Systematic review of SysID - correlation methods

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
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% This is my Matlab live script for introducing correlation methods
% Some contents are based on Arun K. Tangirala's SysID lecture in IIT
% and the textbook "System identification - an introduction" by Keesman
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Part 2. Prediction error methods --- 2-DoF mass-spring-damper system

Define stiffness and mass matrices

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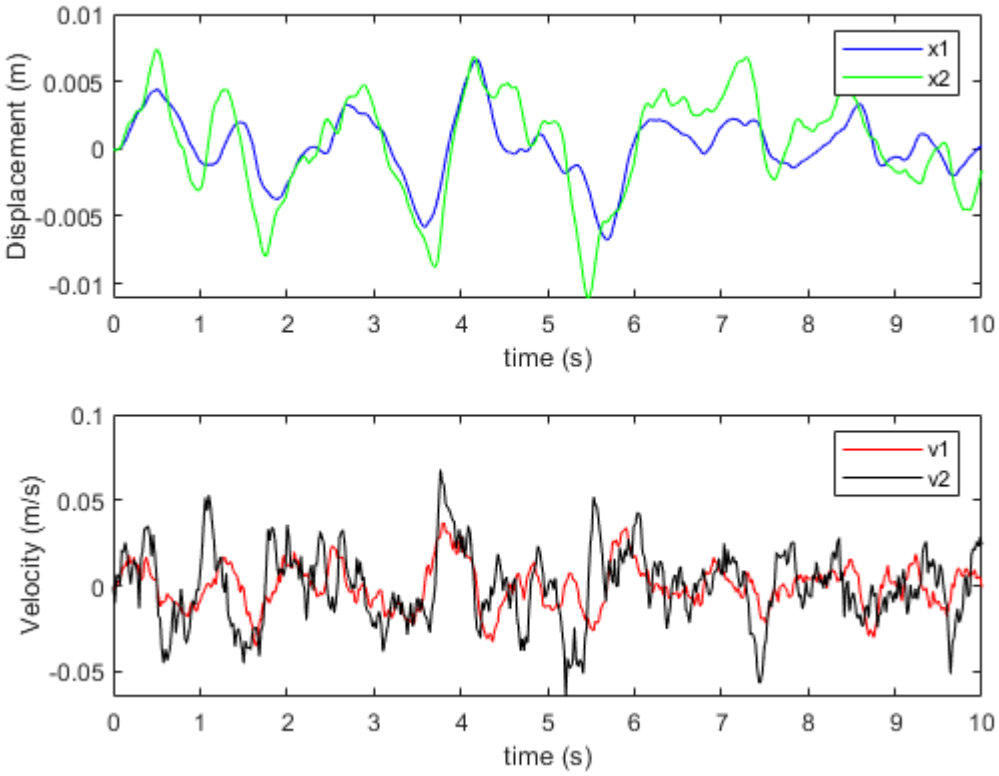
k1 c1 m1 k2 c2 m2

$$M\ddot{X} + CX^{\cdot} + KX = F$$

```
clc;
clear;
close all;
addpath ../functions/
m1=5; %mass 1 [kg]
m2=2; %mass 2 [kg]
k1=200; %spring 1 [N/m]
k2=100; %spring 2 [N/m]
c1=10; % damping coeff 1
c2=10; % damping coeff 2
M=[m1 0;0 m2]; %mass matrix
K=[k1+k2 -k2; -k2 k2]; %stiffness matrix
Damp=[c1+c2 -c2; -c2 c2]; % damping matrix
```

2.1 Load the data generated in script 1

```
ysol = csvread(['../data/2dof.csv']); %load data
T = 10; %length of time duration
nt = 500; %number of time stamps
tspan=linspace(0,T,nt);
figure(1)
plot_dv(tspan,ysol')
```



2.2 Autocorrelation function

The correlation of a signal with a delayed copy of itself as a function of delay.

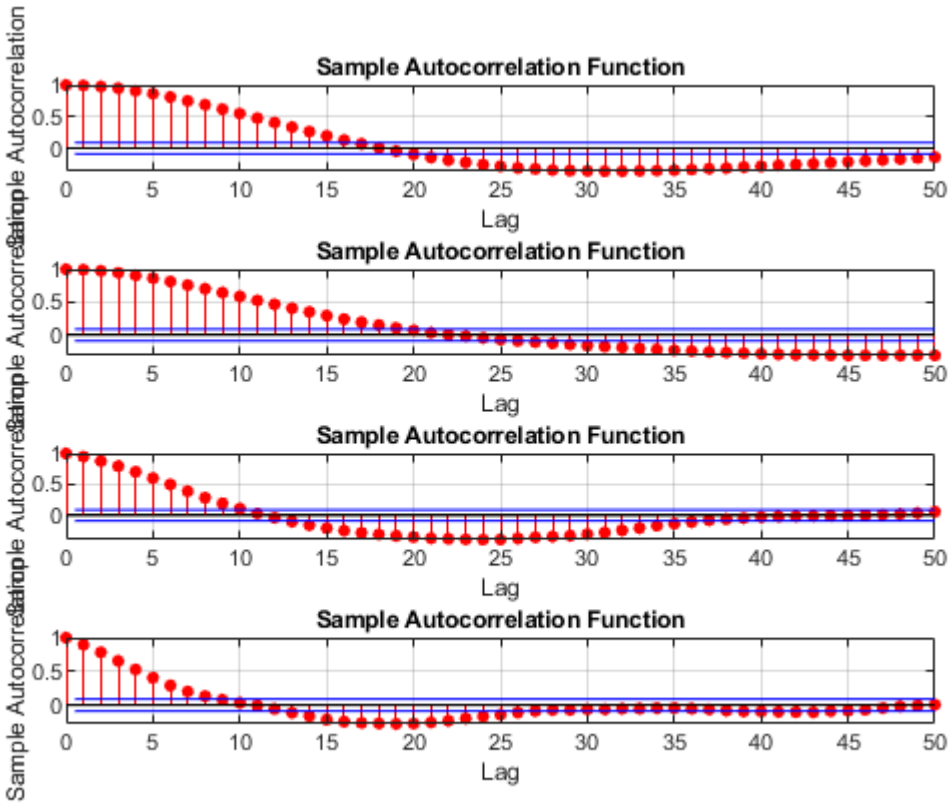
It is a tool for finding repeating patterns.

$$r_{uu}(\tau, t) = E[u(t)u(t+\tau)] = \lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T} u(t)u(t+\tau)dt$$

$$r_{uu}(l) = \lim_{T\to\infty}\frac{1}{2N+1}\sum_{i=-N}^{N} u(i)u(i+l)$$

where τ is the lag time.

```
figure(2)
subplot(4,1,1)
autocorr(ysol(1,:),'NumLags',50)
subplot(4,1,2)
autocorr(ysol(2,:),'NumLags',50)
subplot(4,1,3)
autocorr(ysol(3,:),'NumLags',50)
subplot(4,1,4)
autocorr(ysol(4,:),'NumLags',50)
```



For a MA process, the autocorrelation fucntion abruptly vanishes after lages |l|>1;

For a AR process, the autocorrelation function decays exponentially.

2.3 Cross-correlation function

$r_{uy}(\tau, t) = E[u(t)y(t+\tau)]$