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Waves on Thin Plates: A New (Energy Based) Method on Localization

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Noisy acoustic signal localization is a difficult problem having a wide range of application. We propose a new localization method applicable for thin plates which is based on energy amplitude attenuation and inversed source amplitude comparison. This inversion is tested on synthetic data using a direct model of Lamb wave propagation and on experimental dataset (recorded with 4 Brüel & Kjær Type 4374 miniature piezoelectric shock accelerometers, 1 - 26 kHz frequency range). We compare the performance of this technique with classical source localization algorithms, arrival time localization, time reversal localization, localization based on energy amplitude.

The experimental setup consist of a glass / plexiglass plate having dimensions of 80 cm x 40 cm x 1 cm equipped with four accelerometers and an acquisition card. Signals are generated using a steel, glass or polyamide ball (having different sizes) quasi perpendicular hit (from a height of 2-3 cm) on the plate. Signals are captured by sensors placed on the plate on different locations.

We measure and compare the accuracy of these techniques as function of sampling rate, dynamic range, array geometry, signal to noise ratio and computational time. We show that this new technique, which is very versatile, works better than conventional techniques over a range of sampling rates 8 kHz – 1 MHz. It is possible to have a decent resolution (3cm mean error) using a very cheap equipment set. The numerical simulations allow us to track the contributions of different error sources in different methods. The effect of the reflections is also included in our simulation by using the imaginary sources outside the plate boundaries.

This proposed method can easily be extended for applications in three dimensional environments, to monitor industrial activities (e.g boreholes drilling/production activities) or natural brittle systems (e.g earthquakes, volcanoes, avalanches).