Hodgkin-Huxley

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This is a demo for simulating simulating the Hodgkin-Huxley equations. There are two simulations in this demo: 1: constant current 2: current pulses

We use the package deSolve to simulate the differential equations.

1. simulation with constant input

Constant current is injected in a neuron of 20 μm diameter with Hodgkin-Huxley channels. Try to change the injected current and find the AP threshold!

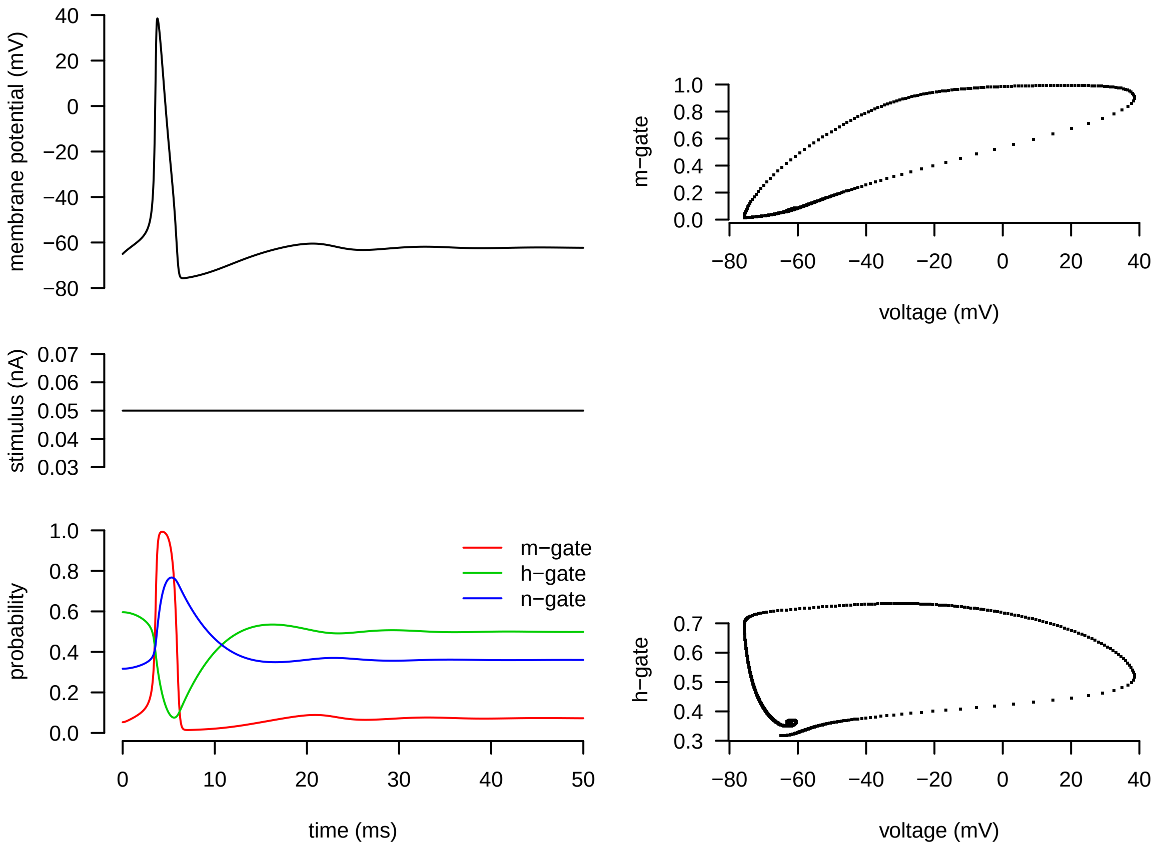
```
I0 <- 1/20/1000 # change this to change the input current!
## meaningful range is between [-1/5, 1] / 1000

times <-  seq(0,50, by=0.02) # the time points for the simulation - in ms!
input <- cbind(times, rep(I0, length(times))) # set the input current, a matrix with two column: [time,
I.ext <- approxfun(input[,1], input[,2], method = "linear", rule = 2) # this is necessary to provide in

params <- c(gK=gK, gNa=gNa, gL=gL, cm=cm, E.Na=E.Na, E.K=E.K, E.L=E.L) # parameters of the system.
# gK, gNa, gL: K, Na and leak maximal conductance in mS,
# cm: membrane capacitance in uF
# E.K, E.Na, E.L: the reversal potential of the K, Na ions and the leak.
# For more details, see the demos/HH_consts.R file
state <- c(v=-65, m=.053, h=.596, n=.317) # initial state of the system
# v: membrane potential in mV
# m, h, n: the opening probability of the gates

out <- ode(y = state, times = times, func = sim.HH, parms = params) #ode is a function that simulates a
```

Now plot the results



2. simulation with a short current pulse

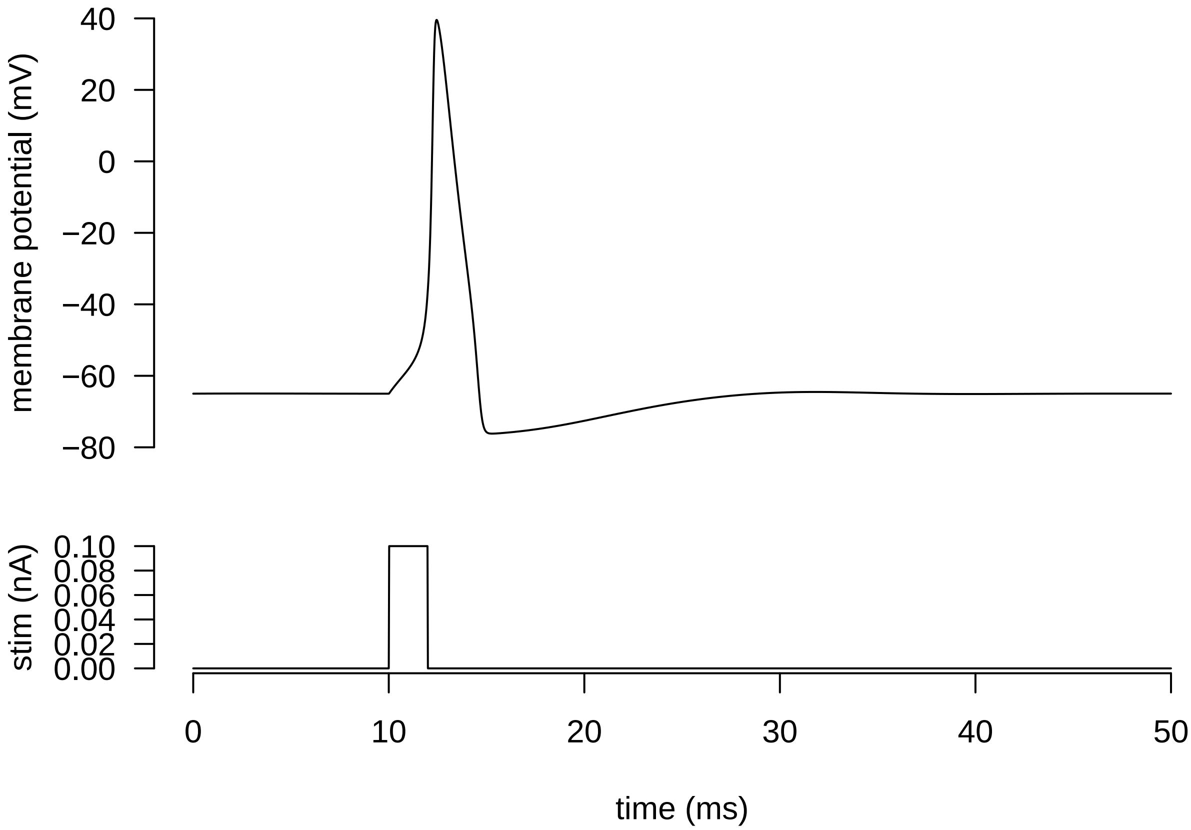
Short (2 ms) current pulse is injected in a neuron of 20 μm diameter with Hodgkin-Huxley Na and K channels. Try to change the current pulse amplitude and find the AP threshold! Try also negative currents, or trains of pulses!

```
I0 <-  0 # the background current
delay <- 10 # the delay of the pulse in ms
I.stim <- 1/10 / 1000 # change this to set the amplitude of the pulse
## meaningful range is between [-1/5, 1] / 1000
times <-  seq(0,50, by=0.02) # # the time points for the simulation - in ms!
input <- cbind(times, rep(I0, length(times))) # input current
input <- set.input(delay, delay+2, I.stim, input) # this function adds a square pulse on the top of con

I.ext <- approxfun(input[,1], input[,2], method = "linear", rule = 2) # input for the DE
params <- c(gK=gK, gNa=gNa, gL=gL, cm=cm, E.Na=E.Na, E.K=E.K, E.L=E.L) # parameters
# gK, gNa, gL: K, Na and leak maximal conductance in mS,
# cm: membrane capacitance in uF
# E.K, E.Na, E.L: the reversal potential of the K, Na ions and the leak.
state <- c(v=-65, m=.053, h=.596, n=.317) # initial state
# v: membrane potential in mV
# m, h, n: the opening probability of the gates

out2 <- ode(y = state, times = times, func = sim.HH, parms = params) ## solving the system of diff. Eqs
```

Now plot the results…



membrane potential (mV)
40
20
0
−20
−40
−60
−80
stim (nA)
0.10
0.08
0.06
0.04
0.02
0.00
0
10
20
30
40
50
time (ms)