

# Sample multi compartment Izhikevich models

Saturday, March 7, 2015

As Giorgio mentioned, the compartmental layouts are fixed. We only have six possibilities for compartment layouts:



As for the parameters, in addition to the 9 parameters for each compartment, we also search for the coupling constants (2 asymmetric constants between 2 compartments), but we keep the resting voltage same for all compartments.

No. of comps.	No. of model parameters to optimize
1	9
2	19
3	29
4	39

To constrain the somatic compartment, we use the features such as the latency to first spike, Inter spike intervals, spike frequency adaptation etc. Dendritic compartment constraints: (i) less excitable dendritic compartments than soma and (ii) Adequate spike propagation and sub-threshold signal propagation in forward direction (dendritic to somatic). I am giving below four sample models (voltage traces are attached to the email).

Model	Parameters	Voltage traces							
1C model <div><math display="block">C \cdot \frac{dv}{dt} = k (v - v_r)(v - v_t) - u + I</math><math display="block">\frac{du}{dt} = a \{b(v - v_r) - u\}</math><math display="block">\text{if } v \geq V_{peak} \text{ then } v \leftarrow v_{min}, \text{ and } u \leftarrow u + d</math></div>	<div>Stratum Pyramidale</div> <div>k=1.6175288 a=0.0026112248 b=3.2574465 d=112.0 C=585.0*pF vR=-57.704437*mV vT=-32.899765*mV vPeak=39.38199*mV vMin=-43.484097*mV</div>	Fig. 1C  A: I = 294pA (from 100ms to 900ms) B: I = 590pA (from 100ms to 900ms)							
2C model  SR==SP	<table><tr><th>SR</th><th>SP (somatic)</th></tr><tr><td>k1=1.6008363 a1=0.17450932 b1=7.815573 d1=35.0 C1=571.0*pF vR1=-58.49131*mV vT1=-21.502506*mV vPeak1=19.81091*mV vMin1=-42.792007*mV  Coupling: G1=72.0*nS P1=0.48559585  G1*P1 towards SP</td><td>k0=2.1039069 a0=0.002563211 b0=-0.4604759 d0=127.0 C0=573.0*pF vR0=-58.49131*mV vT0=-45.993732*mV vPeak0=21.638206*mV vMin0=-52.090427*mV  Coupling: G1*(1-P1) towards SR</td></tr></table>	SR	SP (somatic)	k1=1.6008363 a1=0.17450932 b1=7.815573 d1=35.0 C1=571.0*pF vR1=-58.49131*mV vT1=-21.502506*mV vPeak1=19.81091*mV vMin1=-42.792007*mV  Coupling: G1=72.0*nS P1=0.48559585  G1*P1 towards SP	k0=2.1039069 a0=0.002563211 b0=-0.4604759 d0=127.0 C0=573.0*pF vR0=-58.49131*mV vT0=-45.993732*mV vPeak0=21.638206*mV vMin0=-52.090427*mV  Coupling: G1*(1-P1) towards SR	Fig. 2C  'I_inj' denotes the compartment of current injection. A: I = 308pA (from 100ms to 900ms) B: I = 597pA (from 100ms to 900ms) C: I = 88pA (from 100ms to 600ms), compartments decoupled D: I = 710pA (from 100ms to 600ms), compartments decoupled E: I = 1900pA (from 100ms to 600ms)			
SR	SP (somatic)								
k1=1.6008363 a1=0.17450932 b1=7.815573 d1=35.0 C1=571.0*pF vR1=-58.49131*mV vT1=-21.502506*mV vPeak1=19.81091*mV vMin1=-42.792007*mV  Coupling: G1=72.0*nS P1=0.48559585  G1*P1 towards SP	k0=2.1039069 a0=0.002563211 b0=-0.4604759 d0=127.0 C0=573.0*pF vR0=-58.49131*mV vT0=-45.993732*mV vPeak0=21.638206*mV vMin0=-52.090427*mV  Coupling: G1*(1-P1) towards SR								
3C model  SR==SP==SO	<table><tr><th>SR</th><th>SP (somatic)</th><th>SO</th></tr><tr><td>k1=1.2633001 a1=1.0446243 b1=11.087972 d1=62.0 C1=555.0*pF vR1=-59.66081*mV vT1=-22.832573*mV vPeak1=27.636889*mV vMin1=-29.978874*mV  Coupling: G1=26.0*nS P1=0.8004273  G1*P1 towards SP</td><td>k0=3.9752178 a0=0.0014259194 b0=-11.811985 d0=106.0 C0=551.0*pF vR0=-59.66081*mV vT0=-53.16855*mV vPeak0=34.926968*mV vMin0=-54.317677*mV  Coupling: G1*(1-P1) towards SR G2*(1-P2) towards SO</td><td>k2=1.2054616 a2=0.45259273 b2=3.1462605 d2=62.0 C2=353.0*pF vR2=-59.66081*mV vT2=-17.870737*mV vPeak2=26.31883*mV vMin2=-34.255947*mV  Coupling: G2=43.0*nS P2=0.69688535  G2*P2 towards SP</td></tr></table>	SR	SP (somatic)	SO	k1=1.2633001 a1=1.0446243 b1=11.087972 d1=62.0 C1=555.0*pF vR1=-59.66081*mV vT1=-22.832573*mV vPeak1=27.636889*mV vMin1=-29.978874*mV  Coupling: G1=26.0*nS P1=0.8004273  G1*P1 towards SP	k0=3.9752178 a0=0.0014259194 b0=-11.811985 d0=106.0 C0=551.0*pF vR0=-59.66081*mV vT0=-53.16855*mV vPeak0=34.926968*mV vMin0=-54.317677*mV  Coupling: G1*(1-P1) towards SR G2*(1-P2) towards SO	k2=1.2054616 a2=0.45259273 b2=3.1462605 d2=62.0 C2=353.0*pF vR2=-59.66081*mV vT2=-17.870737*mV vPeak2=26.31883*mV vMin2=-34.255947*mV  Coupling: G2=43.0*nS P2=0.69688535  G2*P2 towards SP	Fig. 3C  'I_inj' denotes the compartment of current injection. A: I = 306pA (from 100ms to 900ms) B: I = 590pA (from 100ms to 900ms)  C through E: compartments decoupled C: I = 37pA (from 100ms to 600ms) D: I = 667pA (from 100ms to 600ms) E: I = 598pA (from 100ms to 600ms)  F: I = 1200pA (from 100ms to 600ms) G: I = 1100pA (from 100ms to 600ms)	
SR	SP (somatic)	SO							
k1=1.2633001 a1=1.0446243 b1=11.087972 d1=62.0 C1=555.0*pF vR1=-59.66081*mV vT1=-22.832573*mV vPeak1=27.636889*mV vMin1=-29.978874*mV  Coupling: G1=26.0*nS P1=0.8004273  G1*P1 towards SP	k0=3.9752178 a0=0.0014259194 b0=-11.811985 d0=106.0 C0=551.0*pF vR0=-59.66081*mV vT0=-53.16855*mV vPeak0=34.926968*mV vMin0=-54.317677*mV  Coupling: G1*(1-P1) towards SR G2*(1-P2) towards SO	k2=1.2054616 a2=0.45259273 b2=3.1462605 d2=62.0 C2=353.0*pF vR2=-59.66081*mV vT2=-17.870737*mV vPeak2=26.31883*mV vMin2=-34.255947*mV  Coupling: G2=43.0*nS P2=0.69688535  G2*P2 towards SP							

4C model					Fig. 4C									
SLM==SR==SP==SO	<table><tr><th>SLM</th><th>SR</th><th>SP (somatic)</th><th>SO</th></tr><tr><td>k3=2.2577047 a3=0.32122386 b3=0.14995363 d3=69.0 C3=425.0*pF vR3=-59.101414*mV vT3=-25.137894*mV vPeak3=13.203414 *mV vMin3=-38.54892*mV</td><td>k2=1.1705916 a2=0.2477681 b2=3.3198094 d2=24.0 C2=367.0*pF vR2=-59.101414*mV vT2=-44.298294*mV vPeak2=20.274296 *mV vMin2=-46.076824 *mV</td><td>k0=2.3330991 a0=0.0021014998 b0=-0.41361538 d0=109.0 C0=550.0*pF vR0=-59.101414*mV vT0=-50.428886*mV vPeak0=24.98698*mV vMin0=-53.223213 *mV</td><td>k1=1.109572 a1=0.29814243 b1=-4.385603 d1=21.0 C1=225.0*pF vR1=-59.101414*mV vT1=-36.55802*mV vPeak1=21.473854 *mV vMin1=-40.343994 *mV</td></tr><tr><td>Coupling: G3=56.0*nS P3=0.90131694  G3*P3 towards SR</td><td>Coupling: G2=33.0*nS P2=0.86049455  G2*P2 towards SP G3*(1-P3) towards SLM</td><td>Coupling: G1*(1-P1) towards SO G2*(1-P2) towards SR</td><td>Coupling: G1=166.0*nS P1=0.29601815  G1*P1 towards SP</td></tr></table>	SLM	SR	SP (somatic)			SO	k3=2.2577047 a3=0.32122386 b3=0.14995363 d3=69.0 C3=425.0*pF vR3=-59.101414*mV vT3=-25.137894*mV vPeak3=13.203414 *mV vMin3=-38.54892*mV	k2=1.1705916 a2=0.2477681 b2=3.3198094 d2=24.0 C2=367.0*pF vR2=-59.101414*mV vT2=-44.298294*mV vPeak2=20.274296 *mV vMin2=-46.076824 *mV	k0=2.3330991 a0=0.0021014998 b0=-0.41361538 d0=109.0 C0=550.0*pF vR0=-59.101414*mV vT0=-50.428886*mV vPeak0=24.98698*mV vMin0=-53.223213 *mV	k1=1.109572 a1=0.29814243 b1=-4.385603 d1=21.0 C1=225.0*pF vR1=-59.101414*mV vT1=-36.55802*mV vPeak1=21.473854 *mV vMin1=-40.343994 *mV	Coupling: G3=56.0*nS P3=0.90131694  G3*P3 towards SR	Coupling: G2=33.0*nS P2=0.86049455  G2*P2 towards SP G3*(1-P3) towards SLM	Coupling: G1*(1-P1) towards SO G2*(1-P2) towards SR
SLM	SR	SP (somatic)	SO											
k3=2.2577047 a3=0.32122386 b3=0.14995363 d3=69.0 C3=425.0*pF vR3=-59.101414*mV vT3=-25.137894*mV vPeak3=13.203414 *mV vMin3=-38.54892*mV	k2=1.1705916 a2=0.2477681 b2=3.3198094 d2=24.0 C2=367.0*pF vR2=-59.101414*mV vT2=-44.298294*mV vPeak2=20.274296 *mV vMin2=-46.076824 *mV	k0=2.3330991 a0=0.0021014998 b0=-0.41361538 d0=109.0 C0=550.0*pF vR0=-59.101414*mV vT0=-50.428886*mV vPeak0=24.98698*mV vMin0=-53.223213 *mV	k1=1.109572 a1=0.29814243 b1=-4.385603 d1=21.0 C1=225.0*pF vR1=-59.101414*mV vT1=-36.55802*mV vPeak1=21.473854 *mV vMin1=-40.343994 *mV											
Coupling: G3=56.0*nS P3=0.90131694  G3*P3 towards SR	Coupling: G2=33.0*nS P2=0.86049455  G2*P2 towards SP G3*(1-P3) towards SLM	Coupling: G1*(1-P1) towards SO G2*(1-P2) towards SR	Coupling: G1=166.0*nS P1=0.29601815  G1*P1 towards SP											