time step.

4. The convenience function convertProbabilityToRandomNumberThreshold(float $*$, uint64_t $*$, int) was changed so that it actually converts firing probability/timestep into a threshold value for the GeNN random number generator (as its name always suggested). The previous functionality of converting a *rate* in kHz into a firing threshold number for the GeNN random number generator is now provided with the name convertRateToRandomNumberThreshold(float $*$, uint64_t $*$, int)

5. Every model definition function `modelDefinition()` now needs to end with calling `NNmodel::finalize()` for the defined network model. This will lock down the model and prevent any further changes to it by the supported methods. It also triggers necessary analysis of the model structure that should only be performed once. If the `finalize()` function is not called, GeNN will issue an error and exit before code generation.

6. To be more consistent in function naming the `pull\<SYNAPSENAME\>FromDevice` and `push\<SYNAPSENAME\>ToDevice` have been renamed to `pull\<SYNAPSENAME\>StateFromDevice` and `push\<SYNAPSENAME\>StateToDevice`. The old versions are still supported through macro definitions to make the transition easier.

7. New convenience macros are now provided to access the current spike numbers and identities of neurons that spiked. These are called spikeCount_XX and spike_XX where "XX" is the name of the neuron group. They access the values for the current time step even if there are synaptic delays and spikes are stored in circular queues.

8. There is now a pre-defined neuron type "SPIKECOURCE" which is empty and can be used to define PyNN style spike source arrays.
9. The macros FLOAT and DOUBLE were replaced with GENN_FLOAT and GENN_DOUBLE due to name clashes with typedefs in Windows that define FLOAT and DOUBLE.

Developer Side Changes

1. We introduced a file definitions.h, which is generated and filled with useful macros such as spkQuePtrShift which tells users where in the circular spike queue their spikes start.

Improvements

1. Improved debugging information for block size optimisation and device choice.
2. Changed the device selection logic so that device occupancy has larger priority than device capability version.
3. A new HH model called TRAUBMILES_PSTEP where one can set the number of inner loops as a parameter is introduced. It uses the TRAUBMILES_SAFE method.
4. An alternative method is added for the insect olfaction model in order to fix the number of connections to a maximum of 10K in order to avoid negative conductance tails.
5. We introduced a preprocessor define directive for an "int_" function that translates floating points to integers.

Bug fixes:

1. AtomicAdd replacement for old GPUs were used by mistake if the model runs in double precision.
2. Timing of individual kernels is fixed and improved.
3. More careful setting of maximum number of connections in sparse connectivity, covering mixed dense/sparse network scenarios.
4. NGRADSYNAPSES was not scaling correctly with varying time step.
5. Fixed a bug where learning kernel with sparse connectivity was going out of range in an array.
6. Fixed synapse kernel name substitutions where the "dd_" prefix was omitted by mistake.

Please refer to the `full documentation` for further details, tutorials and complete code documentation.

Release Notes for GeNN v2.0

Version 2.0 of GeNN comes with a lot of improvements and added features, some of which have necessitated some changes to the structure of parameter arrays among others.

User Side Changes

1. Users are now required to call `initGeNN()` in the model definition function before adding any populations to the neuronal network model.
2. glbscnt is now call glbSpkCnt for consistency with glbSpkEvntCnt.
3. There is no longer a privileged parameter `Epre`. Spike type events are now defined by a code string `spk↩ EvntThreshold`, the same way proper spikes are. The only difference is that Spike type events are specific to a synapse type rather than a neuron type.

4. The function setSynapseG has been deprecated. In a `GLOBALG` scenario, the variables of a synapse group are set to the initial values provided in the `modeldefinition` function.

5. Due to the split of synaptic models into weightUpdateModel and postSynModel, the parameter arrays used during model definition need to be carefully split as well so that each side gets the right parameters. For example, previously

```
float myPNKC_p[3]= {
0.0,            // 0 - Erev: Reversal potential
-20.0,          // 1 - Epre: Presynaptic threshold potential
1.0             // 2 - tau_S: decay time constant for S [ms]
};
```

   would define the parameter array of three parameters, `Erev`, `Epre`, and `tau_S` for a synapse of type `NSYNAPSE`. This now needs to be "split" into

```
float *myPNKC_p= NULL;
float postExpPNKC[2]={
  1.0,            // 0 - tau_S: decay time constant for S [ms]
  0.0             // 1 - Erev: Reversal potential
};
```

   i.e. parameters `Erev` and `tau_S` are moved to the post-synaptic model and its parameter array of two parameters. `Epre` is discontinued as a parameter for `NSYNAPSE`. As a consequence the weightupdate model of `NSYNAPSE` has no parameters and one can pass `NULL` for the parameter array in `addSynapse↩ Population`. The correct parameter lists for all defined neuron and synapse model types are listed in the `User Manual`.

   Note

   If the parameters are not redefined appropriately this will lead to uncontrolled behaviour of models and likely to segmentation faults and crashes.

6. Advanced users can now define variables as type `scalar` when introducing new neuron or synapse types. This will at the code generation stage be translated to the model's floating point type (ftype), `float` or `double`. This works for defining variables as well as in all code snippets. Users can also use the expressions `SCALAR_MAX` and `SCALAR_MIN` for `FLT_MIN`, `FLT_MAX`, `DBL_MIN` and `DBL_MAX`, respectively. Corresponding definitions of `scalar`, `SCALAR_MIN` and `SCALAR_MAX` are also available for user-side code whenever the code-generated file `runner.cc` has been included.

7. The example projects have been re-organized so that wrapper scripts of the `generate_run` type are now all located together with the models they run instead of in a common `tools` directory. Generally the structure now is that each example project contains the wrapper script `generate_run` and a `model` subdirectory which contains the model description file and the user side code complete with Makefiles for Unix and Windows operating systems. The generated code will be deposited in the `model` subdirectory in its own `modelname_CODE` folder. Simulation results will always be deposited in a new sub-folder of the main project directory.

8. The `addSynapsePopulation(...)` function has now more mandatory parameters relating to the introduction of separate weightupdate models (pre-synaptic models) and postynaptic models. The correct syntax for the `addSynapsePopulation(...)` can be found with detailed explanations in teh `User Manual`.

9. We have introduced a simple performance profiling method that users can employ to get an overview over the differential use of time by different kernels. To enable the timers in GeNN generated code, one needs to declare

```
networkmodel.setTiming(TRUE);
```

   This will make available and operate GPU-side cudeEvent based timers whose cumulative value can be found in the double precision variables `neuron_tme`, `synapse_tme` and `learning_tme`. They measure the accumulated time that has been spent calculating the neuron kernel, synapse kernel and learning kernel, respectively. CPU-side timers for the simulation functions are also available and their cumulative values can be obtained through

```
float x= sdkGetTimerValue(&neuron_timer);
float y= sdkGetTimerValue(&synapse_timer);
float z= sdkGetTimerValue(&learning_timer);
```

The Insect olfaction model example shows how these can be used in the user-side code. To enable timing profiling in this example, simply enable it for GeNN:

```
model.setTiming(TRUE);
```

in `MBody1.cc`'s `modelDefinition` function and define the macro `TIMING` in `classol_sim.h`

```
#define TIMING
```

This will have the effect that timing information is output into `OUTNAME_output/OUTNAME.`↩ `timingprofile`.

Developer Side Changes

1. `allocateSparseArrays()` has been changed to take the number of connections, connN, as an argument rather than expecting it to have been set in the Connetion struct before the function is called as was the arrangement previously.
2. For the case of sparse connectivity, there is now a reverse mapping implemented with revers index arrays and a remap array that points to the original positions of variable values in teh forward array. By this mechanism, revers lookups from post to pre synaptic indices are possible but value changes in the sparse array values do only need to be done once.
3. SpkEvnt code is no longer generated whenever it is not actually used. That is also true on a somewhat finer granularity where variable queues for synapse delays are only maintained if the corresponding variables are used in synaptic code. True spikes on the other hand are always detected in case the user is interested in them.

Please refer to the `full documentation` for further details, tutorials and complete code documentation.

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6 User Manual

6.1 Contents

6.2 Introduction

GeNN is a software library for facilitating the simulation of neuronal network models on NVIDIA CUDA enabled GPU hardware. It was designed with computational neuroscience models in mind rather than artificial neural networks. The main philosophy of GeNN is two-fold:

1. GeNN relies heavily on code generation to make it very flexible and to allow adjusting simulation code to the model of interest and the GPU hardware that is detected at compile time.
2. GeNN is lightweight in that it provides code for running models of neuronal networks on GPU hardware but it leaves it to the user to write a final simulation engine. It so allows maximal flexibility to the user who can use any of the provided code but can fully choose, inspect, extend or otherwise modify the generated code. They can also introduce their own optimisations and in particular control the data flow from and to the GPU in any desired granularity.

This manual gives an overview of how to use GeNN for a novice user and tries to lead the user to more expert use later on. With that we jump right in.

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6.3 Defining a network model

A network model is defined by the user by providing the function

```
void modelDefinition(NNmodel &model)
```

in a separate file, such as `MyModel.cc`. In this function, the following tasks must be completed:

1. The name of the model must be defined:

   ```
   model.setName("MyModel");
   ```

2. Neuron populations (at least one) must be added (see Defining neuron populations). The user may add as many neuron populations as they wish. If resources run out, there will not be a warning but GeNN will fail. However, before this breaking point is reached, GeNN will make all necessary efforts in terms of block size optimisation to accommodate the defined models. All populations must have a unique name.
3. Synapse populations (zero or more) can be added (see Defining synapse populations). Again, the number of synaptic connection populations is unlimited other than by resources.

6.3.1 Defining neuron populations

Neuron populations are added using the function

```
model.addNeuronPopulation(name, num, type, para, ini);
```

where the arguments are:

- `const string name`: Unique name of the neuron population
- `unsigned int num`: number of neurons in the population
- `unsigned int type`: Type of the neurons, refers to either a standard type (see Neuron models) or user-defined type; this is an integer that indicates the position in the list of all neuron models where the model in question is stored.
- `vector<double> para`: Parameters of this neuron type
- `vector<double> ini`: Initial values for variables of this neuron type

The user may add as many neuron populations as the model necessitates. They must all have unique names. The possible values for the arguments, predefined models and their parameters and initial values are detailed Neuron models below.

6.3.2 Defining synapse populations

Synapse populations are added with the function

```
model.addSynapsePopulation(name, sType, sConn, gType, delay, postSyn, preName, postName
      , sIni, sParam, postSynIni, postSynParam);
```

where the arguments are

- `const string name`: The name of the synapse population
- `unsigned int sType`: The type of synapse to be added. See Built-in Models below for the available predefined synapse types.
- `unsigned int sConn`: The type of synaptic connectivity. the options currently are "ALLTOALL", "DE↩NSE", "SPARSE" (see Connectivity types).
- `unsigned int gType`: The way how the synaptic conductivity g will be defined. Options are "IN↩DIVIDUALG", "GLOBALG", "INDIVIDUALID" (see LEARN1SYNAPSE (Learning Synapse with a Primitive Piece-wise Linear Rule)).
- `unsigned int delay`: Synaptic delay (in multiples of the simulation time step `DT`).
- `unsigned int postSyn`: Postsynaptic integration method. See Postsynaptic integration methods for predefined types.
- `const string preName`: Name of the (existing!) pre-synaptic neuron population.
- `const string postName`: Name of the (existing!) post-synaptic neuron population.
- `vector<double> sIni`: A vector of doubles containing initial values for the (pre-) synaptic variables.
- `vector<double> sParam`: A vector of double precision that contains parameter values (common to all synapses of the population) which will be used for the defined synapses. The array must contain the right number of parameters in the right order for the chosen synapse type. If too few, segmentation faults will occur, if too many, excess will be ignored. For pre-defined synapse types the required parameters and their meaning are listed in NSYNAPSE (No Learning) below.
- `vector<double> psIni`: A vector of double precision numbers containing initial values for the post-synaptic model variables.
- `vector<double> psPara`: A vector of double precision numbers containing parameters fo the post-snaptic model.

Note

> If the synapse conductance definition type is "GLOBALG" then the global value of the synapse conductances is taken from the initial value provided in `sINI`. (The function setSynapseG() from earlier versions of GeNN has been deprecated).

Synaptic updates can occur per "true" spike (i.e at one point per spike, e.g. after a threshold was crossed) or for all "spike type events" (e.g. all points above a given threshold). This is defined within each given synapse type.

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6.4 Neuron models

There is a number of predefined models which can be chosen in the `addNeuronGroup(...)` function by their unique cardinal number, starting from 0. For convenience, C variables with readable names are predefined

- 0: MAPNEURON

- 1: POISSONNEURON
- 2: TRAUBMILES_FAST
- 3: TRAUBMILES_ALTERNATIVE
- 4: TRAUBMILES_SAFE
- 5: TRAUBMILES_PSTEP
- 6: IZHIKEVICH
- 7: IZHIKEVICH_V
- 8: SPIKESOURCE

Note

Ist is best practice to not depend on the unique cardinal numbers but use predefined names. While it is not intended that the numbers will change the unique names are guaranteed to work in all future versions of GeNN.

6.4.1 MAPNEURON (Map Neurons)

The MAPNEURON type is a map based neuron model based on [4] but in the 1-dimensional map form used in [3] :

$$V(t+\Delta t) = \begin{cases} V_{\rm spike}\left(\frac{\alpha V_{\rm spike}}{V_{\rm spike}-V(t)\beta I_{\rm syn}}+y\right) & V(t)\leq 0 \\ V_{\rm spike}\left(\alpha+y\right) & V(t)\leq V_{\rm spike}\left(\alpha+y\right)\ \&\ V(t-\Delta t)\leq 0 \\ -V_{\rm spike} & \text{otherwise} \end{cases}$$

Note

The `MAPNEURON` type only works as intended for the single time step size of `DT`= 0.5.

The `MAPNEURON` type has 2 variables:

- `V` - the membrane potential
- `preV` - the membrane potential at the previous time step

and it has 4 parameters:

- `Vspike` - determines the amplitude of spikes, typically -60mV
- `alpha` - determines the shape of the iteration function, typically α= 3
- `y` - "shift / excitation" parameter, also determines the iteration function,originally, y= -2.468
- `beta` - roughly speaking equivalent to the input resistance, i.e. it regulates the scale of the input into the neuron, typically β= 2.64 $\mathrm{M}\Omega$.

Note

The initial values array for the `MAPNEURON` type needs two entries for `V` and `Vpre` and the parameter array needs four entries for `Vspike`, `alpha`, `y` and `beta`, *in that order.*

6.4.2 POISSONNEURON (Poisson Neurons)

Poisson neurons have constant membrane potential (`Vrest`) unless they are activated randomly to the `Vspike` value if (t- `SpikeTime`) $>$ `trefract`.

It has 3 variables:

- `V` - Membrane potential
- `Seed` - Seed for random number generation
- `SpikeTime` - Time at which the neuron spiked for the last time

and 4 parameters:

- `therate` - Firing rate
- `trefract` - Refractory period
- `Vspike` - Membrane potential at spike (mV)
- `Vrest` - Membrane potential at rest (mV)

Note

The initial values array for the `POISSONNEURON` type needs three entries for `V`, `Seed` and `SpikeTime` and the parameter array needs four entries for `therate`, `trefract`, `Vspike` and `Vrest`, *in that order*. Internally, GeNN uses a linear approximation for the probability of firing a spike in a given time step of size `DT`, i.e. the probability of firing is `therate` times `DT`: $p = \lambda \Delta t$. This approximation is usually very good, especially for typical, quite small time steps and moderate firing rates. However, it is worth noting that the approximation becomes poor for very high firing rates and large time steps. An unrelated problem may occur with very low firing rates and small time steps. In that case it can occur that the firing probability is so small that the granularity of the 64 bit integer based random number generator begins to show. The effect manifests itself in that small changes in the firing rate do not seem to have an effect on the behaviour of the Poisson neurons because the numbers are so small that only if the random number is identical 0 a spike will be triggered.

6.4.3 TRAUBMILES_FAST (Hodgkin-Huxley neurons with Traub & Miles algorithm)

This conductance based model has been taken from [5] and can be described by the equations:

$$\begin{aligned}
C\frac{dV}{dt} &= -I_{\rm Na} - I_K - I_{\rm leak} - I_M - I_{i,DC} - I_{i,\rm syn} - I_i, \\
I_{\rm Na}(t) &= g_{\rm Na} m_i(t)^3 h_i(t)(V_i(t) - E_{\rm Na}) \\
I_{\rm K}(t) &= g_{\rm K} n_i(t)^4 (V_i(t) - E_{\rm K}) \\
\frac{dy(t)}{dt} &= \alpha_y(V(t))(1 - y(t)) - \beta_y(V(t))y(t),
\end{aligned}$$

where $y_i = m, h, n$, and

$$\begin{aligned}
\alpha_n &= 0.032(-50 - V)/\big(\exp((-50 - V)/5) - 1\big) \\
\beta_n &= 0.5\exp((-55 - V)/40) \\
\alpha_m &= 0.32(-52 - V)/\big(\exp((-52 - V)/4) - 1\big) \\
\beta_m &= 0.28(25 + V)/\big(\exp((25 + V)/5) - 1\big) \\
\alpha_h &= 0.128\exp((-48 - V)/18) \\
\beta_h &= 4/\big(\exp((-25 - V)/5) + 1\big).
\end{aligned}$$

and typical parameters are $C = 0.143$ nF, $g_{\rm leak} = 0.02672$ μS, $E_{\rm leak} = -63.563$ mV, $g_{\rm Na} = 7.15$ μS, $E_{\rm Na} = 50$ mV, $g_{\rm K} = 1.43$ μS, $E_{\rm K} = -95$ mV.

It has 4 variables:

- `V` - membrane potential E
- `m` - probability for Na channel activation m
- `h` - probability for not Na channel blocking h
- `n` - probability for K channel activation n

and 7 parameters:

- `gNa` - Na conductance in 1/(mOhms $*$ cm^2)
- `ENa` - Na equi potential in mV
- `gK` - K conductance in 1/(mOhms $*$ cm^2)
- `EK` - K equi potential in mV
- `gl` - Leak conductance in 1/(mOhms $*$ cm^2)
- `El` - Leak equi potential in mV
- `Cmem` - Membrane capacity density in muF/cm^2

Note

Internally, the ordinary differential equations defining the model are integrated with a linear Euler algorithm and GeNN integrates 25 internal time steps for each neuron for each network time step. I.e., if the network is simulated at `DT= 0.1` ms, then the neurons are integrated with a linear Euler algorithm with `lDT= 0.004` ms.

Other variants of the same model are TRAUBMILES_ALTERNATIVE, TRAUBMILES_SAFE and TRAUBMILES_↩ PSTEP. The former two are adressing the problem of singularities in the original Traub & Miles model [5]. At V= -52 mV, -25 mV, and -50 mV, the equations for α have denominators with value 0. Mathematically this is not a problem because the nominator is 0 as well and the left and right limits towards these singular points coincide. Numerically, however this does lead to nan (not-a-number) results through division by 0. The TRAUBMILES_ALTERNATIVE model adds SCALAR_MIN to the denominators at all times which typically is completely effect-free because it is truncated from teh mantissa, except when the denominator is very close to 0, in which case it avoids the singular value.

TRAUBMILES_SAFE takes a much more direct approach in which at the singular points, the correct value calculated offline with l'Hopital's rule in substituted. This is implemented with "if" statements.

Finally, the TRAUBMILES_PSTEP model allows users to control the number of internal loops, or sub-timesteps, that are used. This is enabled by making the number of time steps an explicit parameter of the model.

6.4.4 IZHIKEVICH (Izhikevich neurons with fixed parameters)

This is the Izhikevich model with fixed parameters [1]. It is usually described as

$$\begin{aligned} \frac{dV}{dt} &= 0.04V^2 + 5V + 140 - U + I, \\ \frac{dU}{dt} &= a(bV - U), \end{aligned}$$

I is an external input current and the voltage V is reset to parameter c and U incremented by parameter d, whenever V $>=$ 30 mV. This is paired with a particular integration procedure of two 0.5 ms Euler time steps for the V equation followed by one 1 ms time step of the U equation. Because of its popularity we provide this model in this form here event though due to the details of the usual implementation it is strictly speaking inconsistent with the displayed equations.

Variables are:

- V - Membrane potential
- U - Membrane recovery variable

Parameters are:

- a - time scale of U
- b - sensitivity of U
- c - after-spike reset value of V
- d - after-spike reset value of U

6.4.5 IZHIKEVICH_V (Izhikevich neurons with variable parameters)

This is the same model as IZHIKEVICH (Izhikevich neurons with fixed parameters) IZHIKEVICH but parameters are defined as "variables" in order to allow users to provide individual values for each individual neuron instead of fixed values for all neurons across the population.

Accordingly, the model has the Variables:

- V - Membrane potential
- U - Membrane recovery variable
- a - time scale of U
- b - sensitivity of U
- c - after-spike reset value of V
- d - after-spike reset value of U

and no parameters.

6.4.6 SPIKESOURCE (empty neuron which allows setting spikes from external sources)

This model does not contain any update code and can be used to implement the equivalent of a SpikeGenerator↩ Group in Brian or a SpikeSourceArray in PyNN.

6.4.7 Defining your own neuron type

In order to define a new neuron type for use in a GeNN application, it is necessary to populate an object of class `neuronModel` and append it to the global vector `nModels`. This can be done conveniently within the model↩ Definition function just before the model is needed. The `neuronModel` class has several data members that make up the full description of the neuron model:

- `simCode` of type `string:` This needs to be assigned a C++ (stl) string that contains the code for executing the integration of the model for one time step. Within this code string, variables need to be referred to by , where NAME is the name of the variable as defined in the vector varNames. The code may refer to the predefined primitives `DT` for the time step size and for the total incoming synaptic current. It can also refer to a unique ID (within the population) using .
  Example:

  ```
  neuronModel model;
  model.simCode=String("$(V)+= (-$(a)$(V)+$(Isyn))*DT;");
  ```

  would implement a leaky integrator $\frac{dV}{dt} = -aV + I_{\rm syn}$.

- `thresholdConditionCode` of type `vector<string>` (if applicable): Condition for true spike detection.

- `supportCode` of type `string`: This allows to define a code snippet that contains supporting code that will be utilized in the otehr code snippets. Typically, these are functions that are needed in the `simCode` or `thresholdConditionCode`. If possible, these should be defined as `__host__ __device__` functions so that both GPU and CPU versions of GeNN code have an appropriate support code function available. The support code is protected with a namespace so that it is exclusively available for the neuronpopulation whose neurons define it. An example of a `supportCode` definition would be

```
n.supportCode= tS(" __host__ __device__ mysin(float x) {\n\
return sin(x);\n\
}");
```

- `varNames` of type `vector<string>`: This vector needs to be filled with the names of variables that make up the neuron state. The variables defined here as `NAME` can then be used in the syntax in the code string.
  Example:

```
model.varNames.push_back(String("V"));
```

  would add the variable V as needed by the code string in the example above.

- `varTypes` of type `vector<string>`: This vector needs to be filled with the variable type (e.g. "float", "double", etc) for the variables defined in `varNames`. Types and variables are matched to each other by position in the respective vectors, i.e. the 0th entry of `varNames` will have the type stored in the 0th entry of `varTypes` and so on.
  Example:

```
model.varTypes.push_back(String("float"));
```

  would designate the variable V to be of type float.

  Note

- `pNames` of type `vector<string>`: This vector will contain the names of parameters relevant to the model. If defined as `NAME` here, they can then be referenced as in the code string. The length of this vector determines the expected number of parameters in the initialisation of the neuron model. Parameters are assumed to be always of type double.

```
model.pNames.push_back(String("a"));
```

  stores the parameter `a` needed in the code example above.

- `dpNames` of type `vector<string>`: Names of "dependent parameters". Dependent parameters are a mechanism for enhanced efficiency when running neuron models. If parameters with model-side meaning, such as time constants or conductances always appear in a certain combination in the model, then it is more efficient to pre-compute this combination and define it as a dependent parameter. This vector contains the names of such dependent parameters.
  For example, if in the example above the original model had been $\frac{dV}{dt} = -g/CV + I_{\text{syn}}$. Then one could define the code string and parameters as

```
model.simCode=String("$(V)+= (-$(a)$(V)+$(Isyn))*DT;");
model.varNames.push_back(String("V"));
model.varTypes.push_back(String("float"));
model.pNames.push_back(String("g"));
model.pNames.push_back(String("C"));
model.dpNames.push_back(String("a"));
```

- dps of type dpclass∗: The dependent parameter class, i.e. an implementation of dpclass which would return the value for dependent parameters when queried for them. E.g. in the example above it would return a when queried for dependent parameter 0 through dpclass::calculateDerivedParameter(). Examples how this is done can be found in the pre-defined classes, e.g. expDecayDp, pwSTDP, rulkovdp etc.

- extraGlobalNeuronKernelParameters of type vector<string>: On occasion, the neurons in a population share the same parameter. This could, for example, be a global reward signal. Such situations are implemented in GeNN with extraGlobalNeuronKernelParameters. This vector takes the names of such parameters. FOr each name, a variable will be created, with the name of the neuron population name appended, that can take a single value per population of the type defined in the extra←GlobalNeuronKernelParameterTypes vector. This variable is available to all neurons in the population. It can also be used in synaptic code snippets; in this case it needs to be addressed with a _pre or _post postfix. For example, if teh pre-synaptic neuron population is of a neuron type that defines:

```
n.extraGlobalNeuronKernelParameters.push_back(tS("R"));
n.extraGlobalNeuronKernelParameterTypes.push_back(tS("float"));
```

  then, a synapse population could have simulation code like

```
s.simCode= tS("$(x)= $(x)+$(R_pre);");
```

  where we have assumed that the synapse type s has a variable x and the synapse type s will only be used in conjunction with pre-synaptic neuron populations that do have the extraGlobalNeuronKernelParameter R. If the pre-synaptic population does not have the required variable/parameter, GeNN will fail when compiling the kernels.

- extraGlobalNeuronKernelParameterTypes of type vector<string>: These are the types of the extraGlobalNeuronKernelParameters. Types are matched to names by their position in the vector.

Once the completed neuronModel object is appended to the nModels vector,

```
nModels.push_back(model);
```

it can be used in network descriptions by referring to its cardinal number in the nModels vector. I.e., if the model is added as the 4th entry, it would be model "3" (counting starts at 0 in usual C convention). The information of the cardinal number of a new model can be obtained by referring to nModels.size() right before appending the new model, i.e. a typical use case would be.

```
int myModel= nModels.size();
nModels.push_back(model);
```

. Then one can use the model as

```
networkModel.addNeuronPopulation(..., myModel, ...);
```

6.4.8 Explicit current input to neurons (NOW REMOVED)

In earlier versions of GeNN External input to a neuron group could be activated by calling the activateDirect←Input function. This was now removed in favour of defining a new neuron model where the direct input can be a parameter (constant over time and homogeneous across the population), a variable (changing in time and non-homogeneous across the population), or an extraGlobalNeuronKernelParameter (changing in time but homogeneous across the population). How this can be done is illustrated for example in the Izh_sparse example project.

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6.5 Synapse models

A synapse model is a weightUpdateModel object which consists of variables, parameters, and string objects which will be substituted in the code. The three strings that will be substituted in the code for synapse update are:

- `simCode`: Simulation code that is used when a true spike is detected. The update is performed only once, one time step after threshold condition detection, which is defined by `thresholdConditionCode` in the neuron model of the corresponding presynaptic neuron population.
  Typically, spikes lead to update of synaptic variables that then lead to the activation of input into the post-synaptic neuron. Most of the time these inputs add linearly at the post-synaptic neuron. This is assumed in GeNN and the term to be added to the activation of the post-synaptic neuron should be provided as the value of the by the $(addtoinsyn) snippet. For example

  ```
  "\$(addtoinsyn) = $(inc);"
  ```

  where "inc" is a parameter of the weightupdate model, would define a constant increment of the synaptic input of a post-synaptic neuron for each pre-synaptic spike.
  When a spike is detected in the presynaptic neuron population, the simCode is executed. Within the code snippet the $(addtoinSyn) update just discussed should be be followed by the $(updatelinsyn) keyword to indicate that the summation of synaptic inputs can now occur. This can then be followed by updates on the internal synapse variables that may have contributed to addtoinSyn. For an example, see NSYNAPSE (No Learning) for a simple synapse update model and LEARN1SYNAPSE (Learning Synapse with a Primitive Piece-wise Linear Rule) for a more complicated model that uses STDP.
- `simCodeEvnt`: Simulation code that is used for spike like events, where updates are done for all instances in which the event condition defined by `evntThreshold` is met. `evntThreshold` is also be provided as a code string. For an example, see NGRADSYNAPSE (Graded Synapse).
- `simLearnPost`: Simulation code which is used in the learnSynapsesPost kernel/function, which performs updates to synapses that are triggered by post-synaptic spikes. This is rather unusual other than in learning rules like e.g. STDP. For an example that uses `simLearnPost`, see LEARN1SYNAPSE (Learning Synapse with a Primitive Piece-wise Linear Rule).
- `synapseDynamics`: Simulation code that applies for every time step, i.e.is unlike the others not gated with a condition. This can be used where synapses have internal variables and dynamics that are described in continuous time, e.g. by ODEs. Usng this mechnanism is typically computationally veruy costly because of the large number of synapses in a typical network.
- `extraGlobalSynapseKernelParameters` of type `vector<string>`: On occasion, the synapses in a synapse population share a global parameter. This could, for example, be a global reward signal. This is supported in GeNN with `extraGlobalSynapseKernelParameters`. The user defines the names of such parameters and pushes them into this vector. GeNN creates variables of this name, with the name of the synapse population appended, that can take a single value per population of the type defined in the extraGlobalSynapseKernelParameterTypes vector. This variable is then available to all synapses in the population.

  Note

  No implicit or explicit copy of `extraGlobalSynapseKernelParameters` is necessary as they are communicated as kernel parameters.
- `extraGlobalSynapseKernelParameterTypes` of type `vector<string>`: These are the types of the `extraGlobalSynapseKernelParameters`. Types are matched to names by their position in the vector.

All code snippets can be used to manipulate any synapse variable and so implement both synaptic dynamics and learning processes.

6.5.1 Built-in Models

Currently 3 predefined synapse models are available:

- NSYNAPSE
- NGRADSYNAPSE
- LEARN1SYNAPSE

These are defined in `lib.include/utils.h`. The `MBody_userdef` example also includes a modified version of these models as user-defined models.

6.5.2 NSYNAPSE (No Learning)

If this model is selected, no learning rule is applied to the synapse and for each pre-synaptic spikes the synaptic conductances are simply added to the postsynaptic input variable. The model has 1 variable:

- `g` - conductance of `scalar` type

and no other parameters.

`simCode` is:

```
" $(addtoinSyn) = $(g);\n\
  $(updatelinsyn);\n"
```

6.5.3 NGRADSYNAPSE (Graded Synapse)

In a graded synapse, the conductance is updated gradually with the rule:

$$gSyn = g * tanh((V - E_{pre})/V_{slope}$$

whenever the membrane potential V is larger than the threshold E_{pre}. The model has 1 variable:

- `g:` conductance of `scalar` type

The parameters are:

- `Epre:` Presynaptic threshold potential
- `Vslope:` Activation slope of graded release

`simCodeEvnt` is:

```
" $(addtoinSyn) = $(g)* tanh(($(V_pre)-($(Epre)))*DT*2/$(Vslope));\n\
  $(updatelinsyn);\n"
```

`evntThreshold` is:

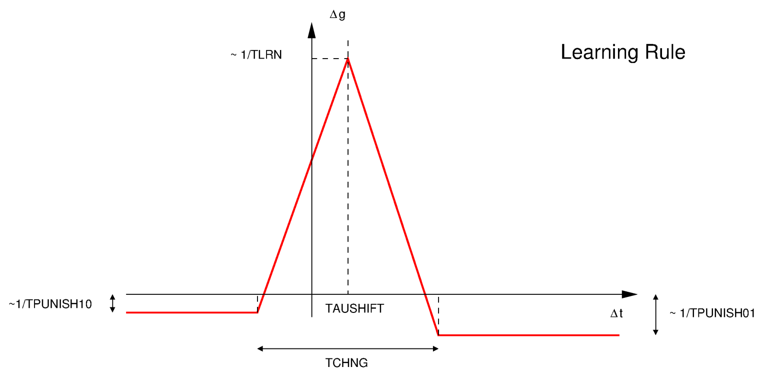
```
" $(V_pre) > $(Epre)"
```

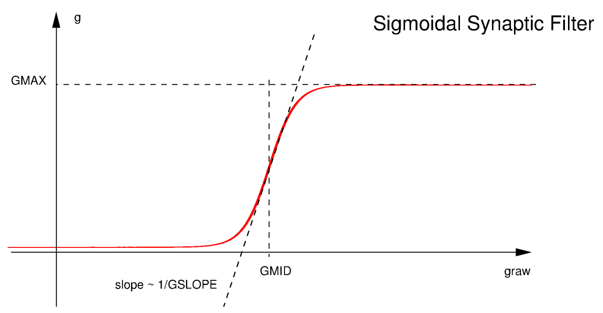
Note

The pre-synaptic variables are referenced with the suffix `_pre` in synapse related code such as an `evnt←Threshold`. Users can also access post-synaptic neuron variables using the suffix `_post`.

6.5.4 LEARN1SYNAPSE (Learning Synapse with a Primitive Piece-wise Linear Rule)

This is a simple STDP rule including a time delay for the finite transmission speed of the synapse, defined as a piecewise function:





The STDP curve is applied to the raw synaptic conductance `gRaw`, which is then filtered through the sugmoidal filter displayed above to obtain the value of `g`.

Note

The STDP curve implies that unpaired pre- and post-synaptic spikes incur a negative increment in `gRaw` (and hence in `g`).
The time of the last spike in each neuron, "sTXX", where XX is the name of a neuron population is (somewhat arbitrarily) initialised to -10.0 ms. If neurons never spike, these spike times are used.
It is the raw synaptic conductance `gRaw` that is subject to the STDP rule. The resulting synaptic conductance is a sigmoid filter of `gRaw`. This implies that `g` is initialised but not `gRaw`, the synapse will revert to the value that corresponds to `gRaw`.

An example how to use this synapse correctly is given in `map_classol.cc` (MBody1 userproject):

```
for (int i= 0; i < model.neuronN[1]*model.neuronN[3]; i++) {
        if (gKCDN[i] < 2.0*SCALAR_MIN){
            cnt++;
            fprintf(stdout, "Too low conductance value %e detected and set to 2*SCALAR_MIN= %e, at index %d
       \n", gKCDN[i], 2*SCALAR_MIN, i);
            gKCDN[i] = 2.0*SCALAR_MIN; //to avoid log(0)/0 below
        }
        scalar tmp = gKCDN[i] / myKCDN_p[5]*2.0 ;
        gRawKCDN[i]=  0.5 * log( tmp / (2.0 - tmp)) /myKCDN_p[7] +
      myKCDN_p[6];
}
cerr << "Total number of low value corrections: " << cnt << endl;
```

Note

One cannot set values of `g` fully to `0`, as this leads to `gRaw=` -infinity and this is not support. I.e., 'g' needs to be some nominal value $>$ 0 (but can be extremely small so that it acts like it's 0).

The model has 2 variables:

- `g:` conductance of `scalar` type
- `gRaw:` raw conductance of `scalar` type

Parameters are (compare to the figure above):

- `Epre:` Presynaptic threshold potential
- `tLrn:` Time scale of learning changes
- `tChng:` Width of learning window
- `tDecay:` Time scale of synaptic strength decay
- `tPunish10:` Time window of suppression in response to 1/0
- `tPunish01:` Time window of suppression in response to 0/1
- `gMax:` Maximal conductance achievable
- `gMid:` Midpoint of sigmoid g filter curve
- `gSlope:` Slope of sigmoid g filter curve
- `tauShift:` Shift of learning curve
- `gSyn0:` Value of syn conductance g decays to

For more details about these built-in synapse models, see [2].

6.5.5 Defining a new synapse model

If users want to define their own models, they can add a new `weightUpdateModel` that includes the variables, parameters, and update codes as desired, and then push this object in the `weightUpdateModels` vector. The model can be used by referring to its index in the `weightUpdateModels` vector when adding a new population by with a call to `addSynapsePopulation`.

6.5.6 Conductance definition methods

The available options work as follows:

- `INDIVIDUALG:` When this option is chosen in the `addSynapsePopulation` command, GeNN reserves an array of size n_pre x n_post float for individual conductance values for each combination of pre and postsynaptic neuron. The actual values of the conductances are passed at runtime from the user side code, using the `pushXXXXXToDevice` function, where XXXX is the name of the synapse population.
- `GLOBALG:` When this option is chosen, the value of the variables of the synapse model (including its conductance) is taken to be the initial value provided for the synapse model's variables. This option can only be sensibly combined with connectivity type ALLTOALL.
- `INDIVIDUALID:` When this option is chosen, GeNN expects to use the same maximal conductance for all existing synaptic connections but which synapses exist will be defined at runtime from the user side code, provided as a binary array (see Insect olfaction model).

6.5.7 Connectivity types

Available options are `DENSE` and `SPARSE`. Various tools are provided under userproject/tools for creating different connectivity schemes.

Different strategies are used by GeNN for different combinations of connecticity types and Conductance definition methods, as explained in the table below:

	ALLTOALL	DENSE	SPARSE
GLOBALG	Fixed values for all synapse members	Fixed values for all synapse members	Fixed values for some synapse members (using sparse indexing)
INDIVIDUALG	Variable values for all synapse members	Variable values for all synapse members	Variable values for some synapse members
INDIVIDUALID	Fixed values for some synapse members (using a binary array). Technically possible but not meaningful.	Fixed values for some synapse members (using a binary array)	N/A

If `INDIVIDUALG` is used with `ALLTOALL` or `DENSE` connectivity (these are equivalent in this case), synapse variables are stored in an array of size npre $*$ npost .

If the connectivity is of SPARSE type, connectivity indices are stored in a struct named SparseProjection in order to minimize the memory requirements. The struct SparseProjection contains the following members: 1: unsigned int connN: number of connections in the population. This value is needed for allocation of arrays. The indices that correspond to these values are defined in a pre-to-post basis by the following arrays: 2: unsigned int ind, of size connN: Indices of corresponding postsynaptic neurons concatenated for each presynaptic neuron. 3: unsigned int $*$indInG, of size `model.neuronN`[model.synapseSource[synInd]]+1: This array defines from which index in the synapse variable array the indices in ind would correspond to the presynaptic neuron that corresponds to the index of the indInG array, with the number of connections being the size of ind. More specifically, `indIng`[n+1]-indIng[n] would give the number of postsynaptic connections for neuron n.

For example, consider a network of two presynaptic neurons connected to three postsynaptic neurons: 0th presynaptic neuron connected to 1st and 2nd postsynaptic neurons, the 1st presynaptic neuron connected to 0th and 2nd neurons. The struct SparseProjection should have these members, with indexing from 0:

```
ConnN = 4

ind= [1 2 0 2]

indIng= [0 2 4]
```

A synapse variable of a sparsely connected synapse will be kept in an array using this conductance for indexing. For example, a variable caled `g` will be kept in an array such as: `g`=[g_Pre0-Post1 g_pre0-post2 g_pre1-post0 g_pre1-post2] If there are no connections for a presynaptic neuron, then `g`[indIng[n]]=gp[indIng[n]+1].

See tools/gen_syns_sparse_IzhModel used in Izh_sparse project to see a working example.

6.5.8 Postsynaptic integration methods

The postSynModel defines how synaptic activation translates into an input current (or other input term for models that are not current based). It also can contain equations defining dynamics that are applied to the (summed) synaptic activation, e.g. an exponential decay over time.

A postSynModel object consists of variables, parameters, derived parameters and two strings that define the code for current generation and continuous dynamics.

- string `postSynDecay`: This code defines the continuous time dynamics of the summed presynaptic inputs at the postsynaptic neuron. This usually consists of some kind of decay function.
- string `postSyntoCurrent`: This code defines how the synaptic inputs lead to an input input current (Isyn) to the postsynaptic neuron.

There are currently 2 built-in postsynaptic integration methods:

EXPDECAY: Exponential decay. Decay time constant and reversal potential parameters are needed for this post-synaptic mechanism.

This model has no variables and two parameters:

- `tau` : Decay time constant
- `E` : Reversal potential

`tau` is used by the derived parameter `expdecay` which returns expf(-dt/tau).

IZHIKEVICH_PS: Empty postsynaptic rule to be used with Izhikevich neurons.

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7 Tutorial 1

In this tutorial we will go through step by step instructions how to create and run a GeNN simulation starting from scratch. Normally, we recommend users to use one of the example projects as a starting point but it can be very instructive to go through the necessary steps one by one once to appreciate what parts make a GeNN simulation.

7.1 The Model Definition

In this tutorial we will use a pre-defined neuron model type (TRAUBMILES) and create a simulation of ten Hodgkin-Huxley neurons [5] without any synaptic connections. We will run this simulation on a GPU and save the results to stdout.

The first step is to write a model definition function in a model definition file. Create a new empty file `tenHH↩ Model.cc` with your favourite editor, e.g.

```
>> emacs tenHHModel.cc &
```

Note

The ">>" in the example code snippets refers to a shell prompt in a unix shell, do not enter them as part of your shell commands.

The model definition file contains the definition of the network model we want to simulate. First, we need to include the GeNN model specification code `modelSpec.h`. Then the model definition takes the form of a function named `modelDefinition` that takes one argument, passed by reference, of type `NNmodel`. Type in your `tenHH↩ Model.cc` file:

```
// Model definintion file tenHHModel.cc

#include "modelSpec.h"

void modelDefinition(NNmodel &model)
{
  // definition of tenHHModel
}
```

Now we need to fill the actual model definition. Three standard elements to the ‘modelDefinition function are initialising GeNN, setting the simulation step size and setting the name of the model:

```
initGeNN();
model.setDT(0.1);
model.setName("tenHHModel");
```

Note

With this we have fixed the integration time step to `0.1` in the usual time units. The typical units in GeNN are `ms`, `mV`, `nF`, and `\form#10S`. Therefore, this defines `DT= 0.1 ms`. The name of the model given in the setName method does not need to match the file name of the model definition file. However, we strongly recommend it and if conflicting, the file name of the model definition file will prevail.

Making the actual model definition makes use of the `addNeuronPopulation` and 'addSynapse↩ Population`member functions of the NNmodel object. The arguments to a call to`addNeuronPopulations are

- `string name`: the name of the population
- `int N`: The number of neurons in the population
- `int type`: The type of neurons in the population
- `double *p`: An array of parameter values for teh neurons in the population
- `double *ini`: An array of initial values for neuron variables

We first create the parameter and initial variable arrays,

```
// definition of tenHHModel
double p[7]= {
  7.15,          // 0 - gNa: Na conductance in muS
  50.0,          // 1 - ENa: Na equi potential in mV
  1.43,          // 2 - gK: K conductance in muS
 -95.0,          // 3 - EK: K equi potential in mV
  0.02672,       // 4 - gl: leak conductance in muS
  -63.563,       // 5 - El: leak equi potential in mV
  0.143          // 6 - Cmem: membr. capacity density in nF
};

double ini[4]= {
  -60.0,         // 0 - membrane potential V
  0.0529324,     // 1 - prob. for Na channel activation m
  0.3176767,     // 2 - prob. for not Na channel blocking h
  0.5961207      // 3 - prob. for K channel activation n
};
```

Note

The comments are obviously only for clarity, they can in principle be omitted. To avoid any confusion about the meaning of parameters and variables, however, we recommend strongly to always include comments of this type.

Having defined the parameter values and initial values we can now create the neuron population,

```
model.addNeuronPopulation("Pop1", 10, TRAUBMILES, p, ini);
```

Note

`TRAUBMILES` is a variable defined in the GeNN model specification that contains the index number of the pre-defined Traub & Miles model [5].

The model definition then needs to end on calling

```
model.finalize();
```

This completes the model definition in this example. The complete `tenHHModel.cc` file now should look like this:

```
// Model definintion file tenHHModel.cc

#include "modelSpec.h"

void modelDefinition(NNmodel &model)
{
  // definition of tenHHModel
  initGeNN();
  model.setDT(0.1);
  model.setName("tenHHModel");
  double p[7]= {
    7.15,          // 0 - gNa: Na conductance in muS
    50.0,          // 1 - ENa: Na equi potential in mV
    1.43,          // 2 - gK: K conductance in muS
   -95.0,          // 3 - EK: K equi potential in mV
    0.02672,       // 4 - gl: leak conductance in muS
    -63.563,       // 5 - El: leak equi potential in mV
    0.143          // 6 - Cmem: membr. capacity density in nF
  };

  double ini[4]= {
    -60.0,         // 0 - membrane potential V
    0.0529324,     // 1 - prob. for Na channel activation m
    0.3176767,     // 2 - prob. for not Na channel blocking h
    0.5961207      // 3 - prob. for K channel activation n
  };
  model.addNeuronPopulation("Pop1", 10, TRAUBMILES, p, ini);
  model.finalize();
}
```

This model definition suffices to generate code for simulating the ten Hodgkin-Huxley neurons on the a GPU or CPU. The second part of a GeNN simulation is the user code that sets up the simulation, does the data handling for input and output and generally defines the numerical experiment to be run.

7.2 User Code

For the purposes of this tutorial we will initially simply run the model for one simulated second and record the final neuron variables into a file. GeNN provides the code for simulating the model in a function called `stepTimeCP↵U()` (execution on CPU only) or `stepTimeGPU()` (execution on a GPU). To make use of this code, we need to define a minimal C/C++ main function. Open a new empty file `tenHHSimulation.cc` in an editor and type

```
// tenHHModel simulation code
#include "tenHHModel.cc"
#include "tenHHModel_CODE/definitions.h"

int main()
{
  allocateMem();
  initialize();

  return 0;
}
```

This boiler plate code includes the relevant model definition file we completed earlier and the header file of entry point to the generated code `definitions.h` in the subdirectory `tenHHModel_CODE` where GeNN deposits all generated code.

Calling `allocateMem()` allocates the memory structures for all neuron variables and `initialize()` sets the initial values and copies values to the GPU.

Now we can use the generated code to execute the integration of the neuron equations provided by GeNN. To do so, we add after `initialize();`

```
stepTimeGPU(1000.0);
```

and we need to copy the result, and output it to stdout,

```
pullPop1fromDevice();
for (int i= 0; i < 10; i++) {
  cout << VPop1[i] << " ";
  cout << mPop1[i] << " ";
  cout << hPop1[i] << " ";
  cout << nPop1[i] << endl;
}
```

`pullPop1fromDevice()` copies all relevant state variables of the `Pop1` neuron group from the GPU to the CPU main memory. Then we can output the results to stdout by looping through all 10 neurons and outputting the state variables VPop1, mPop1, hPop1, nPop1.

Note

> The naming convention for variables in GeNN is the variable name defined by the neuron type, here TRAU↩
> BMILES defining V, m, h, and n, followed by the population name, here `Pop1`.

This completes the user code. The complete `tenHHSimulation.cu` file should now look like

```
// tenHHModel simulation code
#include "tenHHModel.cc"
#include "tenHHModel_CODE/definitions.h"

int main()
{
  allocateMem();
  initialize();
  stepTimeGPU(1000.0);
  pullPop1fromDevice();
  for (int i= 0; i < 10; i++) {
    cout << VPop1[i] << " ";
    cout << mPop1[i] << " ";
    cout << hPop1[i] << " ";
    cout << nPop1[i] << endl;
  }
  return 0;
}
```

7.3 Makefile

A GeNN simulation is built with a simple Makefile. On Unix systems we typically name it `GNUmakefile`. Create this file and enter

```
EXECUTABLE      :=tenHHSimulation
SOURCES         :=tenHHSimulation.cu

include $(GENN_PATH)/userproject/include/makefile_common_gnu.mk
```

This defines that the final executable of this simulation is named tenHHSimulation and the simulation code is given in the file `tenHHSimulation.cu` that we completed above.

Now we are ready to compile and run the simulation

7.4 Making and Running the Simulation

To build the model and generate the GeNN code, type in a terminal where you are in the directory containing your `tenHHModel.cc` file,

```
>> genn-buildmodel.sh tenHHModel.cc
```

If your environment variables `GENN_PATH` and `CUDA_PATH` are correctly configured, you should see some compile output ending in `Model build complete ...`. Now type

```
make
```

This should compile your `tenHHSimulation` executable and you can execute it with

```
./tenHHSimulation
```

The output you obtain should look like

```
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
-63.7838 0.0350042 0.336314 0.563243
```

This completes this tutorial. You have created a GeNN model and simulated it successfully!

7.5 Adding External Input

In the example we have created so far, the neurons are not connected and do not receive input. As the TRAUB↩ MILES model is silent in such conditions, the ten neurons simply will simply rest at their resting potential. To make things more interesting, let us add a constant input to all neurons, add to the end of the `modelDefinition` function

```
model.activateDirectInput("Pop1", CONSTINP);
model.setConstInp("Pop1", 0.1);
```

This will add a constant input of 0.1 nA to all ten neurons. When run with this addition you should observe the output

```
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
-63.1468 0.0211871 0.987233 0.0423695
```

This is still not particularly interesting as we are just observing the final value of the membrane potentials. To see what is going on in the meantime, we need to copy intermediate values from the device and best save them into a file. This can be done in many ways but one sensible way of doing this is to replace the line

```
stepTimeGPU(1000.0);
```

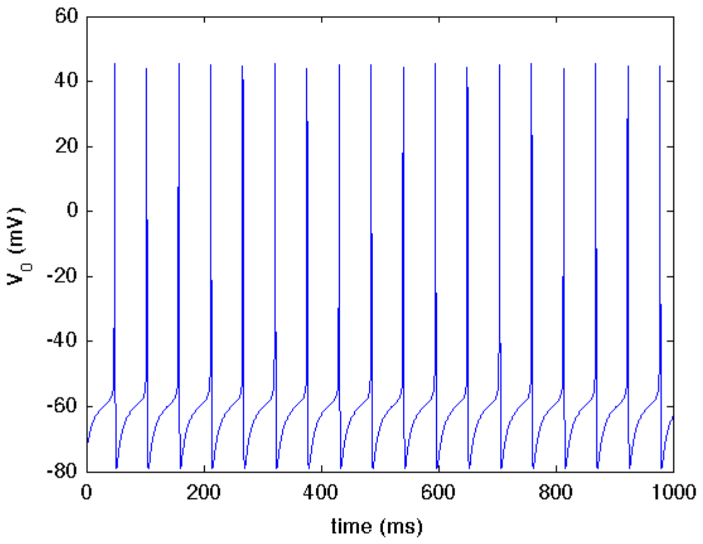
in `tenHHSimulation.cu` to something like this:

```
ofstream os("tenHH_output.V.dat");
double t= 0.0;
for (int i= 0; i < 5000; i++) {
  stepTimeGPU(0.2);
  pullPop1fromDevice();
  os << t << " ";
  for (int j= 0; j < 10; j++) {
    os << VPop1[j] << " ";
  }
  os << endl;
  t+= 0.2;
}
os.close();
```

After building, making and executing,

```
genn-builmodel.sh tenHHModel.cc
make clean all
./tenHHSimulation
```

there should be a file `tenHH_output.V.dat` in the same directory. If you plot column one (time) against column two (voltage of neuron 0), you should observe dynamics like this:



The completed files from this tutorial can be found in `userproject/tenHH_project`.

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8 Tutorial 2

In this tutorial we will learn to add synapsePopulations to connect neurons in neuron groups to each other with synatic models. As an example we will connect the ten Hodgkin-Huxley neurons from tutorial 1 in a ring of excitatory synapses.

First, copy the files from Tutorial 1 into a new directory and rename them to new names, e.g.

```
>> cp -r tenHH_project tenHHRing_project
>> cd tenHHRing_project
>> mv tenHHModel.cc tenHHRingModel.cc
>> mv tenHHSimulation.cu tenHHRingSimulation.cu
```

Now, we need to add a synapse group to the model that allows to connect neurons from the Pop1 group to connect to other neurons of this group. Open `tenHHRingModel.cc`, change the model name inside,

```
model.setName("tenHHRing");
```

8.1 Adding Synaptic connections

Now we need additional initial values and parameters for the synapse and post-synaptic models. We will use the standard `NSYNAPSE` weightupdate model and `EXPDECAY` post-synaptic model. They need intial variables and parameters as follows:

```
double s_ini[1] = {
  0.0      // 0 - g: the synaptic conductance value
};
double *s_p= NULL;
double *ps_ini= NULL;
double ps_p[2]= {
  1.0,      // 0 - tau_S: decay time constant for S [ms]
  -80.0     // 1 - Erev: Reversal potential
};
```

If an array is not needed we set it to the NULL pointer. Here there are for example no synaptic parameters and no initial values for the post-synaptic mechanism. We can then add a synapse population at the end of the `model↩ Definition(...)` function,

```
model.addSynapsePopulation("Pop1self", NSYNAPSE,
      DENSE, INDIVIDUALG, NO_DELAY, EXPDECAY, "Pop1", "Pop1", s_ini, s_p, ps_ini,
       ps_p);
```

The addSynapsePopulation parameters are

- `const char *name`: The name of the synapse population, here "Pop1self"
- `int sType`: The type of synapse to be added, we here use the predefined typse `NSYNAPSE`. See Built-in Models for all available predefined synapse types.
- `int sConn`: The type of synaptic connectivity, here `DENSE` which means we will provide a full connectivity mtrix later.
- `int gType`**:** The way how the synaptic conductivity g will be defined. With `GLOBALG` we indicate that all conductance are of the same conductance value, which will be the value given in `sPara`.
- `int delay`: `NO_DELAY` means that there wil be no delays for synaptic signal propagation.
- `int postSyn`: Postsynaptic integration method, we are here using the standard model of an exponential decay of synaptic excitation.
- `char *preName`: Name of the pre-synaptic neuron population, here the `Pop1` population.
- `char *postName`: Name of the post-synaptic neuron population, here also `Pop1`.
- `double *sIni`: A C-array of doubles containing initial values for the synaptic variables.
- `double *sParam`: A C-array of double precision that contains parameter values (common to all synapses of the population)
- `double *psIni`: A C-array of double precision numbers containing initial values for the post-synaptic model variables
- `double *psPara`: A C-array of double precision numbers containing parameters fo the post-snaptic model.

Adding the addSynapsePopulation command to the model definition informs GeNN that there will be synapses between the named neuron populations, here between population `Pop1` and itself. The detailed connectivity as defined by the variables `g`, we have still to define in the setup of our simulation. As always, the `modelDefinition` function ends on

```
model.finalize();
```

At this point our model definition file `tenHHRingModel.cc` should look like this

```
// Model definintion file tenHHModel.cc

#include "modelSpec.h"

void modelDefinition(NNmodel &model)
{
  // definition of tenHHModel
  initGeNN();
  model.setDT(0.1);
  model.setName("tenHHRingModel");
  double p[7]= {
    7.15,          // 0 - gNa: Na conductance in muS
    50.0,          // 1 - ENa: Na equi potential in mV
    1.43,          // 2 - gK: K conductance in muS
   -95.0,          // 3 - EK: K equi potential in mV
    0.02672,       // 4 - gl: leak conductance in muS
    -63.563,       // 5 - El: leak equi potential in mV
    0.143          // 6 - Cmem: membr. capacity density in nF
  };

  double ini[4]= {
    -60.0,         // 0 - membrane potential V
    0.0529324,     // 1 - prob. for Na channel activation m
    0.3176767,     // 2 - prob. for not Na channel blocking h
    0.5961207      // 3 - prob. for K channel activation n
  };
  model.addNeuronPopulation("Pop1", 10, TRAUBMILES, p, ini);
  model.activateDirectInput("Pop1", CONSTINP);
  model.setConstInp("Pop1", 0.1);
  double s_ini[1] = {
    0.0       // 0 - g: the synaptic conductance value
  };
  double *s_p= NULL;
  double *ps_ini= NULL;
  double ps_p[2]= {
    1.0,      // 0 - tau_S: decay time constant for S [ms]
    -80.0     // 1 - Erev: Reversal potential
  };
  model.addSynapsePopulation("Pop1self", NSYNAPSE,
      DENSE, INDIVIDUALG, NO_DELAY, EXPDECAY, "Pop1", "Pop1", s_ini, s_p, ps_ini,
       ps_p);
  model.finalize();
}
```

8.2 Defining the Detailed Synaptic Connections

Open the `tenHHRingSimulation.cu` file and update the file names of includes:

```
// tenHHRingModel simulation code
#include "tenHHRingModel.cc"
#include "tenHHRingModel_CODE/definitions.h"
```

Now we need to add code to generate the desired ring connectivity.

```
allocateMem();
initialize();
// define the connectivity
int pre, post;
for (int i= 0; i < 10; i++) {
  pre= i;
  post= (i+1)%10;
  gPop1self[pre*10+post]= 0.01;
}
pushPop1selftoDevice();
```

After memory allocation and initialization `gPop1self` will contain only zeros. We then assign in the loop a non-zero conductivity of 0.01 μS to all synapses from neuron `i` to `i+1` (and `9` to `0` to close the ring).

After adjusting the GNUmakefile to read

```
EXECUTABLE      :=tenHHRingSimulation
SOURCES         :=tenHHRingSimulation.cu

include $(GENN_PATH)/userproject/include/makefile_common_gnu.mk
```

we can build the model

```
>> genn-buildmodel.sh tenHHRingModel.cc
```

and make it

```
>> make clean all
```

After this there should be an exectable `tenHHRingSimulation`, which can be executed,

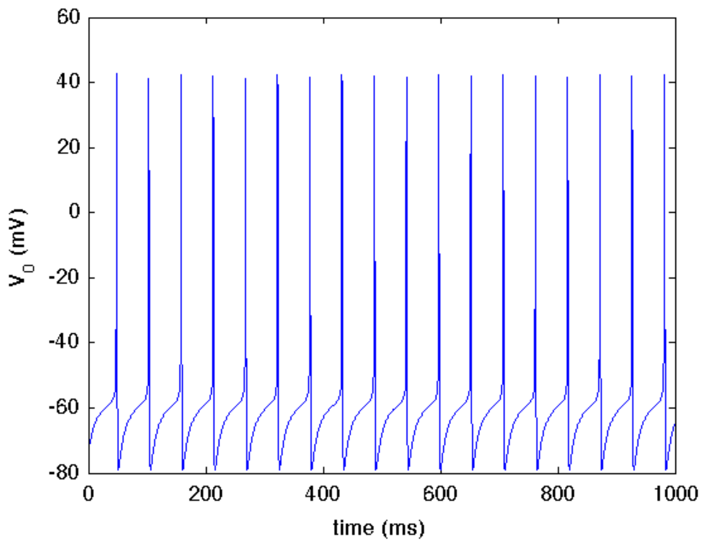
```
>> ./tenHHRingSimulation
```

which should again result in

```
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
```

```
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
-64.9054 0.0147837 0.981337 0.030886
```

If we plot the content of columns one and two of `tenHHexample.V.dat` it looks very similar as in Tutorial 1



This is because the inhibitory synapses we created were all triggered at the same time so that they act during a post-synaptic spike which makes their effect all but invisible.

8.3 Setting Heterogeneous Initial Conditions

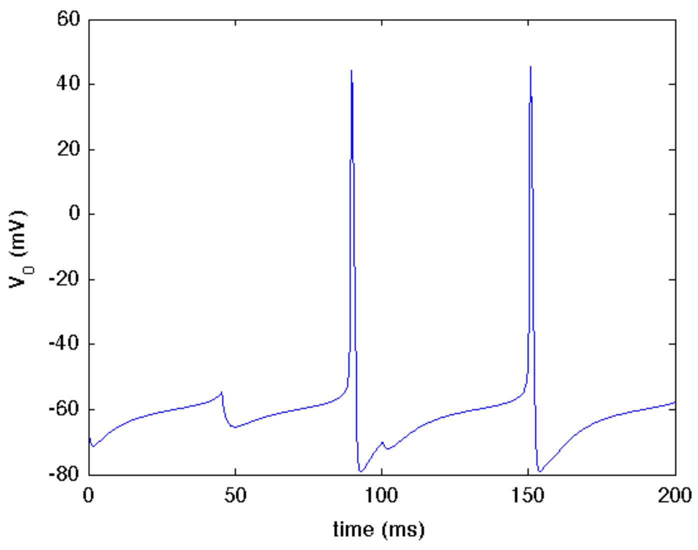
If we define different initial conditions for each of the ten neurons, i.e. add after `initialize()`,

```
// set initial variables
for (int i= 0; i < 10; i++) {
  VPop1[i]= -60.0+i;
}
pushPop1toDevice();
```

then we observe different final values for each neuron,

```
-57.3412 0.06223 0.981374 0.104417
-53.3189 0.442962 0.0664687 0.764513
-73.1413 0.00253709 0.927251 0.0277236
-67.1179 0.00927304 0.986692 0.0206106
-63.5878 0.01938 0.991071 0.0387962
-62.2114 0.0255295 0.990933 0.0504799
-61.404 0.0298902 0.990949 0.0586459
-60.6691 0.034405 0.990225 0.0668015
-59.8977 0.0397467 0.988701 0.0758159
-58.9727 0.0470178 0.98615 0.0866963
```

and zooming in on the first 200 ms, the voltage of the first neuron now looks like this



The complete codes for this tutorial are in `userproject\tenHHRing_project`.

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9 Best practices guide

GeNN generates code according to the network model defined by the user, and allows users to include the generated code in their programs as they want. Here we provide a guideline to setup GeNN and use generated functions. We recommend users to also have a look at the Examples, and to follow the tutorials Tutorial 1 and Tutorial 2.

9.1 Creating and simulating a network model

The user is first expected to create an object of class NNmodel by creating the function modelDefinition() which includes calls to following methods in correct order:

- initGeNN();
- NNmodel::setDT();
- NNmodel::setName();

Then add neuron populations by:

- NNmodel::addNeuronPopulation();

for each neuron population. Add synapse populations by:

- NNmodel::addSynapsePopulation();

for each synapse population.

The modelDefinition() needs to end with calling NNmodel::finalize().

Other optional functions are explained in NNmodel class reference. At the end the function should look like this:

```
void modelDefinition(NNModel &model) {
  initGeNN();
  model.setDT(0.5);
  model.setName("YourModelName");
  model.addNeuronPopulation(...);
  ...
  model.addSynapsePopulation(...);
  ...
  model.finalize();
}
```

modelSpec.h should be included in the file where this function is defined.

This function will be called by generateALL.cc to create corresponding CPU and GPU simulation codes under the <YourModelName>_CODE directory.

These functions can then be used in a .cu file which runs the simulation. This file should include <YourModel↩ Name>_CODE/runner.cc. Generated code differ from one model to the other, but core functions are the same and they should be called in correct order. First, the following variables should be defined and initialized:

- NNmodel model // initialized by calling modelDefinition(model)
- Array containing current input (if any)

The following are declared by GeNN but should be initialized by the user:

- Poisson neuron offset and rates (if any)
- Connectivity matrices (if sparse)
- Neuron and synapse variables (if not initialising to the homogeneous initial value provided during `model↩ Definition`)

Core functions generated by GeNN to be included in the user code include:

- `allocateMem()`
- `deviceMemAllocate()`
- `initialize()`
- `initializeAllSparseArrays()`
- `convertProbabilityToRandomNumberThreshold()`
- `convertRateToRandomNumberThreshold()`
- `copyStateToDevice()`
- `push\<neuron or synapse name\>StatetoDevice()`
- `pull\<neuron or synapse name\>StatefromDevice()`
- `copyStateFromDevice()`
- `copySpikeNFromDevice()`
- `copySpikesFromDevice()`
- `stepTimeCPU()`
- `stepTimeGPU()`
- `freeMem()`
- `freeDeviceMem()`

Before calling the kernels, **make sure you have copied the initial values of all the neuron and synapse variables in the GPU**. You can use the `push\<neuron or synapse name\>StatetoDevice()` to copy from the host to the GPU. At the end of your simulation, if you want to access the variables you need to copy them back from the device using the `pull\<neuron or synapse name\>StatefromDevice()` function. Alternatively, you can directly use the CUDA memcopy functions. **Copying elements between the GPU and the host memory is very costly in terms of performance and should only be done when needed.**

9.2 Floating point precision

Double precision floating point numbers are supported by devices with compute capability 1.3 or higher. If you have an older GPU, you need to use single precision floating point in your models and simulation.

GPUs are designed to work better with single precision while double precision is the standard for CPUs. This difference should be kept in mind while comparing performance.

While setting up the network for GeNN, double precision floating point numbers are used as this part is done on the CPU. For the simulation, GeNN lets users choose between single or double precision. Overall, new variables in the generated code are defined with the precision specified by NNmodel::setPrecision(unsigned int), providing GENN_FLOAT or GENN_DOUBLE as argument. GENN_FLOAT is the default value. The keyword `scalar` can be used in the user-defined model codes for a variable that could either be single or double precision. This keyword is detected at code generation and substituted with "float" or "double" according to the precision set by NNmodel↩ ::setPrecision(unsigned int).

There may be ambiguities in arithmetic operations using explicit numbers. Standard C compilers presume that any number defined as "X" is an integer and any number defined as "X.Y" is a double. Make sure to use the same precision in your operations in order to avoid performance loss.

9.3 Working with variables in GeNN

9.3.1 Model variables

User-defined model variables originate from core units such as neuronModel, weightUpdateModel or postSynModel objects. The name of a variable is defined when the model type is introduced, i.e. with a statement such as

```
neuronModel model;
model.varNames.push_back(String"x"));
model.varTypes.push_back(String("double"));
...
int myModel= nModels.size();
nModels.push_back(model);
```

This declares that whenever the defined model type of cardinal number `myModel` is used, there will be a variable of core name `x`. varType can be of `scalar` type (see Floating point precision). The full GeNN name of this variable is obtained by directly concatenating the core name with the name of the neuron population in which the model type has been used, i.e. after a definition

```
networkModel.addNeuronPopulation("EN", n, myModel, ...);
```

there will be a variable `xEN` of type `double*` available in the global namespace of the simulation program. GeNN will pre-allocate this C array to the correct size of elements corresponding to the size of the neuron population, `n` in the example above. GeNN will also free these variables when the provided function `freeMem()` is called. Users can otherwise manipulate these variable arrays as they wish. For convenience, GeNN provides functions `pullXXStatefromDevice()` and `pushXXStatetoDevice()` to copy the variables associated to a neuron population `XX` from the device into host memory and vice versa. E.g.

```
pullENStatefromDevice();
```

would copy the C array xEN from device memory into host memory (and any other variables that the neuron type of the population EN may have).

The user can also directly use CUDA memory copy commands independent of the provided convenience functions. The relevant device pointers for all variables that exist in host memory have the same name as the host variable but are prefixed with `d_`. For example, the copy command that would be contained in `pullENStatefrom↩ Device()` will look like

```
unsigned int size;
size = sizeof(double) * nEN;
cudaMemcpy(xEN, d_xEN, size, cudaMemcpyDeviceToHost);
```

where nEN is an integer containing the population size of the EN neuron population.

The same convention as for neuron variables applies for the variables of synapse populations, both for those originating from weightupdate models and from post-synaptic models, e.g. the variables in type NSYNAPSE contain the variable g of type float. Then, after

```
networkModel.addSynapsePopulation("ENIN", NSYNAPSE, ...);
```

there will be a global variable of type float* with the name gENIN that is pre-allocated to the right size. There will also be a matching device pointer with the name d_gENIN.

Note

The content of gENIN needs to be interpreted differently for DENSE connectivity and sparse matrix based SPARSE connectivity representations. For DENSE connectivity gENIN would contain "n_pre" times "n_post" elements, ordered along the pre-synaptic neurons as the major dimension, i.e. the value of gENIN for the ith pre-synaptic neuron and the jth post-synaptic neuron would be gENIN[i*n_post+j]. The arrangement of values in the SPARSE representation is explained in section Connectivity types
Be aware that the above naming conventions do assume that variables from the weightupdate models and the postSynModels that are used together in a synapse population are unique. If both the weightupdate model and the postSynModel have a variable of the same name, the behaviour is undefined.

9.3.2 Built-in Variables in GeNN

Since GeNN 2.0, there are no more explicitly hard-coded synapse and neuron variables. Users are free to name the variable of their models as they want. However, there are some reserved variables that are used for intermediary calculations and communication between different parts of the generated code. They can be used in the user defined code but no other variables should be defined with these names.

- DT : Time step (typically in ms) for simulation; Neuron integration can be done in multiple sub-steps inside the neuron model for numerical stability (see Traub-Miles and Izhikevich neuron model variations in Neuron models).
- addtoinSyn : This variable is used by weightUpdateModel for updating synaptic input. The way it is modified is defined in weightUpdateModel.simCode or weightUpdateModel.simCodeEvnt, therefore if a user defines her own model she should update this variable to contain the input to the post-synaptic model.
- updatelinsyn : At the end of the synaptic update by addtoinSyn, final values are copied back to the d_inSyn<synapsePopulation> variables which will be used in the next step of the neuron update to provide the input to the postsynaptic neurons. This keyword designated where the changes to addtoinSyn have been completed and it is safe to update the summed synaptic input and write back to d_inSyn<synapse↩
Population> in device memory.
- inSyn: This is an intermediary synapse variable which contains the summed input into a postsynaptic neuron (originating from the addtoinSyn variables of the incoming synapses) .
- Isyn : This is a local variable which contains the (summed) input current to a neuron. It is typically the sum of any explicit current input and all synaptic inputs. The way its value is calculated during the update of the postsynaptic neuron is defined by the code provided in the postSynModel. For example, the standard EXPDECAY postsynaptic model defines

  ```
  ps.postSyntoCurrent= String("$(inSyn)*($(E)-$(V))");
  ```

  which implements a conductance based synapse in which the postsynaptic current is given by $I_{\rm syn} = g * s * (V_{\rm rev} - V_{\rm post})$.

Note

The `addtoinSyn` variables from all incoming synapses are automatically summed and added to the current value of `inSyn`.

The value resulting from the `postSyntoCurrent` code is assigned to `Isyn` and can then be used in neuron simCode like so:

```
$(V)+= (-$(V)+$(Isyn))*DT
```

- `sT` : As a neuron variable, this is the last spike time in a neuron and is automatically generated for pre and postsynaptic neuron groups of a synapse group i that follows a spike based learning rule (indicated by usesPostLearning[i]= TRUE for the ith synapse population).

In addition to these variables, neuron variables can be referred to in the synapse models by calling $(<neuronVar↩ Name>_pre) for the presynaptic neuron population, and $(<neuronVarName>_post) for the postsynaptic population. For example, $(sT_pre), $(sT_post), $(V_pre), etc.

9.4 Debugging suggestions

In Linux, users can call `cuda-gdb` to debug on the GPU. Example projects in the `userproject` directory come with a flag to enable debugging (DEBUG=1). genn-buildmodel.sh has a debug flag (-d) to generate debugging data. If you are executing a project with debugging on, the code will be compiled with -g -G flags. In CPU mode the executable will be run in gdb, and in GPU mode it will be run in cuda-gdb in tui mode.

On Mac, some versions of `clang` aren't supported by the CUDA toolkit. This is a recurring problem on Fedora as well, where CUDA doesn't keep up with GCC releases. You can either hack the CUDA header which checks compiler versions - `cuda/include/host_config.h` - or just use an older XCode version (6.4 works fine).

Note

Do not forget to switch debugging flags -g and -G off after debugging is complete as they may negatively affect performance.

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10 Credits

GeNN was created by Thomas Nowotny.

Izhikevich model and sparse connectivity by Esin Yavuz.

Block size optimisations, delayed synapses and page-locked memory by James Turner.

Automatic brackets and dense-to-sparse network conversion helper tools by Alan Diamond.

User-defined synaptic and postsynaptic methods by Alex Cope and Esin Yavuz.

Example projects were provided by Alan Diamond, James Turner, Esin Yavuz and Thomas Nowotny.

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11 Namespace Index

11.1 Namespace List

Here is a list of all namespaces with brief descriptions:

12 Hierarchical Index

12.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

13 Class Index

13.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

14 File Index

14.1 File List

Here is a list of all files with brief descriptions:

15 Namespace Documentation

15.1 GENN_FLAGS Namespace Reference

Variables

- unsigned int calcSynapseDynamics = 0
- unsigned int calcSynapses = 1
- unsigned int learnSynapsesPost = 2
- unsigned int calcNeurons = 3

15.1.1 Variable Documentation

15.1.1.1 unsigned int GENN_FLAGS::calcNeurons = 3

15.1.1.2 unsigned int GENN_FLAGS::calcSynapseDynamics = 0

15.1.1.3 unsigned int GENN_FLAGS::calcSynapses = 1

15.1.1.4 unsigned int GENN_FLAGS::learnSynapsesPost = 2

15.2 GENN_PREFERENCES Namespace Reference

Variables

- int optimiseBlockSize = 1

    Flag for signalling whether or not block size optimisation should be performed.
- int autoChooseDevice = 1

    Flag to signal whether the GPU device should be chosen automatically.
- bool optimizeCode = false

    Request speed-optimized code, at the expense of floating-point accuracy.
- bool debugCode = false

    Request debug data to be embedded in the generated code.
- bool showPtxInfo = false

    Request that PTX assembler information be displayed for each CUDA kernel during compilation.
- double asGoodAsZero = 1e-19

    Global variable that is used when detecting close to zero values, for example when setting sparse connectivity from a dense matrix.
- int defaultDevice = 0
- unsigned int neuronBlockSize = 32

    default GPU device; used to determine which GPU to use if chooseDevice is 0 (off)
- unsigned int synapseBlockSize = 32
- unsigned int learningBlockSize = 32
- unsigned int synapseDynamicsBlockSize = 32
- unsigned int autoRefractory = 1

    Flag for signalling whether spikes are only reported if thresholdCondition changes from false to true (autoRefractory == 1) or spikes are emitted whenever thresholdCondition is true no matter what.

15.2.1 Variable Documentation

15.2.1.1 double GENN_PREFERENCES::asGoodAsZero = 1e-19

Global variable that is used when detecting close to zero values, for example when setting sparse connectivity from a dense matrix.

15.2.1.2 int GENN_PREFERENCES::autoChooseDevice = 1

Flag to signal whether the GPU device should be chosen automatically.

15.2.1.3 unsigned int GENN_PREFERENCES::autoRefractory = 1

Flag for signalling whether spikes are only reported if thresholdCondition changes from false to true (autoRefractory == 1) or spikes are emitted whenever thresholdCondition is true no matter what.

15.2.1.4 bool GENN_PREFERENCES::debugCode = false

Request debug data to be embedded in the generated code.

15.2.1.5 int GENN_PREFERENCES::defaultDevice = 0

15.2.1.6 unsigned int GENN_PREFERENCES::learningBlockSize = 32

15.2.1.7 unsigned int GENN_PREFERENCES::neuronBlockSize = 32

default GPU device; used to determine which GPU to use if chooseDevice is 0 (off)

15.2.1.8 int GENN_PREFERENCES::optimiseBlockSize = 1

Flag for signalling whether or not block size optimisation should be performed.

15.2.1.9 bool GENN_PREFERENCES::optimizeCode = false

Request speed-optimized code, at the expense of floating-point accuracy.

15.2.1.10 bool GENN_PREFERENCES::showPtxInfo = false

Request that PTX assembler information be displayed for each CUDA kernel during compilation.

15.2.1.11 unsigned int GENN_PREFERENCES::synapseBlockSize = 32

15.2.1.12 unsigned int GENN_PREFERENCES::synapseDynamicsBlockSize = 32

16 Class Documentation

16.1 classIzh Class Reference

```
#include <Izh_sparse_model.h>
```

Public Member Functions

- classIzh ()
- ∼classIzh ()
- void init (unsigned int)
- void allocate_device_mem_patterns ()
- void allocate_device_mem_input ()
- void copy_device_mem_input ()
- void read_sparsesyns_par (int, struct SparseProjection, FILE ∗, FILE ∗, FILE ∗, scalar ∗)

  Read sparse connectivity from a file.
- void gen_alltoall_syns (scalar ∗, unsigned int, unsigned int, scalar)

  Generate random conductivity values for an all to all network.
- void free_device_mem ()
- void write_input_to_file (FILE ∗)
- void read_input_values (FILE ∗)
- void create_input_values ()
- void run (double, unsigned int)
- void getSpikesFromGPU ()

  Method for copying all spikes of the last time step from the GPU.
- void getSpikeNumbersFromGPU ()

  Method for copying the number of spikes in all neuron populations that have occurred during the last time step.
- void output_state (FILE ∗, unsigned int)
- void output_spikes (FILE ∗, unsigned int)
- void output_params (FILE ∗, FILE ∗)
- void sum_spikes ()
- void setInput (unsigned int)
- void randomizeVar (scalar ∗, scalar, unsigned int)
- void randomizeVarSq (scalar ∗, scalar, unsigned int)
- void initializeAllVars (unsigned int)

Public Attributes

- NNmodel model
- scalar ∗ input1
- scalar ∗ input2
- scalar ∗ d_input1
- scalar ∗ d_input2
- unsigned int sumPExc
- unsigned int sumPInh

16.1.1 Constructor & Destructor Documentation

16.1.1.1 classIzh::classIzh ( )

16.1.1.2 classIzh::∼classIzh ( )

16.1.2 Member Function Documentation

16.1.2.1 void classIzh::allocate_device_mem_input ( )

16.1.2.2 void classIzh::allocate_device_mem_patterns ( )

16.1.2.3 void classIzh::copy_device_mem_input ( )

16.1.2.4 void classIzh::create_input_values ( )

16.1.2.5 void classIzh::free_device_mem ( )

16.1.2.6 void classIzh::gen_alltoall_syns (scalar ∗ *g,* unsigned int *nPre,* unsigned int *nPost,* scalar *gscale*)

Generate random conductivity values for an all to all network.

Parameters

g	the resulting synaptic conductances
nPre	number of pre-synaptic neurons
nPost	number of post-synaptic neurons
gscale	the maximal conductance of generated synapses

16.1.2.7 void classIzh::getSpikeNumbersFromGPU ( )

Method for copying the number of spikes in all neuron populations that have occurred during the last time step.

This method is a simple wrapper for the convenience function copySpikeNFromDevice() provided by GeNN.

16.1.2.8 void classIzh::getSpikesFromGPU ( )

Method for copying all spikes of the last time step from the GPU.

This is a simple wrapper for the convenience function copySpikesFromDevice() which is provided by GeNN.

16.1.2.9 void classIzh::init (unsigned int *which*)

16.1.2.10 void classIzh::initializeAllVars (unsigned int *which*)

16.1.2.11 void classIzh::output_params (FILE ∗ *f,* FILE ∗ *f2*)

16.1.2.12 void classIzh::output_spikes (FILE ∗ *f,* unsigned int *which*)

16.1.2.13 void classIzh::output_state (FILE ∗ *f,* unsigned int *which*)

16.1.2.14 void classIzh::randomizeVar (scalar ∗ *Var,* scalar *strength,* unsigned int *neuronGrp*)

16.1.2.15 void classIzh::randomizeVarSq (scalar ∗ *Var,* scalar *strength,* unsigned int *neuronGrp*)

16.1.2.16 void classIzh::read_input_values (FILE ∗)

16.1.2.17 void classIzh::read_sparsesyns_par (int *synInd,* struct SparseProjection *C,* FILE ∗ *f_ind,* FILE ∗ *f_indInG,* FILE ∗ *f_g,* scalar ∗ *g*)

Read sparse connectivity from a file.

Parameters

synInd	index of the synapse population to be worked on
C	contains teh arrays to be initialized from file
f_ind	file pointer for the indices of post-synaptic neurons
f_indInG	file pointer for the summed post-synaptic neurons numbers
f_g	File handle for a file containing sparse conductivity values
g	array to receive the conductance values

16.1.2.18 void classIzh::run (double *runtime,* unsigned int *which*)

16.1.2.19 void classIzh::setInput (unsigned int *which*)

16.1.2.20 void classIzh::sum_spikes ( )

16.1.2.21 void classIzh::write_input_to_file (FILE ∗ *f*)

16.1.3 Member Data Documentation

16.1.3.1 scalar∗ classIzh::d_input1

16.1.3.2 scalar ∗ classIzh::d_input2

16.1.3.3 scalar∗ classIzh::input1

16.1.3.4 scalar ∗ classIzh::input2

16.1.3.5 NNmodel classIzh::model

16.1.3.6 unsigned int classIzh::sumPExc

16.1.3.7 unsigned int classIzh::sumPInh

The documentation for this class was generated from the following files:

- Izh_sparse_model.h
- Izh_sparse_model.cc

16.2 classol Class Reference

This class cpontains the methods for running the MBody1 example model.

```
#include <map_classol.h>
```

Public Member Functions

- classol ()
- ∼classol ()

Destructor for olfaction model.
- void init (unsigned int)

  Method for initialising variables.
- void allocate_device_mem_patterns ()

  Method for allocating memory on the GPU device to hold the input patterns.
- void free_device_mem ()

  Methods for unallocating the memory for input patterns on the GPU device.
- void read_pnkcsyns (FILE ∗)

  Method for reading the connectivity between PNs and KCs from a file.
- void read_sparsesyns_par (int, struct SparseProjection, scalar ∗, FILE ∗, FILE ∗, FILE ∗)

  Read sparse connectivity from a file.
- void write_pnkcsyns (FILE ∗)

  Method for writing the conenctivity between PNs and KCs back into file.
- void read_pnlhisyns (FILE ∗)

  Method for reading the connectivity between PNs and LHIs from a file.
- void write_pnlhisyns (FILE ∗)

  Method for writing the connectivity between PNs and LHIs to a file.
- void read_kcdnsyns (FILE ∗)

  Method for reading the connectivity between KCs and DNs (detector neurons) from a file.
- void write_kcdnsyns (FILE ∗)

  Method to write the connectivity between KCs and DNs (detector neurons) to a file.
- void read_input_patterns (FILE ∗)

  Method for reading the input patterns from a file.
- void generate_baserates ()

  Method for calculating the baseline rates of the Poisson input neurons.
- void runGPU (scalar)

  Method for simulating the model for a given period of time on the GPU.
- void runCPU (scalar)

  Method for simulating the model for a given period of time on the CPU.
- void output_state (FILE ∗, unsigned int)

  Method for copying from device and writing out to file of the entire state of the model.
- void getSpikesFromGPU ()

  Method for copying all spikes of the last time step from the GPU.
- void getSpikeNumbersFromGPU ()

  Method for copying the number of spikes in all neuron populations that have occurred during the last time step.
- void output_spikes (FILE ∗, unsigned int)

  Method for writing the spikes occurred in the last time step to a file.
- void sum_spikes ()

  Method for summing up spike numbers.
- void get_kcdnsyns ()

  Method for copying the synaptic conductances of the learning synapses between KCs and DNs (detector neurons) back to the CPU memory.
- classol ()
- ∼classol ()
- void init (unsigned int)
- void allocate_device_mem_patterns ()
- void free_device_mem ()
- void read_pnkcsyns (FILE ∗)
- void read_sparsesyns_par (int, struct SparseProjection, scalar ∗, FILE ∗, FILE ∗, FILE ∗)
- void write_pnkcsyns (FILE ∗)
- void read_pnlhisyns (FILE ∗)
- void write_pnlhisyns (FILE ∗)

- void read_kcdnsyns (FILE ∗)
- void write_kcdnsyns (FILE ∗)
- void read_input_patterns (FILE ∗)
- void generate_baserates ()
- void runGPU (scalar)
- void runCPU (scalar)
- void output_state (FILE ∗, unsigned int)
- void getSpikesFromGPU ()
- void getSpikeNumbersFromGPU ()
- void output_spikes (FILE ∗, unsigned int)
- void sum_spikes ()
- void get_kcdnsyns ()
- classol ()
- ∼classol ()
- void init (unsigned int)
- void allocate_device_mem_patterns ()
- void free_device_mem ()
- void read_pnkcsyns (FILE ∗)
- void read_sparsesyns_par (int, struct SparseProjection, scalar ∗, FILE ∗, FILE ∗, FILE ∗)
- void write_pnkcsyns (FILE ∗)
- void read_pnlhisyns (FILE ∗)
- void write_pnlhisyns (FILE ∗)
- void read_kcdnsyns (FILE ∗)
- void write_kcdnsyns (FILE ∗)
- void read_input_patterns (FILE ∗)
- void generate_baserates ()
- void runGPU (scalar)
- void runCPU (scalar)
- void output_state (FILE ∗, unsigned int)
- void getSpikesFromGPU ()
- void getSpikeNumbersFromGPU ()
- void output_spikes (FILE ∗, unsigned int)
- void sum_spikes ()
- void get_kcdnsyns ()
- classol ()
- ∼classol ()
- void init (unsigned int)
- void allocate_device_mem_patterns ()
- void free_device_mem ()
- void read_pnkcsyns (FILE ∗)
- template<class DATATYPE >
  void read_sparsesyns_par (DATATYPE ∗, int, struct SparseProjection, FILE ∗, FILE ∗, FILE ∗)

  Read sparse connectivity from a file.
- void write_pnkcsyns (FILE ∗)
- void read_pnlhisyns (FILE ∗)
- void write_pnlhisyns (FILE ∗)
- void read_kcdnsyns (FILE ∗)
- void write_kcdnsyns (FILE ∗)
- void read_input_patterns (FILE ∗)
- void generate_baserates ()
- void runGPU (scalar)
- void runCPU (scalar)
- void output_state (FILE ∗, unsigned int)
- void getSpikesFromGPU ()

- void getSpikeNumbersFromGPU ()
- void output_spikes (FILE ∗, unsigned int)
- void sum_spikes ()
- void get_kcdnsyns ()
- classol ()
- ∼classol ()
- void init (unsigned int)
- void allocate_device_mem_input ()
- void free_device_mem ()
- void read_PNIzh1syns (scalar ∗, FILE ∗)
- void read_sparsesyns_par (int, struct SparseProjection, FILE ∗, FILE ∗, FILE ∗, double ∗)

  Read sparse connectivity from a file.
- void generate_baserates ()
- void run (float, unsigned int)
- void output_state (FILE ∗, unsigned int)
- void getSpikesFromGPU ()
- void getSpikeNumbersFromGPU ()
- void output_spikes (FILE ∗, unsigned int)
- void sum_spikes ()

Public Attributes

- NNmodel model
- unsigned int offset
- uint64_t ∗ theRates
- scalar ∗ p_pattern
- uint64_t ∗ pattern
- uint64_t ∗ baserates
- uint64_t ∗ d_pattern
- uint64_t ∗ d_baserates
- unsigned int sumPN
- unsigned int sumKC
- unsigned int sumLHI
- unsigned int sumDN
- unsigned int size_g
- unsigned int sumIzh1

16.2.1 Detailed Description

This class cpontains the methods for running the MBody1 example model.

This class cpontains the methods for running the MBody_delayedSyn example model.

16.2.2 Constructor & Destructor Documentation

16.2.2.1 classol::classol ( )

16.2.2.2 classol::∼classol ( )

Destructor for olfaction model.

16.2.2.3 classol::classol ( )

16.2.2.4 classol::∼classol ( )

16.2.2.5 classol::classol ( )

16.2.2.6 classol::∼classol ( )

16.2.2.7 classol::classol ( )

16.2.2.8 classol::∼classol ( )

16.2.2.9 classol::classol ( )

16.2.2.10 classol::∼classol ( )

16.2.3 Member Function Documentation

16.2.3.1 void classol::allocate_device_mem_input ( )

16.2.3.2 void classol::allocate_device_mem_patterns ( )

16.2.3.3 void classol::allocate_device_mem_patterns ( )

16.2.3.4 void classol::allocate_device_mem_patterns ( )

16.2.3.5 void classol::allocate_device_mem_patterns ( )

Method for allocating memory on the GPU device to hold the input patterns.

16.2.3.6 void classol::free_device_mem ( )

16.2.3.7 void classol::free_device_mem ( )

16.2.3.8 void classol::free_device_mem ( )

16.2.3.9 void classol::free_device_mem ( )

16.2.3.10 void classol::free_device_mem ( )

Methods for unallocating the memory for input patterns on the GPU device.

16.2.3.11 void classol::generate_baserates ( )

16.2.3.12 void classol::generate_baserates ( )

16.2.3.13 void classol::generate_baserates ( )

Method for calculating the baseline rates of the Poisson input neurons.

16.2.3.14 void classol::generate_baserates ( )

16.2.3.15 void classol::generate_baserates ( )

16.2.3.16 void classol::get_kcdnsyns ( )

Method for copying the synaptic conductances of the learning synapses between KCs and DNs (detector neurons) back to the CPU memory.

16.2.3.17 void classol::get_kcdnsyns ( )

16.2.3.18 void classol::get_kcdnsyns ( )

16.2.3.19 void classol::get_kcdnsyns ( )

16.2.3.20 void classol::getSpikeNumbersFromGPU ( )

16.2.3.21 void classol::getSpikeNumbersFromGPU ( )

Method for copying the number of spikes in all neuron populations that have occurred during the last time step.

This method is a simple wrapper for the convenience function copySpikeNFromDevice() provided by GeNN.

16.2.3.22 void classol::getSpikeNumbersFromGPU ( )

16.2.3.23 void classol::getSpikeNumbersFromGPU ( )

16.2.3.24 void classol::getSpikeNumbersFromGPU ( )

16.2.3.25 void classol::getSpikesFromGPU ( )

16.2.3.26 void classol::getSpikesFromGPU ( )

Method for copying all spikes of the last time step from the GPU.

This is a simple wrapper for the convenience function copySpikesFromDevice() which is provided by GeNN.

16.2.3.27 void classol::getSpikesFromGPU ( )

16.2.3.28 void classol::getSpikesFromGPU ( )

16.2.3.29 void classol::getSpikesFromGPU ( )

16.2.3.30 void classol::init (unsigned *int*)

16.2.3.31 void classol::init (unsigned *int*)

16.2.3.32 void classol::init (unsigned *int*)

16.2.3.33 void classol::init (unsigned *int*)

16.2.3.34 void classol::init (unsigned int *which*)

Method for initialising variables.

Parameters

which	Flag defining whether GPU or CPU only version is run

16.2.3.35 void classol::output_spikes (FILE ∗ , unsigned *int*)

16.2.3.36 void classol::output_spikes (FILE ∗ *f*, unsigned int *which*)

Method for writing the spikes occurred in the last time step to a file.

Parameters

f	File handle for a file to write spike times to
which	Flag determining whether using GPU or CPU only

16.2.3.37 void classol::output_spikes (FILE ∗ , unsigned *int*)

16.2.3.38 void classol::output_spikes (FILE ∗ , unsigned *int*)

16.2.3.39 void classol::output_spikes (FILE ∗ , unsigned *int*)

16.2.3.40 void classol::output_state (FILE ∗ , unsigned *int*)

16.2.3.41 void classol::output_state (FILE ∗ , unsigned *int*)

16.2.3.42 void classol::output_state (FILE ∗ *f*, unsigned int *which*)

Method for copying from device and writing out to file of the entire state of the model.

Parameters

f	File handle for a file to write the model state to
which	Flag determining whether using GPU or CPU only

16.2.3.43 void classol::output_state (FILE ∗ , unsigned *int*)

16.2.3.44 void classol::output_state (FILE ∗ , unsigned *int*)

16.2.3.45 void classol::read_input_patterns (FILE ∗ *f*)

Method for reading the input patterns from a file.

Parameters

f	File handle for a file containing input patterns

16.2.3.46 void classol::read_input_patterns (FILE ∗)

16.2.3.47 void classol::read_input_patterns (FILE ∗)

16.2.3.48 void classol::read_input_patterns (FILE ∗)

16.2.3.49 void classol::read_kcdnsyns (FILE ∗ *f*)

Method for reading the connectivity between KCs and DNs (detector neurons) from a file.

Parameters

f	File handle for a file containing KC to DN (detector neuron) conductivity values

16.2.3.50 void classol::read_kcdnsyns (FILE ∗)

16.2.3.51 void classol::read_kcdnsyns (FILE ∗)

16.2.3.52 void classol::read_kcdnsyns (FILE ∗)

16.2.3.53 void classol::read_PNIzh1syns (scalar ∗ *gp*, FILE ∗ *f*)

16.2.3.54 void classol::read_pnkcsyns (FILE ∗)

16.2.3.55 void classol::read_pnkcsyns (FILE ∗ *f*)

Method for reading the connectivity between PNs and KCs from a file.

Parameters

f	File handle for a file containing PN to KC conductivity values

16.2.3.56 void classol::read_pnkcsyns (FILE ∗)

16.2.3.57 void classol::read_pnkcsyns (FILE ∗)

16.2.3.58 void classol::read_pnlhisyns (FILE ∗)

16.2.3.59 void classol::read_pnlhisyns (FILE ∗)

16.2.3.60 void classol::read_pnlhisyns (FILE ∗ *f*)

Method for reading the connectivity between PNs and LHIs from a file.

Parameters

f	File handle for a file containing PN to LHI conductivity values

16.2.3.61 void classol::read_pnlhisyns (FILE ∗)

16.2.3.62 void classol::read_sparsesyns_par (int *synInd,* struct SparseProjection *C,* FILE ∗ *f_ind,* FILE ∗ *f_indInG,* FILE ∗ *f_g,* double ∗ *g*)

Read sparse connectivity from a file.

Parameters

synInd	index of the synapse population to be worked on
C	contains the arrays to be initialized from file
f_ind	file pointer for the indices of post-synaptic neurons
f_indInG	file pointer for the summed post-synaptic neurons numbers
f_g	File handle for a file containing sparse conductivity values
g	array to receive the conductance values

16.2.3.63 void classol::read_sparsesyns_par (int , struct SparseProjection , scalar ∗ , FILE ∗ , FILE ∗ , FILE ∗)

16.2.3.64 void classol::read_sparsesyns_par (int *synInd,* struct SparseProjection *C,* scalar ∗ *g,* FILE ∗ *f_ind,* FILE ∗ *f_indInG,* FILE ∗ *f_g*)

Read sparse connectivity from a file.

Parameters

synInd	index of the synapse population to be worked on
C	contains the arrays to be initialized from file
g	array to receive the conductance values
f_ind	file pointer for the indices of post-synaptic neurons
f_indInG	file pointer for the summed post-synaptic neurons numbers
f_g	File handle for a file containing sparse connectivity values

16.2.3.65 void classol::read_sparsesyns_par (int , struct SparseProjection , scalar ∗ , FILE ∗ , FILE ∗ , FILE ∗)

16.2.3.66 template<class DATATYPE > void classol::read_sparsesyns_par (DATATYPE ∗ *wuvar,* int *synInd,* struct SparseProjection *C,* FILE ∗ *f_ind,* FILE ∗ *f_indInG,* FILE ∗ *f_g*)

Read sparse connectivity from a file.

Parameters

wuvar	array to receive the conductance values
synInd	index of the synapse population to be worked on

C	contains the arrays to be initialized from file
f_ind	file pointer for the indices of post-synaptic neurons
f_indInG	file pointer for the summed post-synaptic neurons numbers
f_g	File handle for a file containing sparse conductivity values

16.2.3.67 void classol::run (float *runtime,* unsigned int *which*)

16.2.3.68 void classol::runCPU (scalar)

16.2.3.69 void classol::runCPU (scalar *runtime*)

Method for simulating the model for a given period of time on the CPU.

Method for simulating the model for a given period of time on th CPU.

Parameters

runtime	Duration of time to run the model for

16.2.3.70 void classol::runCPU (scalar)

16.2.3.71 void classol::runCPU (scalar)

16.2.3.72 void classol::runGPU (scalar *runtime*)

Method for simulating the model for a given period of time on the GPU.

Method for simulating the model for a given period of time on th GPU.

Parameters

runtime	Duration of time to run the model for

16.2.3.73 void classol::runGPU (scalar)

16.2.3.74 void classol::runGPU (scalar)

16.2.3.75 void classol::runGPU (scalar)

16.2.3.76 void classol::sum_spikes ( )

16.2.3.77 void classol::sum_spikes ( )

Method for summing up spike numbers.

16.2.3.78 void classol::sum_spikes ( )

16.2.3.79 void classol::sum_spikes ( )

16.2.3.80 void classol::sum_spikes ( )

16.2.3.81 void classol::write_kcdnsyns (FILE ∗ *f*)

Method to write the connectivity between KCs and DNs (detector neurons) to a file.

Parameters

f	File handle for a file to write KC to DN (detectore neuron) conductivity values to

16.2.3.82 void classol::write_kcdnsyns (FILE ∗)

16.2.3.83 void classol::write_kcdnsyns (FILE ∗)

16.2.3.84 void classol::write_kcdnsyns (FILE ∗)

16.2.3.85 void classol::write_pnkcsyns (FILE ∗)

16.2.3.86 void classol::write_pnkcsyns (FILE ∗)

16.2.3.87 void classol::write_pnkcsyns (FILE ∗ *f*)

Method for writing the conenctivity between PNs and KCs back into file.

Parameters

f	File handle for a file to write PN to KC conductivity values to

16.2.3.88 void classol::write_pnkcsyns (FILE ∗)

16.2.3.89 void classol::write_pnlhisyns (FILE ∗)

16.2.3.90 void classol::write_pnlhisyns (FILE ∗ *f*)

Method for writing the connectivity between PNs and LHIs to a file.

Parameters

f	File handle for a file to write PN to LHI conductivity values to

16.2.3.91 void classol::write_pnlhisyns (FILE ∗)

16.2.3.92 void classol::write_pnlhisyns (FILE ∗)

16.2.4 Member Data Documentation

16.2.4.1 uint64_t ∗ classol::baserates

16.2.4.2 uint64_t ∗ classol::d_baserates

16.2.4.3 uint64_t ∗ classol::d_pattern

16.2.4.4 NNmodel classol::model

16.2.4.5 unsigned int classol::offset

16.2.4.6 scalar ∗ classol::p_pattern

16.2.4.7 uint64_t ∗ classol::pattern

16.2.4.8 unsigned int classol::size_g

16.2.4.9 unsigned int classol::sumDN

16.2.4.10 unsigned int classol::sumIzh1

16.2.4.11 unsigned int classol::sumKC

16.2.4.12 unsigned int classol::sumLHI

16.2.4.13 unsigned int classol::sumPN

16.2.4.14 uint64_t∗ classol::theRates

The documentation for this class was generated from the following files:

- MBody1_project/model/map_classol.h
- PoissonIzh-model.h
- MBody1_project/model/map_classol.cc
- PoissonIzh-model.cc

16.3 CodeHelper Class Reference

```
#include <CodeHelper.h>
```

Public Member Functions

- CodeHelper ()
- void setVerbose (bool isVerbose)
- string openBrace (unsigned int level)
- string closeBrace (unsigned int level)
- string endl ()

Public Attributes

- vector< unsigned int > braces
- bool verbose

16.3.1 Constructor & Destructor Documentation

16.3.1.1 CodeHelper::CodeHelper ( ) `[inline]`

16.3.2 Member Function Documentation

16.3.2.1 string CodeHelper::closeBrace (unsigned int *level*) `[inline]`

16.3.2.2 string CodeHelper::endl ( ) `[inline]`

16.3.2.3 string CodeHelper::openBrace (unsigned int *level*) `[inline]`

16.3.2.4 void CodeHelper::setVerbose (bool *isVerbose*) `[inline]`

16.3.3 Member Data Documentation

16.3.3.1 vector<unsigned int> CodeHelper::braces

16.3.3.2 bool CodeHelper::verbose

The documentation for this class was generated from the following file:

- CodeHelper.h

16.4 CStopWatch Class Reference

```
#include <hr_time.h>
```

Public Member Functions

- CStopWatch ()
- void startTimer ()

  This method starts the timer.
- void stopTimer ()

  This method stops the timer.
- double getElapsedTime ()

  This method returns the time elapsed between start and stop of the timer in seconds.

16.4.1 Constructor & Destructor Documentation

16.4.1.1 CStopWatch::CStopWatch ( ) `[inline]`

16.4.2 Member Function Documentation

16.4.2.1 double CStopWatch::getElapsedTime ( )

This method returns the time elapsed between start and stop of the timer in seconds.

16.4.2.2 void CStopWatch::startTimer ( )

This method starts the timer.

16.4.2.3 void CStopWatch::stopTimer ( )

This method stops the timer.

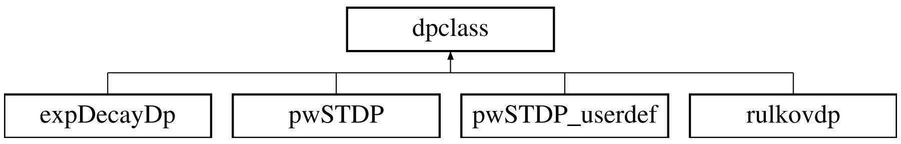
The documentation for this class was generated from the following files:

- hr_time.h
- hr_time.cc

16.5 dpclass Class Reference

```
#include <dpclass.h>
```

Inheritance diagram for dpclass:



Public Member Functions

- virtual double calculateDerivedParameter (int index, vector< double > pars, double dt=0.5)

16.5.1 Member Function Documentation

16.5.1.1 virtual double dpclass::calculateDerivedParameter (int *index*, vector< double > *pars*, double *dt* = `0.5`) `[inline]`, `[virtual]`

Reimplemented in pwSTDP_userdef, rulkovdp, pwSTDP, and expDecayDp.

The documentation for this class was generated from the following file:

- dpclass.h

16.6 errTupel Struct Reference

Public Attributes

- unsigned int id
- double err

16.6.1 Member Data Documentation

16.6.1.1 double errTupel::err

16.6.1.2 unsigned int errTupel::id

The documentation for this struct was generated from the following file:

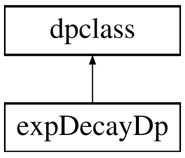
- GA.cc

16.7 expDecayDp Class Reference

Class defining the dependent parameter for exponential decay.

`#include <postSynapseModels.h>`

Inheritance diagram for expDecayDp:



Public Member Functions

- double calculateDerivedParameter (int index, vector< double > pars, double dt=1.0)
- double expDecay (vector< double > pars, double dt)

16.7.1 Detailed Description

Class defining the dependent parameter for exponential decay.

16.7.2 Member Function Documentation

16.7.2.1 double expDecayDp::calculateDerivedParameter (int *index,* vector< double > *pars,* double *dt* = `1.0`) `[inline]`, `[virtual]`

Reimplemented from dpclass.

16.7.2.2 double expDecayDp::expDecay (vector< double > *pars,* double *dt*) `[inline]`

The documentation for this class was generated from the following file:

- postSynapseModels.h

16.8 inputSpec Struct Reference

`#include <helper.h>`

Public Attributes

- double t
- double baseV
- int N
- vector< double > st
- vector< double > V

16.8.1 Member Data Documentation

16.8.1.1 double inputSpec::baseV

16.8.1.2 int inputSpec::N

16.8.1.3 vector<double> inputSpec::st

16.8.1.4 double inputSpec::t

16.8.1.5 vector<double> inputSpec::V

The documentation for this struct was generated from the following file:

- helper.h

16.9 neuronModel Class Reference

class for specifying a neuron model.

`#include <neuronModels.h>`

Public Member Functions

- neuronModel ()

  Constructor for neuronModel objects.
- ∼neuronModel ()

  Destructor for neuronModel objects.

Public Attributes

- string simCode

  Code that defines the execution of one timestep of integration of the neuron model The code will refer to for the value of the variable with name "NN". It needs to refer to the predefined variable "ISYN", i.e. contain , if it is to receive input.
- string thresholdConditionCode

  Code evaluating to a bool (e.g. "V > 20") that defines the condition for a true spike in the described neuron model.
- string resetCode

  Code that defines the reset action taken after a spike occurred. This can be empty.
- string supportCode

  Support code is made available within the neuron kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.

- vector< string > varNames

  Names of the variables in the neuron model.
- vector< string > tmpVarNames

  never used
- vector< string > varTypes

  Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.
- vector< string > tmpVarTypes

  never used
- vector< string > pNames

  Names of (independent) parameters of the model.
- vector< string > dpNames

  Names of dependent parameters of the model. The dependent parameters are functions of independent parameters that enter into the neuron model. To avoid unecessary computational overhead, these parameters are calculated at compile time and inserted as explicit values into the generated code. See method NNmodel::initDerivedNeuronPara for how this is done.
- vector< string > extraGlobalNeuronKernelParameters

  Additional parameter in the neuron kernel; it is translated to a population specific name but otherwise assumed to be one parameter per population rather than per neuron.
- vector< string > extraGlobalNeuronKernelParameterTypes

  Additional parameters in the neuron kernel; they are translated to a population specific name but otherwise assumed to be one parameter per population rather than per neuron.
- dpclass ∗ dps

  Derived parameters.
- bool needPreSt

  Whether presynaptic spike times are needed or not.
- bool needPostSt

  Whether postsynaptic spike times are needed or not.

16.9.1 Detailed Description

class for specifying a neuron model.

16.9.2 Constructor & Destructor Documentation

16.9.2.1 neuronModel::neuronModel ( )

Constructor for neuronModel objects.

16.9.2.2 neuronModel::∼neuronModel ( )

Destructor for neuronModel objects.

16.9.3 Member Data Documentation

16.9.3.1 vector<string> neuronModel::dpNames

Names of dependent parameters of the model. The dependent parameters are functions of independent parameters that enter into the neuron model. To avoid unecessary computational overhead, these parameters are calculated at compile time and inserted as explicit values into the generated code. See method NNmodel::initDerivedNeuronPara for how this is done.

16.9.3.2 dpclass∗ neuronModel::dps

Derived parameters.

16.9.3.3 vector< string > neuronModel::extraGlobalNeuronKernelParameters

Additional parameter in the neuron kernel; it is translated to a population specific name but otherwise assumed to be one parameter per population rather than per neuron.

16.9.3.4 vector< string > neuronModel::extraGlobalNeuronKernelParameterTypes

Additional parameters in the neuron kernel; they are translated to a population specific name but otherwise assumed to be one parameter per population rather than per neuron.

16.9.3.5 bool neuronModel::needPostSt

Whether postsynaptic spike times are needed or not.

16.9.3.6 bool neuronModel::needPreSt

Whether presynaptic spike times are needed or not.

16.9.3.7 vector< string > neuronModel::pNames

Names of (independent) parameters of the model.

16.9.3.8 string neuronModel::resetCode

Code that defines the reset action taken after a spike occurred. This can be empty.

16.9.3.9 string neuronModel::simCode

Code that defines the execution of one timestep of integration of the neuron model The code will refer to for the value of the variable with name "NN". It needs to refer to the predefined variable "ISYN", i.e. contain , if it is to receive input.

16.9.3.10 string neuronModel::supportCode

Support code is made available within the neuron kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.

16.9.3.11 string neuronModel::thresholdConditionCode

Code evaluating to a bool (e.g. "V > 20") that defines the condition for a true spike in the described neuron model.

16.9.3.12 vector< string > neuronModel::tmpVarNames

never used

16.9.3.13 vector< string > neuronModel::tmpVarTypes

never used

16.9.3.14 vector< string > neuronModel::varNames

Names of the variables in the neuron model.

16.9.3.15 vector< string > neuronModel::varTypes

Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.

The documentation for this class was generated from the following files:

- neuronModels.h
- neuronModels.cc

16.10 neuronpop Class Reference

```
#include <OneComp_model.h>
```

Public Member Functions

- neuronpop ()
- ∼neuronpop ()
- void init (unsigned int)
- void run (float, unsigned int)
- void getSpikesFromGPU ()

    Method for copying all spikes of the last time step from the GPU.
- void getSpikeNumbersFromGPU ()

    Method for copying the number of spikes in all neuron populations that have occurred during the last time step.
- void output_state (FILE ∗, unsigned int)
- void output_spikes (FILE ∗, unsigned int)
- void sum_spikes ()

Public Attributes

- NNmodel model
- unsigned int sumIzh1

16.10.1 Constructor & Destructor Documentation

16.10.1.1 neuronpop::neuronpop ( )

16.10.1.2 neuronpop::∼neuronpop ( )

16.10.2 Member Function Documentation

16.10.2.1 void neuronpop::getSpikeNumbersFromGPU ( )

Method for copying the number of spikes in all neuron populations that have occurred during the last time step.

This method is a simple wrapper for the convenience function copySpikeNFromDevice() provided by GeNN.

16.10.2.2 void neuronpop::getSpikesFromGPU ( )

Method for copying all spikes of the last time step from the GPU.

This is a simple wrapper for the convenience function copySpikesFromDevice() which is provided by GeNN.

16.10.2.3 void neuronpop::init (unsigned int *which*)

16.10.2.4 void neuronpop::output_spikes (FILE ∗ *f,* unsigned int *which*)

16.10.2.5 void neuronpop::output_state (FILE ∗ *f,* unsigned int *which*)

16.10.2.6 void neuronpop::run (float *runtime,* unsigned int *which*)

16.10.2.7 void neuronpop::sum_spikes ( )

16.10.3 Member Data Documentation

16.10.3.1 NNmodel neuronpop::model

16.10.3.2 unsigned int neuronpop::sumIzh1

The documentation for this class was generated from the following files:

- OneComp_model.h
- OneComp_model.cc

16.11 NNmodel Class Reference

```
#include <modelSpec.h>
```

Public Member Functions

- NNmodel ()
- ∼NNmodel ()
- void setName (const string)

  Method to set the neuronal network model name.
- void setPrecision (unsigned int)

  Set numerical precision for floating point.
- void setDT (double)

  Set the integration step size of the model.
- void setTiming (bool)

  Set whether timers and timing commands are to be included.
- void setSeed (unsigned int)

  Set the random seed (disables automatic seeding if argument not 0).
- void checkSizes (unsigned int ∗, unsigned int ∗, unsigned int ∗)
- void setGPUDevice (int)

  Method to choose the GPU to be used for the model. If "AUTODEVICE' (-1), GeNN will choose the device based on a heuristic rule.
- string scalarExpr (const double)
- void setPopulationSums ()

  Set the accumulated sums of lowest multiple of kernel block size >= group sizes for all simulated groups.
- void finalize ()

  Declare that the model specification is finalised in modelDefinition().
- void addNeuronPopulation (const string, unsigned int, unsigned int, double ∗, double ∗)

  Method for adding a neuron population to a neuronal network model, using C++ string for the name of the population.
- void addNeuronPopulation (const string, unsigned int, unsigned int, vector< double >, vector< double >)

  Method for adding a neuron population to a neuronal network model, using C++ string for the name of the population.
- void setNeuronClusterIndex (const string neuronGroup, int hostID, int deviceID)

  Function for setting which host and which device a neuron group will be simulated on.
- void activateDirectInput (const string, unsigned int type)

  This function defines the type of the explicit input to the neuron model. Current options are common constant input to all neurons, input from a file and input defines as a rule.
- void setConstInp (const string, double)

  This function has been deprecated in GeNN 2.2.
- unsigned int findNeuronGrp (const string)

  Find the the ID number of a neuron group by its name.
- void addSynapsePopulation (const string name, unsigned int syntype, unsigned int conntype, unsigned int gtype, const string src, const string trg, double ∗p)

This function has been depreciated as of GeNN 2.2.

- void addSynapsePopulation (const string, unsigned int, unsigned int, unsigned int, unsigned int, unsigned int, const string, const string, double ∗, double ∗, double ∗)

  Overloaded version without initial variables for synapses.
- void addSynapsePopulation (const string, unsigned int, unsigned int, unsigned int, unsigned int, unsigned int, const string, const string, double ∗, double ∗, double ∗, double ∗)

  Method for adding a synapse population to a neuronal network model, using C++ string for the name of the population.
- void addSynapsePopulation (const string, unsigned int, unsigned int, unsigned int, unsigned int, unsigned int, const string, const string, vector< double >, vector< double >, vector< double >, vector< double >)

  Method for adding a synapse population to a neuronal network model, using C++ string for the name of the population.
- void setSynapseG (const string, double)

  This function has been depreciated as of GeNN 2.2.
- void setMaxConn (const string, unsigned int)

  This function defines the maximum number of connections for a neuron in the population.
- void setSpanTypeToPre (const string)

  Method for switching the execution order of synapses to pre-to-post.
- void setSynapseClusterIndex (const string synapseGroup, int hostID, int deviceID)

  Function for setting which host and which device a synapse group will be simulated on.
- void initLearnGrps ()
- unsigned int findSynapseGrp (const string)

  This function is a tool to find the numeric ID of a synapse population based on the name of the synapse population.

Public Attributes

- string name

  Name of the neuronal newtwork model.
- string ftype

  Type of floating point variables (float, double, ...; default: float)
- string RNtype

  Underlying type for random number generation (default: long)
- double dt

  The integration time step of the model.
- int final

  Flag for whether the model has been finalized.
- unsigned int needSt

  Whether last spike times are needed at all in this network model (related to STDP)
- unsigned int needSynapseDelay

  Whether delayed synapse conductance is required in the network.
- bool timing
- unsigned int seed
- unsigned int resetKernel

  The identity of the kernel in which the spike counters will be reset.
- unsigned int neuronGrpN

  Number of neuron groups.
- vector< string > neuronName

  Names of neuron groups.
- vector< unsigned int > neuronN

  Number of neurons in group.
- vector< unsigned int > sumNeuronN

  Summed neuron numbers.
- vector< unsigned int > padSumNeuronN

Padded summed neuron numbers.

- vector< unsigned int > neuronPostSyn
- vector< unsigned int > neuronType

  Postsynaptic methods to the neuron.
- vector< vector< double > > neuronPara

  Parameters of neurons.
- vector< vector< double > > dnp

  Derived neuron parameters.
- vector< vector< double > > neuronIni

  Initial values of neurons.
- vector< vector< unsigned int > > inSyn

  The ids of the incoming synapse groups.
- vector< vector< unsigned int > > outSyn

  The ids of the outgoing synapse groups.
- vector< bool > neuronNeedSt

  Whether last spike time needs to be saved for a group.
- vector< bool > neuronNeedTrueSpk

  Whether spike-like events from a group are required.
- vector< bool > neuronNeedSpkEvnt

  Whether spike-like events from a group are required.
- vector< vector< bool > > neuronVarNeedQueue

  Whether a neuron variable needs queueing for syn code.
- vector< string > neuronSpkEvntCondition

  Will contain the spike event condition code when spike events are used.
- vector< unsigned int > neuronDelaySlots

  The number of slots needed in the synapse delay queues of a neuron group.
- vector< int > neuronHostID

  The ID of the cluster node which the neuron groups are computed on.
- vector< int > neuronDeviceID

  The ID of the CUDA device which the neuron groups are comnputed on.
- unsigned int synapseGrpN

  Number of synapse groups.
- vector< string > synapseName

  Names of synapse groups.
- vector< unsigned int > maxConn

  Padded summed maximum number of connections for a neuron in the neuron groups.
- vector< unsigned int > padSumSynapseKrnl
- vector< unsigned int > synapseType

  Types of synapses.
- vector< unsigned int > synapseConnType

  Connectivity type of synapses.
- vector< unsigned int > synapseGType

  Type of specification method for synaptic conductance.
- vector< unsigned int > synapseSpanType

  Execution order of synapses in the kernel. It determines whether synapses are executed in parallel for every postsynaptic neuron (0, default), or for every presynaptic neuron (1).
- vector< unsigned int > synapseSource

  Presynaptic neuron groups.
- vector< unsigned int > synapseTarget

  Postsynaptic neuron groups.
- vector< unsigned int > synapseInSynNo

IDs of the target neurons' incoming synapse variables for each synapse group.
- vector< unsigned int > synapseOutSynNo

  The target neurons' outgoing synapse for each synapse group.
- vector< bool > synapseUsesTrueSpikes

  Defines if synapse update is done after detection of real spikes (only one point after threshold)
- vector< bool > synapseUsesSpikeEvents

  Defines if synapse update is done after detection of spike events (every point above threshold)
- vector< bool > synapseUsesPostLearning

  Defines if anything is done in case of postsynaptic neuron spiking before presynaptic neuron (punishment in STDP etc.)
- vector< bool > synapseUsesSynapseDynamics

  Defines if there is any continuos synapse dynamics defined.
- vector< bool > needEvntThresholdReTest

  Defines whether the Evnt Threshold needs to be retested in the synapse kernel due to multiple non-identical events in the pre-synaptic neuron population.
- vector< vector< double > > synapsePara

  parameters of synapses
- vector< vector< double > > synapseIni

  Initial values of synapse variables.
- vector< vector< double > > dsp_w

  Derived synapse parameters (weightUpdateModel only)
- vector< unsigned int > postSynapseType

  Types of post-synaptic model.
- vector< vector< double > > postSynapsePara

  parameters of postsynapses
- vector< vector< double > > postSynIni

  Initial values of postsynaptic variables.
- vector< vector< double > > dpsp

  Derived postsynapse parameters.
- unsigned int lrnGroups

  Number of synapse groups with learning.
- vector< unsigned int > padSumLearnN

  Padded summed neuron numbers of learn group source populations.
- vector< unsigned int > lrnSynGrp

  Enumeration of the IDs of synapse groups that learn.
- vector< unsigned int > synapseDelay

  Global synaptic conductance delay for the group (in time steps)
- unsigned int synDynGroups

  Number of synapse groups that define continuous synapse dynamics.
- vector< unsigned int > synDynGrp

  Enumeration of the IDs of synapse groups that have synapse Dynamics.
- vector< unsigned int > padSumSynDynN

  Padded summed neuron numbers of synapse dynamics group source populations.
- vector< int > synapseHostID

  The ID of the cluster node which the synapse groups are computed on.
- vector< int > synapseDeviceID

  The ID of the CUDA device which the synapse groups are comnputed on.
- vector< string > neuronKernelParameters
- vector< string > neuronKernelParameterTypes
- vector< string > synapseKernelParameters
- vector< string > synapseKernelParameterTypes
- vector< string > simLearnPostKernelParameters
- vector< string > simLearnPostKernelParameterTypes
- vector< string > synapseDynamicsKernelParameters
- vector< string > synapseDynamicsKernelParameterTypes

16.11.1 Constructor & Destructor Documentation

16.11.1.1 NNmodel::NNmodel ( )

16.11.1.2 NNmodel::∼NNmodel ( )

16.11.2 Member Function Documentation

16.11.2.1 void NNmodel::activateDirectInput (const string *name,* unsigned int *type*)

This function defines the type of the explicit input to the neuron model. Current options are common constant input to all neurons, input from a file and input defines as a rule.

Parameters

name	Name of the neuron population
type	Type of input: 1 if common input, 2 if custom input from file, 3 if custom input as a rule

16.11.2.2 void NNmodel::addNeuronPopulation (const string *name,* unsigned int *nNo,* unsigned int *type,* double ∗ *p,* double ∗ *ini*)

Method for adding a neuron population to a neuronal network model, using C++ string for the name of the population.

This is an overloaded member function, provided for convenience. It differs from the above function only in what argument(s) it accepts.

This function adds a neuron population to a neuronal network models, assigning the name, the number of neurons in the group, the neuron type, parameters and initial values, the latter two defined as double ∗

Parameters

name	The name of the neuron population
nNo	Number of neurons in the population
type	Type of the neurons, refers to either a standard type or user-defined type
p	Parameters of this neuron type
ini	Initial values for variables of this neuron type

16.11.2.3 void NNmodel::addNeuronPopulation (const string *name,* unsigned int *nNo,* unsigned int *type,* vector< double > *p,* vector< double > *ini*)

Method for adding a neuron population to a neuronal network model, using C++ string for the name of the population.

This function adds a neuron population to a neuronal network models, assigning the name, the number of neurons in the group, the neuron type, parameters and initial values. The latter two defined as STL vectors of double.

Parameters

name	The name of the neuron population
nNo	Number of neurons in the population
type	Type of the neurons, refers to either a standard type or user-defined type
p	Parameters of this neuron type
ini	Initial values for variables of this neuron type

16.11.2.4 void NNmodel::addSynapsePopulation (const string *name,* unsigned int *syntype,* unsigned int *conntype,* unsigned int *gtype,* const string *src,* const string *target,* double ∗ *params*)

This function has been depreciated as of GeNN 2.2.

This is an overloaded member function, provided for convenience. It differs from the above function only in what argument(s) it accepts.

This deprecated function is provided for compatibility with the previous release of GeNN. Default values are provide for new parameters, it is strongly recommended these be selected explicity via the new version othe function

Parameters

name	The name of the synapse population
syntype	The type of synapse to be added (i.e. learning mode)
conntype	The type of synaptic connectivity
gtype	The way how the synaptic conductivity g will be defined
src	Name of the (existing!) pre-synaptic neuron population
target	Name of the (existing!) post-synaptic neuron population
params	A C-type array of doubles that contains synapse parameter values (common to all synapses of the population) which will be used for the defined synapses.

16.11.2.5 void NNmodel::addSynapsePopulation (const string *name,* unsigned int *syntype,* unsigned int *conntype,* unsigned int *gtype,* unsigned int *delaySteps,* unsigned int *postsyn,* const string *src,* const string *trg,* double ∗ *p,* double ∗ *PSVini,* double ∗ *ps*)

Overloaded version without initial variables for synapses.

Overloaded old version (deprecated)

Parameters

name	The name of the synapse population
syntype	The type of synapse to be added (i.e. learning mode)
conntype	The type of synaptic connectivity
gtype	The way how the synaptic conductivity g will be defined
delaySteps	Number of delay slots
postsyn	Postsynaptic integration method
src	Name of the (existing!) pre-synaptic neuron population
trg	Name of the (existing!) post-synaptic neuron population
p	A C-type array of doubles that contains synapse parameter values (common to all synapses of the population) which will be used for the defined synapses.
PSVini	A C-type array of doubles that contains the initial values for postsynaptic mechanism variables (common to all synapses of the population) which will be used for the defined synapses.
ps	A C-type array of doubles that contains postsynaptic mechanism parameter values (common to all synapses of the population) which will be used for the defined synapses.

16.11.2.6 void NNmodel::addSynapsePopulation (const string *name,* unsigned int *syntype,* unsigned int *conntype,* unsigned int *gtype,* unsigned int *delaySteps,* unsigned int *postsyn,* const string *src,* const string *trg,* double ∗ *synini,* double ∗ *p,* double ∗ *PSVini,* double ∗ *ps*)

Method for adding a synapse population to a neuronal network model, using C++ string for the name of the population.

This function adds a synapse population to a neuronal network model, assigning the name, the synapse type, the connectivity type, the type of conductance specification, the source and destination neuron populations, and the synaptic parameters.

Parameters

name	The name of the synapse population
syntype	The type of synapse to be added (i.e. learning mode)
conntype	The type of synaptic connectivity
gtype	The way how the synaptic conductivity g will be defined
delaySteps	Number of delay slots
postsyn	Postsynaptic integration method

src	Name of the (existing!) pre-synaptic neuron population
trg	Name of the (existing!) post-synaptic neuron population
synini	A C-type array of doubles that contains the initial values for synapse variables (common to all synapses of the population) which will be used for the defined synapses.
p	A C-type array of doubles that contains synapse parameter values (common to all synapses of the population) which will be used for the defined synapses.
PSVini	A C-type array of doubles that contains the initial values for postsynaptic mechanism variables (common to all synapses of the population) which will be used for the defined synapses.
ps	A C-type array of doubles that contains postsynaptic mechanism parameter values (common to all synapses of the population) which will be used for the defined synapses.

16.11.2.7 void NNmodel::addSynapsePopulation (const string *name,* unsigned int *syntype,* unsigned int *conntype,* unsigned int *gtype,* unsigned int *delaySteps,* unsigned int *postsyn,* const string *src,* const string *trg,* vector< double > *synini,* vector< double > *p,* vector< double > *PSVini,* vector< double > *ps*)

Method for adding a synapse population to a neuronal network model, using C++ string for the name of the population.

This function adds a synapse population to a neuronal network model, assigning the name, the synapse type, the connectivity type, the type of conductance specification, the source and destination neuron populations, and the synaptic parameters.

Parameters

name	The name of the synapse population
syntype	The type of synapse to be added (i.e. learning mode)
conntype	The type of synaptic connectivity
gtype	The way how the synaptic conductivity g will be defined
delaySteps	Number of delay slots
postsyn	Postsynaptic integration method
src	Name of the (existing!) pre-synaptic neuron population
trg	Name of the (existing!) post-synaptic neuron population
synini	A C-type array of doubles that contains the initial values for synapse variables (common to all synapses of the population) which will be used for the defined synapses.
p	A C-type array of doubles that contains synapse parameter values (common to all synapses of the population) which will be used for the defined synapses.
PSVini	A C-type array of doubles that contains the initial values for postsynaptic mechanism variables (common to all synapses of the population) which will be used for the defined synapses.
ps	A C-type array of doubles that contains postsynaptic mechanism parameter values (common to all synapses of the population) which will be used for the defined synapses.

16.11.2.8 void NNmodel::checkSizes (unsigned int ∗ , unsigned int ∗ , unsigned int ∗)

16.11.2.9 void NNmodel::finalize ( )

Declare that the model specification is finalised in modelDefinition().

16.11.2.10 unsigned int NNmodel::findNeuronGrp (const string *nName*)

Find the the ID number of a neuron group by its name.

This function is a tool to find the numeric ID of a neuron population based on the name of the neuron population.

Parameters

nName	Name of the neuron population

16.11.2.11 unsigned int NNmodel::findSynapseGrp (const string *sName*)

This function is a tool to find the numeric ID of a synapse population based on the name of the synapse population.

Parameters

sName	Name of the synapse population

16.11.2.12 void NNmodel::initLearnGrps ( )

16.11.2.13 string NNmodel::scalarExpr (const double *val*)

16.11.2.14 void NNmodel::setConstInp (const string *sName,* double *globalInp0*)

This function has been deprecated in GeNN 2.2.

This function sets a global input value to the specified neuron group.

16.11.2.15 void NNmodel::setDT (double *newDT*)

Set the integration step size of the model.

This function sets the integration time step DT of the model.

16.11.2.16 void NNmodel::setGPUDevice (int *device*)

Method to choose the GPU to be used for the model. If "AUTODEVICE' (-1), GeNN will choose the device based on a heuristic rule.

This function defines the way how the GPU is chosen. If "AUTODEVICE" (-1) is given as the argument, GeNN will use internal heuristics to choose the device. Otherwise the argument is the device number and the indicated device will be used.

16.11.2.17 void NNmodel::setMaxConn (const string *sname,* unsigned int *maxConnP*)

This function defines the maximum number of connections for a neuron in the population.

16.11.2.18 void NNmodel::setName (const string *inname*)

Method to set the neuronal network model name.

16.11.2.19 void NNmodel::setNeuronClusterIndex (const string *neuronGroup,* int *hostID,* int *deviceID*)

Function for setting which host and which device a neuron group will be simulated on.

This function is for setting which host and which device a neuron group will be simulated on.

Parameters

neuronGroup	Name of the neuron population
hostID	ID of the host
deviceID	ID of the device

16.11.2.20 void NNmodel::setPopulationSums ( )

Set the accumulated sums of lowest multiple of kernel block size $>=$ group sizes for all simulated groups.

Accumulate the sums and block-size-padded sums of all simulation groups.

This method saves the neuron numbers of the populations rounded to the next multiple of the block size as well as the sums s(i) = sum_{1...i} n_i of the rounded population sizes. These are later used to determine the branching structure for the generated neuron kernel code.

16.11.2.21 void NNmodel::setPrecision (unsigned int *floattype*)

Set numerical precision for floating point.

This function sets the numerical precision of floating type variables. By default, it is GENN_GENN_FLOAT.

16.11.2.22 void NNmodel::setSeed (unsigned int *inseed*)

Set the random seed (disables automatic seeding if argument not 0).

This function sets the random seed. If the passed argument is $>$ 0, automatic seeding is disabled. If the argument is 0, the underlying seed is obtained from the time() function.

Parameters

inseed	the new seed

16.11.2.23 void NNmodel::setSpanTypeToPre (const string *sname*)

Method for switching the execution order of synapses to pre-to-post.

This function defines the execution order of the synapses in the kernels (0 : execute for every postsynaptic neuron 1: execute for every presynaptic neuron)

16.11.2.24 void NNmodel::setSynapseClusterIndex (const string *synapseGroup,* int *hostID,* int *deviceID*)

Function for setting which host and which device a synapse group will be simulated on.

This function is for setting which host and which device a synapse group will be simulated on.

Parameters

synapseGroup	Name of the synapse population
hostID	ID of the host
deviceID	ID of the device

16.11.2.25 void NNmodel::setSynapseG (const string *sName,* double *g*)

This function has been depreciated as of GeNN 2.2.

This functions sets the global value of the maximal synaptic conductance for a synapse population that was idfenti-fied as conductance specifcation method "GLOBALG".

16.11.2.26 void NNmodel::setTiming (bool *theTiming*)

Set whether timers and timing commands are to be included.

This function sets a flag to determine whether timers and timing commands are to be included in generated code.

16.11.3 Member Data Documentation

16.11.3.1 vector$<$vector$<$double$>$ $>$ NNmodel::dnp

Derived neuron parameters.

16.11.3.2 vector$<$vector$<$double$>$ $>$ NNmodel::dpsp

Derived postsynapse parameters.

16.11.3.3 vector$<$vector$<$double$>$ $>$ NNmodel::dsp_w

Derived synapse parameters (weightUpdateModel only)

16.11.3.4 double NNmodel::dt

The integration time step of the model.

16.11.3.5 int NNmodel::final

Flag for whether the model has been finalized.

16.11.3.6 string NNmodel::ftype

Type of floating point variables (float, double, ...; default: float)

16.11.3.7 vector<vector<unsigned int> > NNmodel::inSyn

The ids of the incoming synapse groups.

16.11.3.8 unsigned int NNmodel::lrnGroups

Number of synapse groups with learning.

16.11.3.9 vector<unsigned int> NNmodel::lrnSynGrp

Enumeration of the IDs of synapse groups that learn.

16.11.3.10 vector<unsigned int> NNmodel::maxConn

Padded summed maximum number of connections for a neuron in the neuron groups.

16.11.3.11 string NNmodel::name

Name of the neuronal newtwork model.

16.11.3.12 vector<bool> NNmodel::needEvntThresholdReTest

Defines whether the Evnt Threshold needs to be retested in the synapse kernel due to multiple non-identical events in the pre-synaptic neuron population.

16.11.3.13 unsigned int NNmodel::needSt

Whether last spike times are needed at all in this network model (related to STDP)

16.11.3.14 unsigned int NNmodel::needSynapseDelay

Whether delayed synapse conductance is required in the network.

16.11.3.15 vector<unsigned int> NNmodel::neuronDelaySlots

The number of slots needed in the synapse delay queues of a neuron group.

16.11.3.16 vector<int> NNmodel::neuronDeviceID

The ID of the CUDA device which the neuron groups are comnputed on.

16.11.3.17 unsigned int NNmodel::neuronGrpN

Number of neuron groups.

16.11.3.18 vector<int> NNmodel::neuronHostID

The ID of the cluster node which the neuron groups are computed on.

16.11.3.19 vector<vector<double> > NNmodel::neuronIni

Initial values of neurons.

16.11.3.20 vector<string> NNmodel::neuronKernelParameters

16.11.3.21 vector< string > NNmodel::neuronKernelParameterTypes

16.11.3.22 vector< unsigned int > NNmodel::neuronN

Number of neurons in group.

16.11.3.23 vector< string > NNmodel::neuronName

Names of neuron groups.

16.11.3.24 vector< bool > NNmodel::neuronNeedSpkEvnt

Whether spike-like events from a group are required.

16.11.3.25 vector< bool > NNmodel::neuronNeedSt

Whether last spike time needs to be saved for a group.

16.11.3.26 vector< bool > NNmodel::neuronNeedTrueSpk

Whether spike-like events from a group are required.

16.11.3.27 vector< vector< double > > NNmodel::neuronPara

Parameters of neurons.

16.11.3.28 vector< unsigned int > NNmodel::neuronPostSyn

16.11.3.29 vector< string > NNmodel::neuronSpkEvntCondition

Will contain the spike event condition code when spike events are used.

16.11.3.30 vector< unsigned int > NNmodel::neuronType

Postsynaptic methods to the neuron.
Types of neurons

16.11.3.31 vector< vector< bool > > NNmodel::neuronVarNeedQueue

Whether a neuron variable needs queueing for syn code.

16.11.3.32 vector< vector< unsigned int > > NNmodel::outSyn

The ids of the outgoing synapse groups.

16.11.3.33 vector< unsigned int > NNmodel::padSumLearnN

Padded summed neuron numbers of learn group source populations.

16.11.3.34 vector< unsigned int > NNmodel::padSumNeuronN

Padded summed neuron numbers.

16.11.3.35 vector< unsigned int > NNmodel::padSumSynapseKrnl

16.11.3.36 vector< unsigned int > NNmodel::padSumSynDynN

Padded summed neuron numbers of synapse dynamics group source populations.

16.11.3.37 vector< vector< double > > NNmodel::postSynapsePara

parameters of postsynapses

16.11.3.38 vector<unsigned int> NNmodel::postSynapseType

Types of post-synaptic model.

16.11.3.39 vector<vector<double> > NNmodel::postSynIni

Initial values of postsynaptic variables.

16.11.3.40 unsigned int NNmodel::resetKernel

The identity of the kernel in which the spike counters will be reset.

16.11.3.41 string NNmodel::RNtype

Underlying type for random number generation (default: long)

16.11.3.42 unsigned int NNmodel::seed

16.11.3.43 vector<string> NNmodel::simLearnPostKernelParameters

16.11.3.44 vector<string> NNmodel::simLearnPostKernelParameterTypes

16.11.3.45 vector<unsigned int> NNmodel::sumNeuronN

Summed neuron numbers.

16.11.3.46 vector<unsigned int> NNmodel::synapseConnType

Connectivity type of synapses.

16.11.3.47 vector<unsigned int> NNmodel::synapseDelay

Global synaptic conductance delay for the group (in time steps)

16.11.3.48 vector<int> NNmodel::synapseDeviceID

The ID of the CUDA device which the synapse groups are comnputed on.

16.11.3.49 vector<string> NNmodel::synapseDynamicsKernelParameters

16.11.3.50 vector<string> NNmodel::synapseDynamicsKernelParameterTypes

16.11.3.51 unsigned int NNmodel::synapseGrpN

Number of synapse groups.

16.11.3.52 vector<unsigned int> NNmodel::synapseGType

Type of specification method for synaptic conductance.

16.11.3.53 vector<int> NNmodel::synapseHostID

The ID of the cluster node which the synapse groups are computed on.

16.11.3.54 vector<vector<double> > NNmodel::synapseIni

Initial values of synapse variables.

16.11.3.55 vector<unsigned int> NNmodel::synapseInSynNo

IDs of the target neurons' incoming synapse variables for each synapse group.

16.11.3.56 vector< string > NNmodel::synapseKernelParameters

16.11.3.57 vector< string > NNmodel::synapseKernelParameterTypes

16.11.3.58 vector< string > NNmodel::synapseName

Names of synapse groups.

16.11.3.59 vector< unsigned int > NNmodel::synapseOutSynNo

The target neurons' outgoing synapse for each synapse group.

16.11.3.60 vector< vector< double > > NNmodel::synapsePara

parameters of synapses

16.11.3.61 vector< unsigned int > NNmodel::synapseSource

Presynaptic neuron groups.

16.11.3.62 vector< unsigned int > NNmodel::synapseSpanType

Execution order of synapses in the kernel. It determines whether synapses are executed in parallel for every postsynaptic neuron (0, default), or for every presynaptic neuron (1).

16.11.3.63 vector< unsigned int > NNmodel::synapseTarget

Postsynaptic neuron groups.

16.11.3.64 vector< unsigned int > NNmodel::synapseType

Types of synapses.

16.11.3.65 vector< bool > NNmodel::synapseUsesPostLearning

Defines if anything is done in case of postsynaptic neuron spiking before presynaptic neuron (punishment in STDP etc.)

16.11.3.66 vector< bool > NNmodel::synapseUsesSpikeEvents

Defines if synapse update is done after detection of spike events (every point above threshold)

16.11.3.67 vector< bool > NNmodel::synapseUsesSynapseDynamics

Defines if there is any continuos synapse dynamics defined.

16.11.3.68 vector< bool > NNmodel::synapseUsesTrueSpikes

Defines if synapse update is done after detection of real spikes (only one point after threshold)

16.11.3.69 unsigned int NNmodel::synDynGroups

Number of synapse groups that define continuous synapse dynamics.

16.11.3.70 vector< unsigned int > NNmodel::synDynGrp

Enumeration of the IDs of synapse groups that have synapse Dynamics.

16.11.3.71 bool NNmodel::timing

The documentation for this class was generated from the following files:

- modelSpec.h
- src/modelSpec.cc

16.12 Parameter Struct Reference

Public Attributes

- string name
- string value

16.12.1 Member Data Documentation

16.12.1.1 string Parameter::name

16.12.1.2 string Parameter::value

The documentation for this struct was generated from the following file:

- experiment.cc

16.13 postSynModel Class Reference

Class to hold the information that defines a post-synaptic model (a model of how synapses affect post-synaptic neuron variables, classically in the form of a synaptic current). It also allows to define an equation for the dynamics that can be applied to the summed synaptic input variable "insyn".

```
#include <postSynapseModels.h>
```

Public Member Functions

- postSynModel ()

  Constructor for postSynModel objects.
- ∼postSynModel ()

  Destructor for postSynModel objects.

Public Attributes

- string postSyntoCurrent

  Code that defines how postsynaptic update is translated to current.
- string postSynDecay

  Code that defines how postsynaptic current decays.
- string supportCode

  Support code is made available within the neuron kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.
- vector< string > varNames

  Names of the variables in the postsynaptic model.
- vector< string > varTypes

  Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.
- vector< string > pNames

  Names of (independent) parameters of the model.

- vector< string > dpNames

  Names of dependent parameters of the model.
- dpclass ∗ dps

  Derived parameters.

16.13.1 Detailed Description

Class to hold the information that defines a post-synaptic model (a model of how synapses affect post-synaptic neuron variables, classically in the form of a synaptic current). It also allows to define an equation for the dynamics that can be applied to the summed synaptic input variable "insyn".

16.13.2 Constructor & Destructor Documentation

16.13.2.1 postSynModel::postSynModel ( )

Constructor for postSynModel objects.

16.13.2.2 postSynModel::∼postSynModel ( )

Destructor for postSynModel objects.

16.13.3 Member Data Documentation

16.13.3.1 vector<string> postSynModel::dpNames

Names of dependent parameters of the model.

16.13.3.2 dpclass∗ postSynModel::dps

Derived parameters.

16.13.3.3 vector<string> postSynModel::pNames

Names of (independent) parameters of the model.

16.13.3.4 string postSynModel::postSynDecay

Code that defines how postsynaptic current decays.

16.13.3.5 string postSynModel::postSyntoCurrent

Code that defines how postsynaptic update is translated to current.

16.13.3.6 string postSynModel::supportCode

Support code is made available within the neuron kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.

16.13.3.7 vector<string> postSynModel::varNames

Names of the variables in the postsynaptic model.

16.13.3.8 vector<string> postSynModel::varTypes

Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.

The documentation for this class was generated from the following files:

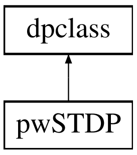
- postSynapseModels.h
- postSynapseModels.cc

16.14 pwSTDP Class Reference

TODO This class definition may be code-generated in a future release.

```
#include <synapseModels.h>
```

Inheritance diagram for pwSTDP:



Public Member Functions

- double calculateDerivedParameter (int index, vector< double > pars, double dt=1.0)
- double lim0 (vector< double > pars, double dt)
- double lim1 (vector< double > pars, double dt)
- double slope0 (vector< double > pars, double dt)
- double slope1 (vector< double > pars, double dt)
- double off0 (vector< double > pars, double dt)
- double off1 (vector< double > pars, double dt)
- double off2 (vector< double > pars, double dt)

16.14.1 Detailed Description

TODO This class definition may be code-generated in a future release.

This class defines derived parameters for the learn1synapse standard weightupdate model

16.14.2 Member Function Documentation

16.14.2.1 double pwSTDP::calculateDerivedParameter (int *index,* vector< double > *pars,* double *dt* = `1.0`) `[inline], [virtual]`

Reimplemented from dpclass.

16.14.2.2 double pwSTDP::lim0 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.3 double pwSTDP::lim1 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.4 double pwSTDP::off0 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.5 double pwSTDP::off1 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.6 double pwSTDP::off2 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.7 double pwSTDP::slope0 (vector< double > *pars,* double *dt*) `[inline]`

16.14.2.8 double pwSTDP::slope1 (vector< double > *pars*, double *dt*) [inline]

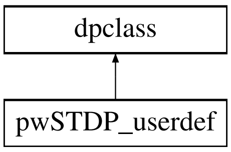
The documentation for this class was generated from the following file:

- synapseModels.h

16.15 pwSTDP_userdef Class Reference

TODO This class definition may be code-generated in a future release.

Inheritance diagram for pwSTDP_userdef:



Public Member Functions

- double calculateDerivedParameter (int index, vector< double > pars, double dt)
- double lim0 (vector< double > pars, double dt)
- double lim1 (vector< double > pars, double dt)
- double slope0 (vector< double > pars, double dt)
- double slope1 (vector< double > pars, double dt)
- double off0 (vector< double > pars, double dt)
- double off1 (vector< double > pars, double dt)
- double off2 (vector< double > pars, double dt)

16.15.1 Detailed Description

TODO This class definition may be code-generated in a future release.

16.15.2 Member Function Documentation

16.15.2.1 double pwSTDP_userdef::calculateDerivedParameter (int *index*, vector< double > *pars*, double *dt*) [inline], [virtual]

Reimplemented from dpclass.

16.15.2.2 double pwSTDP_userdef::lim0 (vector< double > *pars*, double *dt*) [inline]

16.15.2.3 double pwSTDP_userdef::lim1 (vector< double > *pars*, double *dt*) [inline]

16.15.2.4 double pwSTDP_userdef::off0 (vector< double > *pars*, double *dt*) [inline]

16.15.2.5 double pwSTDP_userdef::off1 (vector< double > *pars*, double *dt*) [inline]

16.15.2.6 double pwSTDP_userdef::off2 (vector< double > *pars*, double *dt*) [inline]

16.15.2.7 double pwSTDP_userdef::slope0 (vector< double > *pars*, double *dt*) [inline]

16.15.2.8 double pwSTDP_userdef::slope1 (vector< double > *pars*, double *dt*) [inline]

The documentation for this class was generated from the following file:

- MBody_userdef.cc

16.16 QTIsaac< ALPHA, T > Class Template Reference

Classes

- struct randctx

Public Types

- enum { N = (1<<ALPHA) }
- typedef unsigned char byte

Public Member Functions

- QTIsaac (T a=0, T b=0, T c=0)
- virtual ∼QTIsaac (void)
- T rand (void)
- virtual void randinit (randctx ∗ctx, bool bUseSeed)
- virtual void srand (T a=0, T b=0, T c=0, T ∗s=NULL)

Protected Member Functions

- virtual void isaac (randctx ∗ctx)
- T ind (T ∗mm, T x)
- void rngstep (T mix, T &a, T &b, T ∗&mm, T ∗&m, T ∗&m2, T ∗&r, T &x, T &y)
- virtual void shuffle (T &a, T &b, T &c, T &d, T &e, T &f, T &g, T &h)

16.16.1 Member Typedef Documentation

16.16.1.1 template<int ALPHA = (8), class T = ISAAC_INT> typedef unsigned char **QTIsaac**< ALPHA, T >::**byte**

16.16.2 Member Enumeration Documentation

16.16.2.1 template<int ALPHA = (8), class T = ISAAC_INT> anonymous enum

Enumerator

N

16.16.3 Constructor & Destructor Documentation

16.16.3.1 template<int ALPHA, class T> **QTIsaac**< ALPHA, T >::**QTIsaac** (T *a* = `0`, T *b* = `0`, T *c* = `0`)

16.16.3.2 template<int ALPHA, class T > **QTIsaac**< ALPHA, T >::∼**QTIsaac** (void) `[virtual]`

16.16.4 Member Function Documentation

16.16.4.1 template<int ALPHA, class T> T **QTIsaac**< ALPHA, T >::ind (T ∗ *mm*, T *x*) `[inline]`, `[protected]`

16.16.4.2 template<int ALPHA, class T > void **QTIsaac**< ALPHA, T >::isaac (**randctx** ∗ *ctx*) `[protected]`, `[virtual]`

16.16.4.3 template<int ALPHA, class T > T **QTIsaac**< ALPHA, T >::rand (void) `[inline]`

16.16.4.4 template<int ALPHA, class T > void **QTIsaac**< ALPHA, T >::randinit (**randctx** ∗ *ctx*, bool *bUseSeed*) `[virtual]`

16.16.4.5 template<int ALPHA, class T> void QTIsaac< ALPHA, T >::rngstep (T *mix,* T & *a,* T & *b,* T ∗& *mm,* T ∗& *m,* T ∗& *m2,* T ∗& *r,* T & *x,* T & *y*) `[inline]`, `[protected]`

16.16.4.6 template<int ALPHA, class T> void QTIsaac< ALPHA, T >::shuffle (T & *a,* T & *b,* T & *c,* T & *d,* T & *e,* T & *f,* T & *g,* T & *h*) `[protected]`, `[virtual]`

16.16.4.7 template<int ALPHA, class T> void QTIsaac< ALPHA, T >::srand (T *a* = `0`, T *b* = `0`, T *c* = `0`, T ∗ *s* = `NULL`) `[virtual]`

The documentation for this class was generated from the following file:

- isaac.cc

16.17 QTIsaac< ALPHA, T >::randctx Struct Reference

Public Member Functions

- randctx (void)
- ∼randctx (void)

Public Attributes

- T randcnt
- T ∗ randrsl
- T ∗ randmem
- T randa
- T randb
- T randc

16.17.1 Constructor & Destructor Documentation

16.17.1.1 template<int ALPHA = (8), class T = ISAAC_INT> QTIsaac< ALPHA, T >::randctx::randctx (void) `[inline]`

16.17.1.2 template<int ALPHA = (8), class T = ISAAC_INT> QTIsaac< ALPHA, T >::randctx::∼randctx (void) `[inline]`

16.17.2 Member Data Documentation

16.17.2.1 template<int ALPHA = (8), class T = ISAAC_INT> T QTIsaac< ALPHA, T >::randctx::randa

16.17.2.2 template<int ALPHA = (8), class T = ISAAC_INT> T QTIsaac< ALPHA, T >::randctx::randb

16.17.2.3 template<int ALPHA = (8), class T = ISAAC_INT> T QTIsaac< ALPHA, T >::randctx::randc

16.17.2.4 template<int ALPHA = (8), class T = ISAAC_INT> T QTIsaac< ALPHA, T >::randctx::randcnt

16.17.2.5 template<int ALPHA = (8), class T = ISAAC_INT> T∗ QTIsaac< ALPHA, T >::randctx::randmem

16.17.2.6 template<int ALPHA = (8), class T = ISAAC_INT> T∗ QTIsaac< ALPHA, T >::randctx::randrsl

The documentation for this struct was generated from the following file:

- isaac.cc

16.18 randomGauss Class Reference

Class random Gauss encapsulates the methods for generating random neumbers with Gaussian distribution.

```
#include <gauss.h>
```

Public Member Functions

- randomGauss ()

    Constructor for the Gaussian random number generator class without giving explicit seeds.
- randomGauss (unsigned long, unsigned long, unsigned long)

    Constructor for the Gaussian random number generator class when seeds are provided explicitly.
- ∼randomGauss ()
- double n ()

    Method for obtaining a random number with Gaussian distribution.
- void srand (unsigned long, unsigned long, unsigned long)

    Function for seeding with fixed seeds.

16.18.1 Detailed Description

Class random Gauss encapsulates the methods for generating random neumbers with Gaussian distribution.

A random number from a Gaussian distribution of mean 0 and standard deviation 1 is obtained by calling the method randomGauss::n().

16.18.2 Constructor & Destructor Documentation

16.18.2.1 randomGauss::randomGauss ( ) `[explicit]`

Constructor for the Gaussian random number generator class without giving explicit seeds.

The seeds for random number generation are generated from the internal clock of the computer during execution.

16.18.2.2 randomGauss::randomGauss (unsigned long *seed1*, unsigned long *seed2*, unsigned long *seed3*)

Constructor for the Gaussian random number generator class when seeds are provided explicitly.

The seeds are three arbitrary unsigned long integers.

16.18.2.3 randomGauss::∼randomGauss ( ) `[inline]`

16.18.3 Member Function Documentation

16.18.3.1 double randomGauss::n ( )

Method for obtaining a random number with Gaussian distribution.

Function for generating a pseudo random number from a Gaussian distribution.

16.18.3.2 void randomGauss::srand (unsigned long *seed1*, unsigned long *seed2*, unsigned long *seed3*)

Function for seeding with fixed seeds.

The documentation for this class was generated from the following files:

- gauss.h
- gauss.cc

16.19 randomGen Class Reference

Class randomGen which implements the ISAAC random number generator for uniformely distributed random numbers.

`#include <randomGen.h>`

Public Member Functions

- randomGen ()

    Constructor for the ISAAC random number generator class without giving explicit seeds.
- randomGen (unsigned long, unsigned long, unsigned long)

    Constructor for the Gaussian random number generator class when seeds are provided explicitly.
- ∼randomGen ()
- double n ()

    Method to obtain a random number from a uniform ditribution on [0,1].
- void srand (unsigned long, unsigned long, unsigned long)

    Function for seeding with fixed seeds.

16.19.1 Detailed Description

Class randomGen which implements the ISAAC random number generator for uniformely distributed random numbers.

The random number generator initializes with system timea or explicit seeds and returns a random number according to a uniform distribution on [0,1]; making use of the ISAAC random number generator; C++ Implementation by Quinn Tyler Jackson of the RG invented by Bob Jenkins Jr.

16.19.2 Constructor & Destructor Documentation

16.19.2.1 randomGen::randomGen ( ) `[explicit]`

Constructor for the ISAAC random number generator class without giving explicit seeds.

The seeds for random number generation are generated from the internal clock of the computer during execution.

16.19.2.2 randomGen::randomGen (unsigned long *seed1*, unsigned long *seed2*, unsigned long *seed3*)

Constructor for the Gaussian random number generator class when seeds are provided explicitly.

The seeds are three arbitrary unsigned long integers.

16.19.2.3 randomGen::∼randomGen ( ) `[inline]`

16.19.3 Member Function Documentation

16.19.3.1 double randomGen::n ( )

Method to obtain a random number from a uniform ditribution on [0,1].

Function for generating a pseudo random number from a uniform distribution on the interval [0,1].

16.19.3.2 void randomGen::srand (unsigned long *seed1*, unsigned long *seed2*, unsigned long *seed3*)

Function for seeding with fixed seeds.

The documentation for this class was generated from the following files:

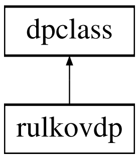
- randomGen.h
- randomGen.cc

16.20 rulkovdp Class Reference

Class defining the dependent parameters of the Rulkov map neuron.

`#include <neuronModels.h>`

Inheritance diagram for rulkovdp:



Public Member Functions

- double calculateDerivedParameter (int index, vector< double > pars, double dt=1.0)
- double ip0 (vector< double > pars)
- double ip1 (vector< double > pars)
- double ip2 (vector< double > pars)

16.20.1 Detailed Description

Class defining the dependent parameters of the Rulkov map neuron.

16.20.2 Member Function Documentation

16.20.2.1 double rulkovdp::calculateDerivedParameter (int *index*, vector< double > *pars*, double *dt* = `1.0`) `[inline]`, `[virtual]`

Reimplemented from dpclass.

16.20.2.2 double rulkovdp::ip0 (vector< double > *pars*) `[inline]`

16.20.2.3 double rulkovdp::ip1 (vector< double > *pars*) `[inline]`

16.20.2.4 double rulkovdp::ip2 (vector< double > *pars*) `[inline]`

The documentation for this class was generated from the following file:

- neuronModels.h

16.21 Schmuker2014_classifier Class Reference

This class cpontains the methods for running the Schmuker_2014_classifier example model.

`#include <Schmuker2014_classifier.h>`

Public Types

- enum data_type { data_type_int, data_type_uint, data_type_float, data_type_double }

Public Member Functions

- Schmuker2014_classifier ()
- ∼Schmuker2014_classifier ()
- void allocateHostAndDeviceMemory ()
- void populateDeviceMemory ()
- void update_input_data_on_device ()
- void clearDownDevice ()
- void run (float runtime, string filename_rasterPlot, bool usePlasticity)
- void getSpikesFromGPU ()
- void getSpikeNumbersFromGPU ()
- void outputSpikes (FILE ∗, string delim)
- void initialiseWeights_SPARSE_RN_PN ()
- void initialiseWeights_WTA_PN_PN ()
- void initialiseWeights_DENSE_PN_AN ()
- void initialiseWeights_WTA_AN_AN ()
- void createWTAConnectivity (float ∗synapse, UINT populationSize, UINT clusterSize, float synapseWeight, float probability)
- bool randomEventOccurred (float probability)
- void updateWeights_PN_AN_on_device ()
- void generate_or_load_inputrates_dataset (unsigned int recordingIdx)
- void generate_inputrates_dataset (unsigned int recordingIdx)
- FILE ∗ openRecordingFile (UINT recordingIndex)
- void applyLearningRuleSynapses (float ∗synapsesPNAN)
- void initialiseInputData ()
- void load_VR_data ()
- void setCorrectClass (UINT recordingIdx)
- UINT getClassCluster (UINT anIdx)
- void loadClassLabels ()
- void addInputRate (float ∗samplePoint, UINT timeStep)
- uint64_t convertToRateCode (float inputRateHz)
- float calculateVrResponse (float ∗samplePoint, float ∗vrPoint)
- void setMaxMinSampleDistances ()
- void findMaxMinSampleDistances (float ∗samples, UINT startAt, UINT totalSamples)
- float getSampleDistance (UINT max0_min1)
- float getManhattanDistance (float ∗pointA, float ∗pointB, UINT numElements)
- float getRand0to1 ()
- UINT calculateOverallWinner ()
- UINT calculateWinner (unsigned int ∗clusterSpikeCount)
- UINT calculateCurrentWindowWinner ()
- void updateIndividualSpikeCountPN ()
- void resetIndividualSpikeCountPN ()
- void updateClusterSpikeCountAN ()
- void resetClusterSpikeCountAN ()
- void resetOverallWinner ()
- void updateWeights_PN_AN ()
- UINT getClusterIndex (UINT neuronIndex, UINT clusterSize)
- void generateSimulatedTimeSeriesData ()
- string getRecordingFilename (UINT recordingIdx)
- bool loadArrayFromTextFile (string path, void ∗array, string delim, UINT arrayLen, data_type dataType)
- void checkContents (string title, void ∗array, UINT howMany, UINT displayPerLine, data_type dataType, UINT decimalPoints)
- void checkContents (string title, void ∗array, UINT howMany, UINT displayPerLine, data_type dataType, UINT decimalPoints, string delim)
- void printSeparator ()
- void resetDevice ()
- void startLog ()

Public Attributes

- double d_maxRandomNumber
- NNmodel model
- uint64_t ∗ inputRates
- unsigned int inputRatesSize
- float ∗ vrData
- unsigned int ∗ classLabel
- unsigned int ∗ individualSpikeCountPN
- unsigned int ∗ overallWinnerSpikeCountAN
- unsigned int ∗ clusterSpikeCountAN
- float ∗ plasticWeights
- uint64_t ∗ d_inputRates
- unsigned int countRN
- unsigned int countPN
- unsigned int countAN
- unsigned int countPNAN
- float ∗ sampleDistance
- string recordingsDir
- string cacheDir
- string outputDir
- string datasetName
- string uniqueRunId
- UINT correctClass
- int winningClass
- FILE ∗ log
- UINT param_SPIKING_ACTIVITY_THRESHOLD_HZ
- UINT param_MAX_FIRING_RATE_HZ
- UINT param_MIN_FIRING_RATE_HZ
- float param_GLOBAL_WEIGHT_SCALING
- float param_WEIGHT_RN_PN
- float param_CONNECTIVITY_RN_PN
- float param_WEIGHT_WTA_PN_PN
- float param_WEIGHT_WTA_AN_AN
- float param_CONNECTIVITY_PN_PN
- float param_CONNECTIVITY_AN_AN
- float param_CONNECTIVITY_PN_AN
- float param_MIN_WEIGHT_PN_AN
- float param_MAX_WEIGHT_PN_AN
- float param_WEIGHT_DELTA_PN_AN
- float param_PLASTICITY_INTERVAL_MS
- bool clearedDownDevice

Static Public Attributes

- static const unsigned int timestepsPerRecording = RECORDING_TIME_MS / DT

16.21.1 Detailed Description

This class cpontains the methods for running the Schmuker_2014_classifier example model.

16.21.2 Member Enumeration Documentation

16.21.2.1 enum Schmuker2014_classifier::data_type

Enumerator

data_type_int

data_type_uint

data_type_float

data_type_double

16.21.3 Constructor & Destructor Documentation

16.21.3.1 Schmuker2014_classifier::Schmuker2014_classifier ( )

16.21.3.2 Schmuker2014_classifier::∼Schmuker2014_classifier ( )

16.21.4 Member Function Documentation

16.21.4.1 void Schmuker2014_classifier::addInputRate (float ∗ *samplePoint,* UINT *timeStep*)

16.21.4.2 void Schmuker2014_classifier::allocateHostAndDeviceMemory ( )

16.21.4.3 void Schmuker2014_classifier::applyLearningRuleSynapses (float ∗ *synapsesPNAN*)

16.21.4.4 UINT Schmuker2014_classifier::calculateCurrentWindowWinner ( )

16.21.4.5 UINT Schmuker2014_classifier::calculateOverallWinner ( )

16.21.4.6 float Schmuker2014_classifier::calculateVrResponse (float ∗ *samplePoint,* float ∗ *vrPoint*)

16.21.4.7 UINT Schmuker2014_classifier::calculateWinner (unsigned int ∗ *clusterSpikeCount*)

16.21.4.8 void Schmuker2014_classifier::checkContents (string *title,* void ∗ *array,* UINT *howMany,* UINT *displayPerLine,* data_type *dataType,* UINT *decimalPoints*)

16.21.4.9 void Schmuker2014_classifier::checkContents (string *title,* void ∗ *array,* UINT *howMany,* UINT *displayPerLine,* data_type *dataType,* UINT *decimalPoints,* string *delim*)

16.21.4.10 void Schmuker2014_classifier::clearDownDevice ( )

16.21.4.11 uint64_t Schmuker2014_classifier::convertToRateCode (float *inputRateHz*)

16.21.4.12 void Schmuker2014_classifier::createWTAConnectivity (float ∗ *synapse,* UINT *populationSize,* UINT *clusterSize,* float *synapseWeight,* float *probability*)

16.21.4.13 void Schmuker2014_classifier::findMaxMinSampleDistances (float ∗ *samples,* UINT *startAt,* UINT *totalSamples*)

16.21.4.14 void Schmuker2014_classifier::generate_inputrates_dataset (unsigned int *recordingIdx*)

16.21.4.15 void Schmuker2014_classifier::generate_or_load_inputrates_dataset (unsigned int *recordingIdx*)

16.21.4.16 void Schmuker2014_classifier::generateSimulatedTimeSeriesData ( )

16.21.4.17 UINT Schmuker2014_classifier::getClassCluster (UINT *anIdx*)

16.21.4.18 UINT Schmuker2014_classifier::getClusterIndex (UINT *neuronIndex,* UINT *clusterSize*)

16.21.4.19 float Schmuker2014_classifier::getManhattanDistance (float ∗ *pointA,* float ∗ *pointB,* UINT *numElements*)

16.21.4.20 float Schmuker2014_classifier::getRand0to1 ( )

16.21.4.21 string Schmuker2014_classifier::getRecordingFilename (UINT *recordingIdx*)

16.21.4.22 float Schmuker2014_classifier::getSampleDistance (UINT *max0_min1*)

16.21.4.23 void Schmuker2014_classifier::getSpikeNumbersFromGPU ( )

16.21.4.24 void Schmuker2014_classifier::getSpikesFromGPU ( )

16.21.4.25 void Schmuker2014_classifier::initialiseInputData ( )

16.21.4.26 void Schmuker2014_classifier::initialiseWeights_DENSE_PN_AN ( )

16.21.4.27 void Schmuker2014_classifier::initialiseWeights_SPARSE_RN_PN ( )

16.21.4.28 void Schmuker2014_classifier::initialiseWeights_WTA_AN_AN ( )

16.21.4.29 void Schmuker2014_classifier::initialiseWeights_WTA_PN_PN ( )

16.21.4.30 void Schmuker2014_classifier::load_VR_data ( )

16.21.4.31 bool Schmuker2014_classifier::loadArrayFromTextFile (string *path,* void ∗ *array,* string *delim,* UINT *arrayLen,* data_type *dataType*)

16.21.4.32 void Schmuker2014_classifier::loadClassLabels ( )

16.21.4.33 FILE ∗ Schmuker2014_classifier::openRecordingFile (UINT *recordingIndex*)

16.21.4.34 void Schmuker2014_classifier::outputSpikes (FILE ∗ *f,* string *delim*)

16.21.4.35 void Schmuker2014_classifier::populateDeviceMemory ( )

16.21.4.36 void Schmuker2014_classifier::printSeparator ( )

16.21.4.37 bool Schmuker2014_classifier::randomEventOccurred (float *probability*)

16.21.4.38 void Schmuker2014_classifier::resetClusterSpikeCountAN ( )

16.21.4.39 void Schmuker2014_classifier::resetDevice ( )

16.21.4.40 void Schmuker2014_classifier::resetIndividualSpikeCountPN ( )

16.21.4.41 void Schmuker2014_classifier::resetOverallWinner ( )

16.21.4.42 void Schmuker2014_classifier::run (float *runtime,* string *filename_rasterPlot,* bool *usePlasticity*)

16.21.4.43 void Schmuker2014_classifier::setCorrectClass (UINT *recordingIdx*)

16.21.4.44 void Schmuker2014_classifier::setMaxMinSampleDistances ( )

16.21.4.45 void Schmuker2014_classifier::startLog ( )

16.21.4.46 void Schmuker2014_classifier::update_input_data_on_device ( )

16.21.4.47 void Schmuker2014_classifier::updateClusterSpikeCountAN ( )

16.21.4.48 void Schmuker2014_classifier::updateIndividualSpikeCountPN ( )

16.21.4.49 void Schmuker2014_classifier::updateWeights_PN_AN ( )

16.21.4.50 void Schmuker2014_classifier::updateWeights_PN_AN_on_device ( )

16.21.5 Member Data Documentation

16.21.5.1 string Schmuker2014_classifier::cacheDir

16.21.5.2 unsigned int∗ Schmuker2014_classifier::classLabel

16.21.5.3 bool Schmuker2014_classifier::clearedDownDevice

16.21.5.4 unsigned int∗ Schmuker2014_classifier::clusterSpikeCountAN

16.21.5.5 UINT Schmuker2014_classifier::correctClass

16.21.5.6 unsigned int Schmuker2014_classifier::countAN

16.21.5.7 unsigned int Schmuker2014_classifier::countPN

16.21.5.8 unsigned int Schmuker2014_classifier::countPNAN

16.21.5.9 unsigned int Schmuker2014_classifier::countRN

16.21.5.10 uint64_t∗ Schmuker2014_classifier::d_inputRates

16.21.5.11 double Schmuker2014_classifier::d_maxRandomNumber

16.21.5.12 string Schmuker2014_classifier::datasetName

16.21.5.13 unsigned int∗ Schmuker2014_classifier::individualSpikeCountPN

16.21.5.14 uint64_t∗ Schmuker2014_classifier::inputRates

16.21.5.15 unsigned int Schmuker2014_classifier::inputRatesSize

16.21.5.16 FILE∗ Schmuker2014_classifier::log

16.21.5.17 NNmodel Schmuker2014_classifier::model

16.21.5.18 string Schmuker2014_classifier::outputDir

16.21.5.19 unsigned int∗ Schmuker2014_classifier::overallWinnerSpikeCountAN

16.21.5.20 float Schmuker2014_classifier::param_CONNECTIVITY_AN_AN

16.21.5.21 float Schmuker2014_classifier::param_CONNECTIVITY_PN_AN

16.21.5.22 float Schmuker2014_classifier::param_CONNECTIVITY_PN_PN

16.21.5.23 float Schmuker2014_classifier::param_CONNECTIVITY_RN_PN

16.21.5.24 float Schmuker2014_classifier::param_GLOBAL_WEIGHT_SCALING

16.21.5.25 UINT Schmuker2014_classifier::param_MAX_FIRING_RATE_HZ

16.21.5.26 float Schmuker2014_classifier::param_MAX_WEIGHT_PN_AN

16.21.5.27 UINT Schmuker2014_classifier::param_MIN_FIRING_RATE_HZ

16.21.5.28 float Schmuker2014_classifier::param_MIN_WEIGHT_PN_AN

16.21.5.29 float Schmuker2014_classifier::param_PLASTICITY_INTERVAL_MS

16.21.5.30 UINT Schmuker2014_classifier::param_SPIKING_ACTIVITY_THRESHOLD_HZ

16.21.5.31 float Schmuker2014_classifier::param_WEIGHT_DELTA_PN_AN

16.21.5.32 float Schmuker2014_classifier::param_WEIGHT_RN_PN

16.21.5.33 float Schmuker2014_classifier::param_WEIGHT_WTA_AN_AN

16.21.5.34 float Schmuker2014_classifier::param_WEIGHT_WTA_PN_PN

16.21.5.35 float∗ Schmuker2014_classifier::plasticWeights

16.21.5.36 string Schmuker2014_classifier::recordingsDir

16.21.5.37 float∗ Schmuker2014_classifier::sampleDistance

16.21.5.38 const unsigned int Schmuker2014_classifier::timestepsPerRecording = RECORDING_TIME_MS / DT `[static]`

16.21.5.39 string Schmuker2014_classifier::uniqueRunId

16.21.5.40 float∗ Schmuker2014_classifier::vrData

16.21.5.41 int Schmuker2014_classifier::winningClass

The documentation for this class was generated from the following files:

- Schmuker2014_classifier.h
- Schmuker2014_classifier.cc

16.22 SparseProjection Struct Reference

class (struct) for defining a spars connectivity projection

`#include <sparseProjection.h>`

Public Attributes

- unsigned int ∗ indInG
- unsigned int ∗ ind
- unsigned int ∗ preInd
- unsigned int ∗ revIndInG
- unsigned int ∗ revInd
- unsigned int ∗ remap
- unsigned int connN

16.22.1 Detailed Description

class (struct) for defining a spars connectivity projection

16.22.2 Member Data Documentation

16.22.2.1 unsigned int SparseProjection::connN

16.22.2.2 unsigned int∗ SparseProjection::ind

16.22.2.3 unsigned int∗ SparseProjection::indInG

16.22.2.4 unsigned int∗ SparseProjection::preInd

16.22.2.5 unsigned int∗ SparseProjection::remap

16.22.2.6 unsigned int∗ SparseProjection::revInd

16.22.2.7 unsigned int∗ SparseProjection::revIndInG

The documentation for this struct was generated from the following file:

- sparseProjection.h

16.23 stdRG Class Reference

`#include <randomGen.h>`

Public Member Functions

- stdRG ()

    Constructor of the standard random number generator class without explicit seed.
- stdRG (unsigned int)

    Constructor of the standard random number generator class with explicit seed.
- ∼stdRG ()
- double n ()

    Method to generate a uniform random number.
- unsigned long nlong ()

16.23.1 Constructor & Destructor Documentation

16.23.1.1 stdRG::stdRG ( ) `[explicit]`

Constructor of the standard random number generator class without explicit seed.

The seed is taken from teh internal clock of the computer.

16.23.1.2 stdRG::stdRG (unsigned int *seed*)

Constructor of the standard random number generator class with explicit seed.

The seed is an arbitrary unsigned int

16.23.1.3 stdRG::∼stdRG ( ) `[inline]`

16.23.2 Member Function Documentation

16.23.2.1 double stdRG::n ( )

Method to generate a uniform random number.

The moethod is a wrapper for the C function rand() and returns a pseudo random number in the interval [0,1[

16.23.2.2 unsigned long stdRG::nlong ( )

The documentation for this class was generated from the following files:

- randomGen.h
- randomGen.cc

16.24 stopWatch Struct Reference

```
#include <hr_time.h>
```

Public Attributes

- timeval start
- timeval stop

16.24.1 Member Data Documentation

16.24.1.1 timeval stopWatch::start

16.24.1.2 timeval stopWatch::stop

The documentation for this struct was generated from the following file:

- hr_time.h

16.25 SynDelay Class Reference

```
#include <SynDelaySim.h>
```

Public Member Functions

- SynDelay (bool usingGPU)
- ∼SynDelay ()
- void run (float t)

16.25.1 Constructor & Destructor Documentation

16.25.1.1 SynDelay::SynDelay (bool *usingGPU*)

16.25.1.2 SynDelay::∼SynDelay ( )

16.25.2 Member Function Documentation

16.25.2.1 void SynDelay::run (float *t*)

The documentation for this class was generated from the following files:

- SynDelaySim.h
- SynDelaySim.cc

16.26 weightUpdateModel Class Reference

Class to hold the information that defines a weightupdate model (a model of how spikes affect synaptic (and/or) (mostly) post-synaptic neuron variables. It also allows to define changes in response to post-synaptic spikes/spike-like events.

```
#include <synapseModels.h>
```

Public Member Functions

- weightUpdateModel ()

  Constructor for weightUpdateModel objects.
- ∼weightUpdateModel ()

  Destructor for weightUpdateModel objects.

Public Attributes

- string simCode

  Simulation code that is used for true spikes (only one time step after spike detection)
- string simCodeEvnt

  Simulation code that is used for spike events (all the instances where event threshold condition is met)
- string simLearnPost

  Simulation code which is used in the learnSynapsesPost kernel/function, where postsynaptic neuron spikes before the presynaptic neuron in the STDP window.
- string evntThreshold

  Simulation code for spike event detection.
- string synapseDynamics

  Simulation code for synapse dynamics independent of spike detection.
- string simCode_supportCode

  Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions; note that this support code is available to simCode, evntThreshold and simCodeEvnt.
- string simLearnPost_supportCode

  Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.
- string synapseDynamics_supportCode

  Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.
- vector< string > varNames

  Names of the variables in the postsynaptic model.
- vector< string > varTypes

  Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.
- vector< string > pNames

  Names of (independent) parameters of the model.
- vector< string > dpNames

  Names of dependent parameters of the model.
- vector< string > extraGlobalSynapseKernelParameters

  Additional parameter in the neuron kernel; it is translated to a population specific name but otherwise assumed to be one parameter per population rather than per synapse.
- vector< string > extraGlobalSynapseKernelParameterTypes

  Additional parameters in the neuron kernel; they are translated to a population specific name but otherwise assumed to be one parameter per population rather than per synapse.
- dpclass ∗ dps
- bool needPreSt

  Whether presynaptic spike times are needed or not.
- bool needPostSt

  Whether postsynaptic spike times are needed or not.

16.26.1 Detailed Description

Class to hold the information that defines a weightupdate model (a model of how spikes affect synaptic (and/or) (mostly) post-synaptic neuron variables. It also allows to define changes in response to post-synaptic spikes/spike-like events.

16.26.2 Constructor & Destructor Documentation

16.26.2.1 weightUpdateModel::weightUpdateModel ( )

Constructor for weightUpdateModel objects.

16.26.2.2 weightUpdateModel::∼weightUpdateModel ( )

Destructor for weightUpdateModel objects.

16.26.3 Member Data Documentation

16.26.3.1 vector<string> weightUpdateModel::dpNames

Names of dependent parameters of the model.

16.26.3.2 dpclass∗ weightUpdateModel::dps

16.26.3.3 string weightUpdateModel::evntThreshold

Simulation code for spike event detection.

16.26.3.4 vector<string> weightUpdateModel::extraGlobalSynapseKernelParameters

Additional parameter in the neuron kernel; it is translated to a population specific name but otherwise assumed to be one parameter per population rather than per synapse.

16.26.3.5 vector<string> weightUpdateModel::extraGlobalSynapseKernelParameterTypes

Additional parameters in the neuron kernel; they are translated to a population specific name but otherwise assumed to be one parameter per population rather than per synapse.

16.26.3.6 bool weightUpdateModel::needPostSt

Whether postsynaptic spike times are needed or not.

16.26.3.7 bool weightUpdateModel::needPreSt

Whether presynaptic spike times are needed or not.

16.26.3.8 vector<string> weightUpdateModel::pNames

Names of (independent) parameters of the model.

16.26.3.9 string weightUpdateModel::simCode

Simulation code that is used for true spikes (only one time step after spike detection)

16.26.3.10 string weightUpdateModel::simCode_supportCode

Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions; note that this support code is available to simCode, evntThreshold and simCodeEvnt.

16.26.3.11 string weightUpdateModel::simCodeEvnt

Simulation code that is used for spike events (all the instances where event threshold condition is met)

16.26.3.12 string weightUpdateModel::simLearnPost

Simulation code which is used in the learnSynapsesPost kernel/function, where postsynaptic neuron spikes before the presynaptic neuron in the STDP window.

16.26.3.13 string weightUpdateModel::simLearnPost_supportCode

Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.

16.26.3.14 string weightUpdateModel::synapseDynamics

Simulation code for synapse dynamics independent of spike detection.

16.26.3.15 string weightUpdateModel::synapseDynamics_supportCode

Support code is made available within the synapse kernel definition file and is meant to contain user defined device functions that are used in the neuron codes. Preprocessor defines are also allowed if appropriately safeguarded against multiple definition by using ifndef; functions should be declared as "__host__ __device__" to be available for both GPU and CPU versions.

16.26.3.16 vector<string> weightUpdateModel::varNames

Names of the variables in the postsynaptic model.

16.26.3.17 vector<string> weightUpdateModel::varTypes

Types of the variable named above, e.g. "float". Names and types are matched by their order of occurrence in the vector.

The documentation for this class was generated from the following files:

- synapseModels.h
- synapseModels.cc

17 File Documentation

17.1 00_MainPage.dox File Reference

17.2 01_Installation.dox File Reference

17.3 02_Quickstart.dox File Reference

17.4 03_Examples.dox File Reference

17.5 09_ReleaseNotes.dox File Reference

17.6 10_UserManual.dox File Reference

17.7 11_Tutorial.dox File Reference

17.8 12_Tutorial.dox File Reference

17.9 13_UserGuide.dox File Reference

17.10 14_Credits.dox File Reference

17.11 classol_sim.cc File Reference

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

```
#include "classol_sim.h"
```

Functions

- int main (int argc, char *argv[])

  This function is the entry point for running the simulation of the MBody1 model network.

17.11.1 Detailed Description

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

17.11.2 Function Documentation

17.11.2.1 int main (int *argc*, char * *argv[]*)

This function is the entry point for running the simulation of the MBody1 model network.

17.12 classol_sim.cc File Reference

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody_delayedSyn mushroom body model.

```
#include "classol_sim.h"
```

Functions

- int main (int argc, char *argv[])

  This function is the entry point for running the simulation of the MBody_delayedSyn model network.

17.12.1 Detailed Description

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody_delayedSyn mushroom body model.

17.12.2 Function Documentation

17.12.2.1 int main (int *argc*, char * *argv[]*)

This function is the entry point for running the simulation of the MBody_delayedSyn model network.

17.13 classol_sim.cc File Reference

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

```
#include "classol_sim.h"
```

Functions

- int main (int argc, char ∗argv[])

  This function is the entry point for running the simulation of the MBody1 model network.

17.13.1 Detailed Description

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

17.13.2 Function Documentation

17.13.2.1 int main (int *argc,* char ∗ *argv[]*)

This function is the entry point for running the simulation of the MBody1 model network.

17.14 classol_sim.cc File Reference

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

```
#include "classol_sim.h"
```

Functions

- int main (int argc, char ∗argv[])

  This function is the entry point for running the simulation of the MBody1 model network.

17.14.1 Detailed Description

Main entry point for the classol (CLASSification in OLfaction) model simulation. Provided as a part of the complete example of simulating the MBody1 mushroom body model.

17.14.2 Function Documentation

17.14.2.1 int main (int *argc,* char ∗ *argv[]*)

This function is the entry point for running the simulation of the MBody1 model network.

17.15 classol_sim.h File Reference

Header file containing global variables and macros used in running the classol / MBody1 model.

```
#include <cassert>
#include "MBody1.cc"
#include "hr_time.h"
#include "utils.h"
#include "stringUtils.h"
#include <cuda_runtime.h>
#include "map_classol.cc"
```

Macros

- #define MYRAND(Y, X) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);
- #define PATTERNNO 100
- #define T_REPORT_TME 10000.0
- #define SYN_OUT_TME 20000.0
- #define PAT_TIME 100.0
- #define PATFTIME 1.5
- #define TOTAL_TME 5000.0

Variables

- scalar InputBaseRate = 2e-04
- int patSetTime
- int patFireTime
- CStopWatch timer

17.15.1 Detailed Description

Header file containing global variables and macros used in running the classol / MBody1 model.

17.15.2 Macro Definition Documentation

17.15.2.1 #define MYRAND(*Y*, *X*) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);

17.15.2.2 #define PAT_TIME 100.0

17.15.2.3 #define PATFTIME 1.5

17.15.2.4 #define PATTERNNO 100

17.15.2.5 #define SYN_OUT_TME 20000.0

17.15.2.6 #define T_REPORT_TME 10000.0

17.15.2.7 #define TOTAL_TME 5000.0

17.15.3 Variable Documentation

17.15.3.1 scalar InputBaseRate = 2e-04

17.15.3.2 int patFireTime

17.15.3.3 int patSetTime

17.15.3.4 CStopWatch timer

17.16 classol_sim.h File Reference

Header file containing global variables and macros used in running the classol / MBody_delayedSyn model.

```
#include <cassert>
#include "hr_time.h"
#include "utils.h"
#include "stringUtils.h"
#include <cuda_runtime.h>
#include "MBody_delayedSyn.cc"
#include "map_classol.cc"
```

Macros

- #define MYRAND(Y, X) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);
- #define DBG_SIZE 10000
- #define PATTERNNO 100
- #define T_REPORT_TME 10000.0
- #define SYN_OUT_TME 20000.0
- #define PAT_TIME 100.0
- #define PATFTIME 1.5
- #define TOTAL_TME 5000.0

Variables

- scalar InputBaseRate = 2e-04
- int patSetTime
- int patFireTime
- CStopWatch timer

17.16.1 Detailed Description

Header file containing global variables and macros used in running the classol / MBody_delayedSyn model.

17.16.2 Macro Definition Documentation

17.16.2.1 #define DBG_SIZE 10000

17.16.2.2 #define MYRAND(*Y*, *X*) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);

17.16.2.3 #define PAT_TIME 100.0

17.16.2.4 #define PATFTIME 1.5

17.16.2.5 #define PATTERNNO 100

17.16.2.6 #define SYN_OUT_TME 20000.0

17.16.2.7 #define T_REPORT_TME 10000.0

17.16.2.8 #define TOTAL_TME 5000.0

17.16.3 Variable Documentation

17.16.3.1 scalar InputBaseRate = 2e-04

17.16.3.2 int patFireTime

17.16.3.3 int patSetTime

17.16.3.4 CStopWatch timer

17.17 classol_sim.h File Reference

Header file containing global variables and macros used in running the classol / MBody_individualID model.

```
#include <cassert>
#include "hr_time.h"
#include "utils.h"
#include "stringUtils.h"
#include <cuda_runtime.h>
#include "MBody_individualID.cc"
#include "map_classol.cc"
```

Macros

- #define MYRAND(Y, X) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);
- #define DBG_SIZE 10000
- #define PATTERNNO 100
- #define T_REPORT_TME 10000.0
- #define SYN_OUT_TME 20000.0
- #define PAT_TIME 100.0
- #define PATFTIME 1.5
- #define TOTAL_TME 5000.0

Variables

- scalar InputBaseRate = 2e-04
- int patSetTime
- int patFireTime
- CStopWatch timer

17.17.1 Detailed Description

Header file containing global variables and macros used in running the classol / MBody_individualID model.

17.17.2 Macro Definition Documentation

17.17.2.1 #define DBG_SIZE 10000

17.17.2.2 #define MYRAND(*Y*, *X*) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);

17.17.2.3 #define PAT_TIME 100.0

17.17.2.4 #define PATFTIME 1.5

17.17.2.5 #define PATTERNNO 100

17.17.2.6 #define SYN_OUT_TME 20000.0

17.17.2.7 #define T_REPORT_TME 10000.0

17.17.2.8 #define TOTAL_TME 5000.0

17.17.3 Variable Documentation

17.17.3.1 scalar InputBaseRate = 2e-04

17.17.3.2 int patFireTime

17.17.3.3 int patSetTime

17.17.3.4 CStopWatch timer

17.18 classol_sim.h File Reference

Header file containing global variables and macros used in running the classol / MBody1 model.

```
#include <cassert>
#include "hr_time.h"
#include "utils.h"
#include "stringUtils.h"
#include <cuda_runtime.h>
#include "MBody_userdef.cc"
#include "map_classol.cc"
```

Macros

- #define MYRAND(Y, X) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);
- #define PATTERNNO 100
- #define T_REPORT_TME 10000.0
- #define SYN_OUT_TME 20000.0
- #define PAT_TIME 100.0
- #define PATFTIME 1.5
- #define TOTAL_TME 5000.0

Variables

- scalar InputBaseRate = 2e-04
- int patSetTime
- int patFireTime
- CStopWatch timer

17.18.1 Detailed Description

Header file containing global variables and macros used in running the classol / MBody1 model.

17.18.2 Macro Definition Documentation

17.18.2.1 #define MYRAND(*Y*, *X*) Y = Y $*$ 1103515245 +12345; X= (Y $>>$ 16);

17.18.2.2 #define PAT_TIME 100.0

17.18.2.3 #define PATFTIME 1.5

17.18.2.4 #define PATTERNNO 100

17.18.2.5 #define SYN_OUT_TME 20000.0

17.18.2.6 #define T_REPORT_TME 10000.0

17.18.2.7 #define TOTAL_TME 5000.0

17.18.3 Variable Documentation

17.18.3.1 scalar InputBaseRate = 2e-04

17.18.3.2 int patFireTime

17.18.3.3 int patSetTime

17.18.3.4 CStopWatch timer

17.19 CodeHelper.h File Reference

```
#include <iostream>
#include <cstdlib>
#include <cstdio>
#include <cstring>
#include <string>
#include <sstream>
#include <vector>
```

Classes

- class CodeHelper

Macros

- #define SAVEP(X) "(" << X << ")"
- #define OB(X) hlp.openBrace(X)
- #define CB(X) hlp.closeBrace(X)
- #define ENDL hlp.endl()

Variables

- CodeHelper hlp

17.19.1 Macro Definition Documentation

17.19.1.1 #define CB(*X*) hlp.closeBrace(X)

17.19.1.2 #define ENDL hlp.endl()

17.19.1.3 #define OB(*X*) hlp.openBrace(X)

17.19.1.4 #define SAVEP(*X*) "(" << X << ")"

17.19.2 Variable Documentation

17.19.2.1 CodeHelper hlp

17.20 command_line_processing.h File Reference

This file contains some tools for parsing the argv array which contains the command line options.

```
#include <string>
```

Functions

- string toUpper (string s)
- string toLower (string s)
- int extract_option (char ∗op, string &option)
- int extract_bool_value (char ∗op, unsigned int &val)
- int extract_string_value (char ∗op, string &val)

17.20.1 Detailed Description

This file contains some tools for parsing the argv array which contains the command line options.

17.20.2 Function Documentation

17.20.2.1 int extract_bool_value (char ∗ *op,* unsigned int & *val*)

17.20.2.2 int extract_option (char ∗ *op,* string & *option*)

17.20.2.3 int extract_string_value (char ∗ *op,* string & *val*)

17.20.2.4 string toLower (string *s*)

17.20.2.5 string toUpper (string *s*)

17.21 dpclass.h File Reference

```
#include <vector>
```

Classes

- class dpclass

17.22 experiment.cc File Reference

```
#include "experiment.h"
#include <time.h>
#include <algorithm>
#include <sys/types.h>
#include <sys/stat.h>
```

Classes

- struct Parameter

Macros

- #define RAND(Y, X) Y = Y ∗ 1103515245 +12345;X= (unsigned int)(Y >> 16) & 32767
- #define S_ISDIR(mode) (((mode) & S_IFMT) == S_IFDIR)

Typedefs

- typedef struct Parameter Parameter

Functions

- bool directoryExists (string const &path)
- bool createDirectory (string path)
- float getAverage (vector< float > &v)
- float getStdDev (vector< float > &v, float avg)
- bool printTextFile (string path)
- string getUniqueRunId ()
- void outputRunParameters ()
- bool applyInputToClassifier (UINT recordingIdx, bool usePlasticity)
- bool vectorContains (vector< int > &vec, int lookingFor)
- void setDefaultParamValues ()
- int main (int argc, char ∗argv[])

Variables

- Schmuker2014_classifier classifier

17.22.1 Macro Definition Documentation

17.22.1.1 #define RAND(*Y,* *X*) Y = Y ∗ 1103515245 +12345;X= (unsigned int)(Y >> 16) & 32767

17.22.1.2 #define S_ISDIR(*mode*) (((mode) & S_IFMT) == S_IFDIR)

17.22.2 Typedef Documentation

17.22.2.1 typedef struct **Parameter Parameter**

17.22.3 Function Documentation

17.22.3.1 bool applyInputToClassifier (**UINT** *recordingIdx,* bool *usePlasticity*)

17.22.3.2 bool createDirectory (string *path*)

17.22.3.3 bool directoryExists (string const & *path*)

17.22.3.4 float getAverage (vector< float > & *v*)

17.22.3.5 float getStdDev (vector< float > & *v,* float *avg*)

17.22.3.6 string getUniqueRunId ( )

17.22.3.7 int main (int *argc,* char ∗ *argv[]*)

17.22.3.8 void outputRunParameters ( )

17.22.3.9 bool printTextFile (string *path*)

17.22.3.10 void setDefaultParamValues ( )

17.22.3.11 bool vectorContains (vector< int > & *vec*, int *lookingFor*)

17.22.4 Variable Documentation

17.22.4.1 Schmuker2014_classifier classifier

17.23 experiment.h File Reference

```
#include <cassert>
#include "hr_time.h"
#include "utils.h"
#include "Schmuker2014_classifier.cc"
```

Macros

- #define divi "/"
- #define D_MAX_RANDOM_NUM 32767
- #define RECORDINGS_DIR "recordings_iris_data"
- #define CACHE_DIR "cached_iris_data"
- #define OUTPUT_DIR "output_iris"
- #define VR_DATA_FILENAME "VR-recordings-iris.data"
- #define DATASET_NAME "Iris"
- #define TOTAL_RECORDINGS 150
- #define N_FOLDING 5
- #define RECORDING_TIME_MS 1000
- #define REPEAT_LEARNING_SET 2
- #define SPIKING_ACTIVITY_THRESHOLD_HZ 5
- #define FLAG_RUN_ON_CPU 1
- #define MAX_FIRING_RATE_HZ 70
- #define MIN_FIRING_RATE_HZ 20
- #define GLOBAL_WEIGHT_SCALING 1.0
- #define WEIGHT_RN_PN 0.5
- #define CONNECTIVITY_RN_PN 0.5
- #define WEIGHT_WTA_PN_PN 0.01
- #define WEIGHT_WTA_AN_AN 0.01
- #define CONNECTIVITY_PN_PN 0.5
- #define CONNECTIVITY_AN_AN 0.5
- #define CONNECTIVITY_PN_AN 0.5
- #define MIN_WEIGHT_PN_AN 0.1
- #define MAX_WEIGHT_PN_AN 0.4
- #define WEIGHT_DELTA_PN_AN 0.04
- #define PLASTICITY_INTERVAL_MS 330

Typedefs

- typedef unsigned int UINT

Variables

- CStopWatch timer

17.23.1 Macro Definition Documentation

17.23.1.1 #define CACHE_DIR "cached_iris_data"

17.23.1.2 #define CONNECTIVITY_AN_AN 0.5

17.23.1.3 #define CONNECTIVITY_PN_AN 0.5

17.23.1.4 #define CONNECTIVITY_PN_PN 0.5

17.23.1.5 #define CONNECTIVITY_RN_PN 0.5

17.23.1.6 #define D_MAX_RANDOM_NUM 32767

17.23.1.7 #define DATASET_NAME "Iris"

17.23.1.8 #define divi "/"

17.23.1.9 #define FLAG_RUN_ON_CPU 1

17.23.1.10 #define GLOBAL_WEIGHT_SCALING 1.0

17.23.1.11 #define MAX_FIRING_RATE_HZ 70

17.23.1.12 #define MAX_WEIGHT_PN_AN 0.4

17.23.1.13 #define MIN_FIRING_RATE_HZ 20

17.23.1.14 #define MIN_WEIGHT_PN_AN 0.1

17.23.1.15 #define N_FOLDING 5

17.23.1.16 #define OUTPUT_DIR "output_iris"

17.23.1.17 #define PLASTICITY_INTERVAL_MS 330

17.23.1.18 #define RECORDING_TIME_MS 1000

17.23.1.19 #define RECORDINGS_DIR "recordings_iris_data"

17.23.1.20 #define REPEAT_LEARNING_SET 2

17.23.1.21 #define SPIKING_ACTIVITY_THRESHOLD_HZ 5

17.23.1.22 #define TOTAL_RECORDINGS 150

17.23.1.23 #define VR_DATA_FILENAME "VR-recordings-iris.data"

17.23.1.24 #define WEIGHT_DELTA_PN_AN 0.04

17.23.1.25 #define WEIGHT_RN_PN 0.5

17.23.1.26 #define WEIGHT_WTA_AN_AN 0.01

17.23.1.27 #define WEIGHT_WTA_PN_PN 0.01

17.23.2 Typedef Documentation

17.23.2.1 typedef unsigned int UINT

17.23.3 Variable Documentation

17.23.3.1 CStopWatch timer

17.24 extra_neurons.h File Reference

Functions

- n varNames clear ()
- n varNames push_back (tS("V"))
- n varTypes push_back (tS("float"))
- n varNames push_back (tS("V_NB"))
- n varNames push_back (tS("tSpike_NB"))
- n varNames push_back (tS("__regime_val"))
- n varTypes push_back (tS("int"))
- n pNames push_back (tS("VReset_NB"))
- n pNames push_back (tS("VThresh_NB"))
- n pNames push_back (tS("tRefrac_NB"))
- n pNames push_back (tS("VRest_NB"))
- n pNames push_back (tS("TAUm_NB"))
- n pNames push_back (tS("Cm_NB"))
- nModels push_back (n)
- n varNames push_back (tS("count_t_NB"))
- n pNames push_back (tS("max_t_NB"))

Variables

- n simCode

17.24.1 Function Documentation

17.24.1.1 ps dpNames clear ( )

17.24.1.2 n varNames push_back (tS("V"))

17.24.1.3 ps varTypes push_back (tS("float"))

17.24.1.4 n varNames push_back (tS("V_NB"))

17.24.1.5 n varNames push_back (tS("tSpike_NB"))

17.24.1.6 n varNames push_back (tS("__regime_val"))

17.24.1.7 n varTypes push_back (tS("int"))

17.24.1.8 n pNames push_back (tS("VReset_NB"))

17.24.1.9 n pNames push_back (tS("VThresh_NB"))

17.24.1.10 n pNames push_back (tS("tRefrac_NB"))

17.24.1.11 n pNames push_back (tS("VRest_NB"))

17.24.1.12 n pNames push_back (tS("TAUm_NB"))

17.24.1.13 n pNames push_back (tS("Cm_NB"))

17.24.1.14 nModels push_back (n)

17.24.1.15 n varNames push_back (tS("count_t_NB"))

17.24.1.16 n pNames push_back (tS("max_t_NB"))

17.24.2 Variable Documentation

17.24.2.1 n simCode

Initial value:

```
= tS(" \
         $(V) = -1000000; \
         if ($(__regime_val)==1) { \n \
$(V_NB) += (Isyn_NB/$(Cm_NB)+($(VRest_NB)-$(V_NB))/$(TAUm_NB))*DT; \n \
                if ($(V_NB)>$(VThresh_NB)) { \n \
$(V_NB) = $(VReset_NB); \n \
$(tSpike_NB) = t; \n \
                $(V) = 100000; \
$(__regime_val) = 2; \n \
} \n \
} \n \
if ($(__regime_val)==2) { \n \
if (t-$(tSpike_NB) > $(tRefrac_NB)) { \n \
$(__regime_val) = 1; \n \
} \n \
} \n \
")
```

17.25 extra_postsynapses.h File Reference

Functions

- ps varNames clear ()
- ps varNames push_back (tS("g_PS"))
- ps varTypes push_back (tS("float"))
- ps pNames push_back (tS("tau_syn_PS"))
- ps pNames push_back (tS("E_PS"))
- postSynModels push_back (ps)

Variables

- ps postSyntoCurrent
- ps postSynDecay

17.25.1 Function Documentation

17.25.1.1 ps varNames clear ( )

17.25.1.2 ps varNames push_back (tS("g_PS"))

17.25.1.3 ps varTypes push_back (tS("float"))

17.25.1.4 ps pNames push_back (tS("tau_syn_PS"))

17.25.1.5 ps pNames push_back (tS("E_PS"))

17.25.1.6 postSynModels push_back (ps)

17.25.2 Variable Documentation

17.25.2.1 ps postSynDecay

Initial value:

```
= tS(" \
         $(g_PS) += (-$(g_PS)/$(tau_syn_PS))*DT; \n \
                        $(inSyn) = 0; \
        ")
```

17.25.2.2 ps postSyntoCurrent

Initial value:

```
= tS(" \
  0; \n \
        float Isyn_NB = 0; \n \
         { \n \
        float v_PS = lV_NB; \n \
         float g_in_PS = $(inSyn); \
$(g_PS) = $(g_PS)+g_in_PS; \n \
Isyn_NB += ($(g_PS)*($(E_PS)-v_PS)); \n \
          } \n \
")
```

17.26 extra_weightupdates.h File Reference

17.27 GA.cc File Reference

```
#include <algorithm>
```

Classes

- struct errTupel

Functions

- int compareErrTupel (const void ∗x, const void ∗y)
- void procreatePop (FILE ∗osb)

17.27.1 Function Documentation

17.27.1.1 int compareErrTupel (const void ∗ *x*, const void ∗ *y*)

17.27.1.2 void procreatePop (FILE ∗ *osb*)

17.28 gauss.cc File Reference

Contains the implementation of the Gaussian random number generator class randomGauss.

```
#include "gauss.h"
```

Macros

- #define GAUSS_CC

  macro for avoiding multiple inclusion during compilation

17.28.1 Detailed Description

Contains the implementation of the Gaussian random number generator class randomGauss.

17.28.2 Macro Definition Documentation

17.28.2.1 #define GAUSS_CC

macro for avoiding multiple inclusion during compilation

17.29 gauss.h File Reference

Random number generator for Gaussian random variable with mean 0 and standard deviation 1.

```
#include <cmath>
#include "randomGen.h"
#include "randomGen.cc"
#include "gauss.cc"
```

Classes

- class randomGauss

  Class random Gauss encapsulates the methods for generating random neumbers with Gaussian distribution.

Macros

- #define GAUSS_H

  macro for avoiding multiple inclusion during compilation

17.29.1 Detailed Description

Random number generator for Gaussian random variable with mean 0 and standard deviation 1.

This random number generator is based on the ratio of uniforms method by A.J. Kinderman and J.F. Monahan and improved with quadratic boundind curves by J.L. Leva. Taken from Algorithm 712 ACM Trans. Math. Softw. 18 p. 454. (the necessary uniform random variables are obtained from the ISAAC random number generator; C++ Implementation by Quinn Tyler Jackson of the RG invented by Bob Jenkins Jr.).

17.29.2 Macro Definition Documentation

17.29.2.1 #define GAUSS_H

macro for avoiding multiple inclusion during compilation

17.30 gen_input_structured.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include "randomGen.h"
#include "randomGen.cc"
```

Functions

- int main (int argc, char ∗argv[])

Variables

- randomGen R

17.30.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool to generate appropriate input patterns for the antennal lobe in the model. The triple "fix" in the filename refers to a three-fold control for having the same number of active inputs for each pattern, even if changing patterns by adding noise.

17.30.2 Function Documentation

17.30.2.1 int main (int *argc*, char ∗ *argv[]*)

17.30.3 Variable Documentation

17.30.3.1 randomGen R

17.31 gen_kcdn_syns.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include "randomGen.h"
#include "gauss.h"
#include "randomGen.cc"
```

Functions

- int main (int argc, char ∗argv[])

Variables

- randomGen R
- randomGauss RG

17.31.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool to generate appropriate connectivity patterns between KCs and DNs (detector neurons) in the model. The connectivity is saved to file and can then be read by the classol method for reading this connectivity.

17.31.2 Function Documentation

17.31.2.1 int main (int *argc*, char ∗ *argv[]*)

17.31.3 Variable Documentation

17.31.3.1 randomGen R

17.31.3.2 randomGauss RG

17.32 gen_kcdn_syns_fixto10K.cc File Reference

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include "randomGen.h"
#include "gauss.h"
#include "randomGen.cc"
```

Functions

- int main (int argc, char *argv[])

Variables

- randomGen R
- randomGen R2
- randomGauss RG

17.32.1 Function Documentation

17.32.1.1 int main (int *argc*, char ∗ *argv[]*)

17.32.2 Variable Documentation

17.32.2.1 randomGen R

17.32.2.2 randomGen R2

17.32.2.3 randomGauss RG

17.33 gen_pnkc_syns.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include "randomGen.h"
#include "gauss.h"
#include "randomGen.cc"
```

Functions

- int main (int argc, char *argv[])

Variables

- randomGen R
- randomGauss RG

17.33.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool to generate appropriate connectivity patterns between PNs and KCs in the model. The connectivity is saved to file and can then be read by the classol method for reading this connectivity.

17.33.2 Function Documentation

17.33.2.1 int main (int *argc,* char ∗ *argv[]*)

17.33.3 Variable Documentation

17.33.3.1 randomGen R

17.33.3.2 randomGauss RG

17.34 gen_pnkc_syns_indivID.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include <cstdint>
#include "gauss.h"
#include "randomGen.h"
#include "randomGen.cc"
```

Macros

- #define B(x, i) ((x) & (0x80000000 >> (i)))

  Extract the bit at the specified position i from x.
- #define setB(x, i) x= ((x) | (0x80000000 >> (i)))

  Set the bit at the specified position i in x to 1.
- #define delB(x, i) x= ((x) & (∼(0x80000000 >> (i))))

  Set the bit at the specified position i in x to 0.

Functions

- int main (int argc, char ∗argv[])

Variables

- randomGen R
- randomGauss RG

17.34.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool to generate appropriate connectivity patterns between PNs and KCs in the model. In contrast to the gen_pnkc_syns.cc tool, here the output is in a format that is suited for the "INDIVIDUALID" method for specifying connectivity. The connectivity is saved to file and can then be read by the classol method for reading this connectivity.

17.34.2 Macro Definition Documentation

17.34.2.1 #define B(*x*, *i*) ((x) & (0x80000000 >> (i)))

Extract the bit at the specified position i from x.

17.34.2.2 #define delB(*x*, *i*) x= ((x) & (∼(0x80000000 >> (i))))

Set the bit at the specified position i in x to 0.

17.34.2.3 #define setB(*x*, *i*) x= ((x) | (0x80000000 >> (i)))

Set the bit at the specified position i in x to 1.

17.34.3 Function Documentation

17.34.3.1 int main (int *argc*, char ∗ *argv[]*)

17.34.4 Variable Documentation

17.34.4.1 randomGen R

17.34.4.2 randomGauss RG

17.35 gen_pnlhi_syns.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
```

Functions

- int main (int argc, char ∗argv[])

17.35.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool to generate appropriate connectivity patterns between PNs and LHIs (lateral horn interneurons) in the model. The connectivity is saved to file and can then be read by the classol method for reading this connectivity.

17.35.2 Function Documentation

17.35.2.1 int main (int *argc*, char ∗ *argv[]*)

17.36 gen_syns_sparse.cc File Reference

This file generates the arrays needed for sparse connectivity. The connectivity is saved to a file for each variable and can then be read to fill the struct of connectivity.

```
#include <iostream>
#include <fstream>
#include <string.h>
#include "randomGen.h"
#include "gauss.h"
#include <vector>
```

Functions

- int main (int argc, char ∗argv[])

Variables

- randomGen R
- randomGauss RG

17.36.1 Detailed Description

This file generates the arrays needed for sparse connectivity. The connectivity is saved to a file for each variable and can then be read to fill the struct of connectivity.

17.36.2 Function Documentation

17.36.2.1 int main (int *argc,* char ∗ *argv[]*)

17.36.3 Variable Documentation

17.36.3.1 randomGen R

17.36.3.2 randomGauss RG

17.37 gen_syns_sparse_izhModel.cc File Reference

This file is part of a tool chain for running the Izhikevich network model.

```
#include <iostream>
#include <fstream>
#include <stdlib.h>
#include <string.h>
#include <vector>
#include "randomGen.h"
#include "randomGen.cc"
```

Functions

- int printVector (vector< unsigned int > &)
- int printVector (vector< double > &)
- int main (int argc, char ∗argv[])

Variables

- randomGen R
- randomGen Rind

- double gsyn
- double ∗ garray
- unsigned int ∗ ind
- double ∗ garray_ee
- std::vector< double > g_ee
- std::vector< unsigned int > indInG_ee
- std::vector< unsigned int > ind_ee
- double ∗ garray_ei
- std::vector< double > g_ei
- std::vector< unsigned int > indInG_ei
- std::vector< unsigned int > ind_ei
- double ∗ garray_ie
- std::vector< double > g_ie
- std::vector< unsigned int > indInG_ie
- std::vector< unsigned int > ind_ie
- double ∗ garray_ii
- std::vector< double > g_ii
- std::vector< unsigned int > indInG_ii
- std::vector< unsigned int > ind_ii

17.37.1 Detailed Description

This file is part of a tool chain for running the Izhikevich network model.

17.37.2 Function Documentation

17.37.2.1 int main (int *argc*, char ∗ *argv[]*)

17.37.2.2 int printVector (vector< unsigned int > & *v*)

17.37.2.3 int printVector (vector< double > & *v*)

17.37.3 Variable Documentation

17.37.3.1 std::vector<double> g_ee

17.37.3.2 std::vector<double> g_ei

17.37.3.3 std::vector<double> g_ie

17.37.3.4 std::vector<double> g_ii

17.37.3.5 double∗ garray

17.37.3.6 double∗ garray_ee

17.37.3.7 double∗ garray_ei

17.37.3.8 double∗ garray_ie

17.37.3.9 double∗ garray_ii

17.37.3.10 double gsyn

17.37.3.11 unsigned int∗ ind

17.37.3.12 std::vector<unsigned int> ind_ee

17.37.3.13 std::vector< unsigned int > ind_ei

17.37.3.14 std::vector< unsigned int > ind_ie

17.37.3.15 std::vector< unsigned int > ind_ii

17.37.3.16 std::vector< unsigned int > indInG_ee

17.37.3.17 std::vector< unsigned int > indInG_ei

17.37.3.18 std::vector< unsigned int > indInG_ie

17.37.3.19 std::vector< unsigned int > indInG_ii

17.37.3.20 randomGen R

17.37.3.21 randomGen Rind

17.38 generate_run.cc File Reference

This file is used to run the HHVclampGA model with a single command line.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

  Main entry point for generate_run.

17.38.1 Detailed Description

This file is used to run the HHVclampGA model with a single command line.

17.38.2 Function Documentation

17.38.2.1 int main (int *argc*, char ∗ *argv[]*)

Main entry point for generate_run.

17.39 generate_run.cc File Reference

This file is part of a tool chain for running the classIzh/Izh_sparse example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <locale>
#include <stringUtils.h>
#include <sys/stat.h>
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- unsigned int openFileGetMax (unsigned int ∗array, unsigned int size, string name)
- int main (int argc, char ∗argv[])

  Main entry point for generate_run.

17.39.1 Detailed Description

This file is part of a tool chain for running the classIzh/Izh_sparse example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.39.2 Function Documentation

17.39.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.39.2.2 unsigned int openFileGetMax (unsigned int ∗ *array,* unsigned int *size,* string *name*)

17.40 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

    Main entry point for generate_run.

17.40.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the MBody1 model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.40.2 Function Documentation

17.40.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.41 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody_delayedSyn example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

    Main entry point for generate_run.

17.41.1 Detailed Description

This file is part of a tool chain for running the classol/MBody_delayedSyn example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the MBody←_delayedSyninition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.41.2 Function Documentation

17.41.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.42 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody_individualID example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

  Main entry point for generate_run.

17.42.1 Detailed Description

This file is part of a tool chain for running the classol/MBody_individualID example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the MBody←_individualID model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.42.2 Function Documentation

17.42.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.43 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody_userdef example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

  Main entry point for generate_run.

17.43.1 Detailed Description

This file is part of a tool chain for running the classol/MBody_userdef example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the MBody_userdef model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.43.2 Function Documentation

17.43.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.44 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])

Main entry point for generate_run.

17.44.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the MBody1 model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using GeNN as it only requires a single command line to execute all necessary tasks.

17.44.2 Function Documentation

17.44.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.45 generate_run.cc File Reference

This file is part of a tool chain for running the classol/MBody1 example model.

```
#include <iostream>
#include <fstream>
#include <string>
#include <sstream>
#include <cstdlib>
#include <cmath>
#include <cfloat>
#include <locale>
#include <sys/stat.h>
#include "stringUtils.h"
#include "command_line_processing.h"
#include "parse_options.h"
```

Functions

- int main (int argc, char ∗argv[])
  Main entry point for generate_run.

17.45.1 Detailed Description

This file is part of a tool chain for running the classol/MBody1 example model.

This file compiles to a tool that wraps all the other tools into one chain of tasks, including running all the gen_↩
∗ tools for generating connectivity, providing the population size information through ./model/sizes.h to the model definition, running the GeNN code generation and compilation steps, executing the model and collecting some timing information. This tool is the recommended way to quickstart using Poisson-Izhikevich example in GeNN as it only requires a single command line to execute all necessary tasks.

17.45.2 Function Documentation

17.45.2.1 int main (int *argc,* char ∗ *argv[]*)

Main entry point for generate_run.

17.46 generateALL.cc File Reference

Main file combining the code for code generation. Part of the code generation section.

```
#include "generateALL.h"
#include "generateRunner.h"
#include "generateCPU.h"
#include "generateKernels.h"
#include "global.h"
#include "modelSpec.h"
#include "utils.h"
#include "stringUtils.h"
#include "CodeHelper.h"
#include <cmath>
#include <sys/stat.h>
```

Functions

- void generate_model_runner (NNmodel &model, string path)

  This function will call the necessary sub-functions to generate the code for simulating a model.
- void chooseDevice (NNmodel &model, string path)

  Helper function that prepares data structures and detects the hardware properties to enable the code generation code that follows.
- int main (int argc, char ∗argv[ ])

  Main entry point for the generateALL executable that generates the code for GPU and CPU.

Variables

- CodeHelper hlp

17.46.1 Detailed Description

Main file combining the code for code generation. Part of the code generation section.

The file includes separate files for generating kernels (generateKernels.cc), generating the CPU side code for running simulations on either the CPU or GPU (generateRunner.cc) and for CPU-only simulation code (generateCP←U.cc).

17.46.2 Function Documentation

17.46.2.1 void chooseDevice (NNmodel & *model,* string *path*)

Helper function that prepares data structures and detects the hardware properties to enable the code generation code that follows.

The main tasks in this function are the detection and characterization of the GPU device present (if any), choosing which GPU device to use, finding and appropriate block size, taking note of the major and minor version of the C←UDA enabled device chosen for use, and populating the list of standard neuron models. The chosen device number is returned.

Parameters

model	the nn model we are generating code for
path	path the generated code will be deposited

17.46.2.2 void generate_model_runner (NNmodel & *model,* string *path*)

This function will call the necessary sub-functions to generate the code for simulating a model.

Parameters

model	Model description
path	Path where the generated code will be deposited

17.46.2.3 int main (int *argc,* char ∗ *argv[]*)

Main entry point for the generateALL executable that generates the code for GPU and CPU.

The main function is the entry point for the code generation engine. It prepares the system and then invokes generate_model_runner to inititate the different parts of actual code generation.

Parameters

argc	number of arguments; expected to be 2
argv	Arguments; expected to contain the target directory for code generation.

17.46.3 Variable Documentation

17.46.3.1 CodeHelper hlp

17.47 generateALL.h File Reference

```
#include "modelSpec.h"
#include <string>
```

Functions

- void generate_model_runner (NNmodel &model, string path)

  This function will call the necessary sub-functions to generate the code for simulating a model.
- void chooseDevice (NNmodel &model, string path)

  Helper function that prepares data structures and detects the hardware properties to enable the code generation code that follows.

17.47.1 Function Documentation

17.47.1.1 void chooseDevice (NNmodel & *model,* string *path*)

Helper function that prepares data structures and detects the hardware properties to enable the code generation code that follows.

The main tasks in this function are the detection and characterization of the GPU device present (if any), choosing which GPU device to use, finding and appropriate block size, taking note of the major and minor version of the C←UDA enabled device chosen for use, and populating the list of standard neuron models. The chosen device number is returned.

Parameters

model	the nn model we are generating code for
path	path the generated code will be deposited

17.47.1.2 void generate_model_runner (NNmodel & *model,* string *path*)

This function will call the necessary sub-functions to generate the code for simulating a model.

Parameters

model	Model description
path	Path where the generated code will be deposited

17.48 generateCPU.cc File Reference

Functions for generating code that will run the neuron and synapse simulations on the CPU. Part of the code generation section.

```
#include "generateCPU.h"
#include "global.h"
#include "utils.h"
#include "stringUtils.h"
#include "CodeHelper.h"
#include <algorithm>
```

Functions

- void genNeuronFunction (NNmodel &model, string &path)

    Function that generates the code of the function the will simulate all neurons on the CPU.
- void generate_process_presynaptic_events_code_CPU (ostream &os, NNmodel &model, unsigned int src, unsigned int trg, int i, string &localID, unsigned int inSynNo, string postfix)

    Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.
- void genSynapseFunction (NNmodel &model, string &path)

    Function that generates code that will simulate all synapses of the model on the CPU.

17.48.1 Detailed Description

Functions for generating code that will run the neuron and synapse simulations on the CPU. Part of the code generation section.

17.48.2 Function Documentation

17.48.2.1 void generate_process_presynaptic_events_code_CPU (ostream & *os,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* int *i,* string & *localID,* unsigned int *inSynNo,* string *postfix*)

Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.

Parameters

os	output stream for code

model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
i	the index of the synapse group being processed
localID	the variable name of the local ID of the thread within the synapse group
inSynNo	the ID number of the current synapse population as the incoming population to the target neuron population
postfix	whether to generate code for true spikes or spike type events

17.48.2.2 void genNeuronFunction (**NNmodel** & *model,* string & *path*)

Function that generates the code of the function the will simulate all neurons on the CPU.

Parameters

model	Model description
path	Path for code generation

17.48.2.3 void genSynapseFunction (**NNmodel** & *model,* string & *path*)

Function that generates code that will simulate all synapses of the model on the CPU.

Parameters

model	Model description
path	Path for code generation

17.49 generateCPU.h File Reference

Functions for generating code that will run the neuron and synapse simulations on the CPU. Part of the code generation section.

```
#include "modelSpec.h"
#include <string>
#include <fstream>
```

Functions

- void genNeuronFunction (NNmodel &model, string &path)

  Function that generates the code of the function the will simulate all neurons on the CPU.
- void generate_process_presynaptic_events_code_CPU (ostream &os, NNmodel &model, unsigned int src, unsigned int trg, int i, string &localID, unsigned int inSynNo, string postfix)

  Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.
- void genSynapseFunction (NNmodel &model, string &path)

  Function that generates code that will simulate all synapses of the model on the CPU.

17.49.1 Detailed Description

Functions for generating code that will run the neuron and synapse simulations on the CPU. Part of the code generation section.

17.49.2 Function Documentation

17.49.2.1 void generate_process_presynaptic_events_code_CPU (ostream & *os,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* int *i,* string & *localID,* unsigned int *inSynNo,* string *postfix*)

Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.

Parameters

os	output stream for code
model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
i	the index of the synapse group being processed
localID	the variable name of the local ID of the thread within the synapse group
inSynNo	the ID number of the current synapse population as the incoming population to the target neuron population
postfix	whether to generate code for true spikes or spike type events

17.49.2.2 void genNeuronFunction (NNmodel & *model,* string & *path*)

Function that generates the code of the function the will simulate all neurons on the CPU.

Parameters

model	Model description
path	Path for code generation

17.49.2.3 void genSynapseFunction (NNmodel & *model,* string & *path*)

Function that generates code that will simulate all synapses of the model on the CPU.

Parameters

model	Model description
path	Path for code generation

17.50 generateKernels.cc File Reference

Contains functions that generate code for CUDA kernels. Part of the code generation section.

```
#include "generateKernels.h"
#include "global.h"
#include "utils.h"
#include "stringUtils.h"
#include "CodeHelper.h"
#include <algorithm>
```

Functions

- void genNeuronKernel (NNmodel &model, string &path)

  Function for generating the CUDA kernel that simulates all neurons in the model.
- void generate_process_presynaptic_events_code (ostream &os, NNmodel &model, unsigned int src, unsigned int trg, int i, string &localID, unsigned int inSynNo, string postfix)

  Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.
- void genSynapseKernel (NNmodel &model, string &path)

  Function for generating a CUDA kernel for simulating all synapses.

Variables

- short ∗ isGrpVarNeeded

17.50.1 Detailed Description

Contains functions that generate code for CUDA kernels. Part of the code generation section.

17.50.2 Function Documentation

17.50.2.1 void generate_process_presynaptic_events_code (ostream & *os,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* int *i,* string & *localID,* unsigned int *inSynNo,* string *postfix*)

Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.

Parameters

os	output stream for code
model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
i	the index of the synapse group being processed
localID	the variable name of the local ID of the thread within the synapse group
inSynNo	the ID number of the current synapse population as the incoming population to the target neuron population
postfix	whether to generate code for true spikes or spike type events

17.50.2.2 void genNeuronKernel (NNmodel & *model,* string & *path*)

Function for generating the CUDA kernel that simulates all neurons in the model.

The code generated upon execution of this function is for defining GPU side global variables that will hold model state in the GPU global memory and for the actual kernel function for simulating the neurons for one time step. Binary flag for the sparse synapses to use atomic operations when the number of connections is bigger than the block size, and shared variables otherwise

Binary flag for the sparse synapses to use atomic operations when the number of connections is bigger than the block size, and shared variables otherwise

Parameters

model	Model description
path	Path for code generation

17.50.2.3 void genSynapseKernel (NNmodel & *model,* string & *path*)

Function for generating a CUDA kernel for simulating all synapses.

This functions generates code for global variables on the GPU side that are synapse-related and the actual CUDA kernel for simulating one time step of the synapses. $<$ "id" if first synapse group, else "lid". lid =(thread index- last thread of the last synapse group)

Parameters

model	Model description
path	Path for code generation

17.50.3 Variable Documentation

17.50.3.1 short∗ isGrpVarNeeded

17.51 generateKernels.h File Reference

Contains functions that generate code for CUDA kernels. Part of the code generation section.

```
#include "modelSpec.h"
#include <string>
#include <fstream>
```

Functions

- void genNeuronKernel (NNmodel &model, string &path)

  Function for generating the CUDA kernel that simulates all neurons in the model.
- void generate_process_presynaptic_events_code (ostream &os, NNmodel &model, unsigned int src, unsigned int trg, int i, string &localID, unsigned int inSynNo, string postfix)

  Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.
- void genSynapseKernel (NNmodel &model, string &path)

  Function for generating a CUDA kernel for simulating all synapses.

17.51.1 Detailed Description

Contains functions that generate code for CUDA kernels. Part of the code generation section.

17.51.2 Function Documentation

17.51.2.1 void generate_process_presynaptic_events_code (ostream & *os,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* int *i,* string & *localID,* unsigned int *inSynNo,* string *postfix*)

Function for generating the CUDA synapse kernel code that handles presynaptic spikes or spike type events.

Parameters

os	output stream for code
model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
i	the index of the synapse group being processed
localID	the variable name of the local ID of the thread within the synapse group
inSynNo	the ID number of the current synapse population as the incoming population to the target neuron population
postfix	whether to generate code for true spikes or spike type events

17.51.2.2 void genNeuronKernel (NNmodel & *model,* string & *path*)

Function for generating the CUDA kernel that simulates all neurons in the model.

The code generated upon execution of this function is for defining GPU side global variables that will hold model state in the GPU global memory and for the actual kernel function for simulating the neurons for one time step. Binary flag for the sparse synapses to use atomic operations when the number of connections is bigger than the block size, and shared variables otherwise

Binary flag for the sparse synapses to use atomic operations when the number of connections is bigger than the block size, and shared variables otherwise

Parameters

model	Model description
path	Path for code generation

17.51.2.3 void genSynapseKernel (NNmodel & *model,* string & *path*)

Function for generating a CUDA kernel for simulating all synapses.

This functions generates code for global variables on the GPU side that are synapse-related and the actual CUDA kernel for simulating one time step of the synapses. < "id" if first synapse group, else "lid". lid =(thread index- last thread of the last synapse group)

Parameters

model	Model description
path	Path for code generation

17.52 generateRunner.cc File Reference

Contains functions to generate code for running the simulation on the GPU, and for I/O convenience functions between GPU and CPU space. Part of the code generation section.

```
#include "generateRunner.h"
#include "global.h"
#include "utils.h"
#include "stringUtils.h"
#include "CodeHelper.h"
#include <stdint.h>
#include <cfloat>
```

Functions

- void variable_def (ofstream &os, string type, string name)

  This function generates host and device variable definitions, of the given type and name.
- void extern_variable_def (ofstream &os, string type, string name)

  This function generates host extern variable definitions, of the given type and name.
- void genRunner (NNmodel &model, string &path)

  A function that generates predominantly host-side code.
- void genRunnerGPU (NNmodel &model, string &path)

  A function to generate the code that simulates the model on the GPU.
- void genMakefile (NNmodel &model, string &path)

  A function that generates the Makefile for all generated GeNN code.

17.52.1 Detailed Description

Contains functions to generate code for running the simulation on the GPU, and for I/O convenience functions between GPU and CPU space. Part of the code generation section.

17.52.2 Function Documentation

17.52.2.1 void extern_variable_def (ofstream & *os,* string *type,* string *name*)

This function generates host extern variable definitions, of the given type and name.

This fucntion generates host extern variable definitions, of the given type and name.

17.52.2.2 void genMakefile (NNmodel & *model,* string & *path*)

A function that generates the Makefile for all generated GeNN code.

Parameters

model	Model description
path	Path for code generation

17.52.2.3 void genRunner (NNmodel & *model*, string & *path*)

A function that generates predominantly host-side code.

In this function host-side functions and other code are generated, including: Global host variables, "allocatedMem()" function for allocating memories, "freeMem" function for freeing the allocated memories, "initialize" for initializing host variables, "gFunc" and "initGRaw()" for use with plastic synapses if such synapses exist in the model. Method for cleaning up and resetting device while quitting GeNN

Parameters

model	Model description
path	Path for code generationn

17.52.2.4 void genRunnerGPU (NNmodel & *model*, string & *path*)

A function to generate the code that simulates the model on the GPU.

The function generates functions that will spawn kernel grids onto the GPU (but not the actual kernel code which is generated in "genNeuronKernel()" and "genSynpaseKernel()"). Generated functions include "copyGToDevice()", "copyGFromDevice()", "copyStateToDevice()", "copyStateFromDevice()", "copySpikesFromDevice()", "copySpike←NFromDevice()" and "stepTimeGPU()". The last mentioned function is the function that will initialize the execution on the GPU in the generated simulation engine. All other generated functions are "convenience functions" to handle data transfer from and to the GPU.

Parameters

model	Model description
path	Path for code generation

17.52.2.5 void variable_def (ofstream & *os*, string *type*, string *name*)

This function generates host and device variable definitions, of the given type and name.

This fucntion generates host and device variable definitions, of the given type and name.

17.53 generateRunner.h File Reference

Contains functions to generate code for running the simulation on the GPU, and for I/O convenience functions between GPU and CPU space. Part of the code generation section.

```
#include "modelSpec.h"
#include <string>
#include <fstream>
```

Functions

- void variable_def (ofstream &os, string type, string name)

  This fucntion generates host and device variable definitions, of the given type and name.
- void extern_variable_def (ofstream &os, string type, string name)

  This fucntion generates host extern variable definitions, of the given type and name.
- void genRunner (NNmodel &model, string &path)

  A function that generates predominantly host-side code.

- void genRunnerGPU (NNmodel &model, string &path)

  A function to generate the code that simulates the model on the GPU.
- void genMakefile (NNmodel &model, string &path)

  A function that generates the Makefile for all generated GeNN code.

17.53.1 Detailed Description

Contains functions to generate code for running the simulation on the GPU, and for I/O convenience functions between GPU and CPU space. Part of the code generation section.

17.53.2 Function Documentation

17.53.2.1 void extern_variable_def (ofstream & *os,* string *type,* string *name*)

This fucntion generates host extern variable definitions, of the given type and name.

This fucntion generates host extern variable definitions, of the given type and name.

17.53.2.2 void genMakefile (NNmodel & *model,* string & *path*)

A function that generates the Makefile for all generated GeNN code.

Parameters

model	Model description
path	Path for code generation

17.53.2.3 void genRunner (NNmodel & *model,* string & *path*)

A function that generates predominantly host-side code.

In this function host-side functions and other code are generated, including: Global host variables, "allocatedMem()" function for allocating memories, "freeMem" function for freeing the allocated memories, "initialize" for initializing host variables, "gFunc" and "initGRaw()" for use with plastic synapses if such synapses exist in the model. Method for cleaning up and resetting device while quitting GeNN

Parameters

model	Model description
path	Path for code generationn

17.53.2.4 void genRunnerGPU (NNmodel & *model,* string & *path*)

A function to generate the code that simulates the model on the GPU.

The function generates functions that will spawn kernel grids onto the GPU (but not the actual kernel code which is generated in "genNeuronKernel()" and "genSynpaseKernel()"). Generated functions include "copyGToDevice()", "copyGFromDevice()", "copyStateToDevice()", "copyStateFromDevice()", "copySpikesFromDevice()", "copySpike↩ NFromDevice()" and "stepTimeGPU()". The last mentioned function is the function that will initialize the execution on the GPU in the generated simulation engine. All other generated functions are "convenience functions" to handle data transfer from and to the GPU.

Parameters

model	Model description
path	Path for code generation

17.53.2.5 void variable_def (ofstream & *os,* string *type,* string *name*)

This fucntion generates host and device variable definitions, of the given type and name.

This fucntion generates host and device variable definitions, of the given type and name.

17.54 GeNNHelperKrnls.cu File Reference

```
#include "GeNNHelperKrnls.h"
```

Functions

- __global__ void setup_kernel (curandState ∗state, unsigned long seed, int sizeofResult)
- void xorwow_setup (curandState ∗devStates, long int sampleSize, long long int seed)
- template<typename T >
  __global__ void generate_random_gpuInput_xorwow (curandState ∗state, T ∗result, int sizeofResult, T Rstrength, T Rshift)
- template<typename T >
  void generate_random_gpuInput_xorwow (curandState ∗state, T ∗result, int sizeofResult, T Rstrength, T Rshift, dim3 sGrid, dim3 sThreads)
- template void generate_random_gpuInput_xorwow< float > (curandState ∗state, float ∗result, int sizeof↩ Result, float Rstrength, float Rshift, dim3 sGrid, dim3 sThreads)
- template void generate_random_gpuInput_xorwow< double > (curandState ∗state, double ∗result, int sizeofResult, double Rstrength, double Rshift, dim3 sGrid, dim3 sThreads)

17.54.1 Function Documentation

17.54.1.1 template<typename T > __global__ void generate_random_gpuInput_xorwow (curandState ∗ *state,* T ∗ *result,* int *sizeofResult,* T *Rstrength,* T *Rshift*)

17.54.1.2 template<typename T > void generate_random_gpuInput_xorwow (curandState ∗ *state,* T ∗ *result,* int *sizeofResult,* T *Rstrength,* T *Rshift,* dim3 *sGrid,* dim3 *sThreads*)

17.54.1.3 template void generate_random_gpuInput_xorwow< double > (curandState ∗ *state,* double ∗ *result,* int *sizeofResult,* double *Rstrength,* double *Rshift,* dim3 *sGrid,* dim3 *sThreads*)

17.54.1.4 template void generate_random_gpuInput_xorwow< float > (curandState ∗ *state,* float ∗ *result,* int *sizeofResult,* float *Rstrength,* float *Rshift,* dim3 *sGrid,* dim3 *sThreads*)

17.54.1.5 __global__ void setup_kernel (curandState ∗ *state,* unsigned long *seed,* int *sizeofResult*)

17.54.1.6 void xorwow_setup (curandState ∗ *devStates,* long int *sampleSize,* long long int *seed*)

17.55 GeNNHelperKrnls.h File Reference

```
#include <curand_kernel.h>
```

Functions

- __global__ void setup_kernel (curandState ∗state, unsigned long seed, int sizeofResult)
- void xorwow_setup (curandState ∗devStates, long int sampleSize, long long int seed)
- template<typename T >
  __global__ void generate_random_gpuInput_xorwow (curandState ∗state, T ∗result, int sizeofResult, T Rstrength, T Rshift)
- template<typename T >
  void generate_random_gpuInput_xorwow (curandState ∗state, T ∗result, int sizeofResult, T Rstrength, T Rshift, dim3 sGrid, dim3 sThreads)

Variables

- const int BlkSz = 256

17.55.1 Function Documentation

17.55.1.1 template<typename T > __global__ void generate_random_gpuInput_xorwow (curandState ∗ *state,* T ∗ *result,* int *sizeofResult,* T *Rstrength,* T *Rshift*)

17.55.1.2 template<typename T > void generate_random_gpuInput_xorwow (curandState ∗ *state,* T ∗ *result,* int *sizeofResult,* T *Rstrength,* T *Rshift,* dim3 *sGrid,* dim3 *sThreads*)

17.55.1.3 __global__ void setup_kernel (curandState ∗ *state,* unsigned long *seed,* int *sizeofResult*)

17.55.1.4 void xorwow_setup (curandState ∗ *devStates,* long int *sampleSize,* long long int *seed*)

17.55.2 Variable Documentation

17.55.2.1 const int BlkSz = 256

17.56 global.cc File Reference

```
#include "global.h"
```

Namespaces

- GENN_FLAGS
- GENN_PREFERENCES

Macros

- #define GLOBAL_CC

Variables

- int neuronBlkSz

  Global variable containing the GPU block size for the neuron kernel.
- int synapseBlkSz

  Global variable containing the GPU block size for the synapse kernel.
- int learnBlkSz

  Global variable containing the GPU block size for the learn kernel.
- int synDynBlkSz

  Global variable containing the GPU block size for the synapse dynamics kernel.
- cudaDeviceProp ∗ deviceProp
- int theDevice

  Global variable containing the currently selected CUDA device's number.
- int deviceCount

  Global variable containing the number of CUDA devices on this host.
- int hostCount

  Global variable containing the number of hosts within the local compute cluster.

17.56.1 Macro Definition Documentation

17.56.1.1 #define GLOBAL_CC

17.56.2 Variable Documentation

17.56.2.1 int deviceCount

Global variable containing the number of CUDA devices on this host.

17.56.2.2 cudaDeviceProp∗ deviceProp

17.56.2.3 int hostCount

Global variable containing the number of hosts within the local compute cluster.

17.56.2.4 int learnBlkSz

Global variable containing the GPU block size for the learn kernel.

17.56.2.5 int neuronBlkSz

Global variable containing the GPU block size for the neuron kernel.

17.56.2.6 int synapseBlkSz

Global variable containing the GPU block size for the synapse kernel.

17.56.2.7 int synDynBlkSz

Global variable containing the GPU block size for the synapse dynamics kernel.

17.56.2.8 int theDevice

Global variable containing the currently selected CUDA device's number.

17.57 global.h File Reference

Global header file containing a few global variables. Part of the code generation section.

```
#include <cuda.h>
#include <cuda_runtime.h>
```

Namespaces

- GENN_FLAGS
- GENN_PREFERENCES

Macros

- #define TRUE true
- #define FALSE false

Variables

- unsigned int GENN_FLAGS::calcSynapseDynamics = 0
- unsigned int GENN_FLAGS::calcSynapses = 1

- unsigned int GENN_FLAGS::learnSynapsesPost = 2
- unsigned int GENN_FLAGS::calcNeurons = 3
- int GENN_PREFERENCES::optimiseBlockSize = 1

  Flag for signalling whether or not block size optimisation should be performed.
- int GENN_PREFERENCES::autoChooseDevice = 1

  Flag to signal whether the GPU device should be chosen automatically.
- bool GENN_PREFERENCES::optimizeCode = false

  Request speed-optimized code, at the expense of floating-point accuracy.
- bool GENN_PREFERENCES::debugCode = false

  Request debug data to be embedded in the generated code.
- bool GENN_PREFERENCES::showPtxInfo = false

  Request that PTX assembler information be displayed for each CUDA kernel during compilation.
- double GENN_PREFERENCES::asGoodAsZero = 1e-19

  Global variable that is used when detecting close to zero values, for example when setting sparse connectivity from a dense matrix.
- int GENN_PREFERENCES::defaultDevice = 0
- unsigned int GENN_PREFERENCES::neuronBlockSize = 32

  default GPU device; used to determine which GPU to use if chooseDevice is 0 (off)
- unsigned int GENN_PREFERENCES::synapseBlockSize = 32
- unsigned int GENN_PREFERENCES::learningBlockSize = 32
- unsigned int GENN_PREFERENCES::synapseDynamicsBlockSize = 32
- unsigned int GENN_PREFERENCES::autoRefractory = 1

  Flag for signalling whether spikes are only reported if thresholdCondition changes from false to true (autoRefractory == 1) or spikes are emitted whenever thresholdCondition is true no matter what.
- int neuronBlkSz

  Global variable containing the GPU block size for the neuron kernel.
- int synapseBlkSz

  Global variable containing the GPU block size for the synapse kernel.
- int learnBlkSz

  Global variable containing the GPU block size for the learn kernel.
- int synDynBlkSz

  Global variable containing the GPU block size for the synapse dynamics kernel.
- cudaDeviceProp ∗ deviceProp
- int theDevice

  Global variable containing the currently selected CUDA device's number.
- int deviceCount

  Global variable containing the number of CUDA devices on this host.
- int hostCount

  Global variable containing the number of hosts within the local compute cluster.

17.57.1 Detailed Description

Global header file containing a few global variables. Part of the code generation section.

17.57.2 Macro Definition Documentation

17.57.2.1 #define FALSE false

17.57.2.2 #define TRUE true

17.57.3 Variable Documentation

17.57.3.1 int deviceCount

Global variable containing the number of CUDA devices on this host.

17.57.3.2 cudaDeviceProp∗ deviceProp

17.57.3.3 int hostCount

Global variable containing the number of hosts within the local compute cluster.

17.57.3.4 int learnBlkSz

Global variable containing the GPU block size for the learn kernel.

17.57.3.5 int neuronBlkSz

Global variable containing the GPU block size for the neuron kernel.

17.57.3.6 int synapseBlkSz

Global variable containing the GPU block size for the synapse kernel.

17.57.3.7 int synDynBlkSz

Global variable containing the GPU block size for the synapse dynamics kernel.

17.57.3.8 int theDevice

Global variable containing the currently selected CUDA device's number.

17.58 helper.h File Reference

```
#include <vector>
```

Classes

- struct inputSpec

Functions

- ostream & operator<< (ostream &os, inputSpec &I)
- void write_para ()
- void single_var_init_fullrange (int n)
- void single_var_reinit (int n, double fac)
- void copy_var (int src, int trg)
- void var_init_fullrange ()
- void var_reinit (double fac)
- void truevar_init ()
- void initexpHH ()
- void truevar_initexpHH ()
- void runexpHH (float t)
- void initI (inputSpec &I)

Variables

- double sigGNa = 0.1
- double sigENa = 10.0
- double sigGK = 0.1
- double sigEK = 10.0

- double sigGl = 0.1
- double sigEl = 10.0
- double sigC = 0.1
- const double limit [7][2]
- double Vexp
- double mexp
- double hexp
- double nexp
- double gNaexp
- double ENaexp
- double gKexp
- double EKexp
- double glexp
- double Elexp
- double Cexp

17.58.1 Function Documentation

17.58.1.1 void copy_var (int *src,* int *trg*)

17.58.1.2 void initexpHH ( )

17.58.1.3 void initI (inputSpec & *I*)

17.58.1.4 ostream& operator<< (ostream & *os,* inputSpec & *I*)

17.58.1.5 void runexpHH (float *t*)

17.58.1.6 void single_var_init_fullrange (int *n*)

17.58.1.7 void single_var_reinit (int *n,* double *fac*)

17.58.1.8 void truevar_init ( )

17.58.1.9 void truevar_initexpHH ( )

17.58.1.10 void var_init_fullrange ( )

17.58.1.11 void var_reinit (double *fac*)

17.58.1.12 void write_para ( )

17.58.2 Variable Documentation

17.58.2.1 double Cexp

17.58.2.2 double EKexp

17.58.2.3 double Elexp

17.58.2.4 double ENaexp

17.58.2.5 double gKexp

17.58.2.6 double glexp

17.58.2.7 double gNaexp

17.58.2.8 double hexp

17.58.2.9 const double limit[7][2]

Initial value:

```
= {{1.0, 200.0},
                           {0.0, 100.0},
                           {1.0, 100.0},
                           {-100.0, -20.0},
                           {1.0, 50.0},
                           {-100.0, -20.0},
                           {1e-1, 10.0}}
```

17.58.2.10 double mexp

17.58.2.11 double nexp

17.58.2.12 double sigC = 0.1

17.58.2.13 double sigEK = 10.0

17.58.2.14 double sigEl = 10.0

17.58.2.15 double sigENa = 10.0

17.58.2.16 double sigGK = 0.1

17.58.2.17 double sigGl = 0.1

17.58.2.18 double sigGNa = 0.1

17.58.2.19 double Vexp

17.59 HHVClamp.cc File Reference

This file contains the model definition of HHVClamp model. It is used in both the GeNN code generation and the user side simulation code. The HHVClamp model implements a population of unconnected Hodgkin-Huxley neurons that evolve to mimick a model run on the CPU, using genetic algorithm techniques.

```
#include "modelSpec.h"
#include "global.h"
#include "HHVClampParameters.h"
```

Functions

- void modelDefinition (NNmodel &model)

  This function defines the HH model with variable parameters.

Variables

- double myHH_ini [11]
- double ∗ myHH_p = NULL

17.59.1 Detailed Description

This file contains the model definition of HHVClamp model. It is used in both the GeNN code generation and the user side simulation code. The HHVClamp model implements a population of unconnected Hodgkin-Huxley neurons that evolve to mimick a model run on the CPU, using genetic algorithm techniques.

17.59.2 Function Documentation

17.59.2.1 void modelDefinition (NNmodel & *model*)

This function defines the HH model with variable parameters.

17.59.3 Variable Documentation

17.59.3.1 double myHH_ini[11]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207,
  120.0,
  55.0,
  36.0,
  -72.0,
  0.3,
  -50.0,
  1.0
}
```

17.59.3.2 double∗ myHH_p = NULL

17.60 hr_time.cc File Reference

This file contains the implementation of the CStopWatch class that provides a simple timing tool based on the system clock.

```
#include <cstdio>
#include "hr_time.h"
```

Macros

- #define HR_TIMER

17.60.1 Detailed Description

This file contains the implementation of the CStopWatch class that provides a simple timing tool based on the system clock.

17.60.2 Macro Definition Documentation

17.60.2.1 #define HR_TIMER

17.61 hr_time.h File Reference

This header file contains the definition of the CStopWatch class that implements a simple timing tool using the system clock.

```
#include <sys/time.h>
```

Classes

- struct stopWatch
- class CStopWatch

17.61.1 Detailed Description

This header file contains the definition of the CStopWatch class that implements a simple timing tool using the system clock.

17.62 isaac.cc File Reference

Header file and implementation of the ISAAC random number generator.

```
#include <stdlib.h>
```

Classes

- class QTIsaac< ALPHA, T >
- struct QTIsaac< ALPHA, T >::randctx

Macros

- #define __ISAAC_HPP

    macro for avoiding multiple inclusion during compilation

Typedefs

- typedef unsigned long int ISAAC_INT

Variables

- const ISAAC_INT GOLDEN_RATIO = ISAAC_INT(0x9e3779b9)

17.62.1 Detailed Description

Header file and implementation of the ISAAC random number generator.

C++ TEMPLATE VERSION OF Robert J. Jenkins Jr.'s ISAAC Random Number Generator.

Ported from vanilla C to to template C++ class by Quinn Tyler Jackson on 16-23 July 1998.

```
qjackson@wave.home.com
```

The function for the expected period of this random number generator, according to Jenkins is:

```
f(a,b) = 2**((a+b*(3+2^^a)-1)
```

```
(where a is ALPHA and b is bitwidth)
```

So, for a bitwidth of 32 and an ALPHA of 8, the expected period of ISAAC is:

```
2^^(8+32*(3+2^^8)-1) = 2^^8295
```

Jackson has been able to run implementations with an ALPHA as high as 16, or

```
2^^2097263
```

17.62.2 Macro Definition Documentation

17.62.2.1 #define __ISAAC_HPP

macro for avoiding multiple inclusion during compilation

17.62.3 Typedef Documentation

17.62.3.1 typedef unsigned long int ISAAC_INT

17.62.4 Variable Documentation

17.62.4.1 const ISAAC_INT GOLDEN_RATIO = ISAAC_INT(0x9e3779b9)

17.63 Izh_sim_sparse.cc File Reference

```
#include <iostream>
#include <fstream>
#include "Izh_sparse_sim.h"
#include <cuda_runtime.h>
#include "GeNNHelperKrnls.h"
```

Functions

- int main (int argc, char ∗argv[])

17.63.1 Function Documentation

17.63.1.1 int main (int *argc,* char ∗ *argv[]*)

17.64 Izh_sparse.cc File Reference

```
#include "modelSpec.h"
#include "global.h"
#include "stringUtils.h"
#include <vector>
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

Variables

- std::vector< unsigned int > neuronPSize
- std::vector< unsigned int > neuronVSize
- std::vector< unsigned int > synapsePSize
- scalar meanInpExc = 5.0∗inputFac
- scalar meanInpInh = 2.0∗inputFac
- double ∗ excIzh_p = NULL
- double ∗ inhIzh_p = NULL
- double IzhExc_ini [7]

- double IzhInh_ini [7]
- double ∗ SynIzh_p = NULL
- double ∗ postExpP = NULL
- double ∗ postSynV = NULL
- double SynIzh_ini [1]

17.64.1 Function Documentation

17.64.1.1 void modelDefinition (NNmodel & *model*)

17.64.2 Variable Documentation

17.64.2.1 double∗ excIzh_p = NULL

17.64.2.2 double∗ inhIzh_p = NULL

17.64.2.3 double IzhExc_ini[7]

Initial value:

```
={

        -65.0,
         0.0,
         0.02,
        0.2,
        -65.0,
        8.0,
        0.0
}
```

17.64.2.4 double IzhInh_ini[7]

Initial value:

```
={

        -65,
         0.0,
         0.02,
        0.25,
        -65.0,
        2.0,
        0.0
}
```

17.64.2.5 scalar meanInpExc = 5.0∗inputFac

17.64.2.6 scalar meanInpInh = 2.0∗inputFac

17.64.2.7 std::vector<unsigned int> neuronPSize

17.64.2.8 std::vector<unsigned int> neuronVSize

17.64.2.9 double∗ postExpP = NULL

17.64.2.10 double∗ postSynV = NULL

17.64.2.11 std::vector<unsigned int> synapsePSize

17.64.2.12 double SynIzh_ini[1]

Initial value:

```
= {
    0.0
}
```

17.64.2.13 double∗ SynIzh_p = NULL

17.65 Izh_sparse_model.cc File Reference

```
#include "Izh_sparse_CODE/definitions.h"
#include "randomGen.h"
#include "gauss.h"
#include "Izh_sparse_model.h"
```

Macros

- #define _IZH_SPARSE_MODEL_CC_

Variables

- randomGauss RG
- randomGen R

17.65.1 Macro Definition Documentation

17.65.1.1 #define _IZH_SPARSE_MODEL_CC_

17.65.2 Variable Documentation

17.65.2.1 randomGen R

17.65.2.2 randomGauss RG

17.66 Izh_sparse_model.h File Reference

Classes

- class classIzh

17.67 Izh_sparse_sim.h File Reference

```
#include <cassert>
#include "hr_time.h"
#include "utils.h"
#include <cuda_runtime.h>
#include "Izh_sparse.cc"
#include "Izh_sparse_model.cc"
```

Macros

- #define DBG_SIZE 5000
- #define T_REPORT_TME 5000.0
- #define TOTAL_TME 1000.0

Variables

- CStopWatch timer

17.67.1 Macro Definition Documentation

17.67.1.1 #define DBG_SIZE 5000

17.67.1.2 #define T_REPORT_TME 5000.0

17.67.1.3 #define TOTAL_TME 1000.0

17.67.2 Variable Documentation

17.67.2.1 CStopWatch timer

17.68 map_classol.cc File Reference

Implementation of the classol class.

```
#include "map_classol.h"
#include "MBody1_CODE/definitions.h"
```

Macros

- #define _MAP_CLASSOL_CC_

  macro for avoiding multiple inclusion during compilation

17.68.1 Detailed Description

Implementation of the classol class.

17.68.2 Macro Definition Documentation

17.68.2.1 #define _MAP_CLASSOL_CC_

macro for avoiding multiple inclusion during compilation

17.69 map_classol.cc File Reference

Implementation of the classol class.

```
#include "map_classol.h"
#include "MBody_delayedSyn_CODE/definitions.h"
```

Macros

- #define _MAP_CLASSOL_CC_

  macro for avoiding multiple inclusion during compilation

17.69.1 Detailed Description

Implementation of the classol class.

17.69.2 Macro Definition Documentation

17.69.2.1 #define _MAP_CLASSOL_CC_

macro for avoiding multiple inclusion during compilation

17.70 map_classol.cc File Reference

Implementation of the classol class.

```
#include "map_classol.h"
#include "MBody_individualID_CODE/definitions.h"
```

Macros

- #define _MAP_CLASSOL_CC_

    macro for avoiding multiple inclusion during compilation

17.70.1 Detailed Description

Implementation of the classol class.

17.70.2 Macro Definition Documentation

17.70.2.1 #define _MAP_CLASSOL_CC_

macro for avoiding multiple inclusion during compilation

17.71 map_classol.cc File Reference

Implementation of the classol class.

```
#include "MBody_userdef_CODE/definitions.h"
#include "global.h"
#include "sparseUtils.h"
#include "map_classol.h"
```

Macros

- #define _MAP_CLASSOL_CC_

    macro for avoiding multiple inclusion during compilation

17.71.1 Detailed Description

Implementation of the classol class.

17.71.2 Macro Definition Documentation

17.71.2.1 #define _MAP_CLASSOL_CC_

macro for avoiding multiple inclusion during compilation

17.72 map_classol.h File Reference

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

```
#include <stdint.h>
```

Classes

- class classol

  This class cpontains the methods for running the MBody1 example model.

17.72.1 Detailed Description

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

The "classol" class is provided as part of a complete example of using GeNN in a user application. The model is a reimplementation of the model in

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005), doi:10.1007/s00422-005-0019-7

17.73 map_classol.h File Reference

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

```
#include <stdint.h>
```

Classes

- class classol

  This class cpontains the methods for running the MBody1 example model.

17.73.1 Detailed Description

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

The "classol" class is provided as part of a complete example of using GeNN in a user application. The model is a reimplementation of the model in

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005), doi:10.1007/s00422-005-0019-7

17.74 map_classol.h File Reference

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

```
#include <stdint.h>
```

Classes

- class classol

  This class cpontains the methods for running the MBody1 example model.

17.74.1 Detailed Description

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

The "classol" class is provided as part of a complete example of using GeNN in a user application. The model is a reimplementation of the model in

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005), doi:10.1007/s00422-005-0019-7

17.75 map_classol.h File Reference

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

```
#include <stdint.h>
```

Classes

- class classol

  This class cpontains the methods for running the MBody1 example model.

17.75.1 Detailed Description

Header file containing the class definition for classol (CLASSification OLfaction model), which contains the methods for setting up, initialising, simulating and saving results of a model of the insect mushroom body.

The "classol" class is provided as part of a complete example of using GeNN in a user application. The model is a reimplementation of the model in

T. Nowotny, R. Huerta, H. D. I. Abarbanel, and M. I. Rabinovich Self-organization in the olfactory system: One shot odor recognition in insects, Biol Cyber, 93 (6): 436-446 (2005), doi:10.1007/s00422-005-0019-7

17.76 MBody1.cc File Reference

This file contains the model definition of the mushroom body "MBody1" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

```
#include "modelSpec.h"
#include "modelSpec.cc"
```

Macros

- #define DT 0.1

  This defines the global time step at which the simulation will run.

Functions

- void modelDefinition (NNmodel &model)

  This function defines the MBody1 model, and it is a good example of how networks should be defined.

Variables

- double myPOI_p [4]
- double myPOI_ini [4]
- double stdTM_p [7]
- double stdTM_ini [4]
- double myPNKC_p [3]
- double postExpPNKC [2]
- double myPNLHI_p [3]
- double postExpPNLHI [2]
- double myLHIKC_p [4]
- double gLHIKC = 0.006
- double postExpLHIKC [2]
- double myKCDN_p [13]
- double postExpKCDN [2]
- double myDNDN_p [4]
- double gDNDN = 0.01
- double postExpDNDN [2]
- double ∗ postSynV = NULL

17.76.1 Detailed Description

This file contains the model definition of the mushroom body "MBody1" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

17.76.2 Macro Definition Documentation

17.76.2.1 #define DT 0.1

This defines the global time step at which the simulation will run.

17.76.3 Function Documentation

17.76.3.1 void modelDefinition (**NNmodel** & *model*)

This function defines the MBody1 model, and it is a good example of how networks should be defined.

17.76.4 Variable Documentation

17.76.4.1 double gDNDN = 0.01

17.76.4.2 double gLHIKC = 0.006

17.76.4.3 double myDNDN_p[4]

Initial value:

```
= {
  -92.0,
  -30.0,
  8.0,
  50.0
}
```

17.76.4.4 double myKCDN_p[13]

Initial value:

```
= {
  0.0,
  -20.0,
  5.0,
  25.0,
  100.0,
  50000.0,
  100000.0,
  100.0,
  0.06,
  0.03,
  33.33,
  10.0,

  0.00006
}
```

17.76.4.5 double myLHIKC_p[4]

Initial value:

```
= {
  -92.0,
  -40.0,
  3.0,
  50.0
}
```

17.76.4.6 double myPNKC_p[3]

Initial value:

```
= {
  0.0,
  -20.0,
  1.0
}
```

17.76.4.7 double myPNLHI_p[3]

Initial value:

```
= {
  0.0,
  -20.0,
  1.0
}
```

17.76.4.8 double myPOI_ini[4]

Initial value:

```
= {
 -60.0,
  0,
  -10.0,
}
```

17.76.4.9 double myPOI_p[4]

Initial value:

```
= {
  0.1,
  2.5,
  20.0,
  -60.0
}
```

17.76.4.10 double postExpDNDN[2]

Initial value:

```
={
  8.0,
  -92.0
}
```

17.76.4.11 double postExpKCDN[2]

Initial value:

```
={
  5.0,
  0.0
}
```

17.76.4.12 double postExpLHIKC[2]

Initial value:

```
={
  3.0,
  -92.0
}
```

17.76.4.13 double postExpPNKC[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.76.4.14 double postExpPNLHI[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.76.4.15 double∗ postSynV = NULL

17.76.4.16 double stdTM_ini[4]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207
}
```

17.76.4.17 double stdTM_p[7]

Initial value:

```
= {
  7.15,
  50.0,
  1.43,
  -95.0,
  0.02672,
  -63.563,
  0.143
}
```

17.77 MBody1.cc File Reference

This file contains the model definition of the mushroom body "MBody1" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

    This function defines the MBody1 model, and it is a good example of how networks should be defined.

Variables

- double myPOI_p [4]
- double myPOI_ini [3]
- double stdTM_p [7]
- double stdTM_ini [4]
- double ∗ myPNKC_p = NULL
- double myPNKC_ini [1]
- double postExpPNKC [2]
- double ∗ myPNLHI_p = NULL
- double myPNLHI_ini [1]
- double postExpPNLHI [2]
- double myLHIKC_p [2]
- double myLHIKC_ini [1]
- double postExpLHIKC [2]
- double myKCDN_p [10]
- double myKCDN_ini [2]
- double postExpKCDN [2]
- double myDNDN_p [2]
- double myDNDN_ini [1]
- double postExpDNDN [2]
- double ∗ postSynV = NULL

17.77.1 Detailed Description

This file contains the model definition of the mushroom body "MBody1" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

17.77.2 Function Documentation

17.77.2.1 void modelDefinition (NNmodel & *model*)

This function defines the MBody1 model, and it is a good example of how networks should be defined.

17.77.3 Variable Documentation

17.77.3.1 double myDNDN_ini[1]

Initial value:

```
={
    5.0/_NLB
}
```

17.77.3.2 double myDNDN_p[2]

Initial value:

```
= {
  -30.0,
  50.0
}
```

17.77.3.3 double myKCDN_ini[2]

Initial value:

```
={
  0.01,
  0.01,
}
```

17.77.3.4 double myKCDN_p[10]

Initial value:

```
= {
  50.0,
  50.0,
  50000.0,
  100000.0,
  200.0,
  0.015,
  0.0075,
  33.33,
  10.0,
  0.00006
}
```

17.77.3.5 double myLHIKC_ini[1]

Initial value:

```
= {
    1.0/_NLHI
}
```

17.77.3.6 double myLHIKC_p[2]

Initial value:

```
= {
  -40.0,
  50.0
}
```

17.77.3.7 double myPNKC_ini[1]

Initial value:

```
= {
  0.01
}
```

17.77.3.8 double∗ myPNKC_p = NULL

17.77.3.9 double myPNLHI_ini[1]

Initial value:

```
= {
    0.0
}
```

17.77.3.10 double∗ myPNLHI_p = NULL

17.77.3.11 double myPOI_ini[3]

Initial value:

```
= {
 -60.0,
  0,
  -10.0
}
```

17.77.3.12 double myPOI_p[4]

Initial value:

```
= {
  0.1,
  2.5,
  20.0,
  -60.0
}
```

17.77.3.13 double postExpDNDN[2]

Initial value:

```
={
  2.5,
  -92.0
}
```

17.77.3.14 double postExpKCDN[2]

Initial value:

```
={
  5.0,
  0.0
}
```

17.77.3.15 double postExpLHIKC[2]

Initial value:

```
={
    1.5,
  -92.0
}
```

17.77.3.16 double postExpPNKC[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.77.3.17 double postExpPNLHI[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.77.3.18 double∗ postSynV = NULL

17.77.3.19 double stdTM_ini[4]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207
}
```

17.77.3.20 double stdTM_p[7]

Initial value:

```
= {
  7.15,
  50.0,
  1.43,
  -95.0,
  0.02672,
  -63.563,
  0.143
}
```

17.78 MBody_delayedSyn.cc File Reference

This file contains the model definition of the mushroom body "MBody_delayedSyn" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

  This function defines the MBody_delayedSyn model, and it is a good example of how networks should be defined.

Variables

- double myPOI_p [4]
- double myPOI_ini [3]
- double stdTM_p [7]
- double stdTM_ini [4]
- double ∗ myPNKC_p = NULL
- double myPNKC_ini [1]
- double postExpPNKC [2]
- double ∗ myPNLHI_p = NULL
- double myPNLHI_ini [1]
- double postExpPNLHI [2]
- double myLHIKC_p [2]
- double myLHIKC_ini [1]
- double postExpLHIKC [2]
- double myKCDN_p [10]
- double myKCDN_ini [2]
- double postExpKCDN [2]
- double myDNDN_p [2]
- double myDNDN_ini [1]
- double postExpDNDN [2]
- double ∗ postSynV = NULL

17.78.1 Detailed Description

This file contains the model definition of the mushroom body "MBody_delayedSyn" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim).

17.78.2 Function Documentation

17.78.2.1 void modelDefinition (**NNmodel** & *model*)

This function defines the MBody_delayedSyn model, and it is a good example of how networks should be defined.

17.78.3 Variable Documentation

17.78.3.1 double myDNDN_ini[1]

Initial value:

```
={
    5.0/_NLB
}
```

17.78.3.2 double myDNDN_p[2]

Initial value:

```
= {
  -30.0,
  50.0
}
```

17.78.3.3 double myKCDN_ini[2]

Initial value:

```
={
  0.01,
  0.01,
}
```

17.78.3.4 double myKCDN_p[10]

Initial value:

```
= {
  50.0,
  50.0,
  50000.0,
  100000.0,
  200.0,
  0.015,
  0.0075,
  33.33,
  10.0,
  0.00006
}
```

17.78.3.5 double myLHIKC_ini[1]

Initial value:

```
= {
    1.0/_NLHI
}
```

17.78.3.6 double myLHIKC_p[2]

Initial value:

```
= {
  -40.0,
  50.0
}
```

17.78.3.7 double myPNKC_ini[1]

Initial value:

```
= {
  0.01
}
```

17.78.3.8 double∗ myPNKC_p = NULL

17.78.3.9 double myPNLHI_ini[1]

Initial value:

```
= {
    0.0
}
```

17.78.3.10 double∗ myPNLHI_p = NULL

17.78.3.11 double myPOI_ini[3]

Initial value:

```
= {
 -60.0,
  0,
  -10.0
}
```

17.78.3.12 double myPOI_p[4]

Initial value:

```
= {
  0.1,
  2.5,
  20.0,
  -60.0
}
```

17.78.3.13 double postExpDNDN[2]

Initial value:

```
={
  2.5,
  -92.0
}
```

17.78.3.14 double postExpKCDN[2]

Initial value:

```
={
  5.0,
  0.0
}
```

17.78.3.15 double postExpLHIKC[2]

Initial value:

```
={
    1.5,
  -92.0
}
```

17.78.3.16 double postExpPNKC[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.78.3.17 double postExpPNLHI[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.78.3.18 double∗ postSynV = NULL

17.78.3.19 double stdTM_ini[4]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207
}
```

17.78.3.20 double stdTM_p[7]

Initial value:

```
= {
  7.15,
  50.0,
  1.43,
  -95.0,
  0.02672,
  -63.563,
  0.143
}
```

17.79 MBody_individualID.cc File Reference

This file contains the model definition of the mushroom body "MBody_incividualID" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim). It uses INDIVIDUALID for the connections from AL to MB allowing quite large numbers of PN and KC.

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

  This function defines the MBody1 model, and it is a good example of how networks should be defined.

Variables

- double myPOI_p [4]
- double myPOI_ini [3]
- double stdTM_p [7]
- double stdTM_ini [4]
- double ∗ myPNKC_p = NULL
- double myPNKC_ini [1]
- double postExpPNKC [2]
- double ∗ myPNLHI_p = NULL
- double myPNLHI_ini [1]
- double postExpPNLHI [2]
- double myLHIKC_p [2]
- double myLHIKC_ini [1]
- double postExpLHIKC [2]
- double myKCDN_p [11]
- double myKCDN_ini [2]

- double postExpKCDN [2]
- double myDNDN_p [2]
- double myDNDN_ini [1]
- double postExpDNDN [2]
- double ∗ postSynV = NULL

17.79.1 Detailed Description

This file contains the model definition of the mushroom body "MBody_incividualID" model. It is used in both the GeNN code generation and the user side simulation code (class classol, file classol_sim). It uses INDIVIDUALID for the connections from AL to MB allowing quite large numbers of PN and KC.

17.79.2 Function Documentation

17.79.2.1 void modelDefinition (NNmodel & *model*)

This function defines the MBody1 model, and it is a good example of how networks should be defined.

17.79.3 Variable Documentation

17.79.3.1 double myDNDN_ini[1]

Initial value:

```
={
    5.0/_NLB
}
```

17.79.3.2 double myDNDN_p[2]

Initial value:

```
= {
  -30.0,
  50.0
}
```

17.79.3.3 double myKCDN_ini[2]

Initial value:

```
={
  0.01,
  0.01,
}
```

17.79.3.4 double myKCDN_p[11]

Initial value:

```
= {
    50.0,
    50.0,
  50000.0,
  100000.0,
  200.0,
  0.015,
  0.0075,
  33.33,
  10.0,
  0.00006
}
```

17.79.3.5 double myLHIKC_ini[1]

Initial value:

```
= {
    1.0/_NLHI
}
```

17.79.3.6 double myLHIKC_p[2]

Initial value:

```
= {
  -40.0,
  50.0
}
```

17.79.3.7 double myPNKC_ini[1]

Initial value:

```
= {
  gPNKC_GLOBAL
}
```

17.79.3.8 double∗ myPNKC_p = NULL

17.79.3.9 double myPNLHI_ini[1]

Initial value:

```
= {
    0.0
}
```

17.79.3.10 double∗ myPNLHI_p = NULL

17.79.3.11 double myPOI_ini[3]

Initial value:

```
= {
 -60.0,
  0,
  -10.0
}
```

17.79.3.12 double myPOI_p[4]

Initial value:

```
= {
  0.1,
  2.5,
  20.0,
  -60.0
}
```

17.79.3.13 double postExpDNDN[2]

Initial value:

```
={
  2.5,
  -92.0
}
```

17.79.3.14 double postExpKCDN[2]

Initial value:

```
={
  5.0,
  0.0
}
```

17.79.3.15 double postExpLHIKC[2]

Initial value:

```
={
    1.5,
  -92.0
}
```

17.79.3.16 double postExpPNKC[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.79.3.17 double postExpPNLHI[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.79.3.18 double∗ postSynV = NULL

17.79.3.19 double stdTM_ini[4]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207
}
```

17.79.3.20 double stdTM_p[7]

Initial value:

```
= {
  7.15,
  50.0,
  1.43,
  -95.0,
  0.02672,
  -63.563,
  0.143
}
```

17.80 MBody_userdef.cc File Reference

This file contains the model definition of the mushroom body model. tis used in the GeNN code generation and the user side simulation code (class classol, file classol_sim).

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Classes

- class pwSTDP_userdef

  TODO This class definition may be code-generated in a future release.

Macros

- #define TIMING

Functions

- void modelDefinition (NNmodel &model)

  This function defines the MBody1 model with user defined synapses.

Variables

- double myPOI_p [4]
- double myPOI_ini [3]
- double stdTM_p [7]
- double stdTM_ini [4]
- double ∗ myPNKC_p = NULL
- double myPNKC_ini [1]
- double postExpPNKC [2]
- double ∗ myPNLHI_p = NULL
- double myPNLHI_ini [1]
- double postExpPNLHI [2]
- double myLHIKC_p [2]
- double myLHIKC_ini [1]
- double postExpLHIKC [2]
- double myKCDN_p [11]
- double myKCDN_ini [2]
- double postExpKCDN [2]
- double myDNDN_p [2]
- double myDNDN_ini [1]
- double postExpDNDN [2]
- double ∗ postSynV = NULL
- double postSynV_EXPDECAY_EVAR [1]
- scalar ∗ gpPNKC = new scalar[_NAL∗_NMB]
- scalar ∗ gpKCDN = new scalar[_NMB∗_NLB]

17.80.1 Detailed Description

This file contains the model definition of the mushroom body model. tis used in the GeNN code generation and the user side simulation code (class classol, file classol_sim).

17.80.2 Macro Definition Documentation

17.80.2.1 #define TIMING

17.80.3 Function Documentation

17.80.3.1 void modelDefinition (NNmodel & *model*)

This function defines the MBody1 model with user defined synapses.

17.80.4 Variable Documentation

17.80.4.1 scalar∗ gpKCDN = new scalar[_NMB∗_NLB]

17.80.4.2 scalar∗ gpPNKC = new scalar[_NAL∗_NMB]

17.80.4.3 double myDNDN_ini[1]

Initial value:

```
={
    5.0/_NLB
}
```

17.80.4.4 double myDNDN_p[2]

Initial value:

```
= {
  -30.0,
  50.0
}
```

17.80.4.5 double myKCDN_ini[2]

Initial value:

```
={
  0.01,
  0.01,
}
```

17.80.4.6 double myKCDN_p[11]

Initial value:

```
= {
  -20.0,
  50.0,
  50.0,
  50000.0,
  100000.0,
  200.0,
  0.015,
  0.0075,
  33.33,
  10.0,
  0.00006
}
```

17.80.4.7 double myLHIKC_ini[1]

Initial value:

```
= {
    1.0/_NLHI
}
```

17.80.4.8 double myLHIKC_p[2]

Initial value:

```
= {
  -40.0,
  50.0
}
```

17.80.4.9 double myPNKC_ini[1]

Initial value:

```
= {
  0.01
}
```

17.80.4.10 double∗ myPNKC_p = NULL

17.80.4.11 double myPNLHI_ini[1]

Initial value:

```
= {
    0.0
}
```

17.80.4.12 double∗ myPNLHI_p = NULL

17.80.4.13 double myPOI_ini[3]

Initial value:

```
= {
 -60.0,
  0,
  -10.0
}
```

17.80.4.14 double myPOI_p[4]

Initial value:

```
= {
  0.1,
  2.5,
  20.0,
  -60.0
}
```

17.80.4.15 double postExpDNDN[2]

Initial value:

```
={
  2.5,
  -92.0
}
```

17.80.4.16 double postExpKCDN[2]

Initial value:

```
={
  5.0,
  0.0
}
```

17.80.4.17 double postExpLHIKC[2]

Initial value:

```
={
  1.5,
  -92.0
}
```

17.80.4.18 double postExpPNKC[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.80.4.19 double postExpPNLHI[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.80.4.20 double∗ postSynV = NULL

17.80.4.21 double postSynV_EXPDECAY_EVAR[1]

Initial value:

```
= {
0
}
```

17.80.4.22 double stdTM_ini[4]

Initial value:

```
= {
  -60.0,
  0.0529324,
  0.3176767,
  0.5961207
}
```

17.80.4.23 double stdTM_p[7]

Initial value:

```
= {
  7.15,
  50.0,
  1.43,
  -95.0,
  0.02672,
  -63.563,
  0.143
}
```

17.81 Model_Schmuker_2014_classifier.cc File Reference

```
#include "modelSpec.h"
#include <iostream>
```

Macros

- #define DT 0.5
- #define NUM_VR 10
- #define NUM_FEATURES 4
- #define NUM_CLASSES 3
- #define NETWORK_SCALE 10
- #define CLUST_SIZE_AN (NETWORK_SCALE ∗ 6)
- #define CLUST_SIZE_PN (NETWORK_SCALE ∗ 6)
- #define CLUST_SIZE_RN (NETWORK_SCALE ∗ 6)
- #define SYNAPSE_TAU_RNPN 1.0
- #define SYNAPSE_TAU_PNPN 5.5
- #define SYNAPSE_TAU_PNAN 1.0
- #define SYNAPSE_TAU_ANAN 8.0

Functions

- void modelDefinition (NNmodel &model)

17.81.1 Macro Definition Documentation

17.81.1.1 #define CLUST_SIZE_AN (NETWORK_SCALE ∗ 6)

17.81.1.2 #define CLUST_SIZE_PN (NETWORK_SCALE ∗ 6)

17.81.1.3 #define CLUST_SIZE_RN (NETWORK_SCALE ∗ 6)

17.81.1.4 #define DT 0.5

17.81.1.5 #define NETWORK_SCALE 10

17.81.1.6 #define NUM_CLASSES 3

17.81.1.7 #define NUM_FEATURES 4

17.81.1.8 #define NUM_VR 10

17.81.1.9 #define SYNAPSE_TAU_ANAN 8.0

17.81.1.10 #define SYNAPSE_TAU_PNAN 1.0

17.81.1.11 #define SYNAPSE_TAU_PNPN 5.5

17.81.1.12 #define SYNAPSE_TAU_RNPN 1.0

17.81.2 Function Documentation

17.81.2.1 void modelDefinition (NNmodel & *model*)

17.82 modelSpec.cc File Reference

17.83 modelSpec.cc File Reference

```
#include "modelSpec.h"
#include "global.h"
#include "utils.h"
#include "stringUtils.h"
#include <cstdio>
#include <cmath>
#include <cassert>
#include <algorithm>
```

Macros

- #define MODELSPEC_CC

Functions

- void initGeNN ()

  Method for GeNN initialisation (by preparing standard models)

Variables

- unsigned int GeNNReady = 0

17.83.1 Macro Definition Documentation

17.83.1.1 #define MODELSPEC_CC

17.83.2 Function Documentation

17.83.2.1 void initGeNN ( )

Method for GeNN initialisation (by preparing standard models)

17.83.3 Variable Documentation

17.83.3.1 unsigned int GeNNReady = 0

17.84 modelSpec.h File Reference

Header file that contains the class (struct) definition of neuronModel for defining a neuron model and the class definition of NNmodel for defining a neuronal network model. Part of the code generation and generated code sections.

```
#include "neuronModels.h"
#include "synapseModels.h"
#include "postSynapseModels.h"
#include <string>
#include <vector>
```

Classes

- class NNmodel

Macros

- #define _MODELSPEC_H_

  macro for avoiding multiple inclusion during compilation
- #define ALLTOALL 0

  Macro attaching the label "ALLTOALL" to connectivity type 0.
- #define DENSE 1

  Macro attaching the label "DENSE" to connectivity type 1.
- #define SPARSE 2

  Macro attaching the label "SPARSE" to connectivity type 2.
- #define INDIVIDUALG 0

  Macro attaching the label "INDIVIDUALG" to method 0 for the definition of synaptic conductances.
- #define GLOBALG 1

  Macro attaching the label "GLOBALG" to method 1 for the definition of synaptic conductances.
- #define INDIVIDUALID 2

  Macro attaching the label "INDIVIDUALID" to method 2 for the definition of synaptic conductances.
- #define NO_DELAY 0

  Macro used to indicate no synapse delay for the group (only one queue slot will be generated)
- #define NOLEARNING 0

  Macro attaching the label "NOLEARNING" to flag 0.
- #define LEARNING 1

  Macro attaching the label "LEARNING" to flag 1.
- #define EXITSYN 0

  Macro attaching the label "EXITSYN" to flag 0 (excitatory synapse)
- #define INHIBSYN 1

  Macro attaching the label "INHIBSYN" to flag 1 (inhibitory synapse)
- #define CPU 0

  Macro attaching the label "CPU" to flag 0.
- #define GPU 1

  Macro attaching the label "GPU" to flag 1.
- #define AUTODEVICE -1

  Macro attaching the label AUTODEVICE to flag -1. Used by setGPUDevice.

Functions

- void initGeNN ()

  Method for GeNN initialisation (by preparing standard models)

Variables

- unsigned int GeNNReady

17.84.1 Detailed Description

Header file that contains the class (struct) definition of neuronModel for defining a neuron model and the class definition of NNmodel for defining a neuronal network model. Part of the code generation and generated code sections.

17.84.2 Macro Definition Documentation

17.84.2.1 #define _MODELSPEC_H_

macro for avoiding multiple inclusion during compilation

17.84.2.2 #define ALLTOALL 0

Macro attaching the label "ALLTOALL" to connectivity type 0.

17.84.2.3 #define AUTODEVICE -1

Macro attaching the label AUTODEVICE to flag -1. Used by setGPUDevice.

17.84.2.4 #define CPU 0

Macro attaching the label "CPU" to flag 0.

17.84.2.5 #define DENSE 1

Macro attaching the label "DENSE" to connectivity type 1.

17.84.2.6 #define EXITSYN 0

Macro attaching the label "EXITSYN" to flag 0 (excitatory synapse)

17.84.2.7 #define GLOBALG 1

Macro attaching the label "GLOBALG" to method 1 for the definition of synaptic conductances.

17.84.2.8 #define GPU 1

Macro attaching the label "GPU" to flag 1.

17.84.2.9 #define INDIVIDUALG 0

Macro attaching the label "INDIVIDUALG" to method 0 for the definition of synaptic conductances.

17.84.2.10 #define INDIVIDUALID 2

Macro attaching the label "INDIVIDUALID" to method 2 for the definition of synaptic conductances.

17.84.2.11 #define INHIBSYN 1

Macro attaching the label "INHIBSYN" to flag 1 (inhibitory synapse)

17.84.2.12 #define LEARNING 1

Macro attaching the label "LEARNING" to flag 1.

17.84.2.13 #define NO_DELAY 0

Macro used to indicate no synapse delay for the group (only one queue slot will be generated)

17.84.2.14 #define NOLEARNING 0

Macro attaching the label "NOLEARNING" to flag 0.

17.84.2.15 #define SPARSE 2

Macro attaching the label "SPARSE" to connectivity type 2.

17.84.3 Function Documentation

17.84.3.1 void initGeNN ( )

Method for GeNN initialisation (by preparing standard models)

17.84.4 Variable Documentation

17.84.4.1 unsigned int GeNNReady

17.85 neuronModels.cc File Reference

```
#include "neuronModels.h"
#include "stringUtils.h"
#include "extra_neurons.h"
```

Macros

- #define NEURONMODELS_CC

Functions

- void prepareStandardModels ()

  Function that defines standard neuron models.

Variables

- vector< neuronModel > nModels

  Global C++ vector containing all neuron model descriptions.
- unsigned int MAPNEURON

  variable attaching the name "MAPNEURON"
- unsigned int POISSONNEURON

  variable attaching the name "POISSONNEURON"
- unsigned int TRAUBMILES_FAST

  variable attaching the name "TRAUBMILES_FAST"
- unsigned int TRAUBMILES_ALTERNATIVE

  variable attaching the name "TRAUBMILES_ALTERNATIVE"
- unsigned int TRAUBMILES_SAFE

  variable attaching the name "TRAUBMILES_SAFE"
- unsigned int TRAUBMILES

  variable attaching the name "TRAUBMILES"
- unsigned int TRAUBMILES_PSTEP

  variable attaching the name "TRAUBMILES_PSTEP"
- unsigned int IZHIKEVICH

  variable attaching the name "IZHIKEVICH"
- unsigned int IZHIKEVICH_V

  variable attaching the name "IZHIKEVICH_V"
- unsigned int SPIKESOURCE

  variable attaching the name "SPIKESOURCE"

17.85.1 Macro Definition Documentation

17.85.1.1 #define NEURONMODELS_CC

17.85.2 Function Documentation

17.85.2.1 void prepareStandardModels ( )

Function that defines standard neuron models.

The neuron models are defined and added to the C++ vector nModels that is holding all neuron model descriptions. User defined neuron models can be appended to this vector later in (a) separate function(s).

17.85.3 Variable Documentation

17.85.3.1 unsigned int IZHIKEVICH

variable attaching the name "IZHIKEVICH"

17.85.3.2 unsigned int IZHIKEVICH_V

variable attaching the name "IZHIKEVICH_V"

17.85.3.3 unsigned int MAPNEURON

variable attaching the name "MAPNEURON"

17.85.3.4 vector<neuronModel> nModels

Global C++ vector containing all neuron model descriptions.

17.85.3.5 unsigned int POISSONNEURON

variable attaching the name "POISSONNEURON"

17.85.3.6 unsigned int SPIKESOURCE

variable attaching the name "SPIKESOURCE"

17.85.3.7 unsigned int TRAUBMILES

variable attaching the name "TRAUBMILES"

17.85.3.8 unsigned int TRAUBMILES_ALTERNATIVE

variable attaching the name "TRAUBMILES_ALTERNATIVE"

17.85.3.9 unsigned int TRAUBMILES_FAST

variable attaching the name "TRAUBMILES_FAST"

17.85.3.10 unsigned int TRAUBMILES_PSTEP

variable attaching the name "TRAUBMILES_PSTEP"

17.85.3.11 unsigned int TRAUBMILES_SAFE

variable attaching the name "TRAUBMILES_SAFE"

17.86 neuronModels.h File Reference

```
#include "dpclass.h"
#include <string>
#include <vector>
```

Classes

- class neuronModel

  class for specifying a neuron model.
- class rulkovdp

  Class defining the dependent parameters of the Rulkov map neuron.

Functions

- void prepareStandardModels ()

  Function that defines standard neuron models.

Variables

- vector< neuronModel > nModels

  Global C++ vector containing all neuron model descriptions.
- unsigned int MAPNEURON

  variable attaching the name "MAPNEURON"
- unsigned int POISSONNEURON

  variable attaching the name "POISSONNEURON"
- unsigned int TRAUBMILES_FAST

  variable attaching the name "TRAUBMILES_FAST"
- unsigned int TRAUBMILES_ALTERNATIVE

  variable attaching the name "TRAUBMILES_ALTERNATIVE"
- unsigned int TRAUBMILES_SAFE

  variable attaching the name "TRAUBMILES_SAFE"
- unsigned int TRAUBMILES

  variable attaching the name "TRAUBMILES"
- unsigned int TRAUBMILES_PSTEP

  variable attaching the name "TRAUBMILES_PSTEP"
- unsigned int IZHIKEVICH

  variable attaching the name "IZHIKEVICH"
- unsigned int IZHIKEVICH_V

  variable attaching the name "IZHIKEVICH_V"
- unsigned int SPIKESOURCE

  variable attaching the name "SPIKESOURCE"
- const unsigned int MAXNRN = 7

17.86.1 Function Documentation

17.86.1.1 void prepareStandardModels ( )

Function that defines standard neuron models.

The neuron models are defined and added to the C++ vector nModels that is holding all neuron model descriptions. User defined neuron models can be appended to this vector later in (a) separate function(s).

17.86.2 Variable Documentation

17.86.2.1 unsigned int IZHIKEVICH

variable attaching the name "IZHIKEVICH"

17.86.2.2 unsigned int IZHIKEVICH_V

variable attaching the name "IZHIKEVICH_V"

17.86.2.3 unsigned int MAPNEURON

variable attaching the name "MAPNEURON"

17.86.2.4 const unsigned int MAXNRN = 7

17.86.2.5 vector< neuronModel > nModels

Global C++ vector containing all neuron model descriptions.

17.86.2.6 unsigned int POISSONNEURON

variable attaching the name "POISSONNEURON"

17.86.2.7 unsigned int SPIKESOURCE

variable attaching the name "SPIKESOURCE"

17.86.2.8 unsigned int TRAUBMILES

variable attaching the name "TRAUBMILES"

17.86.2.9 unsigned int TRAUBMILES_ALTERNATIVE

variable attaching the name "TRAUBMILES_ALTERNATIVE"

17.86.2.10 unsigned int TRAUBMILES_FAST

variable attaching the name "TRAUBMILES_FAST"

17.86.2.11 unsigned int TRAUBMILES_PSTEP

variable attaching the name "TRAUBMILES_PSTEP"

17.86.2.12 unsigned int TRAUBMILES_SAFE

variable attaching the name "TRAUBMILES_SAFE"

17.87 OneComp.cc File Reference

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

Variables

- double exIzh_p [5]
- double exIzh_ini [2]
- double mySyn_p [3]
- double postExp [2]
- double ∗ postSynV = NULL

17.87.1 Function Documentation

17.87.1.1 void modelDefinition (NNmodel & *model*)

17.87.2 Variable Documentation

17.87.2.1 double exIzh_ini[2]

Initial value:

```
={

        -65,
        -20
}
```

17.87.2.2 double exIzh_p[5]

Initial value:

```
={

        0.02,
        0.2,
        -65,
        6,
        4.0
}
```

17.87.2.3 double mySyn_p[3]

Initial value:

```
= {
  0.0,
  -20.0,
  1.0
}
```

17.87.2.4 double postExp[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.87.2.5 double∗ postSynV = NULL

17.88 OneComp_model.cc File Reference

```
#include "OneComp_CODE/definitions.h"
```

Macros

- #define _ONECOMP_MODEL_CC_

17.88.1 Macro Definition Documentation

17.88.1.1 #define _ONECOMP_MODEL_CC_

17.89 OneComp_model.h File Reference

```
#include "OneComp.cc"
```

Classes

- class neuronpop

17.90 OneComp_sim.cc File Reference

```
#include "OneComp_sim.h"
```

Functions

- int main (int argc, char ∗argv[])

17.90.1 Function Documentation

17.90.1.1 int main (int *argc*, char ∗ *argv[]*)

17.91 OneComp_sim.h File Reference

```
#include "utils.h"
#include "stringUtils.h"
#include "hr_time.h"
#include <cuda_runtime.h>
#include <cassert>
#include "OneComp_model.h"
#include "OneComp_model.cc"
```

Macros

- #define DBG_SIZE 10000
- #define T_REPORT_TME 100.0
- #define TOTAL_TME 5000

Variables

- CStopWatch timer

17.91.1 Macro Definition Documentation

17.91.1.1 #define DBG_SIZE 10000

17.91.1.2 #define T_REPORT_TME 100.0

17.91.1.3 #define TOTAL_TME 5000

17.91.2 Variable Documentation

17.91.2.1 CStopWatch timer

17.92 parse_options.h File Reference

Functions

- for (int i=argStart;i< argc;i++)
- if (cpu_only &&(which==1))

Variables

- unsigned int dbgMode = 0
- string ftype = "FLOAT"
- unsigned int fixsynapse = 0
- unsigned int cpu_only = 0
- string option

17.92.1 Function Documentation

17.92.1.1 for ( )

17.92.1.2 if (cpu_only && *which==1*)

17.92.2 Variable Documentation

17.92.2.1 unsigned int cpu_only = 0

17.92.2.2 unsigned int dbgMode = 0

17.92.2.3 unsigned int fixsynapse = 0

17.92.2.4 string ftype = "FLOAT"

17.92.2.5 string option

17.93 PoissonIzh-model.cc File Reference

```
#include "PoissonIzh-model.h"
#include "PoissonIzh_CODE/definitions.h"
#include "modelSpec.h"
```

Macros

- #define _POISSONIZHMODEL_CC_

17.93.1 Macro Definition Documentation

17.93.1.1 #define _POISSONIZHMODEL_CC_

17.94 PoissonIzh-model.h File Reference

```
#include <stdint.h>
```

Classes

- class classol

  This class cpontains the methods for running the MBody1 example model.

17.95 PoissonIzh.cc File Reference

```
#include "modelSpec.h"
#include "global.h"
#include "sizes.h"
```

Functions

- void modelDefinition (NNmodel &model)

Variables

- double myPOI_p [4]
- double myPOI_ini [4]
- double exIzh_p [4]
- double exIzh_ini [2]
- double mySyn_p [3]
- double mySyn_ini [1]
- double postExp [2]
- double ∗ postSynV = NULL

17.95.1 Function Documentation

17.95.1.1 void modelDefinition (**NNmodel** & *model*)

17.95.2 Variable Documentation

17.95.2.1 double exIzh_ini[2]

Initial value:

```
={
        -65,
        -20
}
```

17.95.2.2 double exIzh_p[4]

Initial value:

```
={

        0.02,
        0.2,
        -65,
        6
}
```

17.95.2.3 double myPOI_ini[4]

Initial value:

```
= {
 -60.0,
  0,
  -10.0
}
```

17.95.2.4 double myPOI_p[4]

Initial value:

```
= {

  1,
  2.5,
  20.0,
  -60.0
}
```

17.95.2.5 double mySyn_ini[1]

Initial value:

```
={
  0.0
}
```

17.95.2.6 double mySyn_p[3]

Initial value:

```
= {
  0.0,
  -20.0,
  1.0
}
```

17.95.2.7 double postExp[2]

Initial value:

```
={
  1.0,
  0.0
}
```

17.95.2.8 double∗ postSynV = NULL

17.96 PoissonIzh_sim.cc File Reference

```
#include "PoissonIzh_sim.h"
```

Functions

- int main (int argc, char ∗argv[])

17.96.1 Function Documentation

17.96.1.1 int main (int *argc*, char ∗ *argv[]*)

17.97 PoissonIzh_sim.h File Reference

```
#include "utils.h"
#include "stringUtils.h"
#include "hr_time.h"
#include <cuda_runtime.h>
#include "PoissonIzh.cc"
#include <cassert>
#include "PoissonIzh-model.h"
#include "PoissonIzh-model.cc"
```

Macros

- #define MYRAND(Y, X) Y = Y ∗ 1103515245 +12345; X= (Y >> 16);
- #define T_REPORT_TME 1000.0
- #define SYN_OUT_TME 2000.0
- #define TOTAL_TME 5000

Variables

- scalar InputBaseRate = 2e-02
- CStopWatch timer

17.97.1 Macro Definition Documentation

17.97.1.1 #define MYRAND(*Y*, *X*) Y = Y ∗ 1103515245 +12345; X= (Y >> 16);

17.97.1.2 #define SYN_OUT_TME 2000.0

17.97.1.3 #define T_REPORT_TME 1000.0

17.97.1.4 #define TOTAL_TME 5000

17.97.2 Variable Documentation

17.97.2.1 scalar InputBaseRate = 2e-02

17.97.2.2 CStopWatch timer

17.98 postSynapseModels.cc File Reference

```
#include "postSynapseModels.h"
#include "stringUtils.h"
#include "extra_postsynapses.h"
```

Macros

- #define POSTSYNAPSEMODELS_CC

Functions

- void preparePostSynModels ()

  Function that prepares the standard post-synaptic models, including their variables, parameters, dependent parameters and code strings.

Variables

- vector< postSynModel > postSynModels

  Global C++ vector containing all post-synaptic update model descriptions.
- unsigned int EXPDECAY
- unsigned int IZHIKEVICH_PS

17.98.1 Macro Definition Documentation

17.98.1.1 #define POSTSYNAPSEMODELS_CC

17.98.2 Function Documentation

17.98.2.1 void preparePostSynModels ( )

Function that prepares the standard post-synaptic models, including their variables, parameters, dependent parameters and code strings.

17.98.3 Variable Documentation

17.98.3.1 unsigned int EXPDECAY

17.98.3.2 unsigned int IZHIKEVICH_PS

17.98.3.3 vector<**postSynModel**> postSynModels

Global C++ vector containing all post-synaptic update model descriptions.

17.99 postSynapseModels.h File Reference

```
#include "dpclass.h"
#include <string>
#include <vector>
#include <cmath>
```

Classes

- class postSynModel

  Class to hold the information that defines a post-synaptic model (a model of how synapses affect post-synaptic neuron variables, classically in the form of a synaptic current). It also allows to define an equation for the dynamics that can be applied to the summed synaptic input variable "insyn".
- class expDecayDp

  Class defining the dependent parameter for exponential decay.

Functions

- void preparePostSynModels ()

  Function that prepares the standard post-synaptic models, including their variables, parameters, dependent parameters and code strings.

Variables

- vector< postSynModel > postSynModels

  Global C++ vector containing all post-synaptic update model descriptions.
- unsigned int EXPDECAY
- unsigned int IZHIKEVICH_PS
- const unsigned int MAXPOSTSYN = 2

17.99.1 Function Documentation

17.99.1.1 void preparePostSynModels ( )

Function that prepares the standard post-synaptic models, including their variables, parameters, dependent parameters and code strings.

17.99.2 Variable Documentation

17.99.2.1 unsigned int EXPDECAY

17.99.2.2 unsigned int IZHIKEVICH_PS

17.99.2.3 const unsigned int MAXPOSTSYN = 2

17.99.2.4 vector<postSynModel> postSynModels

Global C++ vector containing all post-synaptic update model descriptions.

17.100 randomGen.cc File Reference

Contains the implementation of the ISAAC random number generator class for uniformly distributed random numbers and for a standard random number generator based on the C function rand().

```
#include "randomGen.h"
```

Macros

- #define RANDOMGEN_CC

  macro for avoiding multiple inclusion during compilation

17.100.1 Detailed Description

Contains the implementation of the ISAAC random number generator class for uniformly distributed random numbers and for a standard random number generator based on the C function rand().

17.100.2 Macro Definition Documentation

17.100.2.1 #define RANDOMGEN_CC

macro for avoiding multiple inclusion during compilation

17.101 randomGen.h File Reference

header file containing the class definition for a uniform random generator based on the ISAAC random number generator

```
#include <time.h>
#include <limits.h>
#include <stdlib.h>
#include <assert.h>
#include "isaac.cc"
```

Classes

- class randomGen

  Class randomGen which implements the ISAAC random number generator for uniformely distributed random numbers.

- class stdRG

Macros

- #define RANDOMGEN_H

  macro for avoiding multiple inclusion during compilation

17.101.1 Detailed Description

header file containing the class definition for a uniform random generator based on the ISAAC random number generator

17.101.2 Macro Definition Documentation

17.101.2.1 #define RANDOMGEN_H

macro for avoiding multiple inclusion during compilation

17.102 Schmuker2014_classifier.cc File Reference

```
#include <stdio.h>
#include <iostream>
#include <string>
#include <sstream>
#include <fstream>
#include <cstdlib>
#include <cstring>
#include <time.h>
#include "Schmuker2014_classifier.h"
#include "Schmuker_2014_classifier_CODE/definitions.h"
#include "stringUtils.h"
#include "sparseUtils.h"
```

Macros

- #define _SCHMUKER2014_CLASSIFIER_

  macro for avoiding multiple inclusion during compilation

17.102.1 Macro Definition Documentation

17.102.1.1 #define _SCHMUKER2014_CLASSIFIER_

macro for avoiding multiple inclusion during compilation

17.103 Schmuker2014_classifier.h File Reference

Header file containing the class definition for the Schmuker2014 classifier, which contains the methods for setting up, initialising, simulating and saving results of a multivariate classifier imspired by the insect olfactory system. See "A neuromorphic network for generic multivariate data classification, Michael Schmuker, Thomas Pfeilc, and Martin Paul Nawrota, 2014".

```
#include <stdint.h>
#include "Model_Schmuker_2014_classifier.cc"
```

Classes

- class Schmuker2014_classifier

  This class cpontains the methods for running the Schmuker_2014_classifier example model.

17.103.1 Detailed Description

Header file containing the class definition for the Schmuker2014 classifier, which contains the methods for setting up, initialising, simulating and saving results of a multivariate classifier imspired by the insect olfactory system. See "A neuromorphic network for generic multivariate data classification, Michael Schmuker, Thomas Pfeilc, and Martin Paul Nawrota, 2014".

17.104 sparseProjection.h File Reference

Classes

- struct SparseProjection

  class (struct) for defining a spars connectivity projection

17.105 sparseUtils.cc File Reference

```
#include "sparseUtils.h"
#include "utils.h"
#include <vector>
```

Macros

- #define SPARSEUTILS_CC

Functions

- void createPosttoPreArray (unsigned int preN, unsigned int postN, SparseProjection ∗C)

  Utility to generate the SPARSE array structure with post-to-pre arrangement from the original pre-to-post arrangement where postsynaptic feedback is necessary (learning etc)
- void createPreIndices (unsigned int preN, unsigned int postN, SparseProjection ∗C)

  Function to create the mapping from the normal index array "ind" to the "reverse" array revInd, i.e. the inverse mapping of remap. This is needed if SynapseDynamics accesses pre-synaptic variables.
- void initializeSparseArray (SparseProjection C, unsigned int ∗dInd, unsigned int ∗dIndInG, unsigned int preN)

  Function for initializing conductance array indices for sparse matrices on the GPU (by copying the values from the host)
- void initializeSparseArrayRev (SparseProjection C, unsigned int ∗dRevInd, unsigned int ∗dRevIndInG, unsigned int ∗dRemap, unsigned int postN)

  Function for initializing reversed conductance array indices for sparse matrices on the GPU (by copying the values from the host)
- void initializeSparseArrayPreInd (SparseProjection C, unsigned int ∗dPreInd)

  Function for initializing reversed conductance arrays presynaptic indices for sparse matrices on the GPU (by copying the values from the host)

17.105.1 Macro Definition Documentation

17.105.1.1 #define SPARSEUTILS_CC

17.105.2 Function Documentation

17.105.2.1 void createPosttoPreArray (unsigned int *preN*, unsigned int *postN*, SparseProjection ∗ *C*)

Utility to generate the SPARSE array structure with post-to-pre arrangement from the original pre-to-post arrangement where postsynaptic feedback is necessary (learning etc)

17.105.2.2 void createPreIndices (unsigned int *preN*, unsigned int *postN*, SparseProjection ∗ *C*)

Function to create the mapping from the normal index array "ind" to the "reverse" array revInd, i.e. the inverse mapping of remap. This is needed if SynapseDynamics accesses pre-synaptic variables.

17.105.2.3 void initializeSparseArray (SparseProjection *C*, unsigned int ∗ *dInd*, unsigned int ∗ *dIndInG*, unsigned int *preN*)

Function for initializing conductance array indices for sparse matrices on the GPU (by copying the values from the host)

17.105.2.4 void initializeSparseArrayPreInd (**SparseProjection** *C*, unsigned int ∗ *dPreInd*)

Function for initializing reversed conductance arrays presynaptic indices for sparse matrices on the GPU (by copying the values from the host)

17.105.2.5 void initializeSparseArrayRev (**SparseProjection** *C*, unsigned int ∗ *dRevInd*, unsigned int ∗ *dRevIndInG*, unsigned int ∗ *dRemap*, unsigned int *postN*)

Function for initializing reversed conductance array indices for sparse matrices on the GPU (by copying the values from the host)

17.106 sparseUtils.h File Reference

```
#include "sparseProjection.h"
#include "global.h"
#include <cstdlib>
#include <cstdio>
#include <string>
#include <cmath>
```

Functions

- template<class DATATYPE >
  unsigned int countEntriesAbove (DATATYPE ∗Array, int sz, double includeAbove)

  Utility to count how many entries above a specified value exist in a float array.
- template<class DATATYPE >
  DATATYPE getG (DATATYPE ∗wuvar, SparseProjection ∗sparseStruct, int x, int y)

  DEPRECATED Utility to get a synapse weight from a SPARSE structure by x,y coordinates NB: as the Sparse↩ Projection struct doesnt hold the preN size (it should!) it is not possible to check the parameter validity. This fn may therefore crash unless user knows max poss X.
- template<class DATATYPE >
  float getSparseVar (DATATYPE ∗wuvar, SparseProjection ∗sparseStruct, int x, int y)
- template<class DATATYPE >
  void setSparseConnectivityFromDense (DATATYPE ∗wuvar, int preN, int postN, DATATYPE ∗tmp_gRNPN, SparseProjection ∗sparseStruct)

  Function for setting the values of SPARSE connectivity matrix.
- template<class DATATYPE >
  void createSparseConnectivityFromDense (DATATYPE ∗wuvar, int preN, int postN, DATATYPE ∗tmp_gR↩ NPN, SparseProjection ∗sparseStruct, bool runTest)

  Utility to generate the SPARSE connectivity structure from a simple all-to-all array.
- void createPosttoPreArray (unsigned int preN, unsigned int postN, SparseProjection ∗C)

  Utility to generate the SPARSE array structure with post-to-pre arrangement from the original pre-to-post arrangement where postsynaptic feedback is necessary (learning etc)
- void createPreIndices (unsigned int preN, unsigned int postN, SparseProjection ∗C)

  Function to create the mapping from the normal index array "ind" to the "reverse" array revInd, i.e. the inverse mapping of remap. This is needed if SynapseDynamics accesses pre-synaptic variables.
- void initializeSparseArray (SparseProjection C, unsigned int ∗dInd, unsigned int ∗dIndInG, unsigned int preN)

  Function for initializing conductance array indices for sparse matrices on the GPU (by copying the values from the host)
- void initializeSparseArrayRev (SparseProjection C, unsigned int ∗dRevInd, unsigned int ∗dRevIndInG, unsigned int ∗dRemap, unsigned int postN)

  Function for initializing reversed conductance array indices for sparse matrices on the GPU (by copying the values from the host)
- void initializeSparseArrayPreInd (SparseProjection C, unsigned int ∗dPreInd)

Function for initializing reversed conductance arrays presynaptic indices for sparse matrices on the GPU (by copying the values from the host)

17.106.1 Function Documentation

17.106.1.1 template<class DATATYPE > unsigned int countEntriesAbove (DATATYPE ∗ *Array,* int *sz,* double *includeAbove*)

Utility to count how many entries above a specified value exist in a float array.

17.106.1.2 void createPosttoPreArray (unsigned int *preN,* unsigned int *postN,* SparseProjection ∗ *C*)

Utility to generate the SPARSE array structure with post-to-pre arrangement from the original pre-to-post arrangement where postsynaptic feedback is necessary (learning etc)

17.106.1.3 void createPreIndices (unsigned int *preN,* unsigned int *postN,* SparseProjection ∗ *C*)

Function to create the mapping from the normal index array "ind" to the "reverse" array revInd, i.e. the inverse mapping of remap. This is needed if SynapseDynamics accesses pre-synaptic variables.

17.106.1.4 template<class DATATYPE > void createSparseConnectivityFromDense (DATATYPE ∗ *wuvar,* int *preN,* int *postN,* DATATYPE ∗ *tmp_gRNPN,* SparseProjection ∗ *sparseStruct,* bool *runTest*)

Utility to generate the SPARSE connectivity structure from a simple all-to-all array.

17.106.1.5 template<class DATATYPE > DATATYPE getG (DATATYPE ∗ *wuvar,* SparseProjection ∗ *sparseStruct,* int *x,* int *y*)

DEPRECATED Utility to get a synapse weight from a SPARSE structure by x,y coordinates NB: as the Sparse↩ Projection struct doesnt hold the preN size (it should!) it is not possible to check the parameter validity. This fn may therefore crash unless user knows max poss X.

17.106.1.6 template<class DATATYPE > float getSparseVar (DATATYPE ∗ *wuvar,* SparseProjection ∗ *sparseStruct,* int *x,* int *y*)

17.106.1.7 void initializeSparseArray (SparseProjection *C,* unsigned int ∗ *dInd,* unsigned int ∗ *dIndInG,* unsigned int *preN*)

Function for initializing conductance array indices for sparse matrices on the GPU (by copying the values from the host)

17.106.1.8 void initializeSparseArrayPreInd (SparseProjection *C,* unsigned int ∗ *dPreInd*)

Function for initializing reversed conductance arrays presynaptic indices for sparse matrices on the GPU (by copying the values from the host)

17.106.1.9 void initializeSparseArrayRev (SparseProjection *C,* unsigned int ∗ *dRevInd,* unsigned int ∗ *dRevIndInG,* unsigned int ∗ *dRemap,* unsigned int *postN*)

Function for initializing reversed conductance array indices for sparse matrices on the GPU (by copying the values from the host)

17.106.1.10 template<class DATATYPE > void setSparseConnectivityFromDense (DATATYPE ∗ *wuvar,* int *preN,* int *postN,* DATATYPE ∗ *tmp_gRNPN,* SparseProjection ∗ *sparseStruct*)

Function for setting the values of SPARSE connectivity matrix.

17.107 stringUtils.cc File Reference

```
#include "stringUtils.h"
#include "utils.h"
#include <regex>
```

Macros

- #define STRINGUTILS_CC

Functions

- void substitute (string &s, const string trg, const string rep)

  Tool for substituting strings in the neuron code strings or other templates.
- void name_substitutions (string &code, string prefix, vector< string > &names, string postfix)

  This function performs a list of name substitutions for variables in code snippets.
- void value_substitutions (string &code, vector< string > &names, vector< double > &values)

  This function performs a list of value substitutions for parameters in code snippets.
- void extended_name_substitutions (string &code, string prefix, vector< string > &names, string ext, string postfix)

  This function performs a list of name substitutions for variables in code snippets where the variables have an extension in their names (e.g. "_pre").
- void extended_value_substitutions (string &code, vector< string > &names, string ext, vector< double > &values)

  This function performs a list of value substitutions for parameters in code snippets where the parameters have an extension in their names (e.g. "_pre").
- void ensureMathFunctionFtype (string &code, string type)

  This function converts code to contain only explicit single precision (float) function calls (C99 standard)
- void doFinal (string &code, unsigned int i, string type, unsigned int &state)

  This function is part of the parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).
- string ensureFtype (string oldcode, string type)

  This function implements a parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).
- void checkUnreplacedVariables (string code, string codeName)

  This function checks for unknown variable definitions and returns a gennError if any are found.
- void neuron_substitutions_in_synaptic_code (string &wCode, NNmodel &model, unsigned int src, unsigned int trg, unsigned int nt_pre, unsigned int nt_post, string offsetPre, string offsetPost, string preIdx, string post↵Idx, string devPrefix)

  Function for performing the code and value substitutions necessary to insert neuron related variables, parameters, and extraGlobal parameters into synaptic code.

Variables

- const string digits = string("0123456789")
- const string op = string("+-∗/(<>= ,;")+string("\n")+string("\t")
- const int __mathFN = 56
- const char ∗ __dnames [__mathFN]
- const char ∗ __fnames [__mathFN]

17.107.1 Macro Definition Documentation

17.107.1.1 #define STRINGUTILS_CC

17.107.2 Function Documentation

17.107.2.1 void checkUnreplacedVariables (string *code,* string *codeName*)

This function checks for unknown variable definitions and returns a gennError if any are found.

17.107.2.2 void doFinal (string & *code,* unsigned int *i,* string *type,* unsigned int & *state*)

This function is part of the parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).

17.107.2.3 string ensureFtype (string *oldcode,* string *type*)

This function implements a parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).

17.107.2.4 void ensureMathFunctionFtype (string & *code,* string *type*)

This function converts code to contain only explicit single precision (float) function calls (C99 standard)

17.107.2.5 void extended_name_substitutions (string & *code,* string *prefix,* vector< string > & *names,* string *ext,* string *postfix*)

This function performs a list of name substitutions for variables in code snippets where the variables have an extension in their names (e.g. "_pre").

17.107.2.6 void extended_value_substitutions (string & *code,* vector< string > & *names,* string *ext,* vector< double > & *values*)

This function performs a list of value substitutions for parameters in code snippets where the parameters have an extension in their names (e.g. "_pre").

17.107.2.7 void name_substitutions (string & *code,* string *prefix,* vector< string > & *names,* string *postfix*)

This function performs a list of name substitutions for variables in code snippets.

17.107.2.8 void neuron_substitutions_in_synaptic_code (string & *wCode,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* unsigned int *nt_pre,* unsigned int *nt_post,* string *offsetPre,* string *offsetPost,* string *preIdx,* string *postIdx,* string *devPrefix*)

Function for performing the code and value substitutions necessary to insert neuron related variables, parameters, and extraGlobal parameters into synaptic code.

Parameters

wCode	the code string to work on
model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
nt_pre	the neuron type of the pre-synaptic neuron
nt_post	the neuron type of the post-synaptic neuron
offsetPre	delay slot offset expression for pre-synaptic vars

offsetPost	delay slot offset expression for post-synaptic vars
preIdx	index of the pre-synaptic neuron to be accessed for _pre variables; differs for different Span)
postIdx	index of the post-synaptic neuron to be accessed for _post variables; differs for different Span)
devPrefix	device prefix, "dd_" for GPU, nothing for CPU

17.107.2.9 void substitute (string & *s*, const string *trg*, const string *rep*)

Tool for substituting strings in the neuron code strings or other templates.

17.107.2.10 void value_substitutions (string & *code*, vector< string > & *names*, vector< double > & *values*)

This function performs a list of value substitutions for parameters in code snippets.

17.107.3 Variable Documentation

17.107.3.1 const char* __dnames[__mathFN]

17.107.3.2 const char* __fnames[__mathFN]

17.107.3.3 const int __mathFN = 56

17.107.3.4 const string digits = string("0123456789")

17.107.3.5 const string op = string("+-*/(<>= ,;")+string("\n")+string("\t")

17.108 stringUtils.h File Reference

```
#include "modelSpec.h"
#include <string>
#include <sstream>
#include <vector>
```

Macros

- #define tS(X) toString(X)

  Macro providing the abbreviated syntax tS() instead of toString().

Functions

- template<class T >
  std::string toString (T t)

  template functions for conversion of various types to C++ strings
- void substitute (string &s, const string trg, const string rep)

  Tool for substituting strings in the neuron code strings or other templates.
- void name_substitutions (string &code, string prefix, vector< string > &names, string postfix="")

  This function performs a list of name substitutions for variables in code snippets.
- void value_substitutions (string &code, vector< string > &names, vector< double > &values)

  This function performs a list of value substitutions for parameters in code snippets.
- void extended_name_substitutions (string &code, string prefix, vector< string > &names, string ext, string postfix="")

  This function performs a list of name substitutions for variables in code snippets where the variables have an extension in their names (e.g. "_pre").
- void extended_value_substitutions (string &code, vector< string > &names, string ext, vector< double > &values)

This function performs a list of value substitutions for parameters in code snippets where the parameters have an extension in their names (e.g. "_pre").

- void ensureMathFunctionFtype (string &code, string type)

  This function converts code to contain only explicit single precision (float) function calls (C99 standard)
- void doFinal (string &code, unsigned int i, string type, unsigned int &state)

  This function is part of the parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).
- string ensureFtype (string oldcode, string type)

  This function implements a parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).
- void checkUnreplacedVariables (string code, string codeName)

  This function checks for unknown variable definitions and returns a gennError if any are found.
- void neuron_substitutions_in_synaptic_code (string &wCode, NNmodel &model, unsigned int src, unsigned int trg, unsigned int nt_pre, unsigned int nt_post, string offsetPre, string offsetPost, string preIdx, string post↩ Idx, string devPrefix)

  Function for performing the code and value substitutions necessary to insert neuron related variables, parameters, and extraGlobal parameters into synaptic code.

17.108.1 Macro Definition Documentation

17.108.1.1 #define tS(*X*) toString(X)

Macro providing the abbreviated syntax tS() instead of toString().

17.108.2 Function Documentation

17.108.2.1 void checkUnreplacedVariables (string *code*, string *codeName*)

This function checks for unknown variable definitions and returns a gennError if any are found.

17.108.2.2 void doFinal (string & *code*, unsigned int *i*, string *type*, unsigned int & *state*)

This function is part of the parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).

17.108.2.3 string ensureFtype (string *oldcode*, string *type*)

This function implements a parser that converts any floating point constant in a code snippet to a floating point constant with an explicit precision (by appending "f" or removing it).

17.108.2.4 void ensureMathFunctionFtype (string & *code*, string *type*)

This function converts code to contain only explicit single precision (float) function calls (C99 standard)

17.108.2.5 void extended_name_substitutions (string & *code*, string *prefix*, vector< string > & *names*, string *ext*, string *postfix* = "")

This function performs a list of name substitutions for variables in code snippets where the variables have an extension in their names (e.g. "_pre").

17.108.2.6 void extended_value_substitutions (string & *code*, vector< string > & *names*, string *ext*, vector< double > & *values*)

This function performs a list of value substitutions for parameters in code snippets where the parameters have an extension in their names (e.g. "_pre").

17.108.2.7 void name_substitutions (string & *code,* string *prefix,* vector< string > & *names,* string *postfix* = "")

This function performs a list of name substitutions for variables in code snippets.

17.108.2.8 void neuron_substitutions_in_synaptic_code (string & *wCode,* NNmodel & *model,* unsigned int *src,* unsigned int *trg,* unsigned int *nt_pre,* unsigned int *nt_post,* string *offsetPre,* string *offsetPost,* string *preIdx,* string *postIdx,* string *devPrefix*)

Function for performing the code and value substitutions necessary to insert neuron related variables, parameters, and extraGlobal parameters into synaptic code.

Parameters

wCode	the code string to work on
model	the neuronal network model to generate code for
src	the number of the src neuron population
trg	the number of the target neuron population
nt_pre	the neuron type of the pre-synaptic neuron
nt_post	the neuron type of the post-synaptic neuron
offsetPre	delay slot offset expression for pre-synaptic vars
offsetPost	delay slot offset expression for post-synaptic vars
preIdx	index of the pre-synaptic neuron to be accessed for _pre variables; differs for different Span)
postIdx	index of the post-synaptic neuron to be accessed for _post variables; differs for different Span)
devPrefix	device prefix, "dd_" for GPU, nothing for CPU

17.108.2.9 void substitute (string & *s,* const string *trg,* const string *rep*)

Tool for substituting strings in the neuron code strings or other templates.

17.108.2.10 template<class T > std::string toString (T *t*)

template functions for conversion of various types to C++ strings

17.108.2.11 void value_substitutions (string & *code,* vector< string > & *names,* vector< double > & *values*)

This function performs a list of value substitutions for parameters in code snippets.

17.109 synapseModels.cc File Reference

```
#include "synapseModels.h"
#include "stringUtils.h"
#include "extra_weightupdates.h"
```

Macros

- #define SYNAPSEMODELS_CC

Functions

- void prepareWeightUpdateModels ()

  Function that prepares the standard (pre) synaptic models, including their variables, parameters, dependent parameters and code strings.

Variables

- vector< weightUpdateModel > weightUpdateModels

Global C++ vector containing all weightupdate model descriptions.

- unsigned int NSYNAPSE

  Variable attaching the name NSYNAPSE to the non-learning synapse.
- unsigned int NGRADSYNAPSE

  Variable attaching the name NGRADSYNAPSE to the graded synapse wrt the presynaptic voltage.
- unsigned int LEARN1SYNAPSE

  Variable attaching the name LEARN1SYNAPSE to the the primitive STDP model for learning.

17.109.1 Macro Definition Documentation

17.109.1.1 #define SYNAPSEMODELS_CC

17.109.2 Function Documentation

17.109.2.1 void prepareWeightUpdateModels ( )

Function that prepares the standard (pre) synaptic models, including their variables, parameters, dependent parameters and code strings.

17.109.3 Variable Documentation

17.109.3.1 unsigned int LEARN1SYNAPSE

Variable attaching the name LEARN1SYNAPSE to the the primitive STDP model for learning.

17.109.3.2 unsigned int NGRADSYNAPSE

Variable attaching the name NGRADSYNAPSE to the graded synapse wrt the presynaptic voltage.

17.109.3.3 unsigned int NSYNAPSE

Variable attaching the name NSYNAPSE to the non-learning synapse.

17.109.3.4 vector<**weightUpdateModel**> weightUpdateModels

Global C++ vector containing all weightupdate model descriptions.

17.110 synapseModels.h File Reference

```
#include "dpclass.h"
#include <string>
#include <vector>
```

Classes

- class weightUpdateModel

  Class to hold the information that defines a weightupdate model (a model of how spikes affect synaptic (and/or) (mostly) post-synaptic neuron variables. It also allows to define changes in response to post-synaptic spikes/spike-like events.
- class pwSTDP

  TODO This class definition may be code-generated in a future release.

Functions

- void prepareWeightUpdateModels ()

  Function that prepares the standard (pre) synaptic models, including their variables, parameters, dependent parameters and code strings.

Variables

- vector< weightUpdateModel > weightUpdateModels

  Global C++ vector containing all weightupdate model descriptions.
- unsigned int NSYNAPSE

  Variable attaching the name NSYNAPSE to the non-learning synapse.
- unsigned int NGRADSYNAPSE

  Variable attaching the name NGRADSYNAPSE to the graded synapse wrt the presynaptic voltage.
- unsigned int LEARN1SYNAPSE

  Variable attaching the name LEARN1SYNAPSE to the the primitive STDP model for learning.
- const unsigned int SYNTYPENO = 4

17.110.1 Function Documentation

17.110.1.1 void prepareWeightUpdateModels ( )

Function that prepares the standard (pre) synaptic models, including their variables, parameters, dependent parameters and code strings.

17.110.2 Variable Documentation

17.110.2.1 unsigned int LEARN1SYNAPSE

Variable attaching the name LEARN1SYNAPSE to the the primitive STDP model for learning.

17.110.2.2 unsigned int NGRADSYNAPSE

Variable attaching the name NGRADSYNAPSE to the graded synapse wrt the presynaptic voltage.

17.110.2.3 unsigned int NSYNAPSE

Variable attaching the name NSYNAPSE to the non-learning synapse.

17.110.2.4 const unsigned int SYNTYPENO = 4

17.110.2.5 vector<weightUpdateModel> weightUpdateModels

Global C++ vector containing all weightupdate model descriptions.

17.111 SynDelay.cc File Reference

```
#include "modelSpec.h"
#include "global.h"
```

Functions

- void modelDefinition (NNmodel &model)

17.111.1 Function Documentation

17.111.1.1 void modelDefinition (NNmodel & *model*)

17.112 SynDelaySim.cc File Reference

```
#include <cstdlib>
#include <iostream>
#include <fstream>
#include "hr_time.h"
#include "utils.h"
#include "stringUtils.h"
#include "SynDelaySim.h"
#include "SynDelay_CODE/definitions.h"
```

Macros

- #define SYNDELAYSIM_CU

Functions

- int main (int argc, char ∗argv[ ])

17.112.1 Macro Definition Documentation

17.112.1.1 #define SYNDELAYSIM_CU

17.112.2 Function Documentation

17.112.2.1 int main (int *argc,* char ∗ *argv[ ]*)

17.113 SynDelaySim.h File Reference

Classes

- class SynDelay

Macros

- #define TOTAL_TIME 5000.0f
- #define REPORT_TIME 1000.0f

17.113.1 Macro Definition Documentation

17.113.1.1 #define REPORT_TIME 1000.0f

17.113.1.2 #define TOTAL_TIME 5000.0f

17.114 utils.cc File Reference

```
#include "utils.h"
#include <fstream>
#include <stdint.h>
```

Macros

- #define UTILS_CC

Functions

- CUresult cudaFuncGetAttributesDriver (cudaFuncAttributes ∗attr, CUfunction kern)

    Function for getting the capabilities of a CUDA device via the driver API.
- void gennError (string error)

    Function called upon the detection of an error. Outputs an error message and then exits.
- void writeHeader (ostream &os)

    Function to write the comment header denoting file authorship and contact details into the generated code.
- unsigned int theSize (string type)

    Tool for determining the size of variable types on the current architecture.

17.114.1 Macro Definition Documentation

17.114.1.1 #define UTILS_CC

17.114.2 Function Documentation

17.114.2.1 CUresult cudaFuncGetAttributesDriver (cudaFuncAttributes ∗ *attr,* CUfunction *kern*)

Function for getting the capabilities of a CUDA device via the driver API.

17.114.2.2 void gennError (string *error*)

Function called upon the detection of an error. Outputs an error message and then exits.

17.114.2.3 unsigned int theSize (string *type*)

Tool for determining the size of variable types on the current architecture.

17.114.2.4 void writeHeader (ostream & *os*)

Function to write the comment header denoting file authorship and contact details into the generated code.

17.115 utils.h File Reference

This file contains standard utility functions provide within the NVIDIA CUDA software development toolkit (SDK). The remainder of the file contains a function that defines the standard neuron models.

```
#include <iostream>
#include <string>
#include <cuda.h>
#include <cuda_runtime.h>
```

Macros

- #define _UTILS_H_

    macro for avoiding multiple inclusion during compilation
- #define CHECK_CU_ERRORS(call) call

    Macros for catching errors returned by the CUDA driver and runtime APIs.
- #define CHECK_CUDA_ERRORS(call)

- #define B(x, i) ((x) & (0x80000000 >> (i)))

  Bit tool macros.
- #define setB(x, i) x= ((x) | (0x80000000 >> (i)))

  Set the bit at the specified position i in x to 1.
- #define delB(x, i) x= ((x) & (∼(0x80000000 >> (i))))

  Set the bit at the specified position i in x to 0.

Functions

- CUresult cudaFuncGetAttributesDriver (cudaFuncAttributes ∗attr, CUfunction kern)

  Function for getting the capabilities of a CUDA device via the driver API.
- void gennError (string error)

  Function called upon the detection of an error. Outputs an error message and then exits.
- unsigned int theSize (string type)

  Tool for determining the size of variable types on the current architecture.
- void writeHeader (ostream &os)

  Function to write the comment header denoting file authorship and contact details into the generated code.

17.115.1 Detailed Description

This file contains standard utility functions provide within the NVIDIA CUDA software development toolkit (SDK). The remainder of the file contains a function that defines the standard neuron models.

17.115.2 Macro Definition Documentation

17.115.2.1 #define _UTILS_H_

macro for avoiding multiple inclusion during compilation

17.115.2.2 #define B(*x,* *i*) ((x) & (0x80000000 >> (i)))

Bit tool macros.

Extract the bit at the specified position i from x

17.115.2.3 #define CHECK_CU_ERRORS(*call*) call

Macros for catching errors returned by the CUDA driver and runtime APIs.

17.115.2.4 #define CHECK_CUDA_ERRORS(*call*)

Value:

```
{                                                             \
    cudaError_t error = call;                                 \
    if (error != cudaSuccess)                                 \
      {                                                       \
        cerr << __FILE__ << ": " <<  __LINE__;                \
        cerr << ": cuda runtime error " << error << ": ";     \
        cerr << cudaGetErrorString(error) << endl;            \
        exit(EXIT_FAILURE);                                   \
      }                                                       \
  }
```

17.115.2.5 #define delB(*x,* *i*) x= ((x) & (∼(0x80000000 >> (i))))

Set the bit at the specified position i in x to 0.

17.115.2.6 #define setB(*x*, *i*) x= ((x) | (0x80000000 >> (i)))

Set the bit at the specified position i in x to 1.

17.115.3 Function Documentation

17.115.3.1 CUresult cudaFuncGetAttributesDriver (cudaFuncAttributes ∗ *attr*, CUfunction *kern*)

Function for getting the capabilities of a CUDA device via the driver API.

17.115.3.2 void gennError (string *error*)

Function called upon the detection of an error. Outputs an error message and then exits.

17.115.3.3 unsigned int theSize (string *type*)

Tool for determining the size of variable types on the current architecture.

17.115.3.4 void writeHeader (ostream & *os*)

Function to write the comment header denoting file authorship and contact details into the generated code.

17.116 VClampGA.cc File Reference

Main entry point for the GeNN project demonstrating realtime fitting of a neuron with a GA running mostly on the GPU.

```
#include "VClampGA.h"
```

Functions

- int main (int argc, char ∗argv[ ])

  This function is the entry point for running the project.

17.116.1 Detailed Description

Main entry point for the GeNN project demonstrating realtime fitting of a neuron with a GA running mostly on the GPU.

17.116.2 Function Documentation

17.116.2.1 int main (int *argc*, char ∗ *argv[ ]*)

This function is the entry point for running the project.

17.117 VClampGA.h File Reference

Header file containing global variables and macros used in running the HHVClamp/VClampGA model.

```
#include <cassert>
#include <cuda_runtime.h>
#include "hr_time.h"
#include "stringUtils.h"
#include "utils.h"
#include "HHVClamp.cc"
#include "HHVClamp_CODE/definitions.h"
#include "randomGen.h"
#include "gauss.h"
#include "helper.h"
#include "GA.cc"
```

Macros

- #define RAND(Y, X) Y = Y ∗ 1103515245 +12345;X= (unsigned int)(Y >> 16) & 32767

Variables

- randomGen R
- randomGauss RG
- CStopWatch timer

17.117.1 Detailed Description

Header file containing global variables and macros used in running the HHVClamp/VClampGA model.

17.117.2 Macro Definition Documentation

17.117.2.1 #define RAND(*Y,* *X*) Y = Y ∗ 1103515245 +12345;X= (unsigned int)(Y >> 16) & 32767

17.117.3 Variable Documentation

17.117.3.1 randomGen R

17.117.3.2 randomGauss RG

17.117.3.3 CStopWatch timer

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