Hidden Markov Model for Poisson-GLM Emission Model

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Abstract

Here I demonstrate the application of a HMM with Poisson-GLM observation model, with parameters estimated as described in Escola et al. (2011). I test this model on simulated data and on multiunit activity (MUA) count recordings from an epileptic subject.

1 Simulation

I simulated 10 channels of a Poisson GLM model which switched behavior half point during the simulation. I expanded the history of this model with two basis function (Figure 1). For the first (second) half of the simulation I used the set of parameters given in the column *True:State 1* (column *True: State 2*) in Table 1. Figure 2 shows the simulated MUA count.

To estimate the model parameters I used a model with two states and I used the true basis functions from the simulation. The columns *Estimated: State i* give the estimated conditional intensity parameters for state i. The estimated sate 1 (2) corresponds to the true state 2 (1) and the estimated parameters are a good fit to the true ones. Figure 3 shows that the estimate model transitions between states at the same time as the simulated model. Figure 4 shows that the estimated mean rates of the emission models of the two states are good approximations to the true ones (notice that the estimated state 1 corresponds to the true state 2). Figure 5 shows the estimated are good approximations to the true filters.

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Table 1: Parameters of the simulated HMM with Poisson-GLM emission model. The conditional intensity function of the simulated model was $\lambda(t) = \mu + f^T xHist(t)$ with $f = c_1\, b_1 + c_2\, b_2$, where b_i is ith basis function, c_i is the weight of the ith basis function and $xHist(t)$ is the history of the time series at time t.

	True		Estimated	
Parameter	State 1	State 2	State 1	State 2
μ	0.40	0.20	0.12	0.44
c_1	0.20	0.00	0.01	0.20
c_2	-0.10	0.00	0.00	-0.10

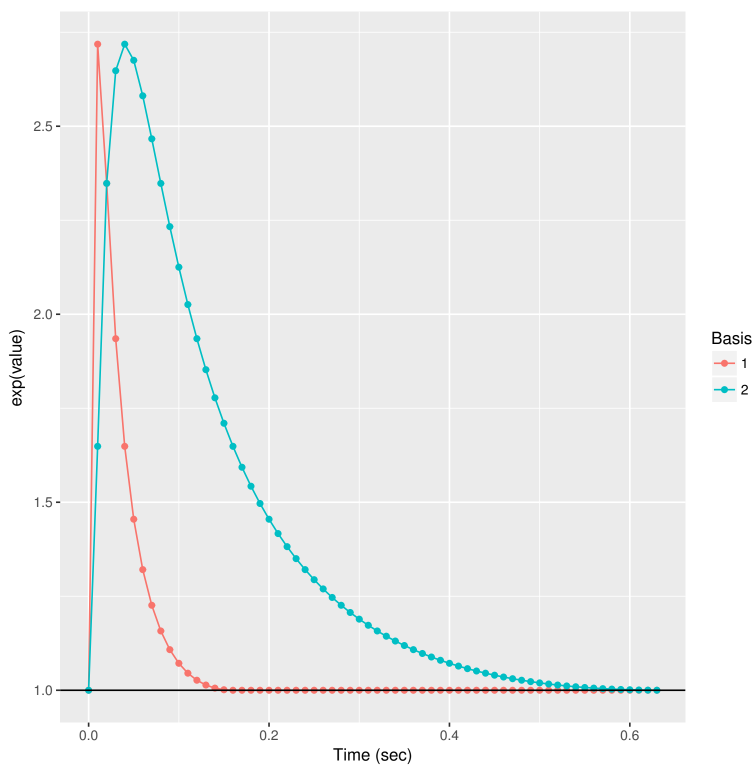

Figure 1: simulation: basis functions

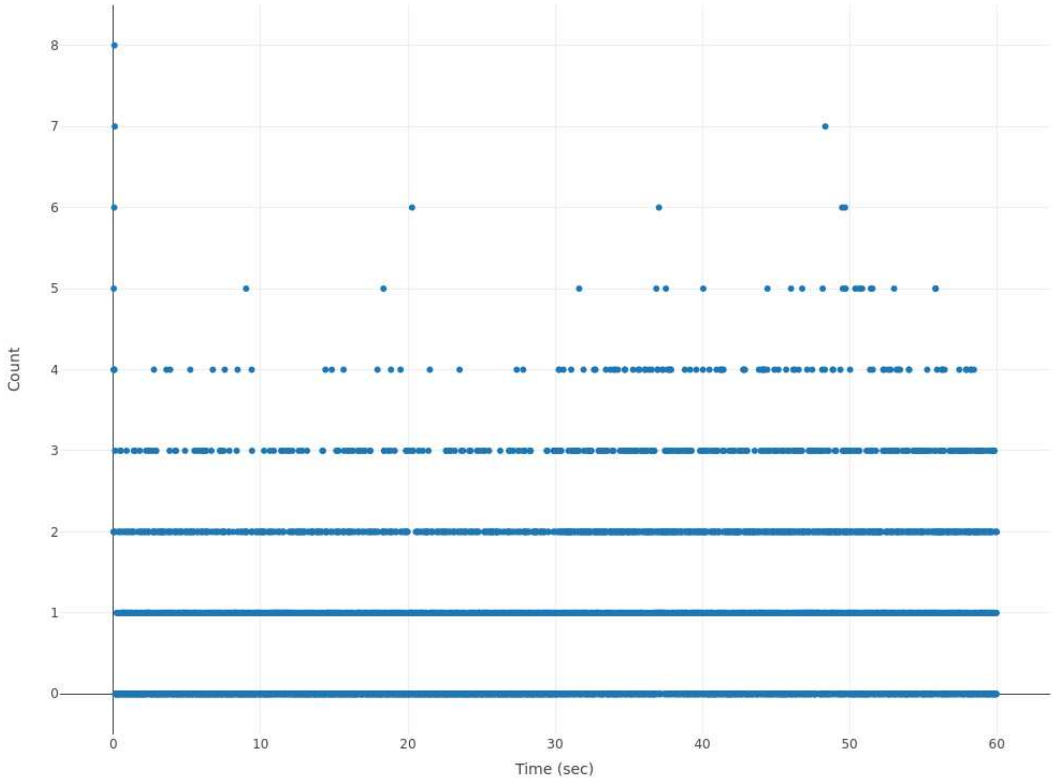

Figure 2: simulation: MUA count total. At time 30 sec the simulation switches from state 1 to state 2.

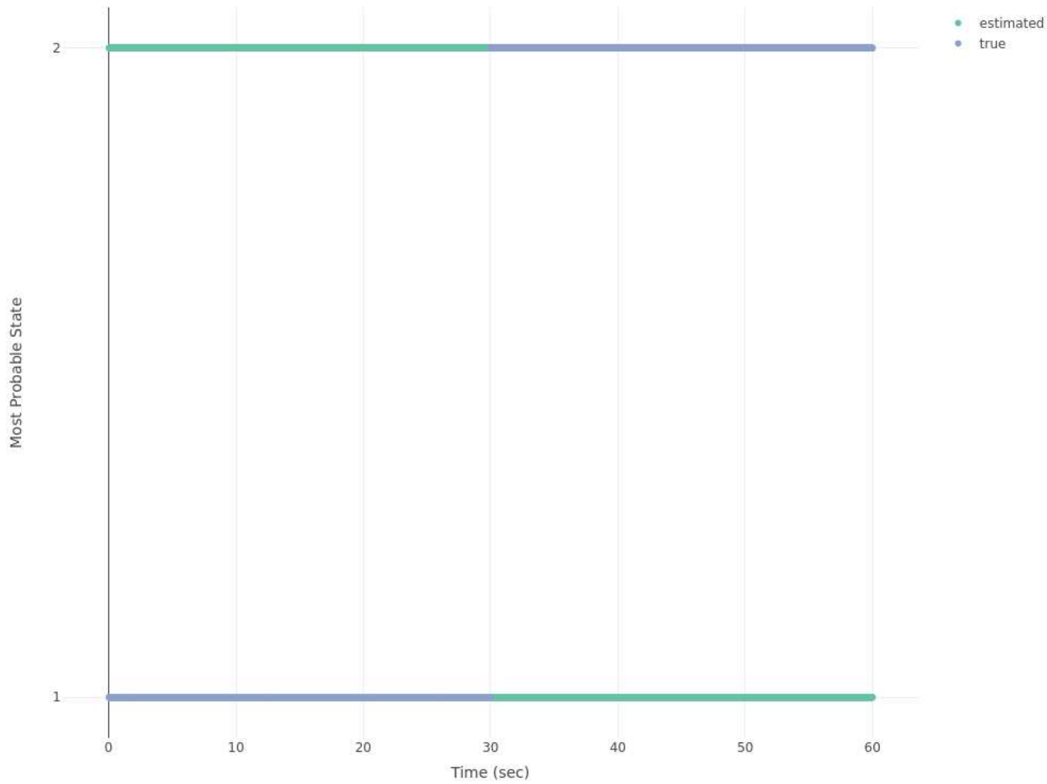

Figure 3: simulation: true and estimated most probable state.

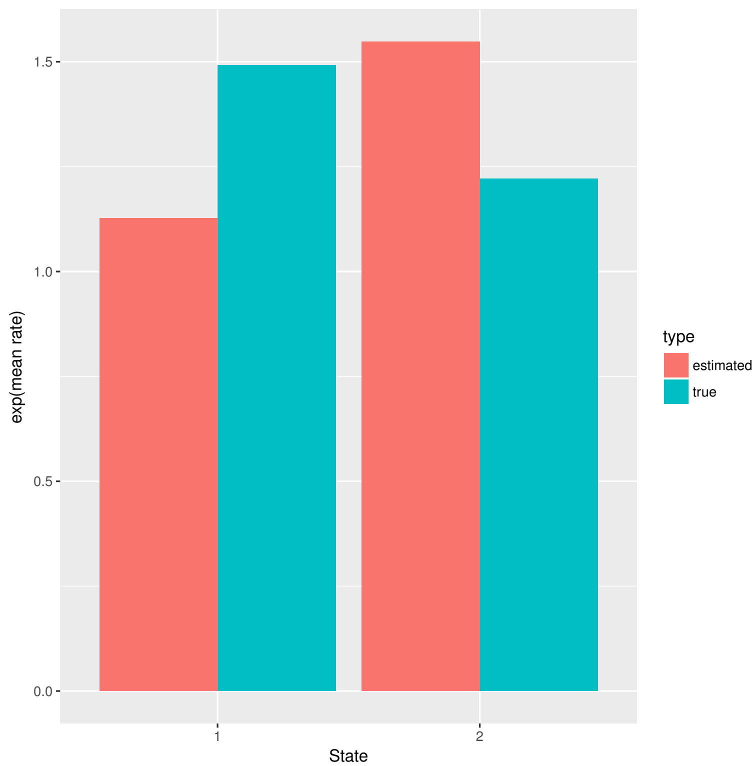

Figure 4: simulation: mean rates (exponentiated) for the emission models of the two states.

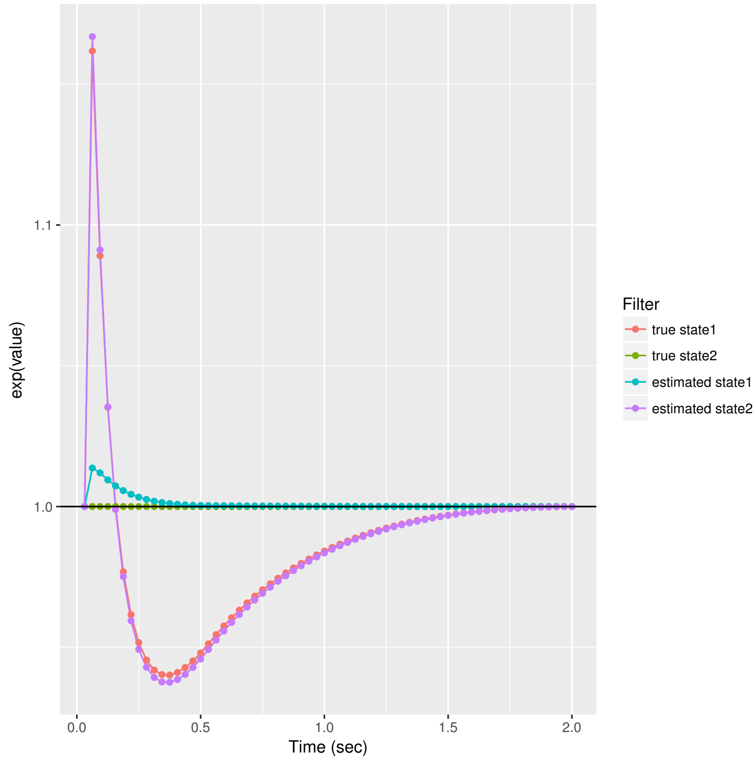

Figure 5: simulation: true and estimated (exponentiated) filters

2 MG63, block 05-103012-025

Figure 6 shows the MUA count recorded in a 40 minutes session from subject MG63. The peak in MUA count starting at 1730 seconds corresponds to the occurrence of a seizure. We used the two basis functions in Figure 7 to expand the auto-history filter. Figure 8 shows that before the seizure the model is in state three, during the seizure the model switches between state three and state one, and after the seizure the model is in state 2. Below I call state 3 the pre-ictal state, state one the ictal state and state 2 the post-ictal state. Figure 9 shows that the mean of the conditional intensity function for the ictal state is substantially larger than that of other states and that the mean for the post-ictal state is smaller than that of other states. This reflects the large increase in mean firing at all electrodes during the seizure and the slight suppression of firing after the seizure. Figure 10 shows the filters for the three states. The ictal state one is the only where the immediate history suppresses the probability of spiking (refractory period). In the pre-ictal state three the immediate history enhances the probability of spiking and in the post-ictal state the immediate previous history does not affect much the probability of spiking, but the spiking 150 msec before the current time largely enhances the probability of spiking at the current time.

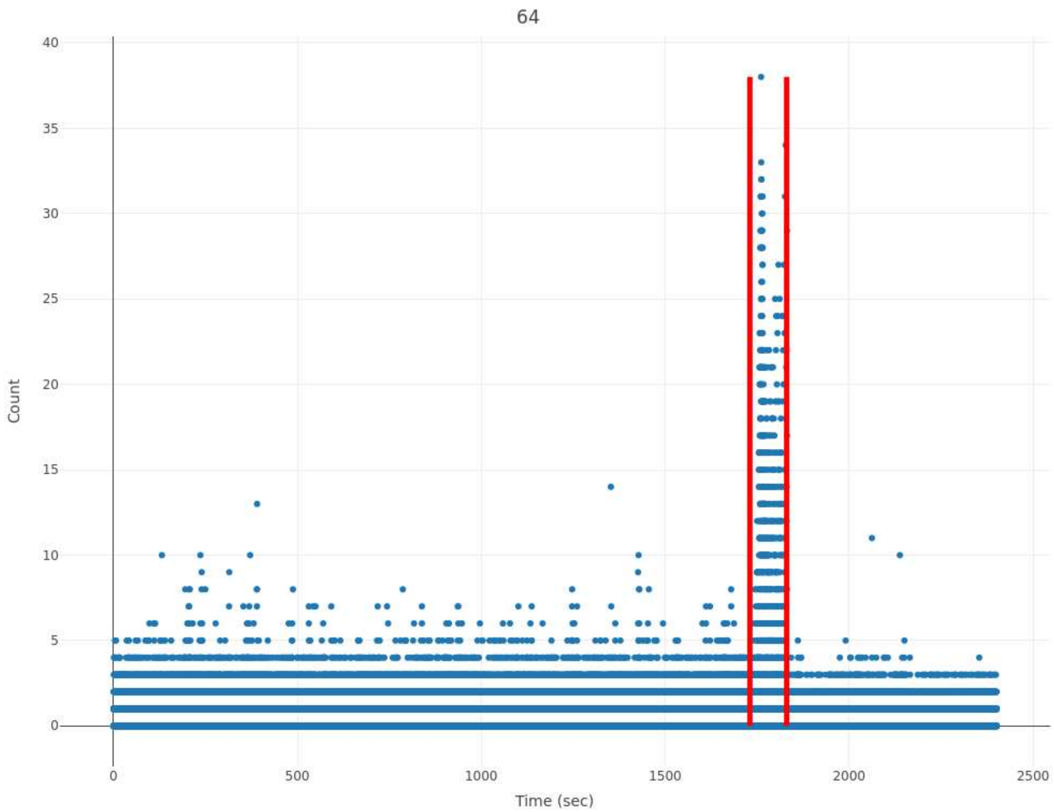

Figure 6: MG63: block 05-103012-025, MUA count total for bin size 32 Hz

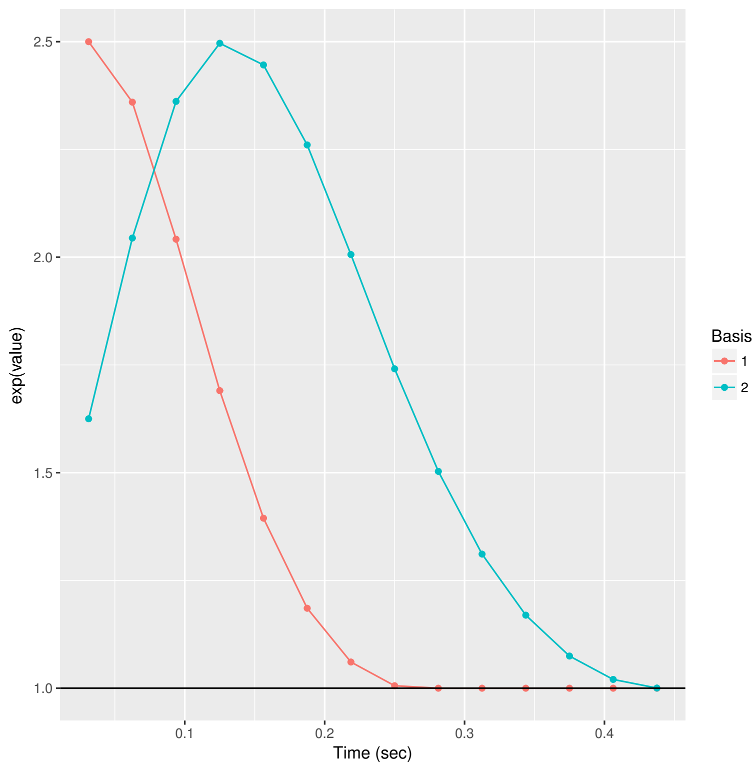

Figure 7: MG63: block 05-103012-025, basis functions used to expand the auto-history filters of the GLM

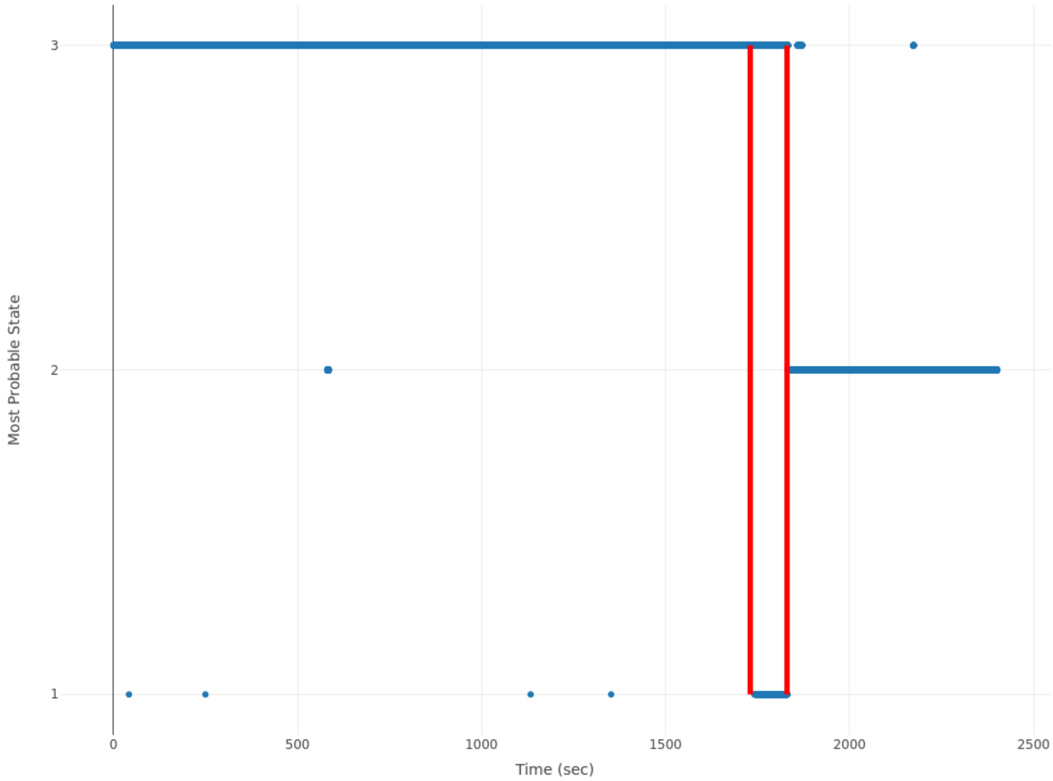

Figure 8: MG63: block 05-103012-025, most-probable state of the HMM as a function of time

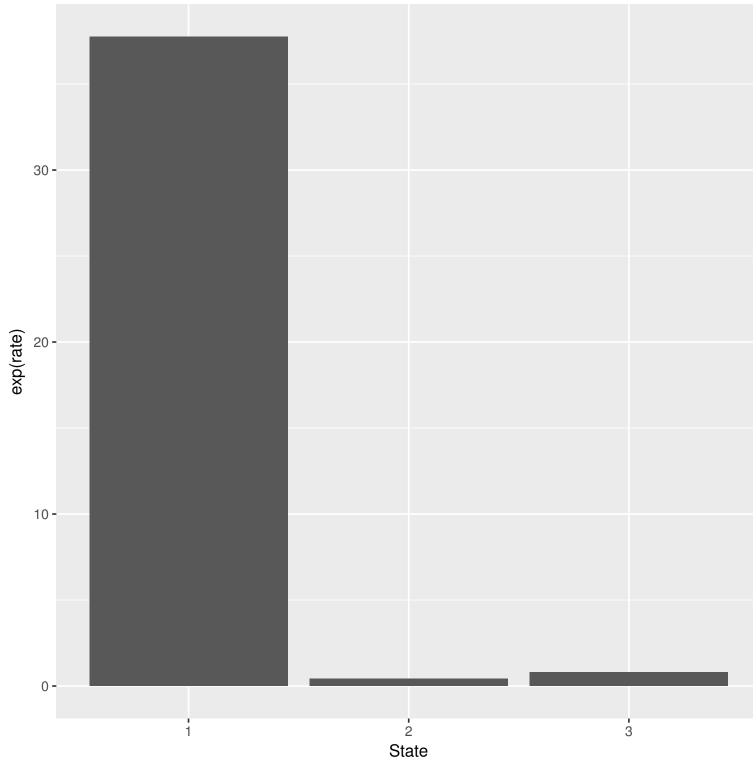

Figure 9: MG63: block 05-103012-025, Poisson mean rate (exponentiated) for the emission models of the three states.

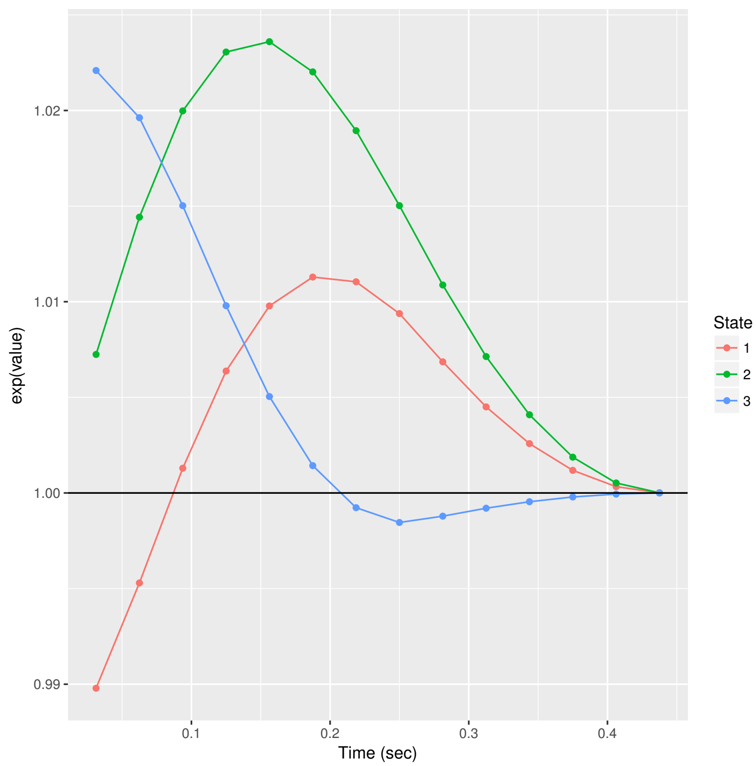

Figure 10: MG63: block 05-103012-025, (exponentiated) auto-history filters of the Poisson GLM emission model.

References

Escola, S., Fontanini, A., Katz, D., and Paninski, L. (2011). Hidden markov models for the stimulus-response relationships of multistate neural systems. *Neural computation*, 23(5):1071–1132.