APCOM & ISCM
11-14th December, 2013, Singapore

Independent Component Analysis: Statistical Independence. Measures and Testing

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Independent Component Analysis has recently been employed in structural damage detection and blind source separation to extract source signals and the unmixing matrix of the system from response signals. This novel method relies on the assumption that source signals are statistically independent. This paper looks at the fundamental properties of statistical independent signals, its measures and testing procedures. First the concepts of kurtosis, negentropy and mutual information are reviewed, followed by Barikov's measures of coefficient of statistical independence and distance correlation between two signals coupled with Hypothesis testing of Type I and Type II are presented. Algorithms are developed to test the level of independence of two arbitrary signals. A case study was investigated, showing that Bakirov's tests are both reliable and rigorous. They are then applied to investigate the effects of noise in source signals on the results of Independent Component analysis with consequent structural damage detection using Artificial Neural Networks.

Keywords: Statistical independence, Independent component analysis, Structural damage detection, Multivariate statistics, Independence coefficient, Distance correlation.