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Investigation of a novel nonlinear detector of weak acoustic signals in noise

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Recent work has identified and explored a method of detecting weak signals in Gaussian noise, based on the response of a nonlinear system to small input perturbations. The technique is applicable to the detection of weak underwater acoustic signals in unwanted ambient sea noise. Much of the research to date has been carried out using a forced Duffing oscillator as the nonlinear system, with parameters selected so as to place the system at the point of transition from a chaotic state to a stable periodic state. The additive input perturbation, most commonly comprising a simulated single frequency embedded in Gaussian noise with a very low input SNR, has been found to initiate the transition as indicated by the appearance of a stable trajectory in phase space. The attendant increase in amplitude at the output of the detector, at or near to the signal frequency, constitutes a detection of that weak signal. This paper presents a quantitative investigation of the technique as applied to underwater acoustic signals (real and simulated), using receiver operating characteristics (ROC) as a measure of its performance. Both the Duffing system, and a more novel version of the technique using a forced Lorenz system, are investigated.