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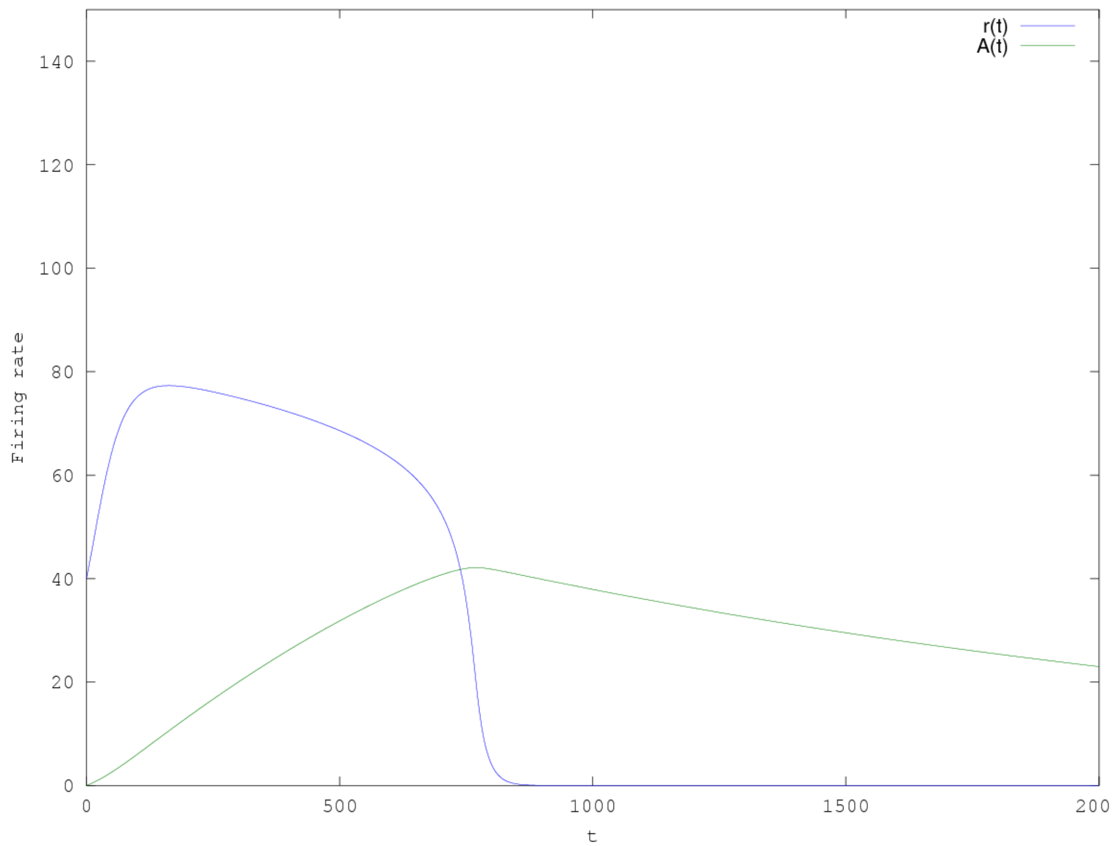
Computational Neuroscience: Homework 4

Due on April 25, 2012

John Rinzel

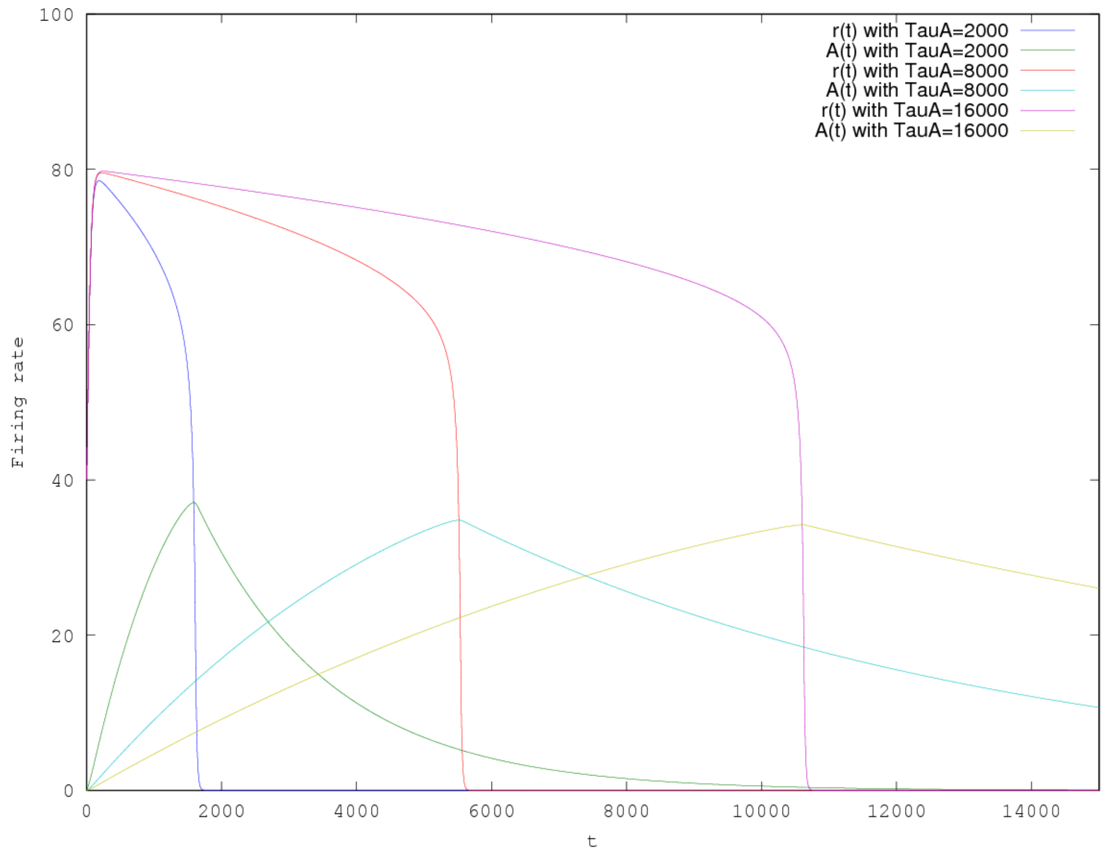
Short-Term Memory model with Adaptation: 1

I based my Matlab script (run in Octave) on STM_MF.m. For the first run, I used $\gamma = 2$ to match the graph in the homework description.



2

For the second set of trials, I changed γ to 1. As I increased τ_A, the system slowed down. A(t) changed more slowly, so it took longer for A(t) to increase to drive R(t) down, and it took longer for A(t) do decrease again after R(t) plummeted. The shape of the curves was qualitatively similar, however.

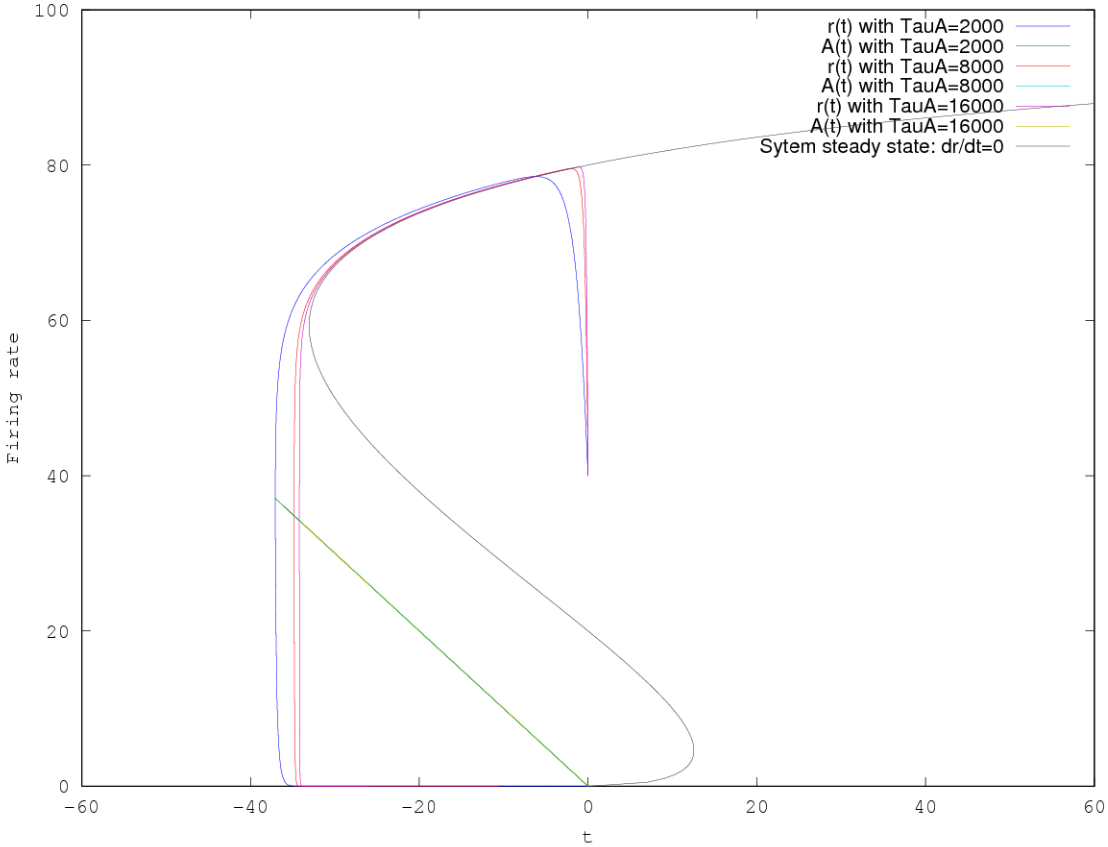


3

I approached finding the steady state curve analytically for individual values of r. Given: $\tau(dr/dt) = -r + S_{NR}(ar - A)$ (I = 0), we can set dr/dt to 0 and calculate from there.

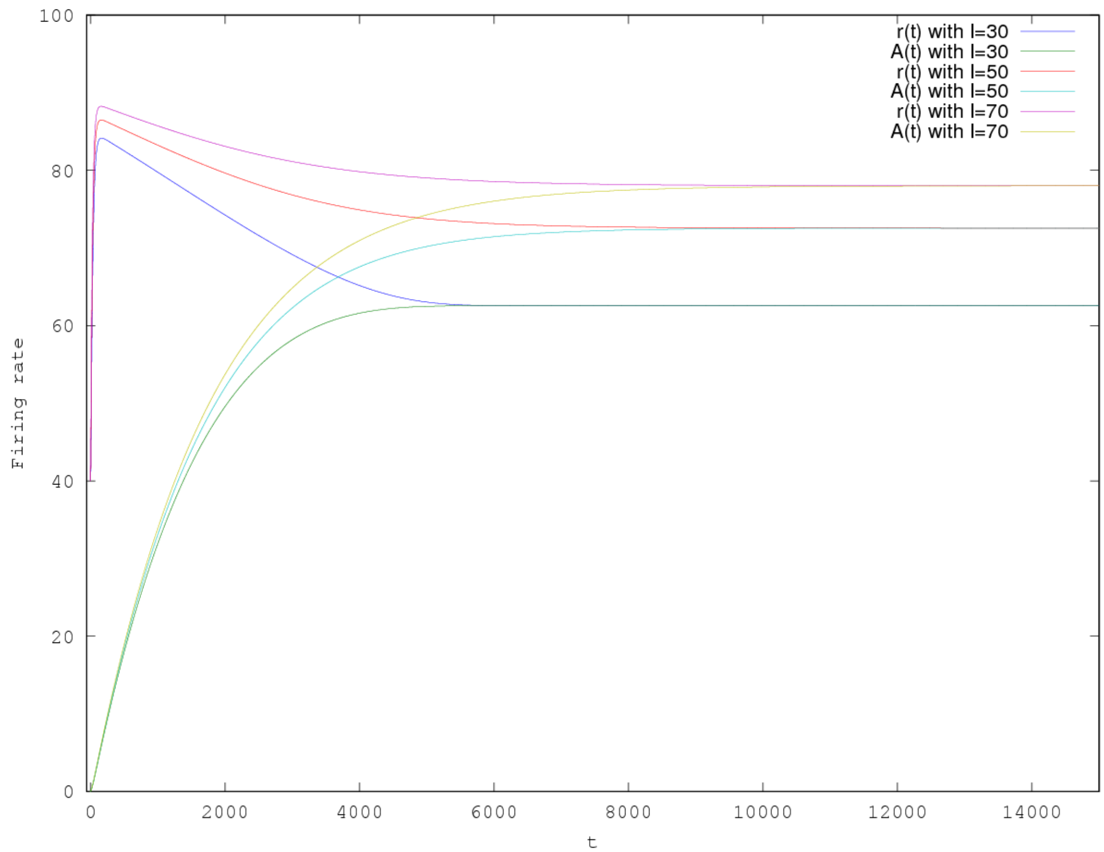
$$
\begin{aligned}
r &= S_{NR}(ar - A) \\
r &= \frac{M * (ar - A)^2}{\sigma^2 + (ar - A)^2} \\
\delta &= (ar - A)^2 \\
r &= \frac{M * \delta}{\sigma^2 + \delta} \\
r\sigma^2 + r\delta &= M * \delta \\
\frac{r\sigma^2}{\delta} &= M - r \\
\frac{1}{\delta} &= \frac{M - r}{r\sigma^2} \\
\delta &= \frac{r\sigma^2}{M - r} \\
A^2 - 2arA + a^2r^2 - \frac{r\sigma^2}{M - r} &= 0 \\
A &= \frac{\sigma}{\sqrt{M/r - 1}} - a * r
\end{aligned}
$$

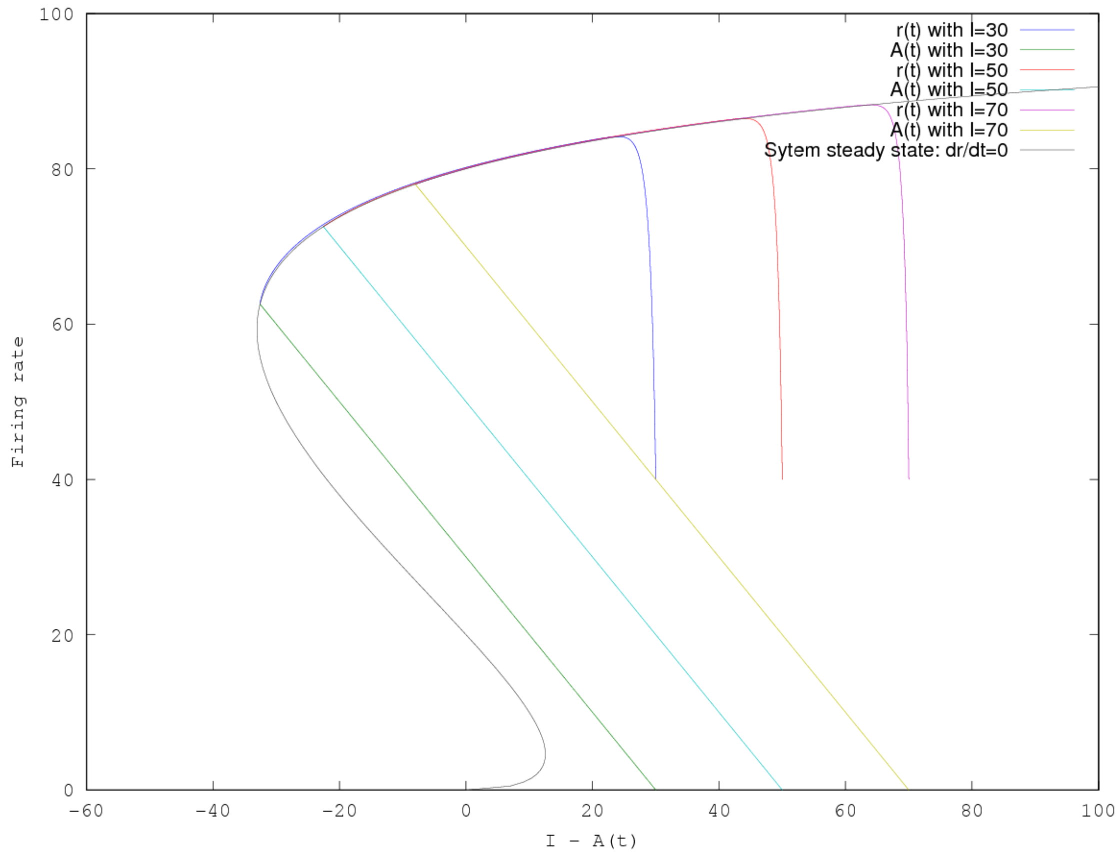
Since everything other than A is constant for a given r, this is a quadratic in A, easily solved. In the graph below, we can see R jump to the upper part of the steady state, then fall to the bottom as the input disappears.


r(t) with TauA=2000
A(t) with TauA=2000
r(t) with TauA=8000
A(t) with TauA=8000
r(t) with TauA=16000
A(t) with TauA=16000
Sytem steady state: dr/dt=0
Firing rate
t
100
80
60
40
20
0
-60
-40
-20
0
20
40
60

4

For varying the values of I, I set τ_A back to 2000. In these time courses, instead of the firing rate falling to nothing, the constant input current causes the neuron to reach a steady state solid firing rate. The steady state is about 62 for I=30, 72 for I=50, and 78 for I=70. For any given I, we could find what steady state it would go to by first checking the sign of dr/dt, to know whether it would go to a zero or positive steady state, then if $dr/dt > 0$, we can solve for r in $r = S_{NA}(ar - A(r))$.




r(t) with I=30
A(t) with I=30
r(t) with I=50
A(t) with I=50
r(t) with I=70
A(t) with I=70
Sytem steady state: dr/dt=0
Firing rate
I - A(t)
0
20
40
60
80
100
-60
-40
-20
0
20
40
60
80
100