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# Pattern recognition of Hodgkin-Huxley equations by auto-regressive Laguerre Volterra network

Kunling Geng[1,2*], Vasilis Z Marmarelis[1,2]

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A nonparametric, data-driven nonlinear auto-regressive Volterra (NARV) [1] model has been successfully applied for capturing the dynamics in the generation of action potentials, which is classically modeled by Hodgkin-Huxley (H-H) equations. However, the compactness still need to be improved for further interpretations. Therefore, we propose a novel Auto-regressive Sparse Laguerre Volterra Network (ASLVN) model (shown in Figure 1A), which is developed from traditional Laguerre Volterra Network (LVN) and principal dynamic mode (PDM) framework [2].

We adopt stochastic global optimization algorithm Simulated Annealing [3] to train the ASLVN instead of Back-propagation method [2] to avoid local minima and convergence problems. We also use lasso regularization [4] to enhance the spasity of the network and prune redundant branches for parsimony. The prediction results are shown in Fig.1B, it can be seen that the exogenous output $z^{(1)}$ represents the subthreshold dynamics in phase III, and the autoregressive output $z^{(2)}$ dominates in the spike shape in phase I, and the cross term output $z^{(x)}$ helps to maintain the refractory period by cancelling the effect of $z^{(1)}$ in phase II and we also observe that refractory inhibition effect decays after initiation of AP, which explains the absolute refractory period and relative refractory period in physiology.

**Authors' details**
[1]Biomedical Engineering Department, University of Southern California, Los Angeles, CA 90089, USA. [2]Biomedical Simulations Resource, Los Angeles, CA 90089, USA.

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* Correspondence: kgeng@usc.edu
[1]Biomedical Engineering Department, University of Southern California, Los Angeles, CA 90089, USA
Full list of author information is available at the end of the article

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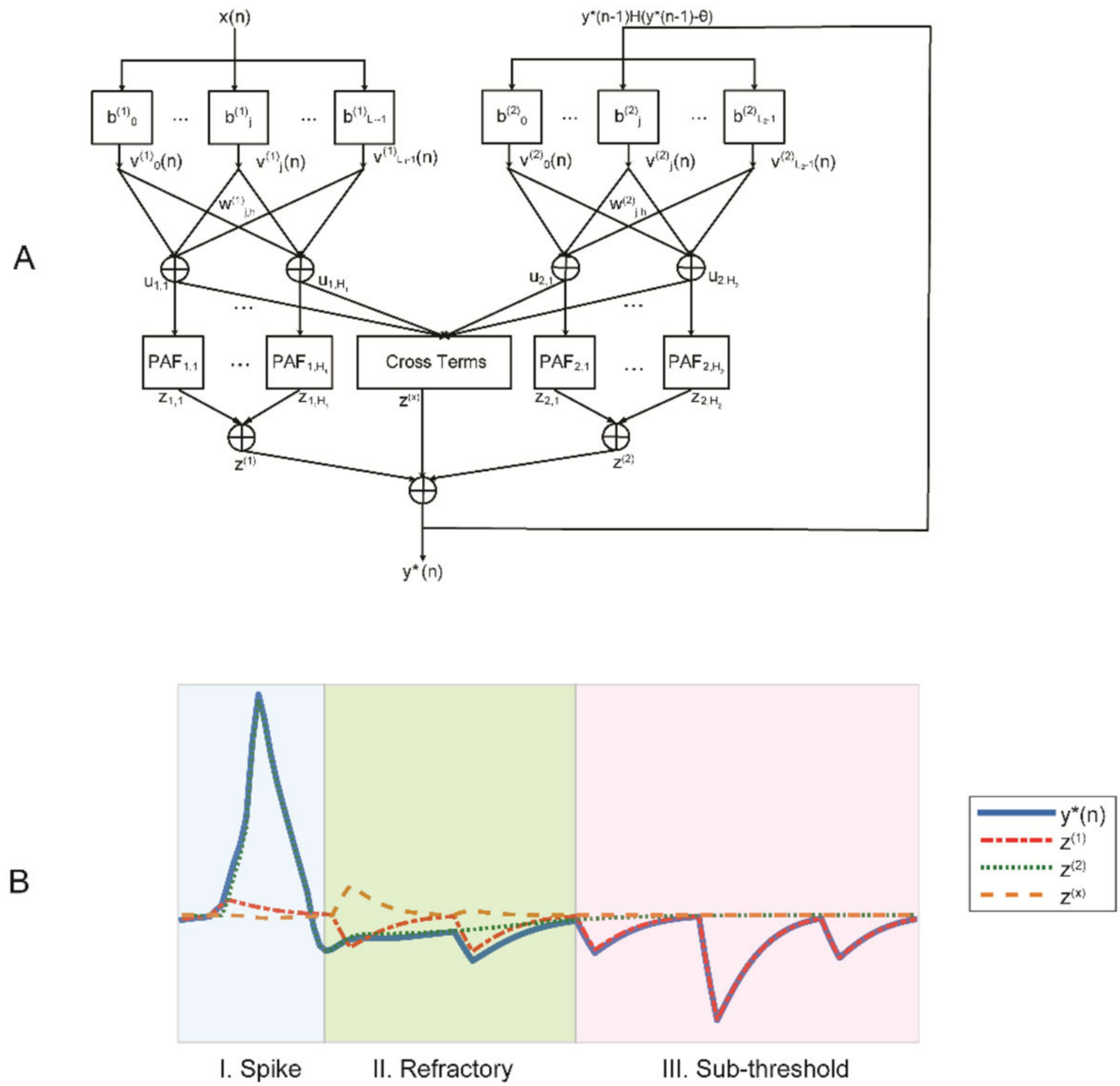


**Figure 1 A Structure of ASLVN for modeling H-H equations, where the input x(n) is the randomly injected current and the output y*(n) is the membrane potential**. **B** The predictions results, $z^{(1)}$ represents the exogenous output, $z^{(2)}$ represents the autoregressive output and $z^{(x)}$ represents the cross term output.