Abstract
A characteristic property of biological neurons is their ability to dynamically change their synaptic weight in response to variable input conditions. This mechanism, known as synaptic depression, significantly contributes to the formation of normalized representations of speech features. Synaptic depression also contributes to the robust performance of biological systems.

In this study, we describe how synaptic depression can be modeled and incorporated into deep neural network architectures to improve their generalization ability. We observed that when synaptic depression is added to the hidden layers of a neural network, it reduces the effect of changing background activity in the node activations. In addition, we show that when synaptic depression is included in a deep neural network trained for phoneme classification, the performance of the network improves under noisy conditions not included in the training phase.

Our results suggest that more complete neuron models may further reduce the gap between the performance of biological and artificial computing, resulting in networks that better generalize to novel signal conditions.

Synaptic depression in deep neural networks

Synaptic depression has been modeled in two different ways: (a) Weight Depression: changing the effective weight given to an input [2]; (b) Bias Depression: changing the firing threshold of the neuron [3].

(a) Weight Depression model
(b) Bias Depression model

Adaptive, nonlinear effects of synaptic depression

Interaction between neuron's nonlinearity and the synaptic depression in separating signal (blue) and noise (red). A change in the bias or gain of the input synaptic depression model in an autoencoder network adapts the activation threshold to the changing statistics of the input and removes the background activity.

References