We construct a conditional random field (CRF) on the observed neural activity. A conditional random field is an undirected graphical model *G = (V, E)* conditioned on the observation variables ***X*** [ref]. Each vertex *v* ϵ *V* in *G* is associated with a target variable **Y***v* in **Y**, which obeys Markov property with respect to *G*. A conditional random field models the conditional distribution p(**Y**|**X**) without explicitly modeling the distribution of **X** or putting any assumptions on **X**, therefore has been successful in many applications [ref].

A conditional random field can be parameterized by a set of node potentials *φ*(**Y***i*) and edge potentials *φ*(**Y***i*, **Y***j*) defined on the graph. These potential functions take the values of the target variable and project them into a real-value space, and are associated with the conditional independencies in the graph. The probability of a specific system state ***y*** given the observation ***x*** can then be written as: , where

, and are usually compactly defined as log-linear functions: *φ*(**Y***i*, **Y***j*).