Time-of-flight estimation using synchronized chaotic systems

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Time-of-flight (ToF) estimates are primary measurands in many metrological applications such as distance measurement, localization, and tracking. From the metrological point of view such applications are required to deliver estimates with low measurement uncertainties in the presence of bandwidth limitations, small signal-to-noise ratios, and different kinds of disturbers.

In the last two decades, the synchronization of chaotic systems has received a great deal of attention in the area of signal processing and communication engineering. In this context the beneficial properties of signals generated by chaotic systems are their unpredictability and their noise-like appearance.

In this work we investigate the use of synchronized chaotic systems in a ToF measurement system. Our setup consists of a narrow-band ultrasonic transmitter-receiver chain. We modulate the amplitude of a carrier signal with the output of a Lorenz system. The demodulated signal is used to synchronize a second Lorenz system at the receiver side. Upon synchronization of the receiver system we apply different methods to estimate the time delay between the two chaotic systems. In particular, we investigate the performance of ToF estimates for different channels using the state space representation of the systems. A comparison of these results with a standard correlation-based approach is given.