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Overview of useful-noise effects in static nonlinear systems

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The term stochastic resonance was originally introduced to describe the mechanism of a constructive action of a white Gaussian noise in the transmission of a sinusoid by a nonlinear dynamic system governed by a double-well potential. Since then, the phenomenon of stochastic resonance has experienced large varieties of extensions with variations concerning the type of noise, the type of information-carrying signal or the type of nonlinear system interacting with the signal-noise mixture. All these extensions of the original setup preserve the possibility of improving the processing of a signal by means of an increase in the level of the noise coupled to this signal. Although no resonance, in the strict physical sense, is involved in static systems, they allow useful-noise effects generally when they include some nonlinearity in their response. Before the introduction of stochastic resonance, a specific useful-noise effect in static nonlinearities was already known under the name of dithering (a purposely added noise used to reduce the rms quantization error in an analog-to-digital conversion). Therefore, constructive action of the noise in static nonlinear systems has often been presented as another form of dithering. Meanwhile, recent explorations have shown useful-noise effects in threshold-free nonlinearities [5], with measures of performance other than the rms error [2-5], other nonadditive signal-noise coupling [1] and in information processes other than quantization [3-5]. It has been then progressively realized that constructive action of the noise in static nonlinearities cannot be reduced to dithering. In the full version of this report we propose a detailed overview on the various forms of mechanism of stochastic resonance (understood in its broader sense as useful-noise effect) in static nonlinear systems. For illustration, we discuss new examples applied to sensors with saturation or curvilinear response and to coherent imaging with both theoretical treatment and experimental validation.

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