Identifiant de la contribution : **246** Type : **non spécifié**

”SHM#3 - Structural Health Monitoring using time reversal techniques in acoustic domains”

jeudi 13 juillet 2023 11:20 (20)

Since it has been theorized by Matthias Fink, time reversal approaches have been applied in various domain such as medicine (lithotripsy), submarine communication and electromagnetic communication. Those applications are using rather high frequency signals and the focalization properties of time reversal techniques. On the other hand, applications of time reversal techniques in structure health monitoring and especially using vibration frequencies lower than 10kHz are scarce. However, time reversal techniques are well suited for monitoring of complex structures using a few transducers. This paper presents developments made in the frame of the ViDeNS project (Vibration DEvice Network on Structures). First, transducers able to act both as sensors and emitters, have been designed. In a second phase, autonomous and lightweight devices were developed to send and acquire vibratory signals. This equipment allowed outdoor experiments on large structures (pipe network, railways, concrete slab ...). The experiments driven tend to prove that time reversal techniques can detect flaws in structures such as added masses and holes with size lower than the limit induced by the low frequency range in wave propagation theory. Theoretical studies have been led in order to explain those phenomena with modal approaches and assess the sensitivity of the technique. This theoretical approach has been used to determine indicators that could be used in the frame of structural health monitoring. Finally knowing potential indicators, statistical studies on the experimental campaigns have been achieved in order to fit flaw detection threshold. As prospective studies, AI algorithms could be applied on both full temporal signals and potential indicators. To conclude, we have shown that very few transducers allow the monitoring of structures larger than 20 meters long with a good sensitivity to centimetric flaws. Further calculation helped us to determine sensitive indicators opening new perspectives for structure health monitoring applications.

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Classification par session : Survishno 15 / Structural Health Monitoring