Simulation Study on Calcium-Activated Dynamics of Compartment Dendrite Model

Norihiro Katayama, Mitsuyuki Nakao, Yoshinari Mizutani, Mitsuaki Yamamoto

Graduate School of Information Science, Tohoku University, Sendai 980, JAPAN,
Telephone & Facsimile: +81-22-263-9437, E-mail: kata@yamamoto.ecei.tohoku.ac.jp

Recent physiological experiments have proved that a neuronal dendritic tree in the central nervous system (CNS) possesses the complex spatio-temporal dynamics. The dynamical properties of dendrite are expected to play an important role for the information processing in CNS. From this point of view, we construct a compartment model of an active dendrite in a discrete form in order to investigate its functional significance. The dynamics of the single compartment model is controlled mainly by the following two kinetic variables. One is the membrane potential which involves the several types of currents: T-type Ca^{2+}, L-type Ca^{2+}, and Ca^{2+}-activated K^+. The other is the intracellular Ca^{2+} concentration that is increased by Ca^{2+} influx and reduced by the cellular homeostatic system. The single compartment model responds in an oscillatory manner when a maintained current stimulation is applied. Figure 1 shows the relationship between the response firing frequency and the current intensity. There is the threshold and the optimal intensity of stimulus for the oscillatory response.

The compartment models of proximal and distal dendrites are made up by connecting longitudinally 10 thick and thin compartments, respectively. Each of the compartments are electrically coupled with the neighboring one. Figure 2 shows the firing frequency of the compartment dendrite models in response to the localized steady current stimulus. We observe the responses of the 1st compartment and 10th compartment, which are indicated by S and T, respectively. The stimulus is applied to S. For the proximal dendrite model, the responses are homogeneous among the compartments and their response firing frequency is lower than that of the single. For the distal, only S and its neighboring compartments fire with high frequency. It is worth noting that their firing frequency tends to be higher than that of the single in the range from 6.6 to $8\mu A/cm^2$, probably due to their spatial cooperation. It has been found that synapses from different regions tend to be located separately on the dendritic system. Therefore the neural information coming from the different regions is suggested to be processed in the location-dependent manner on the dendritic system.

Acknowledgements

We wish to thank *the Sumitomo Foundation* for their partly supporting our study. The author (*N.K.*) thanks *JSPS Fellowships for Japanese Junior Scientists.*

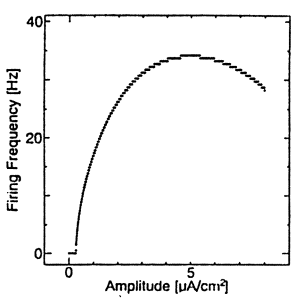

Figure 1: Relationship between firing frequency of single compartment model and intensity of maintained current stimulus.

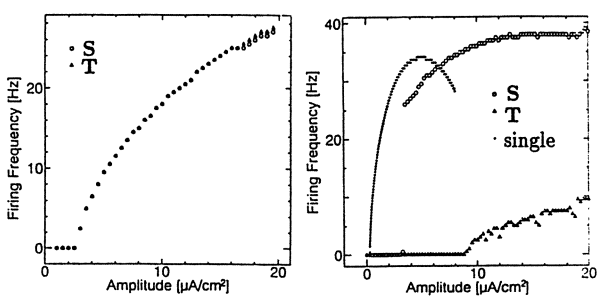

Figure 2: Firing frequency of compartment dendrite model in response to localized steady current stimulus. *left*: proximal dendrite model. *right*: distal dendrite model.

S. Gielen et al. (eds.), *ICANN '93*