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A new spike train metric

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The theoretical and practical importance of quantifying the degree of similarity between pairs of spike trains has resulted in a plethora of spike train metrics. Some are based on cost functions [1,2] while others use smoothing kernels [3] or binning techniques [4] and then rely on spike intervals or precise spike timings to compute the distance. Spike metrics are especially important as they enable the analysis of the neural code, a fundamental and heavily debated issue in neuroscience. Here, we introduce a new class of spike train metrics dependent on smooth kernels. They compute the distance between pairs of spike trains and yield a result that is non-linearly dependent on the precise timing of the differences across the two spike trains. In this situation, the actual position of a spike outweighs the importance of the inter-spike interval. In the exchange of information between two neurons each spike may be as important as the spike train itself [5] and therefore, metrics based on the specific timing of differences are desirable.

The introduced spike train metrics, which will be referred to as max-metrics, are similar to the Hausdorff distance between two non-empty compact sets. They are given in two distinct forms: one that uses a convolution kernel to filter each spike train and, the other that uses the raw spike times. Because the latter does not rely on a smoothing kernel and uses the spike train directly, it does not introduce additional time constants and therefore has the advantage that it is more general. From a mathematical point of view the kernels can be just about any function because the generated metrics are commensurable. Some, however, will have a lesser physiological interpretation than others. The space of spike trains endowed with either form of the max-metric is compact. The implication for learning is that any learning rule based on the metric will eventually converge to a point in the spike train space. Because the max-metric generates the same topology regardless of the choice of kernels, topological properties such as compactness are common to all spike train spaces. The metrics are benchmarked against a simple spike count distance and against the original and a modified version of the van Rossum metric [3].

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