PyReMoto

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Chapter 1

ReMoto in Python

This program is a neuronal simulation system, intended for studying spinal cord neuronal networks responsible for muscle control. These networks are affected by descending drive, afferent drive, and electrical nerve stimulation. The simulator may be used to investigate phenomena at several levels of organization, e.g., at the neuronal membrane level or at the whole muscle behavior level (e.g., muscle force generation). This versatility is due to the fact that each element (neurons, synapses, muscle fibers) has its own specific mathematical model, usually involving the action of voltage- or neurotransmitter-dependent ionic channels. The simulator should be helpful in activities such as interpretation of results obtained from neurophysiological experiments in humans or mammals, proposal of hypothesis or testing models or theories on neuronal dynamics or neuronal network processing, validation of experimental protocols, and teaching neurophysiology.

The elements that take part in the system belong to the following classes: motoneurons, muscle fibers (electrical activity and force generation), Renshaw cells, Ia inhibitory interneurons, Ib inhibitory interneurons, Ia and Ib afferents. The neurons are interconnected by chemical synapses, which can be exhibit depression or facilitation.

The system simulates the following nuclei involved in flexion and extension of the human or cat ankle: Medial Gastrocnemius (MG), Lateral Gastrocnemius (LG), Soleus (SOL), and Tibialis Anterior (TA).

A web-based version can be found in `remoto.leb.usp.br`. The version to which this documentation refers is from a Python program that can be found in `github.com/rnwatanabe/projectPR`.

Chapter 2

projectPR

Neuromuscular simulator in Python.

Under progress....

To run an example, execute the file simulation.py.

Chapter 3

Namespace Index

3.1 Packages

Here are the packages with brief descriptions (if available):

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4.1 Class Hierarchy

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5.1 Class List

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

Chapter 6

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6.1 File List

Here is a list of all files with brief descriptions:

Chapter 7

Namespace Documentation

7.1 AxonDelay Namespace Reference

Classes

- class AxonDelay

  Class that implements a delay correspondent to the nerve.

7.2 ChannelConductance Namespace Reference

Classes

- class ChannelConductance

  Class that implements a model of the ionic Channels in a compartment.

7.3 Compartment Namespace Reference

Classes

- class Compartment

  Class that implements a neural compartment.

Functions

- def calcGLeak (area, specificRes)

  Computes the leak conductance of the compartment.

7.3.1 Function Documentation

7.3.1.1 def Compartment.calcGLeak (*area*, *specificRes*)

Computes the leak conductance of the compartment.

- Input:
  - **area**: area of the compartment in cm ^{2}.
  - **specificRes**: specific resistance of the compartment in $\Omega.cm^2$.
- Output:
  - Leak conductance in MS.

It is compute according to the following formula:

$$g = 10^6.\frac{A}{\rho} \tag{7.1}$$

where A is the compartment area [cm ^{2}], ρ is the specific resistance [$\Omega.cm^2$] and g is the compartment conductance [MS].

Definition at line 32 of file Compartment.py.

7.4 Configuration Namespace Reference

Classes

- class Configuration
  Class that builds an object of Configuration, based on a configuration file.

7.5 Interneuron Namespace Reference

Classes

- class Interneuron
  Class that implements a motor unit model.

Functions

- def runge_kutta (derivativeFunction, t, x, timeStep, timeStepByTwo, timeStepBySix)
  Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

7.5.1 Function Documentation

7.5.1.1 def Interneuron.runge_kutta (*derivativeFunction*, *t*, *x*, *timeStep*, *timeStepByTwo*, *timeStepBySix*)

Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

- Inputs:
  - **derivativeFunction**: function that corresponds to the derivative of the differential equation.
  - **t**: current instant.
  - **x**: current state value.
  - **timeStep**: time step of the solution of the differential equation, in the same unit of t.
  - **timeStepByTwo**: timeStep divided by two, for computational efficiency.
  - **timeStepBySix**: timeStep divided by six, for computational efficiency.

This method is intended to solve the following differential equation:

$$\frac{dx(t)}{dt} = f(t, x(t)) \tag{7.2}$$

First, four derivatives are computed:

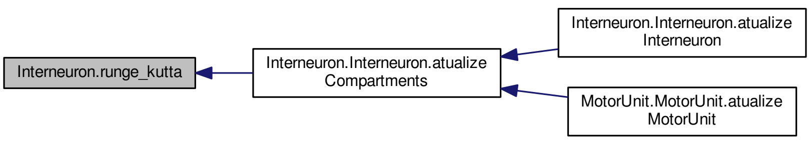
k$_1 = f(t, x(t))$
$k_2 = f(t + \frac{\Delta t}{2}, x(t) + \frac{\Delta t}{2}.k_1)$
$k_3 = f(t + \frac{\Delta t}{2}, x(t) + \frac{\Delta t}{2}.k_2)$
$k_4 = f(t + \Delta t, x(t) + \Delta t.k_3)$ where Δt is the time step of the numerical solution of the differential equation.

Then the value of $x(t + \Delta t)$ is computed with:

$$x(t + \Delta t) = x(t) + \frac{\Delta t}{6}(k_1 + 2k_2 + 2k_3 + k_4) \tag{7.3}$$

Definition at line 51 of file Interneuron.py.

Here is the caller graph for this function:



7.6 InterneuronPool Namespace Reference

Classes

- class InterneuronPool
  Class that implements a motor unit pool.

7.7 jointAnkleForceTask Namespace Reference

Classes

- class jointAnkleForceTask

7.8 jointAnklePositionTask Namespace Reference

Classes

- class jointAnklePositionTask

7.9 MotorUnit Namespace Reference

Classes

- class MotorUnit

  Class that implements a motor unit model.

Functions

- def calcGCoupling (cytR, lComp1, lComp2, dComp1, dComp2)

  Calculates the coupling conductance between two compartments.
- def compGCouplingMatrix (gc)

  Computes the Coupling Matrix to be used in the dVdt function of the N compartments of the motor unit.
- def runge_kutta (derivativeFunction, t, x, timeStep, timeStepByTwo, timeStepBySix)

  Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

7.9.1 Function Documentation

7.9.1.1 def MotorUnit.calcGCoupling (*cytR, lComp1, lComp2, dComp1, dComp2*)

Calculates the coupling conductance between two compartments.

- Inputs:
  - **cytR**: Cytoplasmatic resistivity in Ω.cm.
  - **lComp1, lComp2**: length of the compartments in μm.
  - **dComp1, dComp2**: diameter of the compartments in μm.
- Output:
  - coupling conductance in MS.

The coupling conductance between compartment 1 and 2 is computed by the following equation:

$$g_c = \frac{2.10^2}{\frac{R_{cyt}l_1}{\pi r_1^2} + \frac{R_{cyt}l_2}{\pi r_2^2}} \tag{7.4}$$

where g_c is the coupling conductance [MS], R_{cyt} is the cytoplasmatic resistivity [Ω.cm], l_1 and l_2 are the lengths [μm] of compartments 1 and 2, respectively and r_1 and r_2 are the radius [μm] of compartments 1 and 2, respectively.

Definition at line 46 of file MotorUnit.py.

7.9.1.2 def MotorUnit.compGCouplingMatrix (*gc*)

Computes the Coupling Matrix to be used in the dVdt function of the N compartments of the motor unit.

The Matrix uses the values obtained with the function calcGcoupling.

- Inputs:
  - **gc**: the vector with N elements, with the coupling conductance of each compartment of the Motor Unit.
- Output:
  - the GC matrix

$$GC = \left[\begin{array}{cccccccc} -g_c[0] & g_c[0] & 0 & ... & ... & 0 & 0 & 0 \\ g_c[0] & -g_c[0]-g_c[1] & g_c[1] & 0 & ... & ... & 0 & 0 \\ \vdots & & \ddots & & ... & & 0 & 0 \\ 0 & ... & g_c[i-1] & -g_c[i-1]-g_c[i] & g_c[i] & 0 & ... & 0 \\ 0 & 0 & 0 & ... & ... & & & 0 \\ 0 & & ... & & g_c[N-2] & -g_c[N-2]-g_c[N-1] & g_c[N-1] & 0 \\ 0 & ... & 0 & & & 0 & g_c[N-1] & -g_c[N - \end{array}\right. \tag{7.5}$$

Definition at line 78 of file MotorUnit.py.

7.9.1.3 def MotorUnit.runge_kutta (*derivativeFunction, t, x, timeStep, timeStepByTwo, timeStepBySix*)

Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

- Inputs:
  - **derivativeFunction**: function that corresponds to the derivative of the differential equation.
  - **t**: current instant.
  - **x**: current state value.
  - **timeStep**: time step of the solution of the differential equation, in the same unit of t.
  - **timeStepByTwo**: timeStep divided by two, for computational efficiency.
  - **timeStepBySix**: timeStep divided by six, for computational efficiency.

This method is intended to solve the following differential equation:

$$\frac{dx(t)}{dt} = f(t, x(t)) \tag{7.6}$$

First, four derivatives are computed:

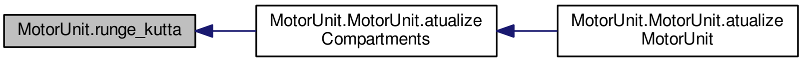
$k_1 = f(t, x(t))$
$k_2 = f(t + \frac{\Delta t}{2}, x(t) + \frac{\Delta t}{2}.k_1)$
$k_3 = f(t + \frac{\Delta t}{2}, x(t) + \frac{\Delta t}{2}.k_2)$
$k_4 = f(t + \Delta t, x(t) + \Delta t.k_3)$ where Δt is the time step of the numerical solution of the differential equation.

Then the value of $x(t + \Delta t)$ is computed with:

$$x(t + \Delta t) = x(t) + \frac{\Delta t}{6}(k_1 + 2k_2 + 2k_3 + k_4) \tag{7.7}$$

Definition at line 133 of file MotorUnit.py.

Here is the caller graph for this function:



7.10 MotorUnitPool Namespace Reference

Classes

- class MotorUnitPool

  Class that implements a motor unit pool.

7.11 MuscleHill Namespace Reference

Classes

- class MuscleHill

7.12 MuscleNoHill Namespace Reference

Classes

- class MuscleNoHill

7.13 MuscularActivation Namespace Reference

Classes

- class MuscularActivation

Functions

- def twitchSaturation (activationsat, b)

  Computes the muscle unit force after the nonlinear saturation.

7.13.1 Function Documentation

7.13.1.1 def MuscularActivation.twitchSaturation (*activationsat*, *b*)

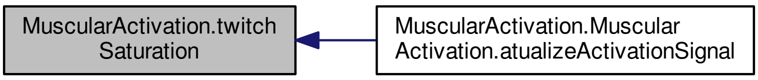
Computes the muscle unit force after the nonlinear saturation.

$$a_{sat} = \frac{1 - e^{-b.a_{nSat}}}{1 + e^{-b.a_{nSat}}} \tag{7.8}$$

- Inputs:
  - **activationsat**: activation signal before the saturation.
  - **b**: saturation function parameter.
- Outputs:
  - Saturated force.

Definition at line 28 of file MuscularActivation.py.

Here is the caller graph for this function:



7.14 NeuralTract Namespace Reference

Classes

- class NeuralTract

  Class that implements a a neural tract, composed by the descending commands from the motor cortex.

7.15 NeuralTractUnit Namespace Reference

Classes

- class NeuralTractUnit

  Class that implements a neural tract unit.

7.16 PointProcessGenerator Namespace Reference

Classes

- class PointProcessGenerator

  Generator of point processes.

Functions

- def gammaPoint (GammaOrder, GammaOrderInv)

  *Generates a number according to a Gamma Distribution with an integer order **GammaOrder**.*

7.16.1 Function Documentation

7.16.1.1 def PointProcessGenerator.gammaPoint (*GammaOrder, GammaOrderInv*)

Generates a number according to a Gamma Distribution with an integer order **GammaOrder**.

- Inputs:
  - **GammaOrder**: integer order of the Gamma distribution.
  - **GammaOrderInv**: inverse of the GammaOrder. This is necessary for computational efficiency.
- Outputs:
  - The number generated from the Gamma distribution.

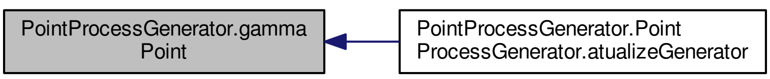
The number is generated according to:

$$\Gamma = -\frac{1}{\lambda}\ln\left(\prod_{i=1}^{\lambda} U(0,1)\right) \tag{7.9}$$

where λ is the order of the Gamma distribution and U(a,b) is a uniform distribution from a to b.

Definition at line 38 of file PointProcessGenerator.py.

Here is the caller graph for this function:



7.17 PulseConductanceState Namespace Reference

Classes

- class PulseConductanceState

  Implements the Destexhe pulse approximation of the solution of the states of the Hodgkin-Huxley neuron model.

Functions

- def compValOn (v0, alpha, beta, t, t0)

  Time course of the state during the pulse for the inactivation states and before and after the pulse for the activation states.
- def compValOff (v0, alpha, beta, t, t0)

  Time course of the state during the pulse for the activation states and before and after the pulse for the inactivation states.

7.17.1 Function Documentation

7.17.1.1 def PulseConductanceState.compValOff (*v0, alpha, beta, t, t0*)

Time course of the state during the pulse for the *activation* states and before and after the pulse for the *inactivation* states.

The value of the state v is computed according to the following equation:

$$v(t) = 1 + (v_0 - 1)\exp[-\alpha(t - t_0)] \tag{7.10}$$

where t_0 is the time at which the pulse changed the value (on to off or off to on) and v_0 is value of the state at that time.

Definition at line 46 of file PulseConductanceState.py.

7.17.1.2 def PulseConductanceState.compValOn (*v0, alpha, beta, t, t0*)

Time course of the state during the pulse for the *inactivation* states and before and after the pulse for the *activation* states.

The value of the state v is computed according to the following equation:

$$v(t) = v_0 \exp[-\beta(t - t_0)] \tag{7.11}$$

where t_0 is the time at which the pulse changed the value (on to off or off to on) and v_0 is value of the state at that time.

Definition at line 28 of file PulseConductanceState.py.

7.18 simulation Namespace Reference

Functions

- def simulator ()

7.18.1 Function Documentation

7.18.1.1 def simulation.simulator ( )

Definition at line 25 of file simulation.py.

7.19 Synapse Namespace Reference

Classes

- class Synapse

  Implements the synapse model from Destexhe (1994) using the computational method from Lytton (1996).

Functions

- def compSynapCond (Gmax, Ron, Roff)

  Computes the synaptic conductance.
- def compRon (Non, rInf, Ron, t0, t, tauOn)

  Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
- def compRoff (Roff, t0, t, tauOff)

  Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
- def compRiStart (ri, t, ti, tPeak, tauOff)

  Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter begin (begin of the pulse).
- def compRiStop (rInf, ri, expFinish)

  Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter release stops (the pulse ends).
- def compRonStart (Ron, ri, synContrib)

  Incorporates a new conductance to the set of conductances during a pulse.
- def compRoffStart (Roff, ri, synContrib)

  Incorporates a new conductance to the set of conductances that are not during a pulse.
- def compRonStop (Ron, ri, synContrib)

  Removes a conductance from the set of conductances during a pulse.
- def compRoffStop (Roff, ri, synContrib)

  Removes a conductance from the set of conductances that are not during a pulse.
- def compDynamicGmax (t, gmax, lastPulse, tau, dynamicGmax, var)

7.19.1 Function Documentation

7.19.1.1 def Synapse.compDynamicGmax (*t, gmax, lastPulse, tau, dynamicGmax, var*)

Definition at line 313 of file Synapse.py.

7.19.1.2 def Synapse.compRiStart (*ri, t, ti, tPeak, tauOff*)

Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter begin (begin of the pulse).

- Inputs:
  - **ri**: the fraction of postsynaptic receptors that were bound to neurotransmitters at the last state change.
  - **t**: current instant, in ms.
  - **ti**: The instant that the last pulse began.
  - **tPeak**: The duration of the pulse.
  - **tauOff**: Time constant after a pulse, in ms.
- Output:
  - individual synapse state value.

It is computed by the following equation:

$$r_{i_{newValue}} = r_{i_{oldValue}} \exp\left(\frac{t_i + T_{dur} - t}{\tau_{off}}\right) \tag{7.12}$$

Definition at line 148 of file Synapse.py.

7.19.1.3 def Synapse.compRiStop (*rInf, ri, expFinish*)

Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter release stops (the pulse ends).

- Inputs:
  - **rInf**: the fraction of postsynaptic receptors that would be bound to neurotransmitters after an infinite amount of time with neurotransmitter being released.
  - **ri**: the fraction of postsynaptic receptors that were bound to neurotransmitters at the last state change.
  - **expFinish**: Is the value of the exponential at the end of the pulse ($\exp(T_{dur}/\tau_{on})$). It is is computed before for computational efficiency.
- Output:
  - individual synapse state value.

It is computed by the following equation:

$$r_{i_{newValue}} = r_{\infty} + (r_{i_{oldValue}} - r_{\infty}) \exp\left(\frac{T_{dur}}{\tau_{on}}\right) \tag{7.13}$$

Definition at line 180 of file Synapse.py.

7.19.1.4 def Synapse.compRoff (*Roff, t0, t, tauOff*)

Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).

- Inputs:
  - **Roff**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
  - **t0**: instant that the last spike arrived to the compartment.
  - **t**: current instant, in ms.
  - **tauOff**: time constant after a pulse, in ms.
- Output:
  - The fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released.

It is computed by the following formula:

$$R_{off_{newValue}} = R_{off_{oldValue}} \exp\left(-\frac{t-t0}{\tau_{off}}\right) \tag{7.14}$$

Definition at line 117 of file Synapse.py.

7.19.1.5 def Synapse.compRoffStart (*Roff, ri, synContrib*)

Incorporates a new conductance to the set of conductances that are not during a pulse.

- Inputs:
  - **Roff**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
  - **ri**: fraction of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.
  - **synContrib**: individual conductance constribution to the global synaptic conductance.
- Output:
  - The new value of the sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).

It is computed as:

$$R_{off_{newValue}} = R_{off_{oldValue}} - r_i S_{indCont} \tag{7.15}$$

Definition at line 244 of file Synapse.py.

7.19.1.6 def Synapse.compRoffStop (*Roff, ri, synContrib*)

Removes a conductance from the set of conductances that are not during a pulse.

- Inputs:
  - **Roff**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
  - **ri**: fraction of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.
  - **synContrib**: individual conductance constribution to the global synaptic conductance.
- Output:
  - The new value of the sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).

It is computed as:

$$R_{off_{newValue}} = R_{off_{oldValue}} + r_i S_{indCont} \tag{7.16}$$

Definition at line 309 of file Synapse.py.

7.19.1.7 def Synapse.compRon (*Non, rInf, Ron, t0, t, tauOn*)

Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).

- Inputs:
  - **Non**: sum of the fractions of the individual conductances that are receiving neurotransmitter (during pulse) relative to the G_{max} ($N_{on} = \sum_{i=1} g_{i_{on}}/G_{max}$).
  - **rInf**: the fraction of postsynaptic receptors that would be bound to neurotransmitters after an infinite amount of time with neurotransmitter being released.
  - **Ron**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
  - **t0**: instant that the last spike arrived to the compartment.
  - **t**: current instant, in ms.
  - **tauOn**: Time constant during a pulse, in ms. $\tau_{on} = \frac{1}{\alpha.T_{max}+\beta}$.
- Outputs:
  - The fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released

It is computed by the following equation:

$$R_{on_{newValue}} = N_{on} r_\infty \left[1 - \exp\left(-\frac{t-t_0}{\tau_{on}}\right)\right] + R_{on_{oldValue}} \exp\left(-\frac{t-t_0}{\tau_{on}}\right) \tag{7.17}$$

Definition at line 81 of file Synapse.py.

7.19.1.8 def Synapse.compRonStart (*Ron*, *ri*, *synContrib*)

Incorporates a new conductance to the set of conductances during a pulse.

- Inputs:
  - **Ron**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
  - **ri**: fraction of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.
  - **synContrib**: individual conductance constribution to the global synaptic conductance.
- Output:
  - The new value of the sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).

It is computed as:

$$R_{on_{newValue}} = R_{on_{oldValue}} + r_i S_{indCont} \tag{7.18}$$

Definition at line 211 of file Synapse.py.

7.19.1.9 def Synapse.compRonStop (*Ron*, *ri*, *synContrib*)

Removes a conductance from the set of conductances during a pulse.

- Inputs:
  - **Ron**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
  - **ri**: fraction of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.
  - **synContrib**: individual conductance constribution to the global synaptic conductance.
- Output:
  - The new value of the sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).

It is computed as:

$$R_{on_{newValue}} = R_{on_{oldValue}} - r_i S_{indCont} \tag{7.19}$$

Definition at line 275 of file Synapse.py.

7.19.1.10 def Synapse.compSynapCond (*Gmax*, *Ron*, *Roff*)

Computes the synaptic conductance.

- Input:
  - **Gmax**: the sum of individual conductances of all synapses in the compartment, in μS.
  - **Ron**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
  - **Roff**: sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
- Output:
  - the synaptic conductance of all synapses in the compartment, in μS.

It is computed by the following formula:

$$G = G_{max}(R_{on} + R_{off}) \tag{7.20}$$

where G is the synaptic conductance of all synapses in the compartment.

Definition at line 41 of file Synapse.py.

7.20 SynapsesFactory Namespace Reference

Classes

- class SynapsesFactory

  Class to build all the synapses in the system.

7.21 SynapticNoise Namespace Reference

Classes

- class SynapticNoise

  Class that implements a synaptic noise for a pool of neurons.

Chapter 8

Class Documentation

8.1 AxonDelay.AxonDelay Class Reference

Class that implements a delay correspondent to the nerve.

Public Member Functions

- def __init__ (self, conf, nerve, pool, index)

  Constructor.
- def addTerminalSpike (self, t)

  Indicates to the AxonDelay object that a spike has occurred in the Terminal.
- def addSpinalSpike (self, t)

  Indicates to the AxonDelay object that a spike has occurred in the soma.

Public Attributes

- index

  Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).
- length_m

  Length, in m, of the part of the nerve that is not modelled as a delay.
- velocity_m_s

  Velocity of conduction, in m/s, of the part of the nerve that is not modelled as a delay.
- stimulusPositiontoTerminal

  Distance, in m, of the stimulus position to the terminal.
- latencyStimulusSpinal_ms

  time, in ms, that the signal takes to travel between the stimulus and the spinal cord.
- latencySpinalTerminal_ms

  time, in ms, that the signal takes to travel between the spinal cord and the terminal.
- latencyStimulusTerminal_ms

  time, in ms, tat the signal takes to travel between the stimulus and the terminal.
- terminalSpikeTrain

  Float with instant, in ms, of the last spike in the terminal.

8.1.1 Detailed Description

Class that implements a delay correspondent to the nerve.

This class corresponds to the part of the axon that is modeled with no dynamics. Ideally this class would not exist and all the axon would be modelled in the motor unit or sensory class with the proper dynamics.

Definition at line 16 of file AxonDelay.py.

8.1.2 Constructor & Destructor Documentation

8.1.2.1 def AxonDelay.AxonDelay.__init__ (*self, conf, nerve, pool, index*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **nerve**: string with type of the nerve. It can be *PTN* (posterior tibial nerve) or *CPN* (common peroneal nerve).
  - **pool**: string with Motor unit pool to which the motor unit belongs.
  - **index**: integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).

Definition at line 35 of file AxonDelay.py.

8.1.3 Member Function Documentation

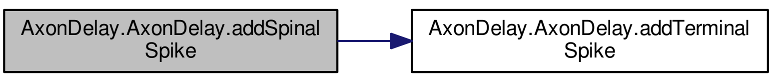
8.1.3.1 def AxonDelay.AxonDelay.addSpinalSpike (*self, t*)

Indicates to the AxonDelay object that a spike has occurred in the soma.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 76 of file AxonDelay.py.

Here is the call graph for this function:



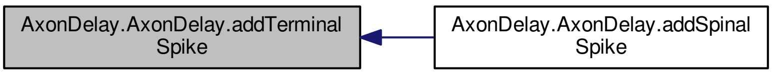
8.1.3.2 def AxonDelay.AxonDelay.addTerminalSpike (*self*, *t*)

Indicates to the AxonDelay object that a spike has occurred in the Terminal.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 65 of file AxonDelay.py.

Here is the caller graph for this function:



8.1.4 Member Data Documentation

8.1.4.1 AxonDelay.AxonDelay.index

Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).

Definition at line 39 of file AxonDelay.py.

8.1.4.2 AxonDelay.AxonDelay.latencySpinalTerminal_ms

time, in ms, that the signal takes to travel between the spinal cord and the terminal.

Definition at line 50 of file AxonDelay.py.

8.1.4.3 AxonDelay.AxonDelay.latencyStimulusSpinal_ms

time, in ms, that the signal takes to travel between the stimulus and the spinal cord.

Definition at line 48 of file AxonDelay.py.

8.1.4.4 AxonDelay.AxonDelay.latencyStimulusTerminal_ms

time, in ms, tat the signal takes to travel between the stimulus and the terminal.

Definition at line 52 of file AxonDelay.py.

8.1.4.5 AxonDelay.AxonDelay.length_m

Length, in m, of the part of the nerve that is not modelled as a delay.

Definition at line 42 of file AxonDelay.py.

8.1.4.6 AxonDelay.AxonDelay.stimulusPositiontoTerminal

Distance, in m, of the stimulus position to the terminal.

Definition at line 46 of file AxonDelay.py.

8.1.4.7 AxonDelay.AxonDelay.terminalSpikeTrain

Float with instant, in ms, of the last spike in the terminal.

Definition at line 55 of file AxonDelay.py.

8.1.4.8 AxonDelay.AxonDelay.velocity_m_s

Velocity of conduction, in m/s, of the part of the nerve that is not modelled as a delay.

Definition at line 44 of file AxonDelay.py.

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

- AxonDelay.py

8.2 ChannelConductance.ChannelConductance Class Reference

Class that implements a model of the ionic Channels in a compartment.

Public Member Functions

- def __init__ (self, kind, conf, compArea, pool, neuronKind, index)

  Constructor.
- def computeCurrent (self, t, V_mV)

  Computes the current genrated by the ionic Channel.
- def compCondKf (self, V_mV)

  Computes the conductance of a Kf Channel.
- def compCondKs (self, V_mV)

  Computes the conductance of a slow potassium Channel.
- def compCondNa (self, V_mV)

  Computes the conductance of a Na Channel.

Public Attributes

- kind

    string with the type of the ionic channel.
- condState

    List of ConductanceState objects, representing each state of the ionic channel.
- EqPot_mV

    Equilibrium Potential of the ionic channel, mV.
- gmax_muS

    Maximal conductance, in μS, of the ionic channel.
- stateType

    String with type of dynamics of the states.
- compCond

    Function that computes the conductance dynamics.
- lenStates

    Integer with the number of states in the ionic channel.

8.2.1 Detailed Description

Class that implements a model of the ionic Channels in a compartment.

Definition at line 16 of file ChannelConductance.py.

8.2.2 Constructor & Destructor Documentation

8.2.2.1 def ChannelConductance.ChannelConductance.__init__ (*self, kind, conf, compArea, pool, neuronKind, index*)

Constructor.

Builds an ionic channel conductance.

-Inputs:

- **kind**: string with the type of the ionic channel. For now it can be *Na* (Sodium), *Ks* (slow Potassium), *Kf* (fast Potassium) or *Ca* (Calcium).
- **conf**: instance of the Configuration class (see Configuration file).
- **compArea**: float with the area of the compartment that the Channel belongs, in cm^2.
- **pool**: the pool that this state belongs.
- **index**: the index of the unit that this state belongs.

Definition at line 38 of file ChannelConductance.py.

8.2.3 Member Function Documentation

8.2.3.1 def ChannelConductance.ChannelConductance.compCondKf (*self*, *V_mV*)

Computes the conductance of a Kf Channel.

This function is assigned as self.compCond to a Kf Channel at the class constructor.

- Input:
  - **V_mV**: membrane potential of the compartment in mV.

Output:

- Conductance in μS.

It is computed as:

$$g = g_{max} n^4 (E_0 - V) \tag{8.1}$$

where E_0 is the equilibrium potential of the compartment, V is the membrane potential and n is the state of a fast potassium channel..

Definition at line 114 of file ChannelConductance.py.

8.2.3.2 def ChannelConductance.ChannelConductance.compCondKs (*self*, *V_mV*)

Computes the conductance of a slow potassium Channel.

This function is assigned as self.compCond to a Ks Channel at the class constructor.

- Input:
  - **V_mV**: membrane potential of the compartment in mV.
- Output:
  - Conductance in μS.

It is computed as:

$$g = g_{max} q^2 (E_0 - V) \tag{8.2}$$

where E_0 is the equilibrium potential of the compartment, V is the membrane potential and q is the state of a slow potassium channel.

Definition at line 137 of file ChannelConductance.py.

8.2.3.3 def ChannelConductance.ChannelConductance.compCondNa (*self*, *V_mV*)

Computes the conductance of a Na Channel.

This function is assigned as self.compCond to a Na Channel at the class constructor. -Input:

- **V_mV**: membrane potential of the compartment in mV.

Output:

- Conductance in μS.

It is computed as:

$$g = g_{max} m^3 h (E_0 - V) \tag{8.3}$$

where E_0 is the equilibrium potential of the compartment, V is the membrane potential and m and h are the states of a sodium channel..

Definition at line 158 of file ChannelConductance.py.

8.2.3.4 def ChannelConductance.ChannelConductance.computeCurrent (*self*, *t*, *V_mV*)

Computes the current genrated by the ionic Channel.

- Inputs:
  - **t**: instant in ms.
  - **V_mV**: membrane potential of the compartment in mV.
- Outputs:
  - Ionic current, in nA

Definition at line 90 of file ChannelConductance.py.

8.2.4 Member Data Documentation

8.2.4.1 ChannelConductance.ChannelConductance.compCond

Function that computes the conductance dynamics.

Definition at line 59 of file ChannelConductance.py.

8.2.4.2 ChannelConductance.ChannelConductance.condState

List of ConductanceState objects, representing each state of the ionic channel.

Definition at line 44 of file ChannelConductance.py.

8.2.4.3 ChannelConductance.ChannelConductance.EqPot_mV

Equilibrium Potential of the ionic channel, mV.

Definition at line 47 of file ChannelConductance.py.

8.2.4.4 ChannelConductance.ChannelConductance.gmax_muS

Maximal conductance, in μS, of the ionic channel.

Definition at line 49 of file ChannelConductance.py.

8.2.4.5 ChannelConductance.ChannelConductance.kind

string with the type of the ionic channel.

For now it can be *Na* (Sodium), *Ks* (slow Potassium), *Kf* (fast Potassium) or *Ca* (Calcium).

Definition at line 42 of file ChannelConductance.py.

8.2.4.6 ChannelConductance.ChannelConductance.lenStates

Integer with the number of states in the ionic channel.

Definition at line 73 of file ChannelConductance.py.

8.2.4.7 ChannelConductance.ChannelConductance.stateType

String with type of dynamics of the states.

For now it accepts the string pulse.

Definition at line 51 of file ChannelConductance.py.

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

- ChannelConductance.py

8.3 Compartment.Compartment Class Reference

Class that implements a neural compartment.

Public Member Functions

- def __init__ (self, kind, conf, pool, index, neuronKind)
  Constructor.
- def computeCurrent (self, t, V_mV)
  Computes the active currents of the compartment.

Public Attributes

- Channels

  List of ChannelConductance objects in the Compartment.
- neuronKind

  String with the type of the motor unit.
- SynapsesOut

  List of summed synapses (see Lytton, 1996) that the Compartment do with other neural components.
- SynapsesIn

  List of summed synapses (see Lytton, 1996) that the Compartment receive from other neural components.
- kind

  The kind of compartment.
- index

  Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).
- length_mum

  Length of the compartment, in μm.
- diameter_mum

  Diameter of the compartment, in μm.
- capacitance_nF

  Capacitance of the compartment, in nF.
- gLeak

  Leak conductance of the compartment, in MS.
- numberChannels

  Integer with the number of ionic channels.

8.3.1 Detailed Description

Class that implements a neural compartment.

For now it is implemented *dendrite* and *soma*.

Definition at line 40 of file Compartment.py.

8.3.2 Constructor & Destructor Documentation

8.3.2.1 def Compartment.Compartment.__init__ (*self, kind, conf, pool, index, neuronKind*)

Constructor.

- Inputs:
  - **kind**: The kind of compartment. For now, it can be *soma* or *dendrite*.
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with Motor unit pool to which the motor unit belongs.
  - **index**: integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).
  - **neuronKind**: string with the type of the motor unit. It can be *S* (slow), *FR* (fast and resistant), and *FF* (fast and fatigable).

Definition at line 60 of file Compartment.py.

8.3.3 Member Function Documentation

8.3.3.1 def Compartment.Compartment.computeCurrent (*self*, *t*, *V_mV*)

Computes the active currents of the compartment.

Active currents are the currents from the ionic channels and from the synapses.

- Inputs:
  - **t**: current instant, in ms.
  - **V_mV**: membrane potential, in mV.

Definition at line 114 of file Compartment.py.

8.3.4 Member Data Documentation

8.3.4.1 Compartment.Compartment.capacitance_nF

Capacitance of the compartment, in nF.

Definition at line 89 of file Compartment.py.

8.3.4.2 Compartment.Compartment.Channels

List of ChannelConductance objects in the Compartment.

Definition at line 63 of file Compartment.py.

8.3.4.3 Compartment.Compartment.diameter_mum

Diameter of the compartment, in μm.

Definition at line 85 of file Compartment.py.

8.3.4.4 Compartment.Compartment.gLeak

Leak conductance of the compartment, in MS.

Definition at line 92 of file Compartment.py.

8.3.4.5 Compartment.Compartment.index

Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).

Definition at line 80 of file Compartment.py.

8.3.4.6 Compartment.Compartment.kind

The kind of compartment.

For now, it can be *soma* or *dendrite*.

Definition at line 76 of file Compartment.py.

8.3.4.7 Compartment.Compartment.length_mum

Length of the compartment, in μm.

Definition at line 83 of file Compartment.py.

8.3.4.8 Compartment.Compartment.neuronKind

String with the type of the motor unit.

It can be *S* (slow), *FR* (fast and resistant), and *FF* (fast and fatigable).

Definition at line 66 of file Compartment.py.

8.3.4.9 Compartment.Compartment.numberChannels

Integer with the number of ionic channels.

Definition at line 102 of file Compartment.py.

8.3.4.10 Compartment.Compartment.SynapsesIn

List of summed synapses (see Lytton, 1996) that the Compartment receive from other neural components.

Definition at line 71 of file Compartment.py.

8.3.4.11 Compartment.Compartment.SynapsesOut

List of summed synapses (see Lytton, 1996) that the Compartment do with other neural components.

Definition at line 68 of file Compartment.py.

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

- Compartment.py

8.4 Configuration.Configuration Class Reference

Class that builds an object of Configuration, based on a configuration file.

Public Member Functions

- def __init__ (self, filename)

    Constructor.
- def parameterSet (self, paramTag, pool, index)

    Function that returns the value of wished parameter specified in the paramTag variable.
- def inputFunctionGet (self, function)

    Returns a numpy array with the values of the function for the whole simulation.
- def determineSynapses (self, neuralSource)

    Function used to determine all the synapses that a given pool makes.

Public Attributes

- confArray

    An array with all the simulation parameters.
- timeStep_ms

    Time step of the numerical solution of the differential equation.
- simDuration_ms

    Total length of the simulation in ms.
- timeStepByTwo_ms

    The variable timeStep divided by two, for computational efficiency.
- timeStepBySix_ms

    The variable timeStep divided by six, for computational efficiency.

8.4.1 Detailed Description

Class that builds an object of Configuration, based on a configuration file.

Definition at line 38 of file Configuration.py.

8.4.2 Constructor & Destructor Documentation

8.4.2.1 def Configuration.Configuration.__init__ (*self*, *filename*)

Constructor.

Builds the Configuration object. A Configuration object is responsible to set the variables that are used in the whole system, such as timeStep and simDuration.

- Inputs:
    - **filename**: name of the file with the parameter values. The extension of the file should be .rmto.

Definition at line 52 of file Configuration.py.

8.4.3 Member Function Documentation

8.4.3.1 def Configuration.Configuration.determineSynapses (*self*, *neuralSource*)

Function used to determine all the synapses that a given pool makes.

It is used in the SynapsesFactory class.

- Inputs:
  - **neuralSource** - string with the pool name from which is desired to know what synapses it will make.
- Outputs:
  - array of strings with all the synapses target that the neuralSource will make.

Definition at line 164 of file Configuration.py.

8.4.3.2 def Configuration.Configuration.inputFunctionGet (*self*, *function*)

Returns a numpy array with the values of the function for the whole simulation.

It is used to obtain before the simulation run all the values of the inputs.

- Inputs:
  - **function**: function from which is desired to obtain its values during the simulation duration.
- Output:
  - narray with the function values for each instant.

Definition at line 148 of file Configuration.py.

8.4.3.3 def Configuration.Configuration.parameterSet (*self*, *paramTag*, *pool*, *index*)

Function that returns the value of wished parameter specified in the paramTag variable.

In the case of min/max parameters, the value returned is the specific to the index of the unit that called the function.

- Inputs:
  - **paramTag**: string with the name of the wished parameter as in the first column of the rmto file.
  - **pool**: pool from which the unit that will receive the parameter value belongs. For example SOL. It is used only in the parameters that have a range.
  - **index**: index of the unit. It is is an integer.
- Outputs:
  - required parameter value

Definition at line 92 of file Configuration.py.

8.4.4 Member Data Documentation

8.4.4.1 Configuration.Configuration.confArray

An array with all the simulation parameters.

Definition at line 55 of file Configuration.py.

8.4.4.2 Configuration.Configuration.simDuration_ms

Total length of the simulation in ms.

Definition at line 65 of file Configuration.py.

8.4.4.3 Configuration.Configuration.timeStep_ms

Time step of the numerical solution of the differential equation.

Definition at line 62 of file Configuration.py.

8.4.4.4 Configuration.Configuration.timeStepBySix_ms

The variable timeStep divided by six, for computational efficiency.

Definition at line 69 of file Configuration.py.

8.4.4.5 Configuration.Configuration.timeStepByTwo_ms

The variable timeStep divided by two, for computational efficiency.

Definition at line 67 of file Configuration.py.

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

- Configuration.py

8.5 Interneuron.Interneuron Class Reference

Class that implements a motor unit model.

Public Member Functions

- def __init__ (self, conf, pool, index)

  Constructor.
- def atualizeInterneuron (self, t)

  Atualize the dynamical and nondynamical (delay) parts of the motor unit.
- def atualizeCompartments (self, t)

  Atualize all neural compartments.
- def dVdt (self, t, V)

  Compute the potential derivative of all compartments of the motor unit.
- def addSomaSpike (self, t)

  When the soma potential is above the threshold a spike is added to the soma.
- def transmitSpikes (self, t)

Public Attributes

- conf

  Configuration object with the simulation parameters.
- pool
- kind
- tSomaSpike

  The instant of the last spike of the Motor unit at the Soma compartment.
- somaSpikeTrain

  Vector with the instants of spikes at the soma.
- index

  Integer corresponding to the Interneuron order in the pool.
- compartment

  Vector of Compartment of the Motor Unit.
- threshold_mV

  Value of the membrane potential, in mV, that is considered a spike.
- position_mm

  Anatomical position of the neuron, in mm.
- compNumber

  Number of compartments.
- v_mV

  Vector with membrane potential,in mV, of all compartments.
- capacitanceInv

  Vector with the inverse of the capacitance of all compartments.
- iIonic

  Vector with current, in nA, of each compartment coming from other elements of the model.
- iInjected

  Vector with the current, in nA, injected in each compartment.
- G

  Matrix of the conductance of the motoneuron.
- somaIndex

  index of the soma compartment.
- RefPer_ms

  Refractory period, in ms, of the motoneuron.
- terminalSpikeTrain

  Vector with the instants of spikes at the terminal.
- SynapsesOut

  Build synapses.
- transmitSpikesThroughSynapses
- indicesOfSynapsesOnTarget

8.5.1 Detailed Description

Class that implements a motor unit model.

Encompasses a motoneuron and a muscle unit.

Definition at line 66 of file Interneuron.py.

8.5.2 Constructor & Destructor Documentation

8.5.2.1 def Interneuron.Interneuron.__init__ (*self, conf, pool, index*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with Interneuron pool to which the motor unit belongs. It can be *RC* (Renshaw cell), *IaIn* (Ia Interneuron), *IbIn* (Ib Interneuron) and *gII*.
  - **index**: integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).

Definition at line 83 of file Interneuron.py.

8.5.3 Member Function Documentation

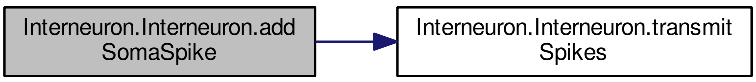
8.5.3.1 def Interneuron.Interneuron.addSomaSpike (*self, t*)

When the soma potential is above the threshold a spike is added to the soma.

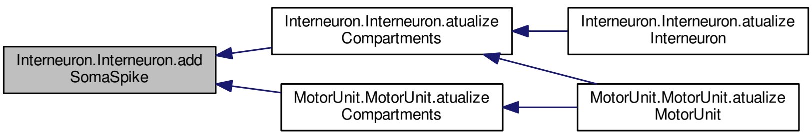
- Inputs:
  - **t**: current instant, in ms.

Definition at line 217 of file Interneuron.py.

Here is the call graph for this function:



Here is the caller graph for this function:



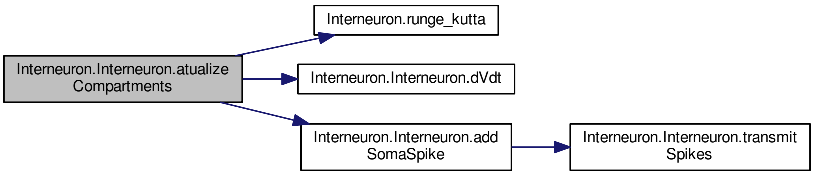
8.5.3.2 def Interneuron.Interneuron.atualizeCompartments (*self*, *t*)

Atualize all neural compartments.

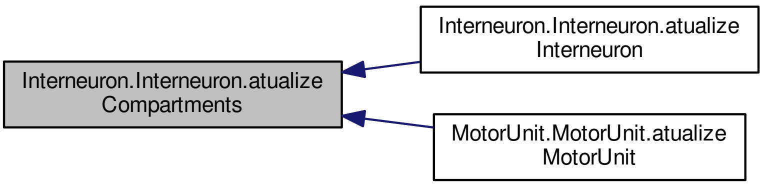
- Inputs:
  - **t**: current instant, in ms.

Definition at line 177 of file Interneuron.py.

Here is the call graph for this function:



Here is the caller graph for this function:



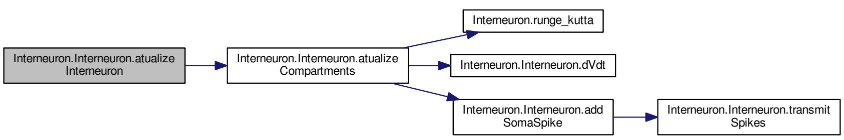
8.5.3.3 def Interneuron.Interneuron.atualizeInterneuron (*self*, *t*)

Atualize the dynamical and nondynamical (delay) parts of the motor unit.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 167 of file Interneuron.py.

Here is the call graph for this function:



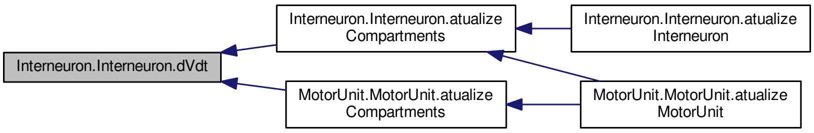
8.5.3.4 def Interneuron.Interneuron.dVdt (*self, t, V*)

Compute the potential derivative of all compartments of the motor unit.

- Inputs:
  - **t**: current instant, in ms.
  - **V**: Vector with the current potential value of all neural compartments of the motor unit.

Definition at line 202 of file Interneuron.py.

Here is the caller graph for this function:

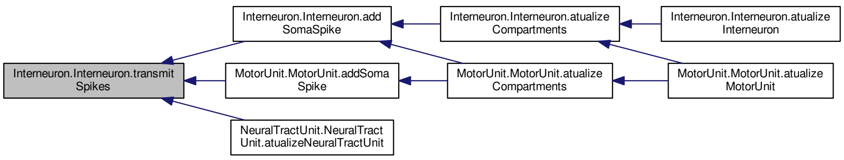


8.5.3.5 def Interneuron.Interneuron.transmitSpikes (*self, t*)

- Inputs:
  - **t**: current instant, in ms.

Definition at line 231 of file Interneuron.py.

Here is the caller graph for this function:



8.5.4 Member Data Documentation

8.5.4.1 Interneuron.Interneuron.capacitanceInv

Vector with the inverse of the capacitance of all compartments.

Definition at line 126 of file Interneuron.py.

8.5.4.2 Interneuron.Interneuron.compartment

Vector of Compartment of the Motor Unit.

Definition at line 101 of file Interneuron.py.

8.5.4.3 Interneuron.Interneuron.compNumber

Number of compartments.

Definition at line 112 of file Interneuron.py.

8.5.4.4 Interneuron.Interneuron.conf

Configuration object with the simulation parameters.

Definition at line 86 of file Interneuron.py.

8.5.4.5 Interneuron.Interneuron.G

Matrix of the conductance of the motoneuron.

Multiplied by the vector self.v_mV, results in the passive currents of each compartment.

Definition at line 140 of file Interneuron.py.

8.5.4.6 Interneuron.Interneuron.iInjected

Vector with the current, in nA, injected in each compartment.

Definition at line 132 of file Interneuron.py.

8.5.4.7 Interneuron.Interneuron.iIonic

Vector with current, in nA, of each compartment coming from other elements of the model.

For example from ionic channels and synapses.

Definition at line 130 of file Interneuron.py.

8.5.4.8 Interneuron.Interneuron.index

Integer corresponding to the Interneuron order in the pool.

Definition at line 99 of file Interneuron.py.

8.5.4.9 Interneuron.Interneuron.indicesOfSynapsesOnTarget

Definition at line 157 of file Interneuron.py.

8.5.4.10 Interneuron.Interneuron.kind

Definition at line 90 of file Interneuron.py.

8.5.4.11 Interneuron.Interneuron.pool

Definition at line 88 of file Interneuron.py.

8.5.4.12 Interneuron.Interneuron.position_mm

Anatomical position of the neuron, in mm.

Definition at line 106 of file Interneuron.py.

8.5.4.13 Interneuron.Interneuron.RefPer_ms

Refractory period, in ms, of the motoneuron.

Definition at line 147 of file Interneuron.py.

8.5.4.14 Interneuron.Interneuron.somaIndex

index of the soma compartment.

Definition at line 144 of file Interneuron.py.

8.5.4.15 Interneuron.Interneuron.somaSpikeTrain

Vector with the instants of spikes at the soma.

Definition at line 97 of file Interneuron.py.

8.5.4.16 Interneuron.Interneuron.SynapsesOut

Build synapses.

Definition at line 155 of file Interneuron.py.

8.5.4.17 Interneuron.Interneuron.terminalSpikeTrain

Vector with the instants of spikes at the terminal.

Definition at line 150 of file Interneuron.py.

8.5.4.18 Interneuron.Interneuron.threshold_mV

Value of the membrane potential, in mV, that is considered a spike.

Definition at line 103 of file Interneuron.py.

8.5.4.19 Interneuron.Interneuron.transmitSpikesThroughSynapses

Definition at line 156 of file Interneuron.py.

8.5.4.20 Interneuron.Interneuron.tSomaSpike

The instant of the last spike of the Motor unit at the Soma compartment.

Definition at line 94 of file Interneuron.py.

8.5.4.21 Interneuron.Interneuron.v_mV

Vector with membrane potential,in mV, of all compartments.

Definition at line 114 of file Interneuron.py.

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

- Interneuron.py

8.6 InterneuronPool.InterneuronPool Class Reference

Class that implements a motor unit pool.

Public Member Functions

- def __init__ (self, conf, pool)
  Constructor.
- def atualizeInterneuronPool (self, t)
  Update all parts of the Motor Unit pool.
- def listSpikes (self)
  List the spikes that occurred in the soma and in the terminal of the different motor units.

Public Attributes

- kind

  Indicates that is Motor Unit pool.
- conf

  Configuration object with the simulation parameters.
- pool

  String with Motor unit pool to which the motor unit belongs.
- Nnumber

  Number of Neurons.
- unit

  List of Interneuron objects.
- poolSomaSpikes

  Vector with the instants of spikes in the soma compartment, in ms.

8.6.1 Detailed Description

Class that implements a motor unit pool.

Encompasses a set of motor units that controls a single muscle.

Definition at line 19 of file InterneuronPool.py.

8.6.2 Constructor & Destructor Documentation

8.6.2.1 def InterneuronPool.InterneuronPool.__init__ (*self, conf, pool*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with Interneuron pool to which the motor unit belongs.

Definition at line 31 of file InterneuronPool.py.

8.6.3 Member Function Documentation

8.6.3.1 def InterneuronPool.InterneuronPool.atualizeInterneuronPool (*self, t*)

Update all parts of the Motor Unit pool.

It consists to update all motor units, the activation signal and the muscle force.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 64 of file InterneuronPool.py.

8.6.3.2 def InterneuronPool.InterneuronPool.listSpikes (*self*)

List the spikes that occurred in the soma and in the terminal of the different motor units.

Definition at line 73 of file InterneuronPool.py.

8.6.4 Member Data Documentation

8.6.4.1 InterneuronPool.InterneuronPool.conf

Configuration object with the simulation parameters.

Definition at line 37 of file InterneuronPool.py.

8.6.4.2 InterneuronPool.InterneuronPool.kind

Indicates that is Motor Unit pool.

Definition at line 34 of file InterneuronPool.py.

8.6.4.3 InterneuronPool.InterneuronPool.Nnumber

Number of Neurons.

Definition at line 41 of file InterneuronPool.py.

8.6.4.4 InterneuronPool.InterneuronPool.pool

String with Motor unit pool to which the motor unit belongs.

Definition at line 39 of file InterneuronPool.py.

8.6.4.5 InterneuronPool.InterneuronPool.poolSomaSpikes

Vector with the instants of spikes in the soma compartment, in ms.

Definition at line 50 of file InterneuronPool.py.

8.6.4.6 InterneuronPool.InterneuronPool.unit

List of Interneuron objects.

Definition at line 44 of file InterneuronPool.py.

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

- InterneuronPool.py

8.7 jointAnkleForceTask.jointAnkleForceTask Class Reference

Public Member Functions

- def __init__ (self, conf, pools)
- def atualizeAnkle (self, t, ankleAngle)
- def atualizeAngle (self, t, ankleAngle)

Public Attributes

- conf
- muscles
- ankleAngle_rad

8.7.1 Detailed Description

Definition at line 12 of file jointAnkleForceTask.py.

8.7.2 Constructor & Destructor Documentation

8.7.2.1 def jointAnkleForceTask.jointAnkleForceTask.__init__ (*self, conf, pools*)

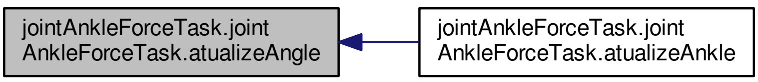
Definition at line 14 of file jointAnkleForceTask.py.

8.7.3 Member Function Documentation

8.7.3.1 def jointAnkleForceTask.jointAnkleForceTask.atualizeAngle (*self, t, ankleAngle*)

Definition at line 37 of file jointAnkleForceTask.py.

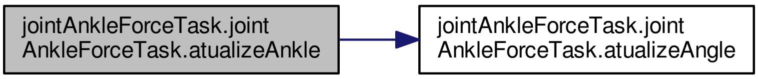
Here is the caller graph for this function:



8.7.3.2 def jointAnkleForceTask.jointAnkleForceTask.atualizeAnkle (*self*, *t*, *ankleAngle*)

Definition at line 28 of file jointAnkleForceTask.py.

Here is the call graph for this function:



8.7.4 Member Data Documentation

8.7.4.1 jointAnkleForceTask.jointAnkleForceTask.ankleAngle_rad

Definition at line 25 of file jointAnkleForceTask.py.

8.7.4.2 jointAnkleForceTask.jointAnkleForceTask.conf

Definition at line 16 of file jointAnkleForceTask.py.

8.7.4.3 jointAnkleForceTask.jointAnkleForceTask.muscles

Definition at line 17 of file jointAnkleForceTask.py.

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

- jointAnkleForceTask.py

8.8 jointAnklePositionTask.jointAnklePositionTask Class Reference

Public Member Functions

- def __init__ (self, conf, pool, MUnumber, MUtypeInumber, musculotendonLength, unit)
- def atualizeForce (self, activation_Sat, musculoTendonLength)

  Compute the muscle force when no muscle dynamics (Hill model) is used.
- def atualizeActivation (self, activation_Sat)
- def computePennationAngle (self)
- def computeForceLengthTypeI (self)
- def computeForceLengthTypeII (self)
- def computeForceVelocityTypeI (self)
- def computeForceVelocityTypeII (self)
- def computeAcceleration (self)
- def dLdt (self)
- def atualizeMuscleForce (self)
- def atualizeTendonForce (self)
- def computeElasticElementForce (self)
- def computeViscousElementForce (self)
- def computeTypeIActiveForce (self)
- def computeTypeIIActiveForce (self)
- def atualizeLenghtsAndVelocity (self)

Public Attributes

- conf
- pool
- MUnumber
- MUtypeInumber
- timeIndex
- twTet

    Twitch-tetanus relationship (see atualizeForce function explanation)
- twitchAmp_N

    Amplitude of the muscle unit twitch, in N (see atualizeForce function explanation).
- maximumActivationForce

    This is used for normalization purposes.
- force

    Muscle force along time, in N.
- tendonForce_N
- contractileForce_N
- elasticForce_N
- viscousForce_N
- length_m
- velocity_m_ms
- tendonLength_m
- pennationAngle_rad
- activationTypeI
- activationTypeII
- optimalLength_m
- pennationAngleAtOptimalLengthSin
- maximumForce_N

    Maximum force of the Hill model, in N.
- elasticity
- strain
- viscosity
- mass
- tendonElasticity
- tendonLinearOnsetLength
- tendonCurvatureConstant
- optimalTendonLength
- lengthNorm
- velocityNorm
- tendonLengthNorm
- forceNorm
- tendonForceNorm
- b_TypeI
- b_TypeII
- p_TypeI
- p_TypeII
- w_TypeI
- w_TypeII
- d_TypeI
- d_TypeII
- a0_TypeI
- a0_TypeII
- a1_TypeI
- a1_TypeII

- a2_TypeI
- a2_TypeII
- c0_TypeI
- c0_TypeII
- c1_TypeI
- c1_TypeII
- Vmax_TypeI
- Vmax_TypeII

8.8.1 Detailed Description

Definition at line 12 of file jointAnklePositionTask.py.

8.8.2 Constructor & Destructor Documentation

8.8.2.1 def jointAnklePositionTask.jointAnklePositionTask.__init__ (*self, conf, pool, MUnumber, MUtypeInumber, musculotendonLength, unit*)

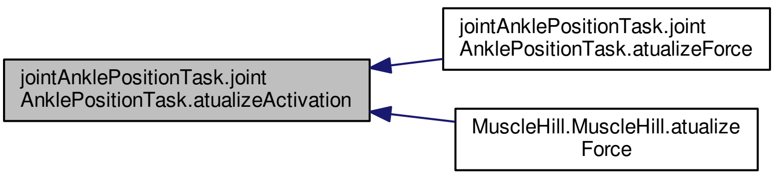
Definition at line 14 of file jointAnklePositionTask.py.

8.8.3 Member Function Documentation

8.8.3.1 def jointAnklePositionTask.jointAnklePositionTask.atualizeActivation (*self, activation_Sat*)

Definition at line 178 of file jointAnklePositionTask.py.

Here is the caller graph for this function:



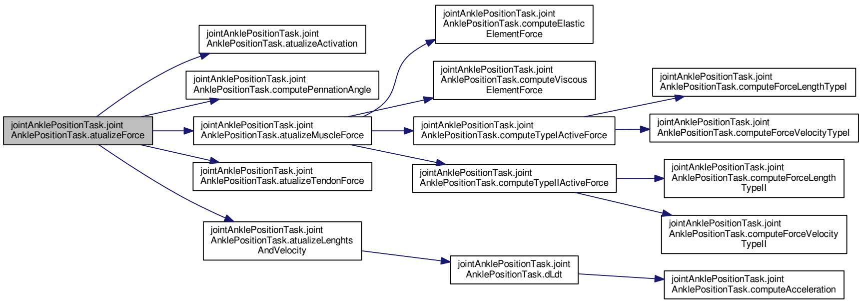
8.8.3.2 def jointAnklePositionTask.jointAnklePositionTask.atualizeForce (*self*, *activation_Sat*, *musculoTendonLength*)

Compute the muscle force when no muscle dynamics (Hill model) is used.

This operation is vectorized. Each element of the vectors correspond to one motor unit. For each motor unit, the force is computed by the following formula:

Definition at line 160 of file jointAnklePositionTask.py.

Here is the call graph for this function:

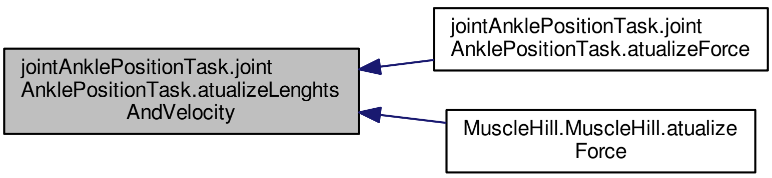


8.8.3.3 def jointAnklePositionTask.jointAnklePositionTask.atualizeLenghtsAndVelocity (*self*)

Definition at line 237 of file jointAnklePositionTask.py.

Here is the call graph for this function:

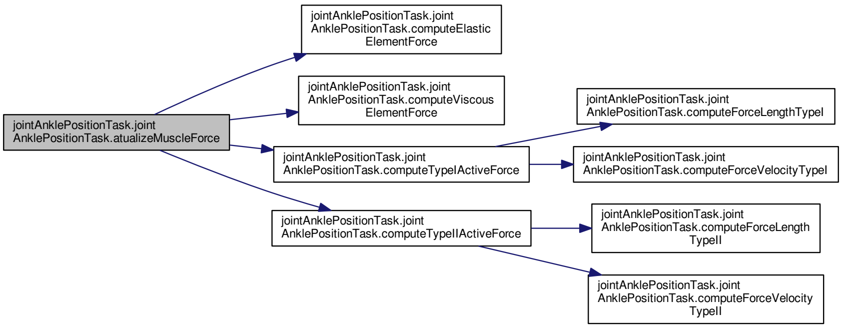
Here is the caller graph for this function:



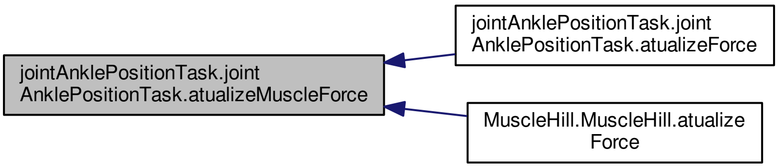
8.8.3.4 def jointAnklePositionTask.jointAnklePositionTask.atualizeMuscleForce (*self*)

Definition at line 217 of file jointAnklePositionTask.py.

Here is the call graph for this function:



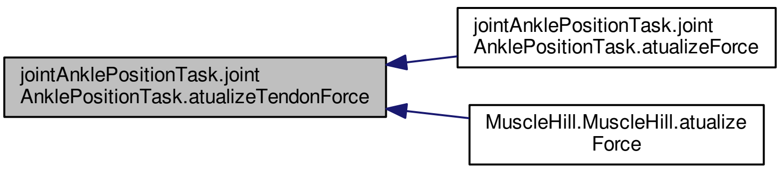
Here is the caller graph for this function:



8.8.3.5 def jointAnklePositionTask.jointAnklePositionTask.atualizeTendonForce (*self*)

Definition at line 221 of file jointAnklePositionTask.py.

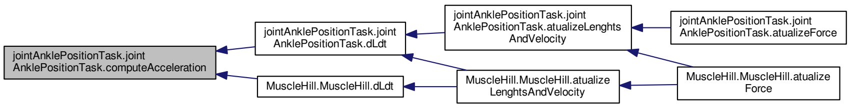
Here is the caller graph for this function:



8.8.3.6 def jointAnklePositionTask.jointAnklePositionTask.computeAcceleration (*self*)

Definition at line 209 of file jointAnklePositionTask.py.

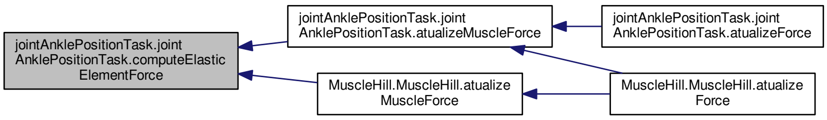
Here is the caller graph for this function:



8.8.3.7 def jointAnklePositionTask.jointAnklePositionTask.computeElasticElementForce (*self*)

Definition at line 225 of file jointAnklePositionTask.py.

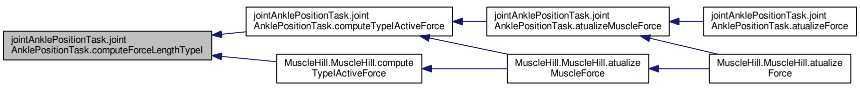
Here is the caller graph for this function:



8.8.3.8 def jointAnklePositionTask.jointAnklePositionTask.computeForceLengthTypeI (*self*)

Definition at line 189 of file jointAnklePositionTask.py.

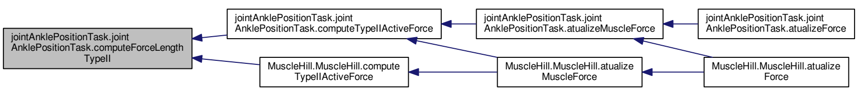
Here is the caller graph for this function:



8.8.3.9 def jointAnklePositionTask.jointAnklePositionTask.computeForceLengthTypeII (*self*)

Definition at line 192 of file jointAnklePositionTask.py.

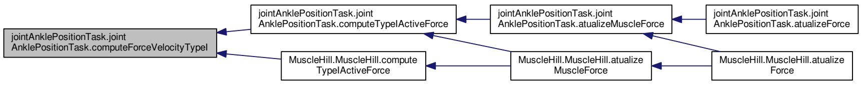
Here is the caller graph for this function:



8.8.3.10 def jointAnklePositionTask.jointAnklePositionTask.computeForceVelocityTypeI (*self*)

Definition at line 195 of file jointAnklePositionTask.py.

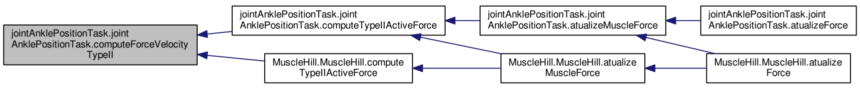
Here is the caller graph for this function:



8.8.3.11 def jointAnklePositionTask.jointAnklePositionTask.computeForceVelocityTypeII (*self*)

Definition at line 202 of file jointAnklePositionTask.py.

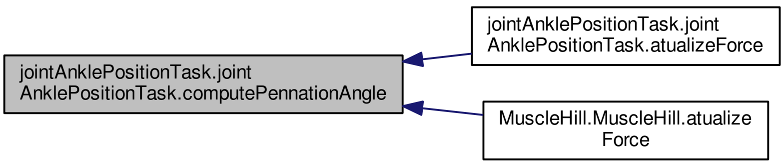
Here is the caller graph for this function:



8.8.3.12 def jointAnklePositionTask.jointAnklePositionTask.computePennationAngle (*self*)

Definition at line 186 of file jointAnklePositionTask.py.

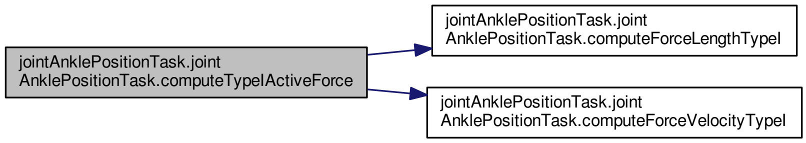
Here is the caller graph for this function:



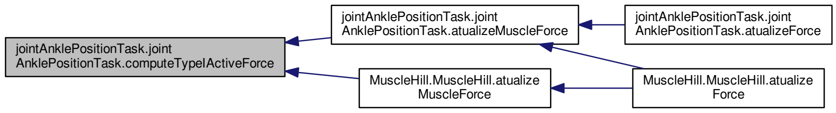
8.8.3.13 def jointAnklePositionTask.jointAnklePositionTask.computeTypeIActiveForce (*self*)

Definition at line 231 of file jointAnklePositionTask.py.

Here is the call graph for this function:



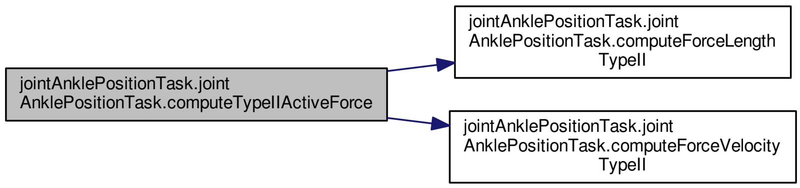
Here is the caller graph for this function:



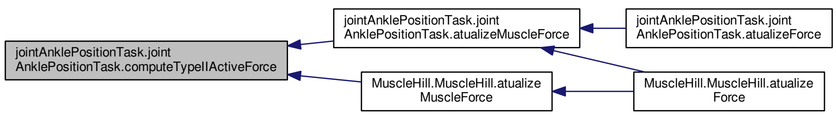
8.8.3.14 def jointAnklePositionTask.jointAnklePositionTask.computeTypeIIActiveForce (*self*)

Definition at line 234 of file jointAnklePositionTask.py.

Here is the call graph for this function:



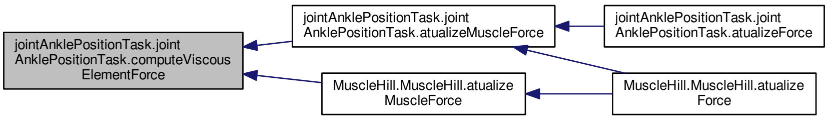
Here is the caller graph for this function:



8.8.3.15 def jointAnklePositionTask.jointAnklePositionTask.computeViscousElementForce (*self*)

Definition at line 228 of file jointAnklePositionTask.py.

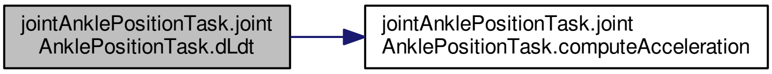
Here is the caller graph for this function:



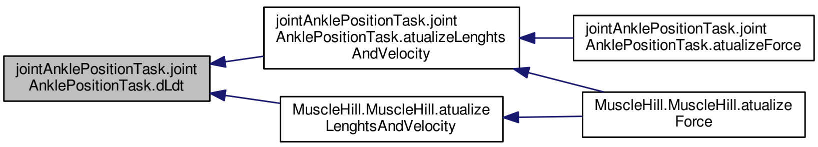
8.8.3.16 def jointAnklePositionTask.jointAnklePositionTask.dLdt (*self*)

Definition at line 214 of file jointAnklePositionTask.py.

Here is the call graph for this function:



Here is the caller graph for this function:



8.8.4 Member Data Documentation

8.8.4.1 jointAnklePositionTask.jointAnklePositionTask.a0_TypeI

Definition at line 91 of file jointAnklePositionTask.py.

8.8.4.2 jointAnklePositionTask.jointAnklePositionTask.a0_TypeII

Definition at line 93 of file jointAnklePositionTask.py.

8.8.4.3 jointAnklePositionTask.jointAnklePositionTask.a1_TypeI

Definition at line 94 of file jointAnklePositionTask.py.

8.8.4.4 jointAnklePositionTask.jointAnklePositionTask.a1_TypeII

Definition at line 96 of file jointAnklePositionTask.py.

8.8.4.5 jointAnklePositionTask.jointAnklePositionTask.a2_TypeI

Definition at line 97 of file jointAnklePositionTask.py.

8.8.4.6 jointAnklePositionTask.jointAnklePositionTask.a2_TypeII

Definition at line 99 of file jointAnklePositionTask.py.

8.8.4.7 jointAnklePositionTask.jointAnklePositionTask.activationTypeI

Definition at line 45 of file jointAnklePositionTask.py.

8.8.4.8 jointAnklePositionTask.jointAnklePositionTask.activationTypeII

Definition at line 46 of file jointAnklePositionTask.py.

8.8.4.9 jointAnklePositionTask.jointAnklePositionTask.b_TypeI

Definition at line 77 of file jointAnklePositionTask.py.

8.8.4.10 jointAnklePositionTask.jointAnklePositionTask.b_TypeII

Definition at line 79 of file jointAnklePositionTask.py.

8.8.4.11 jointAnklePositionTask.jointAnklePositionTask.c0_TypeI

Definition at line 100 of file jointAnklePositionTask.py.

8.8.4.12 jointAnklePositionTask.jointAnklePositionTask.c0_TypeII

Definition at line 102 of file jointAnklePositionTask.py.

8.8.4.13 jointAnklePositionTask.jointAnklePositionTask.c1_TypeI

Definition at line 103 of file jointAnklePositionTask.py.

8.8.4.14 jointAnklePositionTask.jointAnklePositionTask.c1_TypeII

Definition at line 105 of file jointAnklePositionTask.py.

8.8.4.15 jointAnklePositionTask.jointAnklePositionTask.conf

Definition at line 16 of file jointAnklePositionTask.py.

8.8.4.16 jointAnklePositionTask.jointAnklePositionTask.contractileForce_N

Definition at line 38 of file jointAnklePositionTask.py.

8.8.4.17 jointAnklePositionTask.jointAnklePositionTask.d_TypeI

Definition at line 88 of file jointAnklePositionTask.py.

8.8.4.18 jointAnklePositionTask.jointAnklePositionTask.d_TypeII

Definition at line 90 of file jointAnklePositionTask.py.

8.8.4.19 jointAnklePositionTask.jointAnklePositionTask.elasticForce_N

Definition at line 39 of file jointAnklePositionTask.py.

8.8.4.20 jointAnklePositionTask.jointAnklePositionTask.elasticity

Definition at line 53 of file jointAnklePositionTask.py.

8.8.4.21 jointAnklePositionTask.jointAnklePositionTask.force

Muscle force along time, in N.

Definition at line 36 of file jointAnklePositionTask.py.

8.8.4.22 jointAnklePositionTask.jointAnklePositionTask.forceNorm

Definition at line 73 of file jointAnklePositionTask.py.

8.8.4.23 jointAnklePositionTask.jointAnklePositionTask.length_m

Definition at line 41 of file jointAnklePositionTask.py.

8.8.4.24 jointAnklePositionTask.jointAnklePositionTask.lengthNorm

Definition at line 68 of file jointAnklePositionTask.py.

8.8.4.25 jointAnklePositionTask.jointAnklePositionTask.mass

Definition at line 59 of file jointAnklePositionTask.py.

8.8.4.26 jointAnklePositionTask.jointAnklePositionTask.maximumActivationForce

This is used for normalization purposes.

It is the maximum force that the muscle reach when the Hill model is not used.

Definition at line 34 of file jointAnklePositionTask.py.

8.8.4.27 jointAnklePositionTask.jointAnklePositionTask.maximumForce_N

Maximum force of the Hill model, in N.

Definition at line 50 of file jointAnklePositionTask.py.

8.8.4.28 jointAnklePositionTask.jointAnklePositionTask.MUnumber

Definition at line 18 of file jointAnklePositionTask.py.

8.8.4.29 jointAnklePositionTask.jointAnklePositionTask.MUtypeInumber

Definition at line 19 of file jointAnklePositionTask.py.

8.8.4.30 jointAnklePositionTask.jointAnklePositionTask.optimalLength_m

Definition at line 47 of file jointAnklePositionTask.py.

8.8.4.31 jointAnklePositionTask.jointAnklePositionTask.optimalTendonLength

Definition at line 65 of file jointAnklePositionTask.py.

8.8.4.32 jointAnklePositionTask.jointAnklePositionTask.p_TypeI

Definition at line 81 of file jointAnklePositionTask.py.

8.8.4.33 jointAnklePositionTask.jointAnklePositionTask.p_TypeII

Definition at line 83 of file jointAnklePositionTask.py.

8.8.4.34 jointAnklePositionTask.jointAnklePositionTask.pennationAngle_rad

Definition at line 44 of file jointAnklePositionTask.py.

8.8.4.35 jointAnklePositionTask.jointAnklePositionTask.pennationAngleAtOptimalLengthSin

Definition at line 48 of file jointAnklePositionTask.py.

8.8.4.36 jointAnklePositionTask.jointAnklePositionTask.pool

Definition at line 17 of file jointAnklePositionTask.py.

8.8.4.37 jointAnklePositionTask.jointAnklePositionTask.strain

Definition at line 55 of file jointAnklePositionTask.py.

8.8.4.38 jointAnklePositionTask.jointAnklePositionTask.tendonCurvatureConstant

Definition at line 64 of file jointAnklePositionTask.py.

8.8.4.39 jointAnklePositionTask.jointAnklePositionTask.tendonElasticity

Definition at line 62 of file jointAnklePositionTask.py.

8.8.4.40 jointAnklePositionTask.jointAnklePositionTask.tendonForce_N

Definition at line 37 of file jointAnklePositionTask.py.

8.8.4.41 jointAnklePositionTask.jointAnklePositionTask.tendonForceNorm

Definition at line 74 of file jointAnklePositionTask.py.

8.8.4.42 jointAnklePositionTask.jointAnklePositionTask.tendonLength_m

Definition at line 43 of file jointAnklePositionTask.py.

8.8.4.43 jointAnklePositionTask.jointAnklePositionTask.tendonLengthNorm

Definition at line 72 of file jointAnklePositionTask.py.

8.8.4.44 jointAnklePositionTask.jointAnklePositionTask.tendonLinearOnsetLength

Definition at line 63 of file jointAnklePositionTask.py.

8.8.4.45 jointAnklePositionTask.jointAnklePositionTask.timeIndex

Definition at line 21 of file jointAnklePositionTask.py.

8.8.4.46 jointAnklePositionTask.jointAnklePositionTask.twitchAmp_N

Amplitude of the muscle unit twitch, in N (see atualizeForce function explanation).

Definition at line 26 of file jointAnklePositionTask.py.

8.8.4.47 jointAnklePositionTask.jointAnklePositionTask.twTet

Twitch-tetanus relationship (see atualizeForce function explanation)

Definition at line 24 of file jointAnklePositionTask.py.

8.8.4.48 jointAnklePositionTask.jointAnklePositionTask.velocity_m_ms

Definition at line 42 of file jointAnklePositionTask.py.

8.8.4.49 jointAnklePositionTask.jointAnklePositionTask.velocityNorm

Definition at line 70 of file jointAnklePositionTask.py.

8.8.4.50 jointAnklePositionTask.jointAnklePositionTask.viscosity

Definition at line 57 of file jointAnklePositionTask.py.

8.8.4.51 jointAnklePositionTask.jointAnklePositionTask.viscousForce_N

Definition at line 40 of file jointAnklePositionTask.py.

8.8.4.52 jointAnklePositionTask.jointAnklePositionTask.Vmax_TypeI

Definition at line 106 of file jointAnklePositionTask.py.

8.8.4.53 jointAnklePositionTask.jointAnklePositionTask.Vmax_TypeII

Definition at line 108 of file jointAnklePositionTask.py.

8.8.4.54 jointAnklePositionTask.jointAnklePositionTask.w_TypeI

Definition at line 85 of file jointAnklePositionTask.py.

8.8.4.55 jointAnklePositionTask.jointAnklePositionTask.w_TypeII

Definition at line 87 of file jointAnklePositionTask.py.

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

- jointAnklePositionTask.py

8.9 MotorUnit.MotorUnit Class Reference

Class that implements a motor unit model.

Public Member Functions

- def __init__ (self, conf, pool, index, kind)

  Constructor.
- def atualizeMotorUnit (self, t)

  Atualize the dynamical and nondynamical (delay) parts of the motor unit.
- def atualizeCompartments (self, t)

  Atualize all neural compartments.
- def dVdt (self, t, V)

  Compute the potential derivative of all compartments of the motor unit.
- def addSomaSpike (self, t)

  When the soma potential is above the threshold a spike is added tom the soma.
- def atualizeDelay (self, t)

  Atualize the terminal spike train, by considering the Delay of the nerve.
- def transmitSpikes (self, t)

Public Attributes

- conf

    Configuration object with the simulation parameters.
- kind

    String with the type of the motor unit.
- tSomaSpike

    The instant of the last spike of the Motor unit at the Soma compartment.
- somaSpikeTrain

    Vector with the instants of spikes at the soma.
- index

    Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).
- compartment

    Vector of Compartment of the Motor Unit.
- threshold_mV

    Value of the membrane potential, in mV, that is considered a spike.
- position_mm

    Anatomical position of the neuron, in mm.
- compNumber

    Number of compartments.
- v_mV

    Vector with membrane potential,in mV, of all compartments.
- capacitanceInv

    Vector with the inverse of the capacitance of all compartments.
- iIonic

    Vector with current, in nA, of each compartment coming from other elements of the model.
- iInjected

    Vector with the current, in nA, injected in each compartment.
- G

    Matrix of the conductance of the motoneuron.
- somaIndex

    index of the soma compartment.
- MNRefPer_ms

    Refractory period, in ms, of the motoneuron.
- nerve

    String with type of the nerve.
- Delay

    AxonDelay object of the motor unit.
- terminalSpikeTrain

    Vector with the instants of spikes at the terminal.
- TwitchTc_ms

    Contraction time of the twitch muscle unit, in ms.
- TwitchAmp_N

    Amplitude of the muscle unit twitch, in N.
- bSat

    Parameter of the saturation.
- twTet

    Twitch- tetanus relationship.
- SynapsesOut

    EMG data.
- transmitSpikesThroughSynapses
- indicesOfSynapsesOnTarget

8.9.1 Detailed Description

Class that implements a motor unit model.

Encompasses a motoneuron and a muscle unit.

Definition at line 148 of file MotorUnit.py.

8.9.2 Constructor & Destructor Documentation

8.9.2.1 def MotorUnit.MotorUnit.__init__ (*self*, *conf*, *pool*, *index*, *kind*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.

cyto + **pool**: string with Motor unit pool to which the motor unit belongs.

- **index**: integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).
- **kind**: string with the type of the motor unit. It can be *S* (slow), *FR* (fast and resistant), and *FF* (fast and fatigable).

Definition at line 167 of file MotorUnit.py.

8.9.3 Member Function Documentation

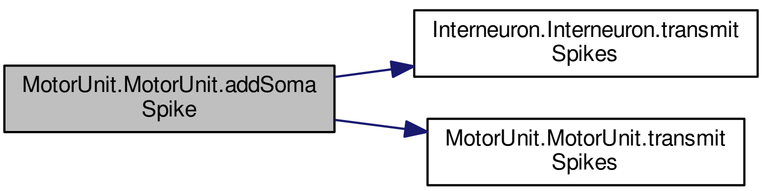
8.9.3.1 def MotorUnit.MotorUnit.addSomaSpike (*self*, *t*)

When the soma potential is above the threshold a spike is added tom the soma.

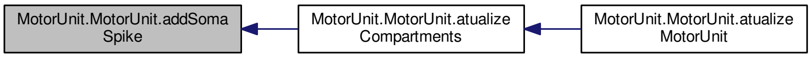
- Inputs:
  - **t**: current instant, in ms.

Definition at line 335 of file MotorUnit.py.

Here is the call graph for this function:



Here is the caller graph for this function:



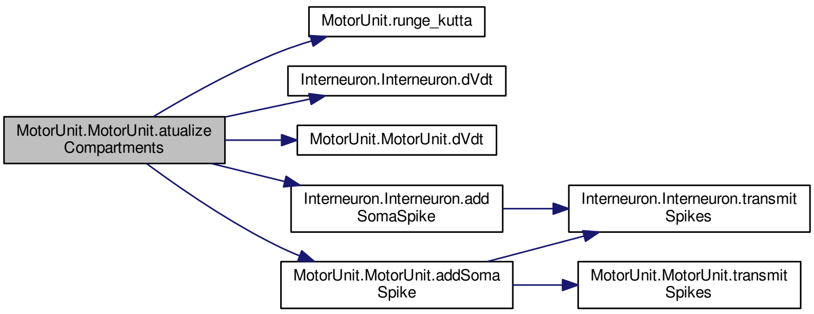
8.9.3.2 def MotorUnit.MotorUnit.atualizeCompartments (*self*, *t*)

Atualize all neural compartments.

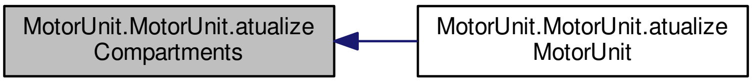
- Inputs:
  - **t**: current instant, in ms.

Definition at line 298 of file MotorUnit.py.

Here is the call graph for this function:



Here is the caller graph for this function:



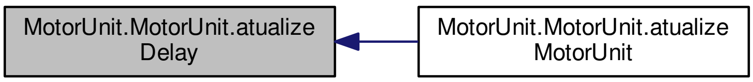
8.9.3.3 def MotorUnit.MotorUnit.atualizeDelay (*self*, *t*)

Atualize the terminal spike train, by considering the Delay of the nerve.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 352 of file MotorUnit.py.

Here is the caller graph for this function:



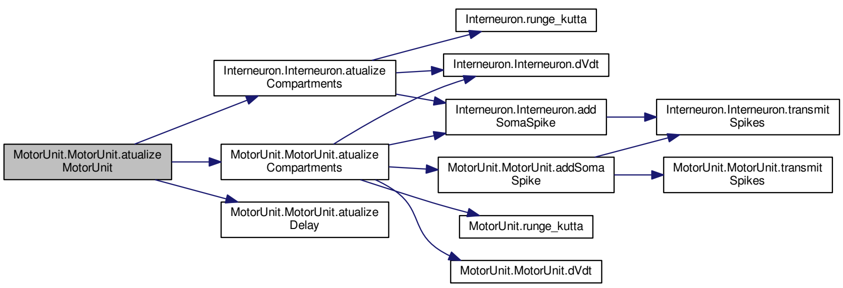
8.9.3.4 def MotorUnit.MotorUnit.atualizeMotorUnit (*self*, *t*)

Atualize the dynamical and nondynamical (delay) parts of the motor unit.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 286 of file MotorUnit.py.

Here is the call graph for this function:



8.9.3.5 def MotorUnit.MotorUnit.dVdt (*self*, *t*, *V*)

Compute the potential derivative of all compartments of the motor unit.

- Inputs:
  - **t**: current instant, in ms.
  - **V**: Vector with the current potential value of all neural compartments of the motor unit.

Definition at line 321 of file MotorUnit.py.

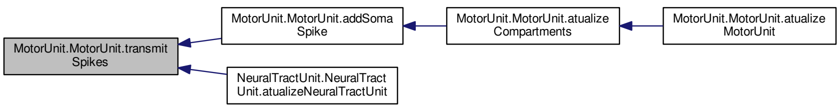
Here is the caller graph for this function:

8.9.3.6 def MotorUnit.MotorUnit.transmitSpikes (*self*, *t*)

- Inputs:
  - **t**: current instant, in ms.

Definition at line 362 of file MotorUnit.py.

Here is the caller graph for this function:



8.9.4 Member Data Documentation

8.9.4.1 MotorUnit.MotorUnit.bSat

Parameter of the saturation.

Definition at line 267 of file MotorUnit.py.

8.9.4.2 MotorUnit.MotorUnit.capacitanceInv

Vector with the inverse of the capacitance of all compartments.

Definition at line 219 of file MotorUnit.py.

8.9.4.3 MotorUnit.MotorUnit.compartment

Vector of Compartment of the Motor Unit.

Definition at line 187 of file MotorUnit.py.

8.9.4.4 MotorUnit.MotorUnit.compNumber

Number of compartments.

Definition at line 197 of file MotorUnit.py.

8.9.4.5 MotorUnit.MotorUnit.conf

Configuration object with the simulation parameters.

Definition at line 170 of file MotorUnit.py.

8.9.4.6 MotorUnit.MotorUnit.Delay

AxonDelay object of the motor unit.

Definition at line 252 of file MotorUnit.py.

8.9.4.7 MotorUnit.MotorUnit.G

Matrix of the conductance of the motoneuron.

Multiplied by the vector self.v_mV, results in the passive currents of each compartment.

Definition at line 234 of file MotorUnit.py.

8.9.4.8 MotorUnit.MotorUnit.iInjected

Vector with the current, in nA, injected in each compartment.

Definition at line 225 of file MotorUnit.py.

8.9.4.9 MotorUnit.MotorUnit.iIonic

Vector with current, in nA, of each compartment coming from other elements of the model.

For example from ionic channels and synapses.

Definition at line 223 of file MotorUnit.py.

8.9.4.10 MotorUnit.MotorUnit.index

Integer corresponding to the motor unit order in the pool, according to the Henneman's principle (size principle).

Definition at line 185 of file MotorUnit.py.

8.9.4.11 MotorUnit.MotorUnit.indicesOfSynapsesOnTarget

Definition at line 277 of file MotorUnit.py.

8.9.4.12 MotorUnit.MotorUnit.kind

String with the type of the motor unit.

It can be *S* (slow), *FR* (fast and resistant) and ∗FF∗∗ (fast and fatigable).

Definition at line 175 of file MotorUnit.py.

8.9.4.13 MotorUnit.MotorUnit.MNRefPer_ms

Refractory period, in ms, of the motoneuron.

Definition at line 241 of file MotorUnit.py.

8.9.4.14 MotorUnit.MotorUnit.nerve

String with type of the nerve.

It can be PTN (posterior tibial nerve) or CPN (common peroneal nerve).

Definition at line 247 of file MotorUnit.py.

8.9.4.15 MotorUnit.MotorUnit.position_mm

Anatomical position of the neuron, in mm.

Definition at line 192 of file MotorUnit.py.

8.9.4.16 MotorUnit.MotorUnit.somaIndex

index of the soma compartment.

Definition at line 238 of file MotorUnit.py.

8.9.4.17 MotorUnit.MotorUnit.somaSpikeTrain

Vector with the instants of spikes at the soma.

Definition at line 183 of file MotorUnit.py.

8.9.4.18 MotorUnit.MotorUnit.SynapsesOut

EMG data.

Build synapses

Definition at line 275 of file MotorUnit.py.

8.9.4.19 MotorUnit.MotorUnit.terminalSpikeTrain

Vector with the instants of spikes at the terminal.

Definition at line 256 of file MotorUnit.py.

8.9.4.20 MotorUnit.MotorUnit.threshold_mV

Value of the membrane potential, in mV, that is considered a spike.

Definition at line 189 of file MotorUnit.py.

8.9.4.21 MotorUnit.MotorUnit.transmitSpikesThroughSynapses

Definition at line 276 of file MotorUnit.py.

8.9.4.22 MotorUnit.MotorUnit.tSomaSpike

The instant of the last spike of the Motor unit at the Soma compartment.

Definition at line 180 of file MotorUnit.py.

8.9.4.23 MotorUnit.MotorUnit.TwitchAmp_N

Amplitude of the muscle unit twitch, in N.

Definition at line 265 of file MotorUnit.py.

8.9.4.24 MotorUnit.MotorUnit.TwitchTc_ms

Contraction time of the twitch muscle unit, in ms.

Definition at line 263 of file MotorUnit.py.

8.9.4.25 MotorUnit.MotorUnit.twTet

Twitch- tetanus relationship.

Definition at line 269 of file MotorUnit.py.

8.9.4.26 MotorUnit.MotorUnit.v_mV

Vector with membrane potential,in mV, of all compartments.

Definition at line 199 of file MotorUnit.py.

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

- MotorUnit.py

8.10 MotorUnitPool.MotorUnitPool Class Reference

Class that implements a motor unit pool.

Public Member Functions

- def __init__ (self, conf, pool)

  Constructor.
- def atualizeMotorUnitPool (self, t)

  Update all parts of the Motor Unit pool.
- def listSpikes (self)

  List the spikes that occurred in the soma and in the terminal of the different motor units.

Public Attributes

- kind

  Indicates that is Motor Unit pool.
- conf

  Configuration object with the simulation parameters.
- pool

  String with Motor unit pool to which the motor unit belongs.
- MUnumber

  Number of motor units.
- unit

  List of MotorUnit objects.
- poolSomaSpikes

  Vector with the instants of spikes in the soma compartment, in ms.
- poolTerminalSpikes

  Vector with the instants of spikes in the terminal, in ms.
- Activation
- hillModel

  String indicating whther a Hill model is used or not.
- Muscle

8.10.1 Detailed Description

Class that implements a motor unit pool.

Encompasses a set of motor units that controls a single muscle.

Definition at line 26 of file MotorUnitPool.py.

8.10.2 Constructor & Destructor Documentation

8.10.2.1 def MotorUnitPool.MotorUnitPool.__init__ (*self*, *conf*, *pool*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with Motor unit pool to which the motor unit belongs.

Definition at line 38 of file MotorUnitPool.py.

8.10.3 Member Function Documentation

8.10.3.1 def MotorUnitPool.MotorUnitPool.atualizeMotorUnitPool (*self*, *t*)

Update all parts of the Motor Unit pool.

It consists to update all motor units, the activation signal and the muscle force.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 93 of file MotorUnitPool.py.

8.10.3.2 def MotorUnitPool.MotorUnitPool.listSpikes (*self*)

List the spikes that occurred in the soma and in the terminal of the different motor units.

Definition at line 104 of file MotorUnitPool.py.

8.10.4 Member Data Documentation

8.10.4.1 MotorUnitPool.MotorUnitPool.Activation

Definition at line 71 of file MotorUnitPool.py.

8.10.4.2 MotorUnitPool.MotorUnitPool.conf

Configuration object with the simulation parameters.

Definition at line 44 of file MotorUnitPool.py.

8.10.4.3 MotorUnitPool.MotorUnitPool.hillModel

String indicating whther a Hill model is used or not.

For now, it can be *No*.

Definition at line 75 of file MotorUnitPool.py.

8.10.4.4 MotorUnitPool.MotorUnitPool.kind

Indicates that is Motor Unit pool.

Definition at line 41 of file MotorUnitPool.py.

8.10.4.5 MotorUnitPool.MotorUnitPool.MUnumber

Number of motor units.

Definition at line 51 of file MotorUnitPool.py.

8.10.4.6 MotorUnitPool.MotorUnitPool.Muscle

Definition at line 77 of file MotorUnitPool.py.

8.10.4.7 MotorUnitPool.MotorUnitPool.pool

String with Motor unit pool to which the motor unit belongs.

Definition at line 46 of file MotorUnitPool.py.

8.10.4.8 MotorUnitPool.MotorUnitPool.poolSomaSpikes

Vector with the instants of spikes in the soma compartment, in ms.

Definition at line 66 of file MotorUnitPool.py.

8.10.4.9 MotorUnitPool.MotorUnitPool.poolTerminalSpikes

Vector with the instants of spikes in the terminal, in ms.

Definition at line 68 of file MotorUnitPool.py.

8.10.4.10 MotorUnitPool.MotorUnitPool.unit

List of MotorUnit objects.

Definition at line 54 of file MotorUnitPool.py.

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

- MotorUnitPool.py

8.11 MuscleHill.MuscleHill Class Reference

Public Member Functions

- def __init__ (self, conf, pool, MUnumber, MUtypeInumber, unit)
- def atualizeForce (self, activation_Sat)

  Compute the muscle force when no muscle dynamics (Hill model) is used.
- def atualizeActivation (self, activation_Sat)
- def computePennationAngle (self)
- def computeForceLengthTypeI (self)
- def computeForceLengthTypeII (self)
- def computeForceVelocityTypeI (self)
- def computeForceVelocityTypeII (self)
- def computeAcceleration (self)
- def dLdt (self)
- def atualizeMuscleForce (self)
- def atualizeTendonForce (self)
- def computeElasticElementForce (self)
- def computeViscousElementForce (self)
- def computeTypeIActiveForce (self)
- def computeTypeIIActiveForce (self)
- def atualizeLenghtsAndVelocity (self)
- def atualizeMusculoTendonLength (self, ankleAngle)
- def atualizeMomentArm (self, ankleAngle)

Public Attributes

- conf
- pool
- MUnumber
- MUtypeInumber
- timeIndex
- twTet

  Twitch-tetanus relationship (see atualizeForce function explanation)
- twitchAmp_N

  Amplitude of the muscle unit twitch, in N (see atualizeForce function explanation).
- maximumActivationForce

  This is used for normalization purposes.
- force

  Muscle force along time, in N.

- tendonForce_N
- contractileForce_N
- elasticForce_N
- viscousForce_N
- length_m
- velocity_m_ms
- tendonLength_m
- pennationAngle_rad
- activationTypeI
- activationTypeII
- musculoTendonLength_m
- momentArm_m
- optimalLength_m
- pennationAngleAtOptimalLengthSin
- maximumForce_N

    Maximum force of the Hill model, in N.
- elasticity
- strain
- viscosity
- mass
- tendonElasticity
- tendonLinearOnsetLength
- tendonCurvatureConstant
- optimalTendonLength
- lengthNorm
- velocityNorm
- tendonLengthNorm
- forceNorm
- tendonForceNorm
- b_TypeI
- b_TypeII
- p_TypeI
- p_TypeII
- w_TypeI
- w_TypeII
- d_TypeI
- d_TypeII
- a0_TypeI
- a0_TypeII
- a1_TypeI
- a1_TypeII
- a2_TypeI
- a2_TypeII
- c0_TypeI
- c0_TypeII
- c1_TypeI
- c1_TypeII
- Vmax_TypeI
- Vmax_TypeII
- m0
- m1
- m2
- m3
- m4

- n0
- n1
- n2
- n3
- n4

8.11.1 Detailed Description

Definition at line 12 of file MuscleHill.py.

8.11.2 Constructor & Destructor Documentation

8.11.2.1 def MuscleHill.MuscleHill.__init__ (*self*, *conf*, *pool*, *MUnumber*, *MUtypeInumber*, *unit*)

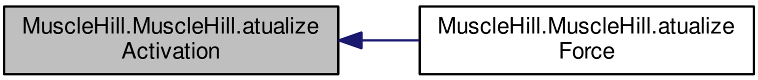
Definition at line 14 of file MuscleHill.py.

8.11.3 Member Function Documentation

8.11.3.1 def MuscleHill.MuscleHill.atualizeActivation (*self*, *activation_Sat*)

Definition at line 205 of file MuscleHill.py.

Here is the caller graph for this function:



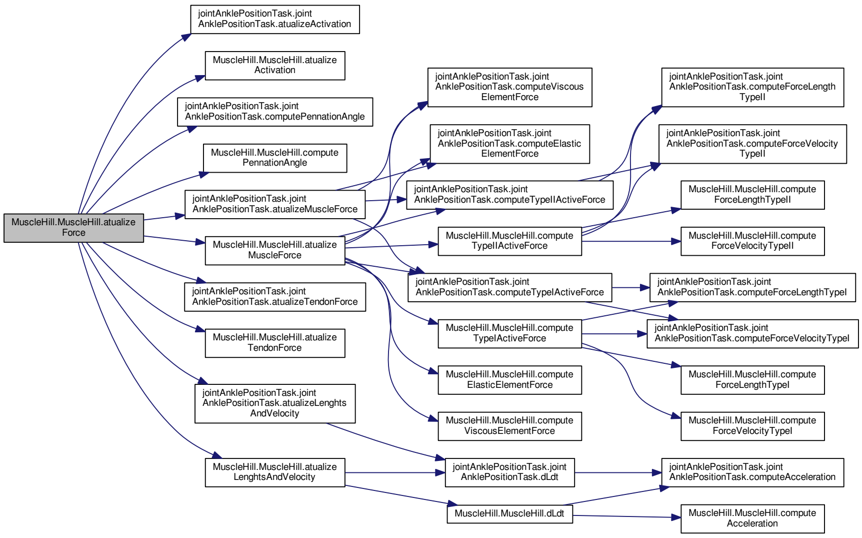
8.11.3.2 def MuscleHill.MuscleHill.atualizeForce (*self*, *activation_Sat*)

Compute the muscle force when no muscle dynamics (Hill model) is used.

This operation is vectorized. Each element of the vectors correspond to one motor unit. For each motor unit, the force is computed by the following formula:

Definition at line 185 of file MuscleHill.py.

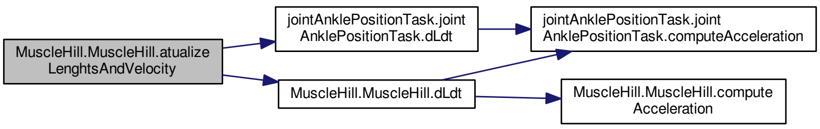
Here is the call graph for this function:



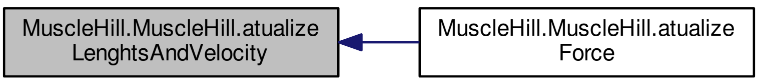
8.11.3.3 def MuscleHill.MuscleHill.atualizeLenghtsAndVelocity (*self*)

Definition at line 266 of file MuscleHill.py.

Here is the call graph for this function:



Here is the caller graph for this function:



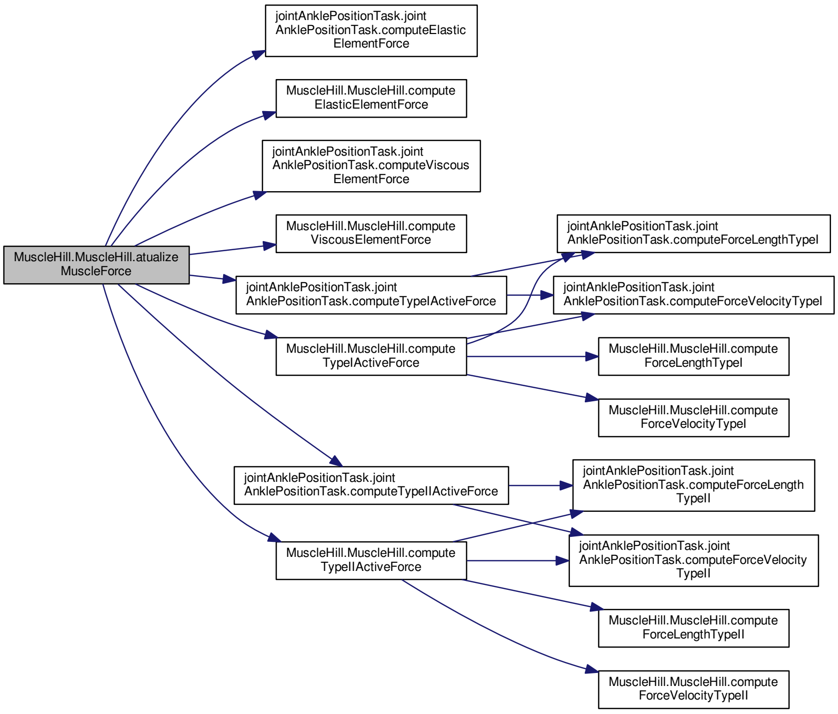
8.11.3.4 def MuscleHill.MuscleHill.atualizeMomentArm (*self*, *ankleAngle*)

Definition at line 277 of file MuscleHill.py.

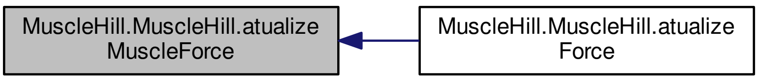
8.11.3.5 def MuscleHill.MuscleHill.atualizeMuscleForce (*self*)

Definition at line 244 of file MuscleHill.py.

Here is the call graph for this function:



Here is the caller graph for this function:



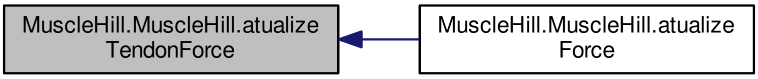
8.11.3.6 def MuscleHill.MuscleHill.atualizeMusculoTendonLength (*self, ankleAngle*)

Definition at line 270 of file MuscleHill.py.

8.11.3.7 def MuscleHill.MuscleHill.atualizeTendonForce (*self*)

Definition at line 248 of file MuscleHill.py.

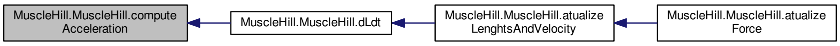
Here is the caller graph for this function:



8.11.3.8 def MuscleHill.MuscleHill.computeAcceleration (*self*)

Definition at line 236 of file MuscleHill.py.

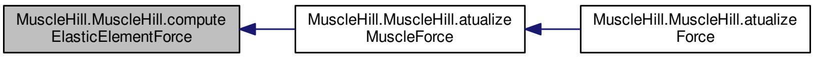
Here is the caller graph for this function:



8.11.3.9 def MuscleHill.MuscleHill.computeElasticElementForce (*self*)

Definition at line 252 of file MuscleHill.py.

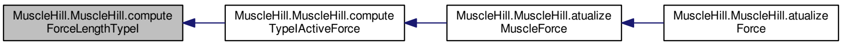
Here is the caller graph for this function:



8.11.3.10 def MuscleHill.MuscleHill.computeForceLengthTypeI (*self*)

Definition at line 216 of file MuscleHill.py.

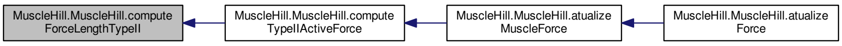
Here is the caller graph for this function:



8.11.3.11 def MuscleHill.MuscleHill.computeForceLengthTypeII (*self*)

Definition at line 219 of file MuscleHill.py.

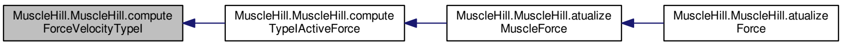
Here is the caller graph for this function:



8.11.3.12 def MuscleHill.MuscleHill.computeForceVelocityTypeI (*self*)

Definition at line 222 of file MuscleHill.py.

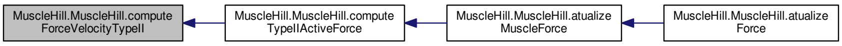
Here is the caller graph for this function:



8.11.3.13 def MuscleHill.MuscleHill.computeForceVelocityTypeII (*self*)

Definition at line 229 of file MuscleHill.py.

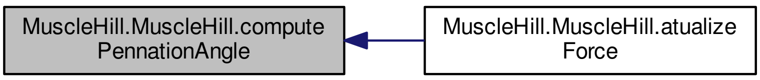
Here is the caller graph for this function:



8.11.3.14 def MuscleHill.MuscleHill.computePennationAngle (*self*)

Definition at line 213 of file MuscleHill.py.

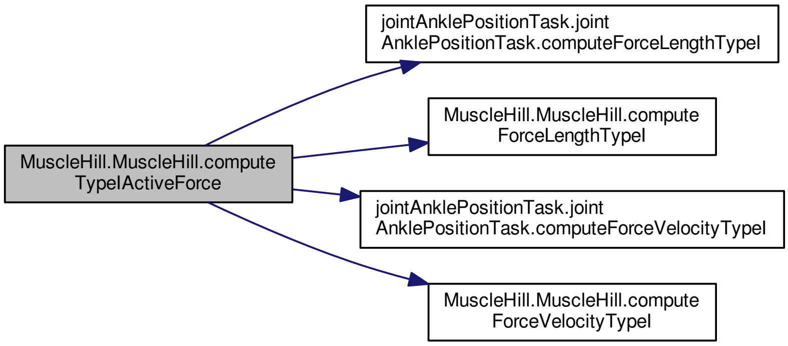
Here is the caller graph for this function:



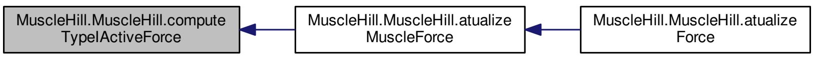
8.11.3.15 def MuscleHill.MuscleHill.computeTypeIActiveForce (*self*)

Definition at line 258 of file MuscleHill.py.

Here is the call graph for this function:



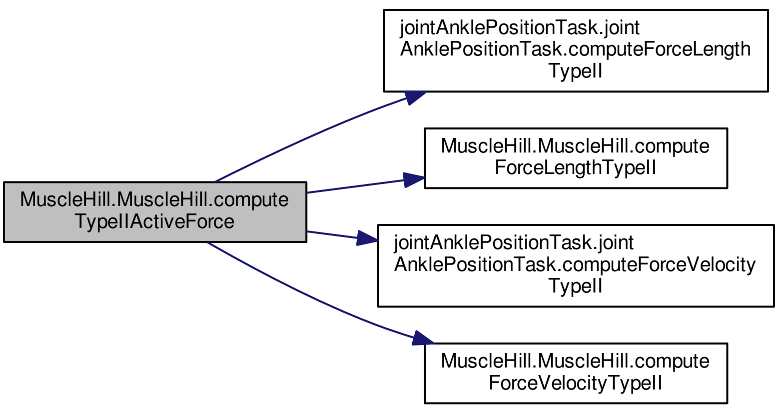
Here is the caller graph for this function:



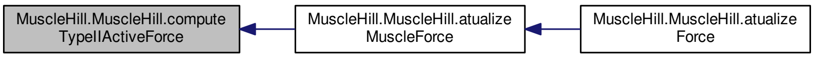
8.11.3.16 def MuscleHill.MuscleHill.computeTypeIIActiveForce (*self*)

Definition at line 262 of file MuscleHill.py.

Here is the call graph for this function:



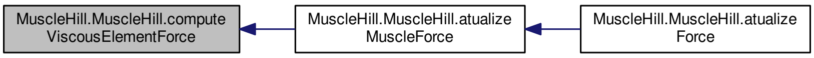
Here is the caller graph for this function:



8.11.3.17 def MuscleHill.MuscleHill.computeViscousElementForce (*self*)

Definition at line 255 of file MuscleHill.py.

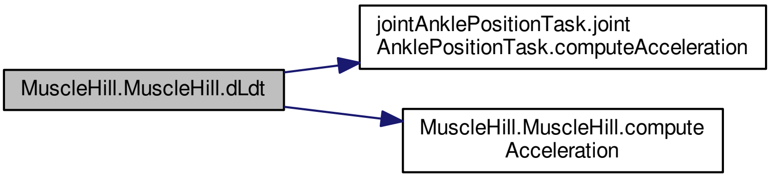
Here is the caller graph for this function:



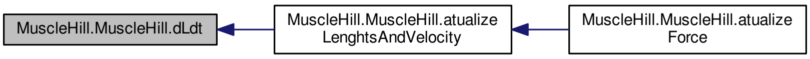
8.11.3.18 def MuscleHill.MuscleHill.dLdt (*self*)

Definition at line 241 of file MuscleHill.py.

Here is the call graph for this function:



Here is the caller graph for this function:



8.11.4 Member Data Documentation

8.11.4.1 MuscleHill.MuscleHill.a0_TypeI

Definition at line 93 of file MuscleHill.py.

8.11.4.2 MuscleHill.MuscleHill.a0_TypeII

Definition at line 95 of file MuscleHill.py.

8.11.4.3 MuscleHill.MuscleHill.a1_TypeI

Definition at line 96 of file MuscleHill.py.

8.11.4.4 MuscleHill.MuscleHill.a1_TypeII

Definition at line 98 of file MuscleHill.py.

8.11.4.5 MuscleHill.MuscleHill.a2_TypeI

Definition at line 99 of file MuscleHill.py.

8.11.4.6 MuscleHill.MuscleHill.a2_TypeII

Definition at line 101 of file MuscleHill.py.

8.11.4.7 MuscleHill.MuscleHill.activationTypeI

Definition at line 45 of file MuscleHill.py.

8.11.4.8 MuscleHill.MuscleHill.activationTypeII

Definition at line 46 of file MuscleHill.py.

8.11.4.9 MuscleHill.MuscleHill.b_TypeI

Definition at line 79 of file MuscleHill.py.

8.11.4.10 MuscleHill.MuscleHill.b_TypeII

Definition at line 81 of file MuscleHill.py.

8.11.4.11 MuscleHill.MuscleHill.c0_TypeI

Definition at line 102 of file MuscleHill.py.

8.11.4.12 MuscleHill.MuscleHill.c0_TypeII

Definition at line 104 of file MuscleHill.py.

8.11.4.13 MuscleHill.MuscleHill.c1_TypeI

Definition at line 105 of file MuscleHill.py.

8.11.4.14 MuscleHill.MuscleHill.c1_TypeII

Definition at line 107 of file MuscleHill.py.

8.11.4.15 MuscleHill.MuscleHill.conf

Definition at line 16 of file MuscleHill.py.

8.11.4.16 MuscleHill.MuscleHill.contractileForce_N

Definition at line 38 of file MuscleHill.py.

8.11.4.17 MuscleHill.MuscleHill.d_TypeI

Definition at line 90 of file MuscleHill.py.

8.11.4.18 MuscleHill.MuscleHill.d_TypeII

Definition at line 92 of file MuscleHill.py.

8.11.4.19 MuscleHill.MuscleHill.elasticForce_N

Definition at line 39 of file MuscleHill.py.

8.11.4.20 MuscleHill.MuscleHill.elasticity

Definition at line 55 of file MuscleHill.py.

8.11.4.21 MuscleHill.MuscleHill.force

Muscle force along time, in N.

Definition at line 36 of file MuscleHill.py.

8.11.4.22 MuscleHill.MuscleHill.forceNorm

Definition at line 75 of file MuscleHill.py.

8.11.4.23 MuscleHill.MuscleHill.length_m

Definition at line 41 of file MuscleHill.py.

8.11.4.24 MuscleHill.MuscleHill.lengthNorm

Definition at line 70 of file MuscleHill.py.

8.11.4.25 MuscleHill.MuscleHill.m0

Definition at line 112 of file MuscleHill.py.

8.11.4.26 MuscleHill.MuscleHill.m1

Definition at line 114 of file MuscleHill.py.

8.11.4.27 MuscleHill.MuscleHill.m2

Definition at line 116 of file MuscleHill.py.

8.11.4.28 MuscleHill.MuscleHill.m3

Definition at line 118 of file MuscleHill.py.

8.11.4.29 MuscleHill.MuscleHill.m4

Definition at line 120 of file MuscleHill.py.

8.11.4.30 MuscleHill.MuscleHill.mass

Definition at line 61 of file MuscleHill.py.

8.11.4.31 MuscleHill.MuscleHill.maximumActivationForce

This is used for normalization purposes.

It is the maximum force that the muscle reach when the Hill model is not used.

Definition at line 34 of file MuscleHill.py.

8.11.4.32 MuscleHill.MuscleHill.maximumForce_N

Maximum force of the Hill model, in N.

Definition at line 52 of file MuscleHill.py.

8.11.4.33 MuscleHill.MuscleHill.momentArm_m

Definition at line 48 of file MuscleHill.py.

8.11.4.34 MuscleHill.MuscleHill.MUnumber

Definition at line 18 of file MuscleHill.py.

8.11.4.35 MuscleHill.MuscleHill.musculoTendonLength_m

Definition at line 47 of file MuscleHill.py.

8.11.4.36 MuscleHill.MuscleHill.MUtypeInumber

Definition at line 19 of file MuscleHill.py.

8.11.4.37 MuscleHill.MuscleHill.n0

Definition at line 123 of file MuscleHill.py.

8.11.4.38 MuscleHill.MuscleHill.n1

Definition at line 125 of file MuscleHill.py.

8.11.4.39 MuscleHill.MuscleHill.n2

Definition at line 127 of file MuscleHill.py.

8.11.4.40 MuscleHill.MuscleHill.n3

Definition at line 129 of file MuscleHill.py.

8.11.4.41 MuscleHill.MuscleHill.n4

Definition at line 131 of file MuscleHill.py.

8.11.4.42 MuscleHill.MuscleHill.optimalLength_m

Definition at line 49 of file MuscleHill.py.

8.11.4.43 MuscleHill.MuscleHill.optimalTendonLength

Definition at line 67 of file MuscleHill.py.

8.11.4.44 MuscleHill.MuscleHill.p_TypeI

Definition at line 83 of file MuscleHill.py.

8.11.4.45 MuscleHill.MuscleHill.p_TypeII

Definition at line 85 of file MuscleHill.py.

8.11.4.46 MuscleHill.MuscleHill.pennationAngle_rad

Definition at line 44 of file MuscleHill.py.

8.11.4.47 MuscleHill.MuscleHill.pennationAngleAtOptimalLengthSin

Definition at line 50 of file MuscleHill.py.

8.11.4.48 MuscleHill.MuscleHill.pool

Definition at line 17 of file MuscleHill.py.

8.11.4.49 MuscleHill.MuscleHill.strain

Definition at line 57 of file MuscleHill.py.

8.11.4.50 MuscleHill.MuscleHill.tendonCurvatureConstant

Definition at line 66 of file MuscleHill.py.

8.11.4.51 MuscleHill.MuscleHill.tendonElasticity

Definition at line 64 of file MuscleHill.py.

8.11.4.52 MuscleHill.MuscleHill.tendonForce_N

Definition at line 37 of file MuscleHill.py.

8.11.4.53 MuscleHill.MuscleHill.tendonForceNorm

Definition at line 76 of file MuscleHill.py.

8.11.4.54 MuscleHill.MuscleHill.tendonLength_m

Definition at line 43 of file MuscleHill.py.

8.11.4.55 MuscleHill.MuscleHill.tendonLengthNorm

Definition at line 74 of file MuscleHill.py.

8.11.4.56 MuscleHill.MuscleHill.tendonLinearOnsetLength

Definition at line 65 of file MuscleHill.py.

8.11.4.57 MuscleHill.MuscleHill.timeIndex

Definition at line 21 of file MuscleHill.py.

8.11.4.58 MuscleHill.MuscleHill.twitchAmp_N

Amplitude of the muscle unit twitch, in N (see atualizeForce function explanation).

Definition at line 26 of file MuscleHill.py.

8.11.4.59 MuscleHill.MuscleHill.twTet

Twitch-tetanus relationship (see atualizeForce function explanation)

Definition at line 24 of file MuscleHill.py.

8.11.4.60 MuscleHill.MuscleHill.velocity_m_ms

Definition at line 42 of file MuscleHill.py.

8.11.4.61 MuscleHill.MuscleHill.velocityNorm

Definition at line 72 of file MuscleHill.py.

8.11.4.62 MuscleHill.MuscleHill.viscosity

Definition at line 59 of file MuscleHill.py.

8.11.4.63 MuscleHill.MuscleHill.viscousForce_N

Definition at line 40 of file MuscleHill.py.

8.11.4.64 MuscleHill.MuscleHill.Vmax_TypeI

Definition at line 108 of file MuscleHill.py.

8.11.4.65 MuscleHill.MuscleHill.Vmax_TypeII

Definition at line 110 of file MuscleHill.py.

8.11.4.66 MuscleHill.MuscleHill.w_TypeI

Definition at line 87 of file MuscleHill.py.

8.11.4.67 MuscleHill.MuscleHill.w_TypeII

Definition at line 89 of file MuscleHill.py.

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

- MuscleHill.py

8.12 MuscleNoHill.MuscleNoHill Class Reference

Public Member Functions

- def __init__ (self, conf, pool, MUnumber, MUtypeInumber, unit)
- def atualizeForce (self, activation_Sat)

  Compute the muscle force when no muscle dynamics (Hill model) is used.

Public Attributes

- conf
- pool
- MUnumber
- MUtypeInumber
- twTet

  Twitch- tetanus relationship (see atualizeForceNoHill function explanation)
- twitchAmp_N

  Amplitude of the muscle unit twitch, in N (see atualizeForceNoHill function explanation).
- maximumActivationForce

  This is used for normalization purposes.
- force

  Muscle force along time, in N.
- timeIndex

8.12.1 Detailed Description

Definition at line 10 of file MuscleNoHill.py.

8.12.2 Constructor & Destructor Documentation

8.12.2.1 def MuscleNoHill.MuscleNoHill.__init__ (*self*, *conf*, *pool*, *MUnumber*, *MUtypeInumber*, *unit*)

Definition at line 12 of file MuscleNoHill.py.

8.12.3 Member Function Documentation

8.12.3.1 def MuscleNoHill.MuscleNoHill.atualizeForce (*self*, *activation_Sat*)

Compute the muscle force when no muscle dynamics (Hill model) is used.

This operation is vectorized. Each element of the vectors correspond to one motor unit. For each motor unit, the force is computed by the following formula:

Definition at line 55 of file MuscleNoHill.py.

8.12.4 Member Data Documentation

8.12.4.1 MuscleNoHill.MuscleNoHill.conf

Definition at line 14 of file MuscleNoHill.py.

8.12.4.2 MuscleNoHill.MuscleNoHill.force

Muscle force along time, in N.

Definition at line 31 of file MuscleNoHill.py.

8.12.4.3 MuscleNoHill.MuscleNoHill.maximumActivationForce

This is used for normalization purposes.

It is the maximum force that the muscle reach when the Hill model is not used.

Definition at line 29 of file MuscleNoHill.py.

8.12.4.4 MuscleNoHill.MuscleNoHill.MUnumber

Definition at line 16 of file MuscleNoHill.py.

8.12.4.5 MuscleNoHill.MuscleNoHill.MUtypeInumber

Definition at line 17 of file MuscleNoHill.py.

8.12.4.6 MuscleNoHill.MuscleNoHill.pool

Definition at line 15 of file MuscleNoHill.py.

8.12.4.7 MuscleNoHill.MuscleNoHill.timeIndex

Definition at line 33 of file MuscleNoHill.py.

8.12.4.8 MuscleNoHill.MuscleNoHill.twitchAmp_N

Amplitude of the muscle unit twitch, in N (see atualizeForceNoHill function explanation).

Definition at line 22 of file MuscleNoHill.py.

8.12.4.9 MuscleNoHill.MuscleNoHill.twTet

Twitch- tetanus relationship (see atualizeForceNoHill function explanation)

Definition at line 20 of file MuscleNoHill.py.

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

- MuscleNoHill.py

8.13 MuscularActivation.MuscularActivation Class Reference

Public Member Functions

- def __init__ (self, conf, pool, MUnumber, unit)
- def atualizeActivationSignal (self, t, unit)

  Update the activation signal of the motor units.

Public Attributes

- conf
- pool
- MUnumber
- activationModel

  Model of the activation signal.
- ActMatrix

  Matrix that multiplied by the vector formed as the formula below gives the activation signal at instant n:

  $$Av(n) = \left[\begin{array}{cccccccccccc} a_1(n-1) & a_1(n-2) & e_1(n-1) & \ldots & a_i(n-i) & a_i(n-2) & e_i(n-1) & \ldots & a_{N_{MU}(n-1)} & a_{N_{MU}(n-2)} & e_{N_{MU}}(n-1) \end{array} \right]^T \tag{8.4}$$

  where $a_i(n)$ is the activation signal of the motor unit i, $e_i(n)$ is 1/T (inverse of simulation time step, Dirac's delta approximation) if the motor unit i, fired at instant n.
- an

  Is a vector formed as:

  $$Av(n) = \left[\begin{array}{cccccccccccc} a_1(n-1) & a_1(n-2) & e_1(n-1) & \ldots & a_i(n-i) & a_i(n-2) & e_i(n-1) & \ldots & a_{N_{MU}(n-1)} & a_{N_{MU}(n-2)} & e_{N_{MU}}(n-1) \end{array} \right]^T \tag{8.5}$$

  It is multiplied by the matriz actMatrix to obtain the activation signal (see actMatrix explanation)
- activation_nonSat

  The non-saturated activation signal of all motor units (see actMatrix explanation).
- bSat

  The parameter b (see twitchSaturation function explanation) of each motor unit.
- activation_Sat

  The non-saturated activation signal of all motor units (see actMatrix explanation).
- diracDeltaValue

  Dirac's delta approximation amplitude value.

8.13.1 Detailed Description

Definition at line 31 of file MuscularActivation.py.

8.13.2 Constructor & Destructor Documentation

8.13.2.1 def MuscularActivation.MuscularActivation.__init__ (*self, conf, pool, MUnumber, unit*)

Definition at line 34 of file MuscularActivation.py.

8.13.3 Member Function Documentation

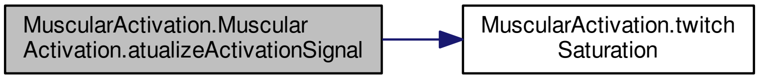
8.13.3.1 def MuscularActivation.MuscularActivation.atualizeActivationSignal (*self, t, unit*)

Update the activation signal of the motor units.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 109 of file MuscularActivation.py.

Here is the call graph for this function:



8.13.4 Member Data Documentation

8.13.4.1 MuscularActivation.MuscularActivation.activation_nonSat

The non-saturated activation signal of all motor units (see actMatrix explanation).

Definition at line 86 of file MuscularActivation.py.

8.13.4.2 MuscularActivation.MuscularActivation.activation_Sat

The non-saturated activation signal of all motor units (see actMatrix explanation).

Definition at line 97 of file MuscularActivation.py.

8.13.4.3 MuscularActivation.MuscularActivation.activationModel

Model of the activation signal.

For now, it can be *SOCDS* (second order critically damped system).

Definition at line 41 of file MuscularActivation.py.

8.13.4.4 MuscularActivation.MuscularActivation.ActMatrix

Matrix that multiplied by the vector formed as the formula below gives the activation signal at instant n:

$$Av(n) = \begin{bmatrix} a_1(n-1) & a_1(n-2) & e_1(n-1) & \ldots & a_i(n-i) & a_i(n-2) & e_i(n-1) & \ldots & a_{N_{MU}(n-1)} & a_{N_{MU}(n-2)} & e_{N_{MU}}(n-1) \end{bmatrix}^T \tag{8.6}$$

where $a_i(n)$ is the activation signal of the motor unit i, $e_i(n)$ is 1/T (inverse of simulation time step, Dirac's delta approximation) if the motor unit i, fired at instant n.

The vector Av is updated every step at the function atualizeActivationSignal. The activation matrix itself is formed as:

$$A=\begin{bmatrix} 2\exp\left(-\frac{T}{T_{c_1}}\right) & -\exp\left(-2\frac{T}{T_{c_1}}\right) & \frac{T^2}{T_{c_1}}\exp\left(1-\frac{T}{T_{c_1}}\right) & 0 & \ldots & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \ddots & \ldots & & & & & \ldots & 0 \\ 0 & \ldots & & 0 & 2\exp\left(-\frac{T}{T_{c_i}}\right) & -\exp\left(-2\frac{T}{T_{c_i}}\right) & \frac{T^2}{T_{c_i}}\exp\left(1-\frac{T}{T_{c_i}}\right) & 0 & & & 0 \\ 0 & 0 & \ldots & & & 0 & 0 & \ddots & 0 & 0 & \\ 0 & 0 & 0 & \ldots & & & & 0 & 2\exp\left(-\frac{T}{T_{c_{N_{MU}}}}\right) & -\exp\left(-2\frac{T}{T_{c_{N_{MU}}}}\right) & \frac{T^2}{T_{c_{MU}}}\exp\left(1-\frac{T}{T_{c_{N_{MU}}}}\right) \end{bmatrix} \tag{8.7}$$

The nonsaturated activation signal a of all the motor units is obtained with:

$$a = A.Av \tag{8.8}$$

where each elemement o a is the activation signal of a motor unit.

Definition at line 69 of file MuscularActivation.py.

8.13.4.5 MuscularActivation.MuscularActivation.an

Is a vector formed as:

$$Av(n) = \left[\begin{array}{cccccccccccc} a_1(n-1) & a_1(n-2) & e_1(n-1) & \ldots & a_i(n-i) & a_i(n-2) & e_i(n-1) & \ldots & a_{N_{MU}(n-1)} & a_{N_{MU}(n-2)} & e_{N_{MU}}(n-1) \end{array}\right]^T \quad (8.9)$$

It is multiplied by the matriz actMatrix to obtain the activation signal (see actMatrix explanation)

Definition at line 83 of file MuscularActivation.py.

8.13.4.6 MuscularActivation.MuscularActivation.bSat

The parameter b (see twitchSaturation function explanation) of each motor unit.

Definition at line 89 of file MuscularActivation.py.

8.13.4.7 MuscularActivation.MuscularActivation.conf

Definition at line 36 of file MuscularActivation.py.

8.13.4.8 MuscularActivation.MuscularActivation.diracDeltaValue

Dirac's delta approximation amplitude value.

Is the inverse of the simulation time step ($1/T$).

Definition at line 100 of file MuscularActivation.py.

8.13.4.9 MuscularActivation.MuscularActivation.MUnumber

Definition at line 38 of file MuscularActivation.py.

8.13.4.10 MuscularActivation.MuscularActivation.pool

Definition at line 37 of file MuscularActivation.py.

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

- MuscularActivation.py

8.14 NeuralTract.NeuralTract Class Reference

Class that implements a a neural tract, composed by the descending commands from the motor cortex.

Public Member Functions

- def __init__ (self, conf, pool)

    Constructor.
- def atualizePool (self, t)

    Update all neural tract units from the neural tract.
- def listSpikes (self)

    List the spikes that occurred in neural tract units.

Public Attributes

- kind

    Indicates that is a neural tract.
- pool

    String with the name of the Neural tract.
- Number

    The number of neural tract units.
- unit

    List of NeuralTRactUnit objects.
- GammaOrder
- poolTerminalSpikes

    Vector with the instants of spikes in the terminal, in ms.
- target

    Indicates the measure that the TargetFunction of the spikes follows.
- FR

    The mean firing rate of the neural tract units.
- timeIndex

8.14.1 Detailed Description

Class that implements a a neural tract, composed by the descending commands from the motor cortex.

Definition at line 15 of file NeuralTract.py.

8.14.2 Constructor & Destructor Documentation

8.14.2.1 def NeuralTract.NeuralTract.__init__ (*self*, *conf*, *pool*)

Constructor.

- Inputs:
    - **conf**: Configuration object with the simulation parameters.
    - **pool**: string with the name of the Neural tract.

Definition at line 26 of file NeuralTract.py.

8.14.3 Member Function Documentation

8.14.3.1 def NeuralTract.NeuralTract.atualizePool (*self*, *t*)

Update all neural tract units from the neural tract.

- Inputs:
  - **t**: cuurent instant, in ms.

Definition at line 67 of file NeuralTract.py.

8.14.3.2 def NeuralTract.NeuralTract.listSpikes (*self*)

List the spikes that occurred in neural tract units.

Definition at line 75 of file NeuralTract.py.

8.14.4 Member Data Documentation

8.14.4.1 NeuralTract.NeuralTract.FR

The mean firing rate of the neural tract units.

Definition at line 53 of file NeuralTract.py.

8.14.4.2 NeuralTract.NeuralTract.GammaOrder

Definition at line 37 of file NeuralTract.py.

8.14.4.3 NeuralTract.NeuralTract.kind

Indicates that is a neural tract.

Definition at line 28 of file NeuralTract.py.

8.14.4.4 NeuralTract.NeuralTract.Number

The number of neural tract units.

Definition at line 32 of file NeuralTract.py.

8.14.4.5 NeuralTract.NeuralTract.pool

String with the name of the Neural tract.

Definition at line 30 of file NeuralTract.py.

8.14.4.6 NeuralTract.NeuralTract.poolTerminalSpikes

Vector with the instants of spikes in the terminal, in ms.

Definition at line 42 of file NeuralTract.py.

8.14.4.7 NeuralTract.NeuralTract.target

Indicates the measure that the TargetFunction of the spikes follows.

For now ita can be *ISI* (interspike interval) or *FR* (firing rate).

Definition at line 46 of file NeuralTract.py.

8.14.4.8 NeuralTract.NeuralTract.timeIndex

Definition at line 56 of file NeuralTract.py.

8.14.4.9 NeuralTract.NeuralTract.unit

List of NeuralTRactUnit objects.

Definition at line 35 of file NeuralTract.py.

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

- NeuralTract.py

8.15 NeuralTractUnit.NeuralTractUnit Class Reference

Class that implements a neural tract unit.

Public Member Functions

- def __init__ (self, conf, pool, GammaOrder, index)

  Constructor.
- def atualizeNeuralTractUnit (self, t, FR)
- def transmitSpikes (self, t)

Public Attributes

- GammaOrder

    Integer order of the Gamma distribution.
- spikesGenerator

    A PointProcessGenerator object, corresponding the generator of spikes of the neural tract unit.
- terminalSpikeTrain

    List of the spikes of the neural tract unit.
- kind
- SynapsesOut
- transmitSpikesThroughSynapses
- indicesOfSynapsesOnTarget
- index

    Integer corresponding to the neural tract unit identification.

8.15.1 Detailed Description

Class that implements a neural tract unit.

It consists of a point process generator.

Definition at line 21 of file NeuralTractUnit.py.

8.15.2 Constructor & Destructor Documentation

8.15.2.1 def NeuralTractUnit.NeuralTractUnit.__init__ (*self, conf, pool, GammaOrder, index*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with the name of the Neural tract.
  - **index**: integer corresponding to the neural tract unit identification.

Definition at line 36 of file NeuralTractUnit.py.

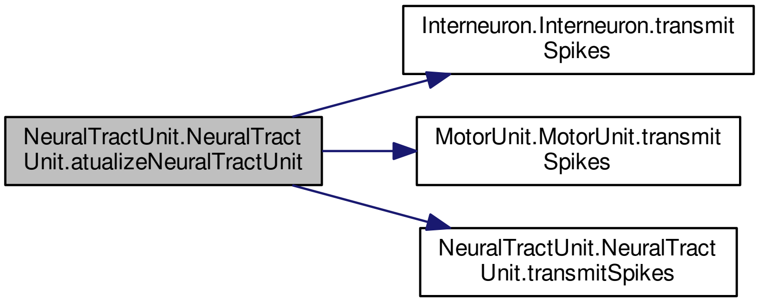
8.15.3 Member Function Documentation

8.15.3.1 def NeuralTractUnit.NeuralTractUnit.atualizeNeuralTractUnit (*self*, *t*, *FR*)

- Inputs:
  - **t**: current instant, in ms.
  - **FR**:

Definition at line 68 of file NeuralTractUnit.py.

Here is the call graph for this function:

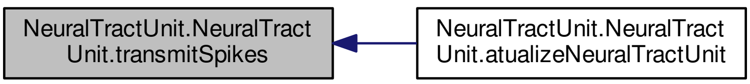


8.15.3.2 def NeuralTractUnit.NeuralTractUnit.transmitSpikes (*self*, *t*)

- Inputs:
  - **t**: current instant, in ms.

Definition at line 80 of file NeuralTractUnit.py.

Here is the caller graph for this function:



8.15.4 Member Data Documentation

8.15.4.1 NeuralTractUnit.NeuralTractUnit.GammaOrder

Integer order of the Gamma distribution.

Definition at line 39 of file NeuralTractUnit.py.

8.15.4.2 NeuralTractUnit.NeuralTractUnit.index

Integer corresponding to the neural tract unit identification.

Definition at line 57 of file NeuralTractUnit.py.

8.15.4.3 NeuralTractUnit.NeuralTractUnit.indicesOfSynapsesOnTarget

Definition at line 54 of file NeuralTractUnit.py.

8.15.4.4 NeuralTractUnit.NeuralTractUnit.kind

Definition at line 47 of file NeuralTractUnit.py.

8.15.4.5 NeuralTractUnit.NeuralTractUnit.spikesGenerator

A PointProcessGenerator object, corresponding the generator of spikes of the neural tract unit.

Definition at line 43 of file NeuralTractUnit.py.

8.15.4.6 NeuralTractUnit.NeuralTractUnit.SynapsesOut

Definition at line 52 of file NeuralTractUnit.py.

8.15.4.7 NeuralTractUnit.NeuralTractUnit.terminalSpikeTrain

List of the spikes of the neural tract unit.

Definition at line 45 of file NeuralTractUnit.py.

8.15.4.8 NeuralTractUnit.NeuralTractUnit.transmitSpikesThroughSynapses

Definition at line 53 of file NeuralTractUnit.py.

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

- NeuralTractUnit.py

8.16 object Class Reference

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

- NeuralTract.py

8.17 PointProcessGenerator.PointProcessGenerator Class Reference

Generator of point processes.

Public Member Functions

- def __init__ (self, GammaOrder, index)
  Constructor.
- def atualizeGenerator (self, t, firingRate)

Public Attributes

- GammaOrder
  Integer order of the Gamma distribution.
- GammaOrderInv
  Inverse of the GammaOrder.
- index
  Integer corresponding to the unit order in the pool to which this generator is associated.
- y
  Auxiliary variable cummulating a value that indicates whether there will be a new spike or not.
- threshold
  Spike threshold.
- points
  List of spike instants of the generator.

8.17.1 Detailed Description

Generator of point processes.

Definition at line 47 of file PointProcessGenerator.py.

8.17.2 Constructor & Destructor Documentation

8.17.2.1 def PointProcessGenerator.PointProcessGenerator.__init__ (*self, GammaOrder, index*)

Constructor.

- Inputs:
  - **GammaOrder**: integer order of the Gamma distribution.
  - **index**: integer corresponding to the unit order in the pool.

Definition at line 58 of file PointProcessGenerator.py.

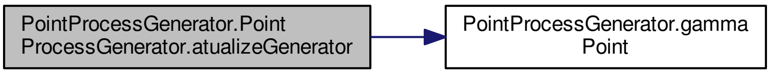
8.17.3 Member Function Documentation

8.17.3.1 def PointProcessGenerator.PointProcessGenerator.atualizeGenerator (*self*, *t*, *firingRate*)

- Inputs:
  - **t**: current instant, in ms.
  - **firingRate**: instant firing rate, in spikes/s.

Definition at line 87 of file PointProcessGenerator.py.

Here is the call graph for this function:



8.17.4 Member Data Documentation

8.17.4.1 PointProcessGenerator.PointProcessGenerator.GammaOrder

Integer order of the Gamma distribution.

Gamma order 1 is Poisson process and order 10 is a Gaussian process.

Definition at line 61 of file PointProcessGenerator.py.

8.17.4.2 PointProcessGenerator.PointProcessGenerator.GammaOrderInv

Inverse of the GammaOrder.

This is necessary for computational efficiency.

Definition at line 64 of file PointProcessGenerator.py.

8.17.4.3 PointProcessGenerator.PointProcessGenerator.index

Integer corresponding to the unit order in the pool to which this generator is associated.

Definition at line 67 of file PointProcessGenerator.py.

8.17.4.4 PointProcessGenerator.PointProcessGenerator.points

List of spike instants of the generator.

Definition at line 77 of file PointProcessGenerator.py.

8.17.4.5 PointProcessGenerator.PointProcessGenerator.threshold

Spike threshold.

When the auxiliary variable y reaches the value of threshold, there is a new spike.

Definition at line 75 of file PointProcessGenerator.py.

8.17.4.6 PointProcessGenerator.PointProcessGenerator.y

Auxiliary variable cummulating a value that indicates whether there will be a new spike or not.

Definition at line 71 of file PointProcessGenerator.py.

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

- PointProcessGenerator.py

8.18 PulseConductanceState.PulseConductanceState Class Reference

Implements the Destexhe pulse approximation of the solution of the states of the Hodgkin-Huxley neuron model.

Public Member Functions

- def __init__ (self, kind, conf, pool, neuronKind, index)
  Initializes the pulse conductance state.
- def changeState (self, t)
  Void function that modify the current situation (true/false) of the state.
- def computeStateValue (self, t)
  Compute the state value by using the approximation of Destexhe (1997) to compute the Hodgkin-Huxley states.

Public Attributes

- kind
- value
- v0
- t0
- state
- beta_ms1
- alpha_ms1
- PulseDur_ms
- actType
- computeValueOn
- computeValueOff

8.18.1 Detailed Description

Implements the Destexhe pulse approximation of the solution of the states of the Hodgkin-Huxley neuron model.

Definition at line 54 of file PulseConductanceState.py.

8.18.2 Constructor & Destructor Documentation

8.18.2.1 def PulseConductanceState.PulseConductanceState.__init__ (*self*, *kind*, *conf*, *pool*, *neuronKind*, *index*)

Initializes the pulse conductance state.

Variables: *kind* - type of the state(m, h, n, q). *conf* - an instance of the Configuration class with the functions to correctly parameterize the model. See the Configuration class. *pool* - the pool that this state belongs. *neuronKind* - *index* - the index of the unit that this state belongs.

Definition at line 66 of file PulseConductanceState.py.

8.18.3 Member Function Documentation

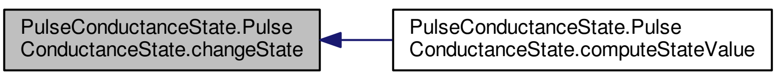
8.18.3.1 def PulseConductanceState.PulseConductanceState.changeState (*self*, *t*)

Void function that modify the current situation (true/false) of the state.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 105 of file PulseConductanceState.py.

Here is the caller graph for this function:



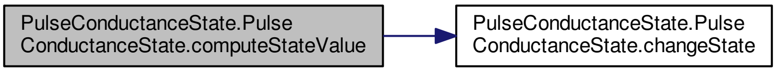
8.18.3.2 def PulseConductanceState.PulseConductanceState.computeStateValue (*self*, *t*)

Compute the state value by using the approximation of Destexhe (1997) to compute the Hodgkin-Huxley states.

- Input:
  - **t**: current instant, in ms.

Definition at line 117 of file PulseConductanceState.py.

Here is the call graph for this function:



8.18.4 Member Data Documentation

8.18.4.1 PulseConductanceState.PulseConductanceState.actType

Definition at line 81 of file PulseConductanceState.py.

8.18.4.2 PulseConductanceState.PulseConductanceState.alpha_ms1

Definition at line 77 of file PulseConductanceState.py.

8.18.4.3 PulseConductanceState.PulseConductanceState.beta_ms1

Definition at line 76 of file PulseConductanceState.py.

8.18.4.4 PulseConductanceState.PulseConductanceState.computeValueOff

Definition at line 91 of file PulseConductanceState.py.

8.18.4.5 PulseConductanceState.PulseConductanceState.computeValueOn

Definition at line 90 of file PulseConductanceState.py.

8.18.4.6 PulseConductanceState.PulseConductanceState.kind

Definition at line 67 of file PulseConductanceState.py.

8.18.4.7 PulseConductanceState.PulseConductanceState.PulseDur_ms

Definition at line 78 of file PulseConductanceState.py.

8.18.4.8 PulseConductanceState.PulseConductanceState.state

Definition at line 74 of file PulseConductanceState.py.

8.18.4.9 PulseConductanceState.PulseConductanceState.t0

Definition at line 72 of file PulseConductanceState.py.

8.18.4.10 PulseConductanceState.PulseConductanceState.v0

Definition at line 71 of file PulseConductanceState.py.

8.18.4.11 PulseConductanceState.PulseConductanceState.value

Definition at line 68 of file PulseConductanceState.py.

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

- PulseConductanceState.py

8.19 Synapse.Synapse Class Reference

Implements the synapse model from Destexhe (1994) using the computational method from Lytton (1996).

Public Member Functions

- def __init__ (self, conf, pool, index, compartment, kind, neuronKind)

  Constructor.

Public Attributes

- pool
- kind
- neuronKind
- EqPot_mV
- alpha_ms1
- beta_ms1
- Tmax_mM
- tPeak_ms

  Pulse duration, in ms.
- gmax_muS
- delay_ms
- dynamics
- variation
- timeConstant_ms
- gMaxTot_muS

  The sum of individual conductances of all synapses in the compartment, in μS ($G_{max} = \sum_{i=1}^N g_i$).
- numberOfIncomingSynapses
- rInf

  The fraction of postsynaptic receptors that would be bound to neurotransmitters after an infinite amount of time with neurotransmitter being released.
- tauOn

  Time constant during a pulse, in ms.
- tauOff

  Time constant after a pulse, in ms.
- expFinish

  Is the value of the exponential at the end of the pulse.
- Non

  Sum of the fractions of the individual conductances that are receiving neurotransmitter (during pulse) relative to the G_{max}.
- Ron

  Sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
- Roff

  Sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
- t0

  Instant that the last spike arrived to the compartment.
- conductanceState
- tBeginOfPulse
- tEndOfPulse
- tLastPulse
- ri

  List with the fractions of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.
- ti

  List with the instants of spike arriving at each conductance, in ms.
- dynamicGmax

8.19.1 Detailed Description

Implements the synapse model from Destexhe (1994) using the computational method from Lytton (1996).

Definition at line 323 of file Synapse.py.

8.19.2 Constructor & Destructor Documentation

8.19.2.1 def Synapse.Synapse.__init__ (*self, conf, pool, index, compartment, kind, neuronKind*)

Constructor.

- Input:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with identification of the pool to which the synapse belongs.
  - **index**: integer identification of the unit in the pool.
  - **compartment**: integer identification of the compartment of the unit where the synapse is.
  - **kind**: string with the type of synapse. It can be *excitatory* or *inhibitory*.
  - **neuronKind**:

Definition at line 343 of file Synapse.py.

8.19.3 Member Data Documentation

8.19.3.1 Synapse.Synapse.alpha_ms1

Definition at line 349 of file Synapse.py.

8.19.3.2 Synapse.Synapse.beta_ms1

Definition at line 350 of file Synapse.py.

8.19.3.3 Synapse.Synapse.conductanceState

Definition at line 400 of file Synapse.py.

8.19.3.4 Synapse.Synapse.delay_ms

Definition at line 356 of file Synapse.py.

8.19.3.5 Synapse.Synapse.dynamicGmax

Definition at line 412 of file Synapse.py.

8.19.3.6 Synapse.Synapse.dynamics

Definition at line 357 of file Synapse.py.

8.19.3.7 Synapse.Synapse.EqPot_mV

Definition at line 348 of file Synapse.py.

8.19.3.8 Synapse.Synapse.expFinish

Is the value of the exponential at the end of the pulse.

It is computed as $\exp(T_{dur}/\tau_{on})$.

Definition at line 380 of file Synapse.py.

8.19.3.9 Synapse.Synapse.gmax_muS

Definition at line 355 of file Synapse.py.

8.19.3.10 Synapse.Synapse.gMaxTot_muS

The sum of individual conductances of all synapses in the compartment, in μS ($G_{max} = \sum_{i=1}^{N} g_i$).

Definition at line 363 of file Synapse.py.

8.19.3.11 Synapse.Synapse.kind

Definition at line 345 of file Synapse.py.

8.19.3.12 Synapse.Synapse.neuronKind

Definition at line 346 of file Synapse.py.

8.19.3.13 Synapse.Synapse.Non

Sum of the fractions of the individual conductances that are receiving neurotransmitter (during pulse) relative to the G_{max}.

(

Definition at line 387 of file Synapse.py.

8.19.3.14 Synapse.Synapse.numberOfIncomingSynapses

Definition at line 364 of file Synapse.py.

8.19.3.15 Synapse.Synapse.pool

Definition at line 344 of file Synapse.py.

8.19.3.16 Synapse.Synapse.ri

List with the fractions of postsynaptic receptors that are bound to neurotransmitters of the individual synapses.

Definition at line 407 of file Synapse.py.

8.19.3.17 Synapse.Synapse.rInf

The fraction of postsynaptic receptors that would be bound to neurotransmitters after an infinite amount of time with neurotransmitter being released.

Definition at line 370 of file Synapse.py.

8.19.3.18 Synapse.Synapse.Roff

Sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).

Definition at line 396 of file Synapse.py.

8.19.3.19 Synapse.Synapse.Ron

Sum of the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).

Definition at line 391 of file Synapse.py.

8.19.3.20 Synapse.Synapse.t0

Instant that the last spike arrived to the compartment.

Definition at line 398 of file Synapse.py.

8.19.3.21 Synapse.Synapse.tauOff

Time constant after a pulse, in ms.

$\tau_{off} = \frac{1}{\beta}$

Definition at line 376 of file Synapse.py.

8.19.3.22 Synapse.Synapse.tauOn

Time constant during a pulse, in ms.

$\tau_{on} = \frac{1}{\alpha.T_{max}+\beta}$

Definition at line 373 of file Synapse.py.

8.19.3.23 Synapse.Synapse.tBeginOfPulse

Definition at line 401 of file Synapse.py.

8.19.3.24 Synapse.Synapse.tEndOfPulse

Definition at line 402 of file Synapse.py.

8.19.3.25 Synapse.Synapse.ti

List with the instants of spike arriving at each conductance, in ms.

Definition at line 410 of file Synapse.py.

8.19.3.26 Synapse.Synapse.timeConstant_ms

Definition at line 359 of file Synapse.py.

8.19.3.27 Synapse.Synapse.tLastPulse

Definition at line 403 of file Synapse.py.

8.19.3.28 Synapse.Synapse.Tmax_mM

Definition at line 351 of file Synapse.py.

8.19.3.29 Synapse.Synapse.tPeak_ms

Pulse duration, in ms.

Definition at line 353 of file Synapse.py.

8.19.3.30 Synapse.Synapse.variation

Definition at line 358 of file Synapse.py.

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

- Synapse.py

8.20 SynapsesFactory.SynapsesFactory Class Reference

Class to build all the synapses in the system.

Public Member Functions

- def __init__ (self, conf, pools)

  Constructor.

Public Attributes

- numberOfSynapses

  Total number of synapses in the system.

8.20.1 Detailed Description

Class to build all the synapses in the system.

Definition at line 18 of file SynapsesFactory.py.

8.20.2 Constructor & Destructor Documentation

8.20.2.1 def SynapsesFactory.SynapsesFactory.__init__ (*self, conf, pools*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pools**: list of all the pools in the system.

Definition at line 32 of file SynapsesFactory.py.

8.20.3 Member Data Documentation

8.20.3.1 SynapsesFactory.SynapsesFactory.numberOfSynapses

Total number of synapses in the system.

Definition at line 34 of file SynapsesFactory.py.

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

- SynapsesFactory.py

8.21 SynapticNoise.SynapticNoise Class Reference

Class that implements a synaptic noise for a pool of neurons.

Public Member Functions

- def __init__ (self, conf, pool)

  Constructor.
- def atualizePool (self, t)

  Update all neural tract units from the neural tract.
- def listSpikes (self)

  List the spikes that occurred in neural tract units.

Public Attributes

- kind

  Indicates that is a neural tract.
- pool

  String with the name of the pool.
- Number

  The number of neural tract units.
- unit

  List of NeuralTractUnit objects.
- GammaOrder
- poolTerminalSpikes

  Vector with the instants of spikes in the terminal, in ms.
- target

  Indicates the measure that the TargetFunction of the spikes follows.
- FR

  The mean firing rate of the neural tract units.
- timeIndex

8.21.1 Detailed Description

Class that implements a synaptic noise for a pool of neurons.

Definition at line 14 of file SynapticNoise.py.

8.21.2 Constructor & Destructor Documentation

8.21.2.1 def SynapticNoise.SynapticNoise.__init__ (*self*, *conf*, *pool*)

Constructor.

- Inputs:
  - **conf**: Configuration object with the simulation parameters.
  - **pool**: string with the name of the pool.

Definition at line 25 of file SynapticNoise.py.

8.21.3 Member Function Documentation

8.21.3.1 def SynapticNoise.SynapticNoise.atualizePool (*self*, *t*)

Update all neural tract units from the neural tract.

- Inputs:
  - **t**: current instant, in ms.

Definition at line 67 of file SynapticNoise.py.

8.21.3.2 def SynapticNoise.SynapticNoise.listSpikes (*self*)

List the spikes that occurred in neural tract units.

Definition at line 77 of file SynapticNoise.py.

8.21.4 Member Data Documentation

8.21.4.1 SynapticNoise.SynapticNoise.FR

The mean firing rate of the neural tract units.

Definition at line 52 of file SynapticNoise.py.

8.21.4.2 SynapticNoise.SynapticNoise.GammaOrder

Definition at line 36 of file SynapticNoise.py.

8.21.4.3 SynapticNoise.SynapticNoise.kind

Indicates that is a neural tract.

Definition at line 27 of file SynapticNoise.py.

8.21.4.4 SynapticNoise.SynapticNoise.Number

The number of neural tract units.

Definition at line 31 of file SynapticNoise.py.

8.21.4.5 SynapticNoise.SynapticNoise.pool

String with the name of the pool.

Definition at line 29 of file SynapticNoise.py.

8.21.4.6 SynapticNoise.SynapticNoise.poolTerminalSpikes

Vector with the instants of spikes in the terminal, in ms.

Definition at line 41 of file SynapticNoise.py.

8.21.4.7 SynapticNoise.SynapticNoise.target

Indicates the measure that the TargetFunction of the spikes follows.

For now it can be *ISI* (interspike interval) or *FR* (firing rate).

Definition at line 45 of file SynapticNoise.py.

8.21.4.8 SynapticNoise.SynapticNoise.timeIndex

Definition at line 55 of file SynapticNoise.py.

8.21.4.9 SynapticNoise.SynapticNoise.unit

List of NeuralTractUnit objects.

Definition at line 34 of file SynapticNoise.py.

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

- SynapticNoise.py

Chapter 9

File Documentation

9.1 AxonDelay.py File Reference

Classes

- class AxonDelay.AxonDelay
  Class that implements a delay correspondent to the nerve.

Namespaces

- AxonDelay

9.2 ChannelConductance.py File Reference

Classes

- class ChannelConductance.ChannelConductance
  Class that implements a model of the ionic Channels in a compartment.

Namespaces

- ChannelConductance

9.3 Compartment.py File Reference

Classes

- class Compartment.Compartment
  Class that implements a neural compartment.

Namespaces

- Compartment

Functions

- def Compartment.calcGLeak (area, specificRes)
  Computes the leak conductance of the compartment.

9.4 Configuration.py File Reference

Classes

- class Configuration.Configuration
  Class that builds an object of Configuration, based on a configuration file.

Namespaces

- Configuration

9.5 Interneuron.py File Reference

Classes

- class Interneuron.Interneuron
  Class that implements a motor unit model.

Namespaces

- Interneuron

Functions

- def Interneuron.runge_kutta (derivativeFunction, t, x, timeStep, timeStepByTwo, timeStepBySix)
  Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

9.6 InterneuronPool.py File Reference

Classes

- class InterneuronPool.InterneuronPool
  Class that implements a motor unit pool.

Namespaces

- InterneuronPool

9.7 jointAnkleForceTask.py File Reference

Classes

- class jointAnkleForceTask.jointAnkleForceTask

Namespaces

- jointAnkleForceTask

9.8 jointAnklePositionTask.py File Reference

Classes

- class jointAnklePositionTask.jointAnklePositionTask

Namespaces

- jointAnklePositionTask

9.9 MotorUnit.py File Reference

Classes

- class MotorUnit.MotorUnit

  Class that implements a motor unit model.

Namespaces

- MotorUnit

Functions

- def MotorUnit.calcGCoupling (cytR, lComp1, lComp2, dComp1, dComp2)

  Calculates the coupling conductance between two compartments.
- def MotorUnit.compGCouplingMatrix (gc)

  Computes the Coupling Matrix to be used in the dVdt function of the N compartments of the motor unit.
- def MotorUnit.runge_kutta (derivativeFunction, t, x, timeStep, timeStepByTwo, timeStepBySix)

  Function to implement the fourth order Runge-Kutta Method to solve numerically a differential equation.

9.10 MotorUnitPool.py File Reference

Classes

- class MotorUnitPool.MotorUnitPool
  Class that implements a motor unit pool.

Namespaces

- MotorUnitPool

9.11 MuscleHill.py File Reference

Classes

- class MuscleHill.MuscleHill

Namespaces

- MuscleHill

9.12 MuscleNoHill.py File Reference

Classes

- class MuscleNoHill.MuscleNoHill

Namespaces

- MuscleNoHill

9.13 MuscularActivation.py File Reference

Classes

- class MuscularActivation.MuscularActivation

Namespaces

- MuscularActivation

Functions

- def MuscularActivation.twitchSaturation (activationsat, b)
  Computes the muscle unit force after the nonlinear saturation.

9.14 NeuralTract.py File Reference

Classes

- class NeuralTract.NeuralTract
  Class that implements a a neural tract, composed by the descending commands from the motor cortex.

Namespaces

- NeuralTract

9.15 NeuralTractUnit.py File Reference

Classes

- class NeuralTractUnit.NeuralTractUnit
  Class that implements a neural tract unit.

Namespaces

- NeuralTractUnit

9.16 PointProcessGenerator.py File Reference

Classes

- class PointProcessGenerator.PointProcessGenerator
  Generator of point processes.

Namespaces

- PointProcessGenerator

Functions

- def PointProcessGenerator.gammaPoint (GammaOrder, GammaOrderInv)
  *Generates a number according to a Gamma Distribution with an integer order **GammaOrder**.*

9.17 PulseConductanceState.py File Reference

Classes

- class PulseConductanceState.PulseConductanceState

  Implements the Destexhe pulse approximation of the solution of the states of the Hodgkin-Huxley neuron model.

Namespaces

- PulseConductanceState

Functions

- def PulseConductanceState.compValOn (v0, alpha, beta, t, t0)

  Time course of the state during the pulse for the inactivation states and before and after the pulse for the activation states.
- def PulseConductanceState.compValOff (v0, alpha, beta, t, t0)

  Time course of the state during the pulse for the activation states and before and after the pulse for the inactivation states.

9.18 README.md File Reference

9.19 simulation.py File Reference

Namespaces

- simulation

Functions

- def simulation.simulator ()

9.20 Synapse.py File Reference

Classes

- class Synapse.Synapse

  Implements the synapse model from Destexhe (1994) using the computational method from Lytton (1996).

Namespaces

- Synapse

Functions

- def Synapse.compSynapCond (Gmax, Ron, Roff)

  Computes the synaptic conductance.
- def Synapse.compRon (Non, rInf, Ron, t0, t, tauOn)

  Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that have neurotransmitters being released (during the pulse).
- def Synapse.compRoff (Roff, t0, t, tauOff)

  Computes the fraction of postsynaptic receptors that are bound to neurotransmitters of all the individual synapses that do not have neurotransmitters being released (before and after the pulse).
- def Synapse.compRiStart (ri, t, ti, tPeak, tauOff)

  Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter begin (begin of the pulse).
- def Synapse.compRiStop (rInf, ri, expFinish)

  Computes the fraction of bound postsynaptic receptors to neurotransmitters in individual synapses when the neurotransmitter release stops (the pulse ends).
- def Synapse.compRonStart (Ron, ri, synContrib)

  Incorporates a new conductance to the set of conductances during a pulse.
- def Synapse.compRoffStart (Roff, ri, synContrib)

  Incorporates a new conductance to the set of conductances that are not during a pulse.
- def Synapse.compRonStop (Ron, ri, synContrib)

  Removes a conductance from the set of conductances during a pulse.
- def Synapse.compRoffStop (Roff, ri, synContrib)

  Removes a conductance from the set of conductances that are not during a pulse.
- def Synapse.compDynamicGmax (t, gmax, lastPulse, tau, dynamicGmax, var)

9.21 SynapsesFactory.py File Reference

Classes

- class SynapsesFactory.SynapsesFactory

  Class to build all the synapses in the system.

Namespaces

- SynapsesFactory

9.22 SynapticNoise.py File Reference

Classes

- class SynapticNoise.SynapticNoise

  Class that implements a synaptic noise for a pool of neurons.

Namespaces

- SynapticNoise