Short-Term Depression

Wang–Buzsáki (WB) Reduced Traub-Miles(RTM)

$$C_m \frac{dv}{dt} = -I_{Na} - I_K - I_L - I_{syn} + I_{app}$$

$$I_{Na} = g_{Na} m_\infty^3 h(v - E_{Na}),$$

$$\frac{dh}{dt} = \alpha_h(1-h) - \beta_h h$$

$$m_\infty = \alpha_m/(\alpha_m + \beta_m)$$

$$\begin{aligned} \alpha_m &= -0.1(v+35)/(\exp(-0.1(v+35))-1), \\ \alpha_h &= 0.07\exp(-(v+58)/20), \\ \beta_m &= 4\exp(-(v+60)/18), \\ \beta_h &= 1/(\exp(-0.1(v+28))+1), \end{aligned}$$

$$I_K = g_K n^4 (v - E_K)$$

$$\frac{dn}{dt} = \alpha_n(1-n) - \beta_n n$$

$$\begin{aligned} \alpha_n &= -0.01(v+34)/(\exp(-0.1(v+34))-1), \\ \beta_n &= 0.125\exp(-(v+44)/80). \end{aligned}$$

$$I_L = g_L(v - E_L),$$

$$I_{syn} = \bar{g}_{syn}\, s(t)\,(V_{rev} - V_{post})$$

$$\frac{ds}{dt} = q\,\frac{(1-s)}{\tau_r} - \frac{s}{\tau_d}$$

$$\frac{dp}{dt} = \frac{1-(p+q)}{\tau_{rec}} - \gamma_1 \varepsilon \partial \left(1+\tanh\frac{v}{1.}\right) p \ln \frac{1}{1-U}$$

$$\frac{dq}{dt} = -\frac{q}{\tau_{d,q}} + \gamma_1 \varepsilon \partial \left(1+\tanh\frac{v}{1.}\right) p \ln \frac{1}{1-U}$$

```
clc;%Clear Command Window
clear;%Remove items from workspace,freeing up system memory
clf;%Clear current figure window

g_k=9;   g_na=35;    g_l=0.1;

v_k=-90;  v_na=55;    v_l=-65;

c=1;

U=0.5;
C=1.25;

tau_rec=500;    tau_d_q=5;    tau_r=3;tau_d=9;

i_ext=0.5;

t_final=200;
dt=0.01;
dt05=dt/2;
m_steps=round(t_final/dt);

z=zeros(m_steps+1,1);
v=z; m=z; h=z; n=z; p=z; q=z; s=z;

v(1)=-70;
m(1)=m_inf(v(1));
h(1)=h_inf(v(1));
n(1)=n_inf(v(1));

p(1)=1;
q(1)=0;
s(1)=0;

num_spikes=0;
```

Table S1: Parameters for Wang-Buzsáki neurons.

parameter	value
g_L	0.1 (mS/cm^2)
g_{Na}	35 (mS/cm^2)
g_K	9 (mS/cm^2)
E_L	-65 (mV)
E_{Na}	55 (mV)
E_K	-90 (mV)
E_{syn}	-75 (mV)
g_{syn}	0.1 (mS/cm^2)
θ_{syn}	0 (mV)
α	12 ($msec^{-1}$)
β	0.1 ($msec^{-1}$)
C_m	1.0 ($\mu F/cm^2$)
threshold(spike)	-55 (mV)

RTM=1.45

WB $\longrightarrow \gamma = C(1+\tanh)$

Iapp

Number of steps

Z=[0 0 ... 0]

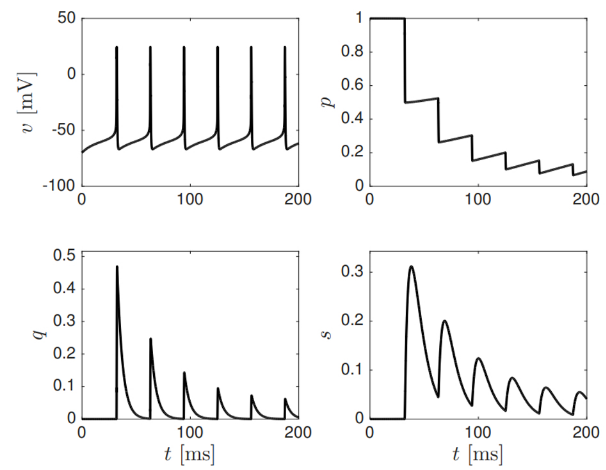
```
for k=1:m_steps,
    v_inc=(g_k*n(k)^4*(v_k-v(k))+g_na*m(k)^3*h(k)*(v_na-v(k))+g_l*(v_l-v(k))+i_ext.
    n_inc=alpha_n(v(k))*(1-n(k))-beta_n(v(k))*n(k);
    h_inc=alpha_h(v(k))*(1-h(k))-beta_h(v(k))*h(k);
    p_inc=-C*(1+tanh(v(k)/10))*p(k)*log(1/(1-U))+(1-p(k)-q(k))/tau_rec;
    q_inc= C*(1+tanh(v(k)/10))*p(k)*log(1/(1-U))-q(k)/tau_d_q;
    s_inc=q(k)*(1-s(k))/tau_r-s(k)/tau_d;

    v_tmp=v(k)+dt05*v_inc;
    h_tmp=h(k)+dt05*h_inc;
    n_tmp=n(k)+dt05*n_inc;
    m_tmp=m_inf(v_tmp);
    p_tmp=p(k)+dt05*p_inc;
    q_tmp=q(k)+dt05*q_inc;
    s_tmp=s(k)+dt05*s_inc;

    v_inc=(g_k*n_tmp^4*(v_k-v_tmp)+g_na*m_tmp^3*h_tmp*(v_na-v_tmp)+g_l*(v_l-v_tmp)+i_ext)/c;
    h_inc=alpha_h(v_tmp)*(1-h_tmp)-beta_h(v_tmp)*h_tmp;
    n_inc=alpha_n(v_tmp)*(1-n_tmp)-beta_n(v_tmp)*n_tmp;
    p_inc=-C*(1+tanh(v_tmp/10))*p_tmp*log(1/(1-U))+(1-p_tmp-q_tmp)/tau_rec;
    q_inc= C*(1+tanh(v_tmp/10))*p_tmp*log(1/(1-U))-q_tmp/tau_d_q;
    s_inc=q_tmp*(1-s_tmp)/tau_r-s_tmp/tau_d;

    v(k+1)=v(k)+dt*v_inc;
    h(k+1)=h(k)+dt*h_inc;
    n(k+1)=n(k)+dt*n_inc;
    m(k+1)=m_inf(v(k+1));
    p(k+1)=p(k)+dt*p_inc;
    q(k+1)=q(k)+dt*q_inc;
    s(k+1)=s(k)+dt*s_inc;

    if v(k+1)<-20 && v(k)>=-20,
        num_spikes=num_spikes+1;
    end;
end;
```



V=-70

$\alpha_m \quad \alpha_h \quad \alpha_n$

$\beta_m \quad \beta_h \quad \beta_n$

$m_\infty = \alpha_m/(\alpha_m + \beta_m)$.

$h_\infty = \alpha_h/(\alpha_h + \beta_h)$.

$n_\infty = \alpha_n/(\alpha_n + \beta_n)$.

p=1 , q=0 , s=0

step=1 *0.01* *2*0.005*

V(0.005)=

$\alpha_m \quad \alpha_h \quad \alpha_n$

$\beta_m \quad \beta_h \quad \beta_n$

$m_\infty = \alpha_m/(\alpha_m + \beta_m)$.

h(0.005)= n(0.005)=

p(0.005)= q(0.005)= s(0.005)=

V(0.01)=

$\alpha_m \quad \alpha_h \quad \alpha_n$

$\beta_m \quad \beta_h \quad \beta_n$

$m_\infty = \alpha_m/(\alpha_m + \beta_m)$.

h(0.01)= n(0.01)=

save *p(0.01)= q(0.01)= s(0.01)=*