独立成分分析法（ICA）の車両振動計測への適用

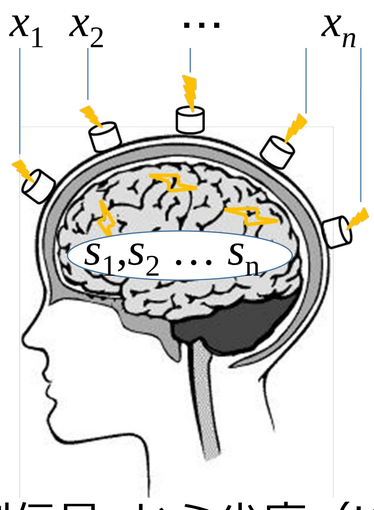
Independent Component Analysis Applied to Measurement of Vehicle Vibration

English Version

Partner: IMV Corp. and Mitsubishi Motors Corporation
Fund: Grant-in-Aid for Scientific Research

独立成分分析 Independent component analysis

Observed signal $x(t)$



$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_n(t) \end{bmatrix} = [A] \begin{bmatrix} s_1(t) \\ s_2(t) \\ \vdots \\ s_n(t) \end{bmatrix}$$

$$\begin{bmatrix} s_1(t) \\ s_2(t) \\ \vdots \\ s_n(t) \end{bmatrix} = W \begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_n(t) \end{bmatrix}$$

観測信号xから尖度（Kurtosis）を最大にするWを繰り返し計算で求める．この時のsは推定する信号源の候補．

$$kurt(s) = E(s^4) - 3[E(s^2)]^2$$

力学系への応用 Applications for dynamics

$$\begin{bmatrix} s_1(s) \\ s_2(s) \\ \vdots \\ s_n(s) \end{bmatrix} = \begin{bmatrix} W_{11}(s) & & \\ & \cdots & \\ & & \end{bmatrix} \begin{bmatrix} x_1(s) \\ x_2(s) \\ \vdots \\ x_n(s) \end{bmatrix}$$

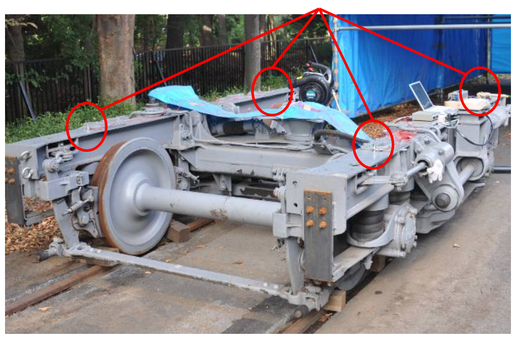
$$\begin{bmatrix} s^1{}_1(t) \\ s^2{}_1(t) \\ s^3{}_1(t) \\ \vdots \\ s^2{}_n(t) \\ s^3{}_n(t) \end{bmatrix} = \begin{bmatrix} W^{11}{}_{11} & W^{12}{}_{11} & W^{13}_{11} \\ W^{21}{}_{11} & W^{22}{}_{11} & W^{23}{}_{11} \\ W^{31}{}_{11} & W^{32}{}_{11} & W^{33}{}_{11} \\ & & \end{bmatrix} \begin{bmatrix} \dot{x}_1(t) \\ x_1(t) \\ \int x_1(t)\,dt \\ \vdots \\ x_n(t) \\ \int x_n(t)\,dt \end{bmatrix}$$

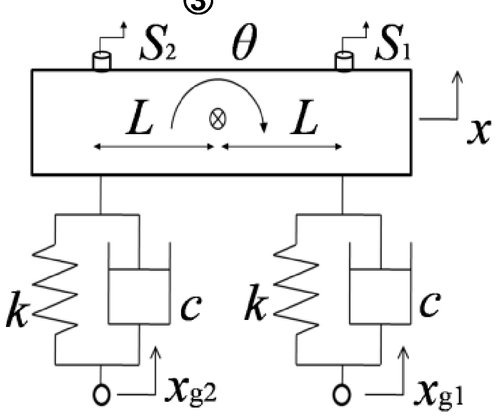
伝達関数から線形方程式を立てる．ここでのsはラプラス演算子．

鉄道台車への入力推定

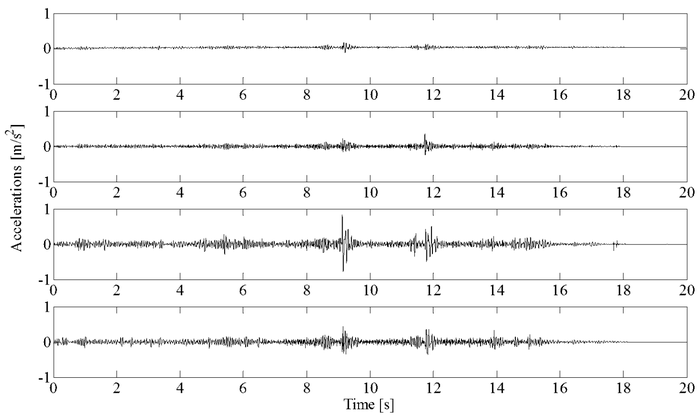
Input estimation on rail vehicle bogie

Accelerometer

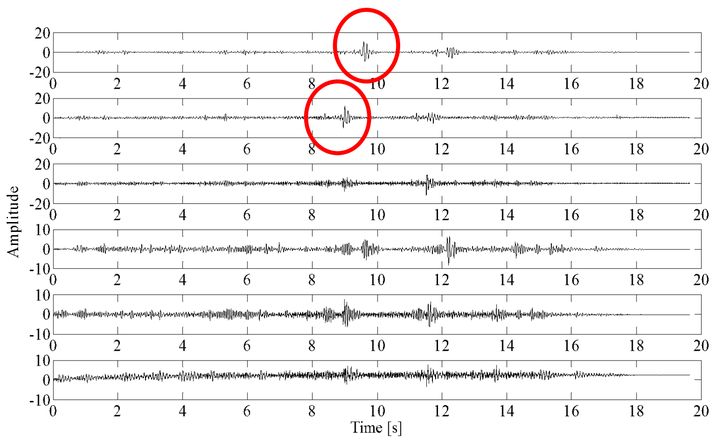




Measured acceleration

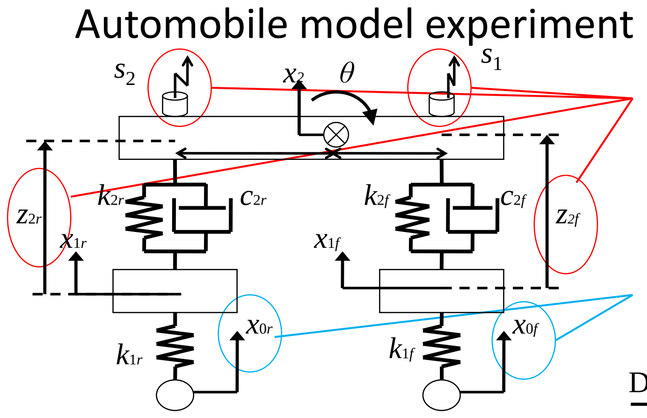


Estimated source



自動車モデルでの実験

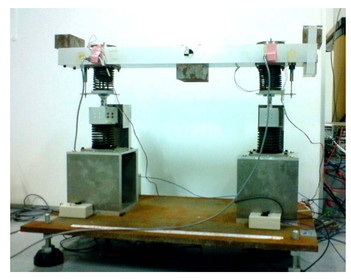
Automobile model experiment



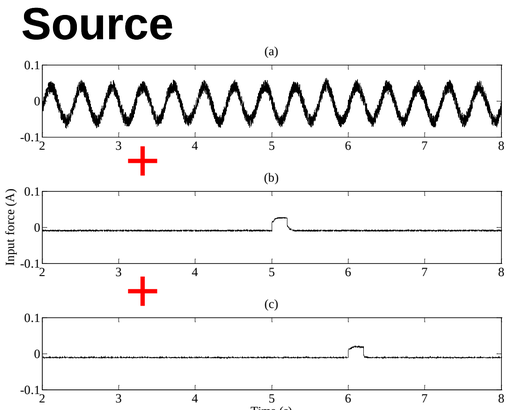
Measured signal

Source to be estimated

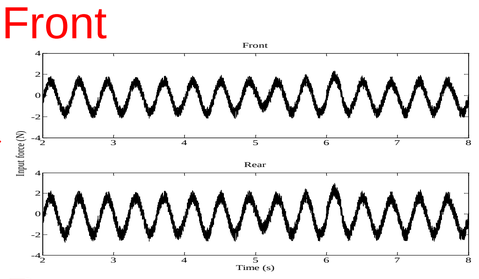
Direction



Source



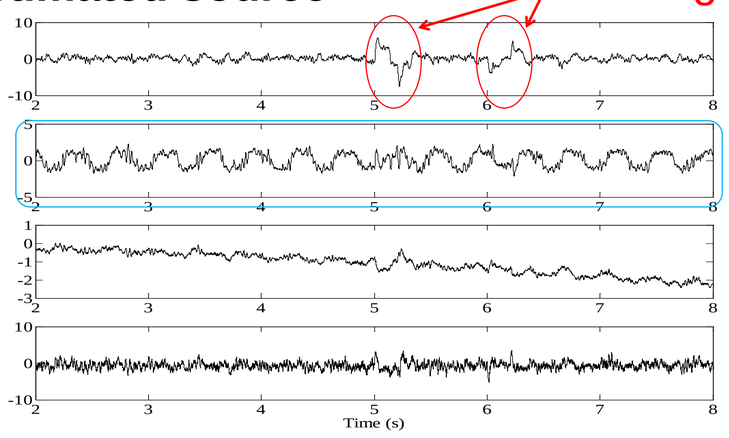
Front



Rear

Estimated source

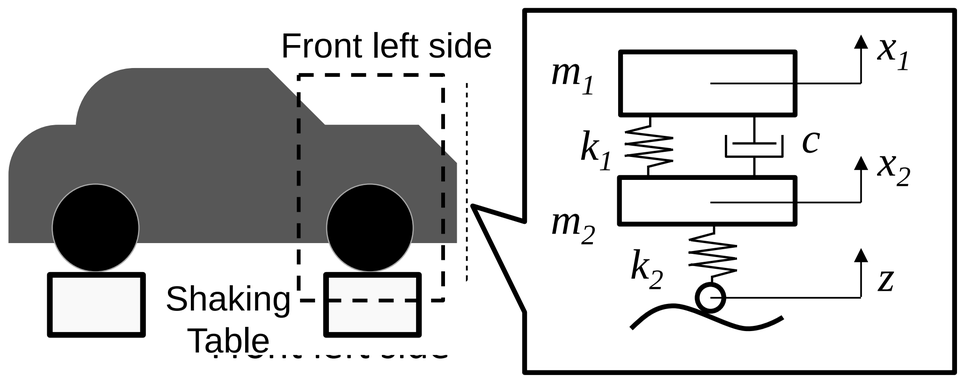
Rectangle

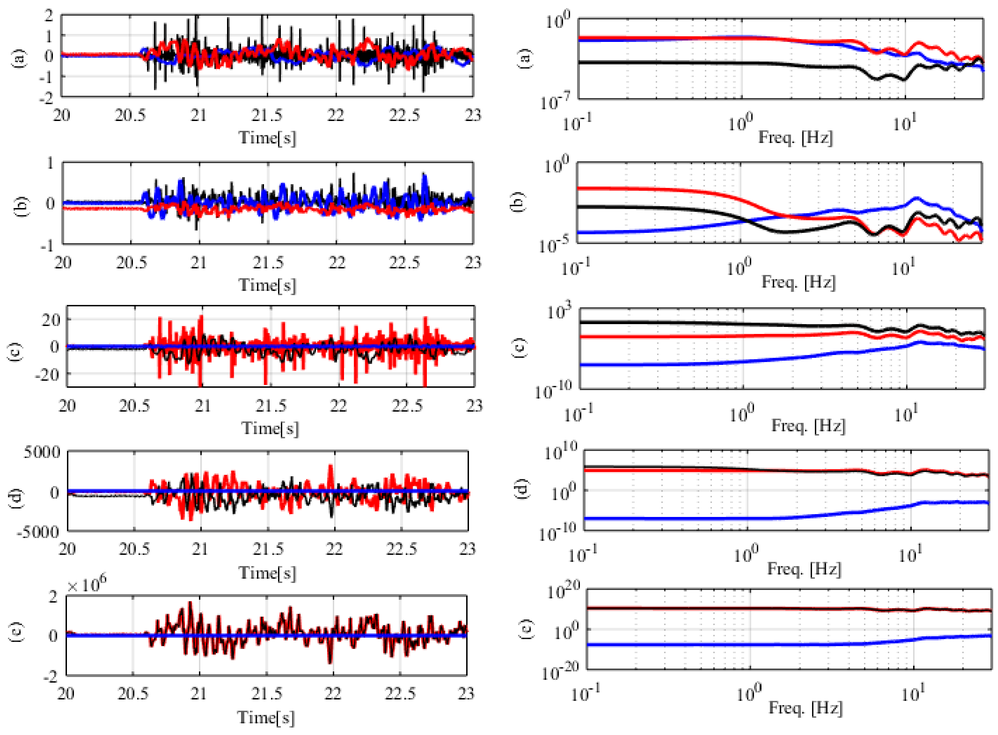


2.5Hz sinusoidal wave

実車での推定

Estimation on real vehicle





Red, Proposed ICA; Black, Conventional ICA; and Blue, Table Motion

Publications

Nakamura H., Nakano K., Uchiyama Y., Kakihara S., 2013, Application of independent component analysis for road profile estimation, Transactions of JSME Series C, 79(805), pp. 3002-3013.

Shimono K., Kaizuka T., Nakano K., Sakai E., Kono M., 2015, Estimation of road profile from vehicle body acceleration by independent component analysis, JSAE Annual Congress Proceedings (Autumn), pp.497-500, 14-16 October, Fukuoka, Japan.