Adaptation loops

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The adaptation loops is the mechanism in the CASP models that models forward masking. Forward masking is though to arise from the process of neural adapation, where the neuron adapts to a high input level, making them less sensitive.

The adaptation loops serve two purposes:

1. They convert the level of the input from a linear scale to a logarithmic like scale.

2. They model the effect of forward masking.

1   Mathematics

The time constant τ is given by

$$\tau = \begin{pmatrix} 0.005 \\ 0.050 \\ 0.129 \\ 0.253 \\ 0.500 \end{pmatrix}. \tag{1}$$

The time constant are used to define the filtering constants a:

$$a = \exp\left(-\frac{1}{\tau \cdot fs}\right). \tag{2}$$

These constants are used in the difference equations using the *state* variable s. In the following, $n = 0, \ldots, N - 1$ and $k = 0, \ldots, N_{\text{loops}} - 1$. In the style of mathematics, we denote the input signal (the driving term of the difference equations) by F and the output by Y.

$$s_{n+1,1} = a_1 s_{n,1} + (1 - a_1) \frac{F_n}{s_{n,1}}$$

$$s_{n+1,2} = a_2 s_{n,2} + \frac{1 - a_2}{1 - a_1} \frac{s_{n+1,1} - a_1 s_{n,1}}{s_{n,2}}$$

$$\cdots \quad \cdots \quad \cdots$$

$$s_{n+1,5} \quad = \quad a_5 s_{n,5} + \frac{1 - a_5}{1 - a_4} \frac{s_{n+1,4} - a_4 s_{n,4}}{s_{n,5}}$$

$$Y_n \quad = \quad \frac{1}{1 - a_5} \left(s_{n+1,5} - a_5 s_{n,5} \right)$$

2 Issues

There are two issues with the standard adaptation loops

1. They cannot handle a signal level of 0. Therefore, before adaptation, all values in the signal below a certain threshhold are replaced by the threshhold:
$$F_n = \max\left(F_n, minlvl\right)$$

2. They produce a too high overshoot when going from a low level input signal to a high level input signal. Therefore, the formulas are modified in the case when any of $F_n/s_{n,1}$, $F_n/\left(s_{n,1}s_{n,2}\right)$, $F_n/\left(s_{n,1}s_{n,2}s_{n,3}\right)$, $F_n/\left(s_{n,1}s_{n,2}s_{n,3}s_{n,4}\right)$ or $F_n/\left(s_{n,1}s_{n,2}s_{n,3}s_{n,4}s_{n,5}\right)$ are greater than 1.

3 Revised equations

$$s_{n+1,1} \quad = \quad a_1 s_{n,1} + (1 - a_1) \frac{F_n}{s_{n,1}}$$

$$s_{n+1,2} \quad = \quad a_2 s_{n,2} + \frac{1 - a_2}{1 - a_1} \frac{s_{n+1,1} - a_1 s_{n,1}}{s_{n,2}}$$

$$\cdots \quad \cdots \quad \cdots$$

$$s_{n+1,5} \quad = \quad a_5 s_{n,5} + \frac{1 - a_5}{1 - a_4} \frac{s_{n+1,4} - a_4 s_{n,4}}{s_{n,5}}$$

$$Y_n \quad = \quad \frac{1}{1 - a_5} \left(s_{n+1,5} - a_5 s_{n,5} \right)$$

4 Examples

See http://caspmodel.sourceforge.net/doc/examples/examp_adaptloop.php.

References