Software for Cell Simulation

Results 1 - 10 of about 344,000 for action potential simulation software

1. Propagated Action Potential
   This program simulates the generation and propagation of the action potential by solving the Hodgkin and Huxley (HH) model for the space-clamped membrane ...

2. nerve.bsd.uchicago.edu/nerve1.html - 7k - Cached - Similar pages -

iROCKET Learning Module: Cardiac Action Potential Simulator

The Cardiac Action Potential Simulator aims to conduct a graphical review of cardiac membrane physiology and to demonstrate the effects of common ...

missinglink.ucsf.edu/lm/cardiac_action_potential_sim/ - 10k

Simulation of developmental changes in action potentials with ...

Computational Challenges in Cell Simulation: A Software Engineering Approach - Article/Reference Simulation of developmental changes in action potentials ...

www.e-cell.org/e-cell/bibliographyfolder/itoh_simulation 2007 - 53k

Software for characterizing the ionic basis of the molluscan ...

Simulation software will be useful for developing hypotheses ... Recordings of action potentials in the molluscan cardiac muscle by use of the single- ...

Computing Action Potentials

Compute new ion currents
\[
[i_{\text{Na}(i)}, g_{\text{Na}(i)}, m_{\text{Na}}, h_{\text{Na}}, j_{\text{Na}}] = I_{\text{Na}}(V(i), th, m_{\text{Na}}, h_{\text{Na}}, j_{\text{Na}}); \\
[i_{\text{si}(i)}, g_{\text{si}(i)}, m_{\text{si}}, h_{\text{si}}] = I_{\text{si}}(V(i), th, m_{\text{si}}, h_{\text{si}}); \\
[i_{K}(i), g_{K}(i), m_{K}] = I_{K}(V(i), th, m_{K}); \\
[i_{K1}(i), g_{K1}(i), h_{\text{t}}, \tau_{ht}] = I_{K1}(V(i)); \\
[i_{Kp}(i), g_{Kp}(i)] = I_{Kp}(V(i)); \\
[i_{b}(i), g_{b}(i)] = I_{b}(V(i));
\]

Compute total current (Id = stimulus)
\[
I = I_{d} + i_{\text{Na}}(i) + i_{\text{si}}(i) + i_{K}(i) + i_{K1}(i) + i_{Kp}(i) + i_{b}(i);
\]

Compute incremental voltage change
\[
dV = -I/C_{m};
\]

Update value of voltage and time
\[
V(i+1) = V(i) + dV*th; \\
t(i+1) = t(i) + th;
\]

Increment counter
\[
i = i+1;
\]

Computing the Currents: IKp (plateau)

\[
i_{Kp} = g_{Kp}K_{p}(V_{m} - E_{K})
\]

\[
K_{p} = \frac{1}{1 + e^{\frac{7.488 - V_{m}}{5.98}}}
\]

function [I,gKp] = IKp(V)
\%
I_{Kp} Plateau potassium current
\%
I = I_{Kp}(V)
\%
g_{Kp} conductance
\%
V membrane potential (mV)
\%
Reference: QN:Luo94a
\%
global R T F K_o K_i;
\%
G_{Kp} = 0.0183;
\%
E_{Kp} = (R*T/F)*log(K_o/K_i);
\%
umTimeStep = length(V);
\%
for i=1:numTimeStep
\%
Kp = 1/(1+exp((7.488-V(i))/5.98));
\%
gKp(i) = G_{Kp}*Kp;
\%
I(i) = gKp(i)*(V(i)-E_{Kp});
\%
end
Computing the Currents: IK (time dependent)

\[ i_K = g_K m h (V_m - E_K) \]

\[ g_K = g_K \sqrt{\frac{[K^+]_e}{5.4}} \]

\[ h = 1.0 \]

\[ h = 2.837 \frac{e^{0.04(V_m+77)} - 1}{(V_m + 77)e^{0.04(V_m+35)}} \]

function [I,gK,mm] = IK(V,th,m)
GK_ = 0.282*sqrt(K_o/5.4);  % millisiemens/uF
EK = (R*T/F)*log((K_o+PNa_K*Na_o)/(K_i+PNa_K*Na_i));  % mV
if V > -100
    h = 2.837*(exp(0.04*(V+77))-1)/(exp(0.04*(V+35)));
else
    h = 1;
end

gK = GK_*m*h;
I = gK*(V-EK);

Computing the Currents: IK activation

\[ m = m_{\infty}(v_o) - (m_{\infty}(v_o) - m_0)e^{-t/\tau_m(v_o)} \]

\[ \tau_m = \frac{1}{\alpha_m(V) + \beta_m(V)} \]

\[ m_{\infty} = \frac{\alpha_m(V)}{\alpha_m(V) + \beta_m(V)} \]

\[ \alpha_m = 0.0005 \left( \frac{e^{0.083(V_m+50)}}{1 + e^{0.057(V_m+50)}} \right) \]

\[ \beta_m = 0.0013 \left( \frac{e^{-0.06(V_m+20)}}{1 + e^{-0.04(V_m+20)}} \right) \]

am = 0.0005*exp(0.083*(V+50))/(1+exp(0.057*(V+50)));
bm = 0.0013*exp(-0.06*(V+20))/(1+exp(-0.04*(V+20)));

minf = am/(am+bm);
taum = 1/(am+bm);

mm = minf - (minf-m)*exp(-th/taum);
**Computing the Currents: IK1**

(time independent)

\[
i_{K1} = g_{K1}K_{1\infty}(V_m - E_K)
\]

\[
g_{K1} = gK1 \sqrt{\frac{[K^+]_e}{5.4}}
\]

\[
K_{1\infty} = \frac{\alpha_{K1}}{\alpha_{K1} + \beta_{K1}}
\]

```matlab
function [I,gK1,hinf,tauh] = IK1(V)

GK1_ = 0.6047*sqrt(K_o/5.4);
EK1 = (R*T/F)*log(K_o/K_i);
numTimeStep = length(V);

for i=1:numTimeStep
    ah(i) = 1.02/(1+exp(0.2385*(V(i)-EK1-59.215)));
    bh(i) = (0.49124*exp(0.08032*(V(i)-EK1+5.476)) + ...
                   exp(0.06175*(V(i)-EK1-594.31)))/ (1+exp(-0.5143*(V(i)-EK1+4.753)));
    hinf(i) = ah(i)/(ah(i)+bh(i));
    tauh(i) = 1/(ah(i)+bh(i));
    gK1(i) = GK1_*hinf(i);
    I(i) = gK1(i)*(V(i)-EK1);
end
```

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**Optimization of Code**

- **Time step**

```matlab
I = I_d + I_Na(i) + I_{isi(i)} + I_{K1(i)} + I_{Kp}(i) + I_{ib}(i);
v = v/C_m;
th = TSmin*dVmax/abs(dV);
if th > Tmax
    th = Tmax;
elseif th < Tmin
    th = Tmin;
end
```

http://thevirtualheart.org/

Virtual Heart Examples

Nerve Action Potential
Virtual Heart Examples
Cardiac Action Potential

LabHeart
http://www.labheart.org
CellML

- www.cellml.org
- Standardized interface to cell simulations
- Includes geometry, electrophysiology and signal transduction
- Based on markup language (ML) standards
- Part of larger set of ML’s for simulation

HH Model in CellML structure

CellML Luo-Rudy II

- Additional complexity hidden from user
- Software layer provides interface from user to CellML functions
CellML + JSim

- Tcl script based interface to CellML functions

J-Sim